Taking a unified perspective

Resolutions and highlighting in the semantics of attitudes and particles

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INSTITUTE FOR LOGIC, LANGUAGE AND COMPUTATION

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Academisch Proefschrift

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. ir. K.I.J. Maex
ten overstaan van een door het College voor Promoties ingestelde
commissie, in het openbaar te verdedigen in de Agnietenkapel
op vrijdag 28 juni 2019, te 10.00 uur

door

Nadine Theiler

geboren te Celle

Promotiecommisie

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Contents

Part Two.   Particles   135

Contents (detailed)

Acknowledgments

My most important thanks go to my advisors, Floris Roelofsen and Maria Aloni. I'm humbled by the sheer amounts of time, advice, and trust that I have received from them. Floris has a calm clarity and an uncanny ability to really listen, two qualities that I found immensely comforting in all the vagaries of my PhD project. If over the years they have rubbed off on me just a bit, I consider myself a better linguist than before, and a better person too. Maria's support throughout the last years was invaluable. She was relentlessly on my side, always, cheering at the successes and full of optimism after the setbacks. But this didn't keep her from giving me critical comments, sometimes crucial ones. I'm grateful for all of this.

I further thank my committee members, Veneeta Dayal, Donka Farkas, Jeroen Groenendijk, Maribel Romero, Robert van Rooij, Katrin Schulz, and Frank Veltman, for taking the time to read and evaluate this thesis. To Donka and Maribel, I am also grateful beyond this, for their support.

I had the privilege of traveling a lot during the last four years, and this dissertation has benefited substantially from comments I received in the context of workshops, conferences and visits. For suggestions, advice and discussion, I'd like to thank Boban Arsenijevic, David Beaver, John Beavers, Maria Biezma, Justin Bledin, Lucas Champollion, Liz Coppock, Eva Csipak, Gisela Disselkamp, Regine Eckardt, Patrick Elliott, Mitcho Erlewine, Alex Goebel, Dan Goodhue, Mira Grubic, Larry Horn, Nathan Klinedinst, Angelika Kratzer, Kyle Rawlins, Julian Schlöder, Mandy Simons, Benjamin Spector, Yasu Sudo, Wataru Uegaki, Yimei Xiang, and Malte Zimmermann. My biggest thanks in this regard, however, belong to Mike Deigan, who never seems to tire of discussing my work with me and who has managed to make me think a bit more like a philosopher.

Back home at the ILLC, I am grateful to the present and past members of the inquisitive semantics research group, who have provided much feedback and inspiration: thanks to Ivano Ciardelli, Alexandre Cremers, Jakub Dotlačil, and Matthijs Westera, with extra thanks to Thom van Gessel for translating the summary of this dissertation to Dutch.

Introduction

Some expressions describe properties of individuals or the relations that hold between them. Other expressions describe properties of events. Yet others characterize the properties of more elusive objects, namely those objects that are the semantic content of sentences. One example of this latter kind of expression are *attitude predicates* such as *know* and *care*, which relate the content of their complement clause to a subject. From (1a) we learn that Eddy stands in a *know*-relation to the content of the clause *the subway stops running at midnight*; and from (1b) we learn that Carla stands in a *care*-relation to the content of the clause *Magda won the race*. I will refer to expressions of this kind—expressions that operate on the semantic content of clauses—as *c-expressions*.

(1) a. Eddy knows that the subway stops running at midnight.
     b. Carla cares that Magda won the race.

Another example of c-expressions are *speaker-oriented adverbs* such as *surprisingly* or *unfortunately*, which comment on the content of their containing sentence, often with an evaluative flavor. The speaker of (2a), for instance, finds the content of *Ginger won the race* surprising, while the speaker of (2b) finds it fortunate.

(2) a. Surprisingly, Ginger won the race.
     b. Fortunately, Ginger won the race.

Similarly, speakers can use *discourse particles* to comment on the content of a sentence by relating this content to some property of the discourse or the interlocutors. If a speaker uses the German particle *ja*, they indicate that the content of the sentence containing *ja* is either already common knowledge of speaker and hearer or can be verified on the spot (Kratzer 2004). The speaker of (3), for instance, signals that the hearer already knows the content of *Die U-Bahn fährt alle fünf Minuten* or that this content can be verified from the immediate context.

(3) Die U-Bahn fährt ja alle fünf Minuten.
     The subway runs ʝᴀ every five minutes.

Finally, *additive particles* such as *too* may also be seen as commenting on the content of their containing clause: they indicate that this content is part of an incremental strategy to answer the question that is currently being discussed (Beaver and Clark 2008). Under this view, the *too* in (4), for example, indicates that the content of *Otto called* is just a partial answer to the question who called, and that another partial answer (here: Ginger called) has already been asserted.

(4)   Ginger called. Otto called, too.

The question that ties together the chapters of this dissertation is how best to model the semantic content on which expressions like these operate. We will address this question from one particular angle, starting from the contention that c-expressions appearing with interrogatives should be taken just as seriously as those appearing with declaratives.

C-expressions with interrogatives

Research in formal semantics has traditionally focused on declarative clauses, whose semantic content is classically modeled as a proposition. In view of this, it is unsurprising that c-expressions have typically been analyzed as operating on the *propositional content* of a sentence. The verb *know* in (1a), for example, would be analyzed as relating Eddy's epistemic state to the propositional content of *the subway stops running at midnight*.

Intuitive as this perspective may be for declarative clauses, it stumbles once we turn our attention to interrogatives. Different from declaratives, interrogatives are not usually taken to have propositional content. Rather, following the seminal work of Hamblin (1973), their meaning is often modeled as a set of propositions, exactly those propositions that answer the question expressed by the interrogative.

For accounts that treat c-expressions as operating on propositional content, this is problematic because many c-expressions that can appear with declaratives can also appear with interrogatives. In (5), for example, the attitude predicates familiar from (1) take interrogative complements instead of declarative ones.

(5)   a.   Eddy knows whether the subway stops running at midnight.
      b.   Carla cares who won the race.

Moreover, there are c-expressions that appear exclusively with interrogatives. As shown in (6), the predicate *depend on*, for example, doesn't accept declarative

complements, and, as shown in (7), the German discourse particle *denn* isn't licensed in declaratives.[1]

(6) a. How often the subway runs depends on the time of day.
    b. *That the subway runs every five minutes depends on the time of day.

(7) a. Wie oft fährt die U-Bahn denn?
       How often does the subway DENN *run?*
    b. *Die U-Bahn fährt denn alle fünf Minuten.
       The subway runs DENN *every five minutes.*

Finally, there are certain c-expressions for which, whether they are licensed in an interrogative, depends on the interpretation of the interrogative. The additive particle *also*, for example, usually can't appear in a genuine wh-question like (8), but is licensed in wh-questions whose answer the speaker already knows, such as (9) (Umbach 2012).[2]

(8) [After hearing that Ginger finished the race, Carla wants to know who else did:]

    I already know that Ginger finished the race. #Who also finished it?

(9) [Examiner asks during oral exam in history:]

    Okay, that's all correct. But what also happened in 1776?

All of these data points are prima facie problematic for the view that c-expressions operate on propositional content, and different strategies have been brought forward in response to them.

   To deal with attitude predicates like *know* that accept both declarative and interrogative complements, it is often assumed that a silent answer operator applies to interrogative complements. This operator compresses the set of propositions generated by the complement into a single proposition, with which the proposition-taking predicate can combine (a.o., Heim 1994, Dayal 1996, Beck and Rullmann 1999). As will be discussed in Chapter 1, however, there are problems associated with this strategy—as well as with other ways of reducing the interrogative-embedding use of attitude predicates to their declarative-embedding use.

   For discourse particles that can appear in different sentence types, the descriptive literature usually assumes several distinct lexical entries (e.g., Kwon

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[1]To be accurate, discourse particle *denn* is homonymous with a causal conjunction, and this conjunction is licensed in declaratives. A unified account of particle *denn* and conjunction *denn* will be proposed in Chapter 3.

[2]Of course, *also* is focus-sensitive, and whether it is licensed also depends on the phrase with which it associates. More details of the empirical picture will be discussed in Chapter 4.

2005; for a critical discussion see also Karagjosova 2004). In the theoretical literature, these particles are sometimes analyzed as commenting on or modifying the *speech act* or a *mood operator*, rather than being sensitive to any specific semantic content made available by their containing clause (e.g., Gutzmann 2015). Chapter 3 will argue that for certain particles, notably German *denn*, this view isn't fine-grained enough.

The solutions proposed in this dissertation differ from the above strategies: they take the semantic content of declaratives and interrogatives into account, but they do so in a *uniform* way. This means, rather than reducing the interrogative-directed use of an expression to its declarative-directed use, we will specify just a single lexical entry for the expression, which can apply to declaratives and interrogatives alike.

Uniform notions of semantic content

What allows us to specify lexical entries that can apply uniformly to declaratives and interrogatives are uniform notions of semantic content. It is assumed that both declarative and interrogative clauses make the same kind of semantic objects available for c-expressions to operate on. More specifically, in this dissertation two different uniform notions of semantic content (as well as some variations thereof) will be considered: in Part 1, the notion of *resolution* familiar from inquisitive semantics (Ciardelli *et al.* 2018) will play a prominent role, while in Part 2, the notion of *highlighting* in the sense of Roelofsen and Farkas (2015) will take center stage.

RESOLUTION. As mentioned above, the meaning of a sentence is traditionally construed as a proposition, i.e., a set of possible worlds. Intuitively, a proposition carves out a region in the space of all possible worlds, and in asserting a sentence, a speaker is taken to provide the information that the actual world is located within this region. In this way, the proposition expressed by a sentence captures the information conveyed by the sentence.

Inquisitive semantics conceives of sentences not only in terms of the information they convey, but also in terms of the information they request. Every sentence, regardless whether declarative or interrogative, is taken to raise an *issue*, a request for information. In the case of a declarative, this request is trivial: the declarative itself provides enough information to resolve the issue. In the case of an interrogative, on the other hand, the request is non-trivial: in order to satisfy it, information beyond the information provided by the interrogative itself is needed. This understanding of declaratives and interrogatives in terms

(a) Amy left.　　(b) Did Amy leave?　　(c) Who left?
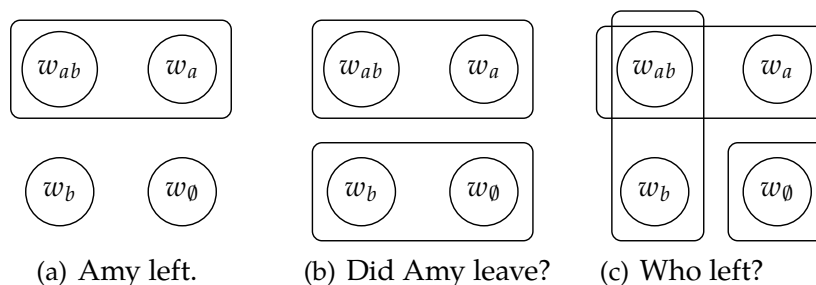
FIGURE 1. Examples of sentence meanings qua resolution sets.

of the issues they raise provides the conceptual backdrop against which we can construe the meaning of both sentence types as the same kind of semantic object: both are taken to denote sets of propositions. These propositions, called *resolutions*, are exactly those propositions that resolve the issue raised by the sentence. When a speaker utters a sentence with meaning P, she is taken to raise an issue whose resolution requires establishing one of the propositions in P, while at the same time providing the information that at least one of these propositions must be true.

For example, consider the diagrams in Figure 1, which each depict the meaning of a sentence, that is, the set of resolutions associated with the sentence.[3] In each diagram, w_{ab} is a world in which both Amy and Bill left, w_a one in which only Amy left, w_b one in which only Bill left, and $w_\emptyset$ one in which neither of the two left. The meaning of the declarative *Amy left*, depicted in Figure 1a, contains a single resolution, namely the proposition that Amy left. The meaning of the corresponding polar interrogative *Did Amy leave?*, depicted in Figure 1b, contains two resolutions, namely again the proposition that Amy left and the proposition that she didn't leave. Finally, the meaning of the wh-interrogative *Who left?*, depicted in Figure 1c, contains several resolutions, namely the proposition that Amy left, the proposition that Bill left, and the proposition that nobody left.

HIGHLIGHTING. While resolutions approach the concept of semantic content from the perspective of information exchange, highlighting is a more surface-oriented notion, modeling the semantic objects a sentence makes salient. When a question is asked or an assertion is made in discourse, this changes the context in which the subsequent utterance is interpreted. For example, saying *yes* in

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[3]Here, we gloss over many details, such as the fact that sentence meanings are downward-closed in inquisitive semantics. Slightly more rigorous introductions to the framework will be given in Chapter 1 and Chapter 2.

response to the polar question or the assertion in (10) conveys that the door is open, while in response to the polar question or the assertion in (11) it conveys that the door is closed. In response to the wh-question *Where was Carla born?* in (12), *yes* and *no* are meaningless. But if (12) receives the term answer *Athens*, this conveys that Carla was born in Athens.

(10)   Is the door open? / The door is open.

    a.   Yes. $\rightsquigarrow$ open
    b.   No. $\rightsquigarrow$ closed

(11)   Is the door closed? / The door is closed.

    a.   Yes. $\rightsquigarrow$ closed
    b.   No. $\rightsquigarrow$ open

(12)   Where was Carla born?

    a.   *Yes./*No.
    b.   Athens. $\rightsquigarrow$ Carla was born in Athens.

These discourse effects can be modeled by assuming that the utterance of a question or an assertion makes certain semantic objects salient, which then become available for subsequent anaphoric reference (Groenendijk and Stokhof 1984, von Stechow 1991, Krifka 2001, Aloni *et al.* 2007). In this dissertation, we will use a particular implementation of this idea, namely Roelofsen and Farkas (2015)'s notion of highlighting, which applies uniformly to declaratives and different kinds of interrogatives. Roelofsen and Farkas assume that every sentence highlights an n-place property, where $n \geq 0$ is the number of wh-elements in the sentence. Declaratives and polar interrogatives highlight 0-place properties, i.e., propositions, while wh-interrogatives highlight n-place properties with $n \geq 1$. For instance, both the declarative in (13a) and the polar interrogative in (13b) highlight the proposition that Amy left, while the wh-question in (13c) highlights the 1-place property of having left.

(13)   a.   Amy left.
    b.   Did Amy leave?
    c.   Who left?

RESOLUTION AND HIGHLIGHTING. All sentences make both kinds of semantic content available for c-expressions to operate on. Which kind of content an expression picks up, and which it simply ignores, depends on the expression itself. If we want to find out whether an expression is sensitive to resolutions, highlighting, or maybe both, we have to rely on indirect evidence. We can

observe whether the behavior of the expression patterns in certain ways. Some patterns, as we will see below, are impossible to capture with resolutions alone, while others are impossible to capture with highlighting alone.

Predicting differences in a uniform account

At first glance, a uniform account might seem to predict that a c-directed expression will behave exactly the same when it appears with a declarative and when it appears with an interrogative. In particular, a uniform account might seem to predict that all c-expressions can appear with both declaratives and interrogatives. Such a prediction would clearly not match the empirical picture. There are straightforward examples of c-expressions that accept only declaratives or that accept only interrogatives. As illustrated in (14), *believe* falls into the former category, while *wonder*, as illustrated in (15), falls into the latter.

(14) a.   Eddy believes that the subway stops running at midnight.
      b.   *Eddy believes whether the subway stops running at midnight.
      c.   *Eddy believes when the subway stops running.

(15) a.   *Eddy wonders that the subway stops running at midnight.
      b.   Eddy wonders whether the subway stops running at midnight.
      c.   Eddy wonders when the subway stops running.

In a non-uniform account, predicates like *believe* are typically treated as selecting for a single proposition, while predicates like *wonder* are modeled as selecting for sets of propositions. This distinction can be used to predict the data in (14) and (15), since in a non-uniform account declaratives are taken to denote propositions, while interrogatives are taken to denote sets of propositions. However, there are problems associated with this and similar approaches, which will be discussed in Chapter 2.

Fortunately, also in a uniform account, we have the means to capture differences like those in (14) and (15), and possibly even to push the explanation of these differences one level deeper. This is because, while declarative and interrogative clauses are taken to make the same *kinds* of semantic objects available, these objects still come apart in some of their more specific properties. This allows us to derive selectional and distributional restrictions from the way in which those properties interact with independently motivated characteristics of the expression under investigation.

Informativeness and inquisitiveness.   In inquisitive semantics, declaratives and interrogatives are alike in that they both denote sets of resolutions, but

they differ in that their respective sets of resolutions have different proper-
ties. While declaratives typically convey information, interrogatives do not—
or rather, the information they convey is trivial.[4] This is reflected by the fact
that the resolutions of a declarative typically cover only a subset of the logical
space—a property we call *informativeness*.[5] By contrast, the resolutions of an in-
terrogative cover the entire logical space—we call this *non-informativeness*.[6] This
difference can also be seen from the diagrams in Figure 1: the worlds w_b and
$w_\emptyset$ are not contained in any resolution of the declarative *Amy left*, whereas the
resolutions of the interrogatives *Did Amy leave?* and *Who left?* cover all worlds.

Conversely, as mentioned above, interrogatives typically raise non-trivial
issues, while declaratives raise trivial issues.[7] This is reflected by the fact
that an interrogative typically has several resolutions—we say it is *inquisitive*,
whereas a declarative has only a single resolution—we say it is *non-inquisitive*.[8]
This difference is also visible in the diagrams in Figure 1: the declarative *Amy
left* has just a single resolution, whereas the interrogatives *Did Amy leave?* and
Who left? each have several resolutions.

We hence see that the properties of informativeness and inquisitiveness,
defined in terms of resolutions, make it possible to keep declaratives and in-
terrogatives apart. Chapter 2 utilizes these properties to derive the selectional
restrictions of a range of attitude predicates. The incompatibility of *believe*
with interrogative complements, for instance, arises from the way in which the
lexical semantics of this verb interacts with the non-informativeness of inter-
rogative complements. Similarly, the incompatibility of *wonder* with declarative
complements is traced back to the way in which the lexical semantics of this
verb interacts with the non-inquisitiveness of declarative complements.

Highlighted semantic objects.   While for *believe* and *wonder* the relevant split
in behavior is between declaratives and interrogatives, there are also expres-
sions that pattern differently. The German discourse particle *denn*, for instance,
exhibits a striking asymmetry between polar and wh-interrogatives. In the dis-
course in (16), it is natural for interlocutor B to inquire which of the two Annas
is the intended referent, either by asking a wh-interrogative, as in (16a), or by

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[4]To be precise, interrogatives may also trigger presuppositions, and can therefore convey
non-at-issue information. But they typically don't convey at-issue information in the sense of
Potts 2005 or Simons *et al.* 2010.

[5]The only declaratives whose resolutions do cover the whole logical space are tautologies
such as *Everyone is identical to themselves*.

[6]To be accurate, the resolutions of presuppositional interrogatives cover only a subset of the
logical space, namely exactly that subset for which the meaning of the interrogative is defined.

[7]The only interrogatives that raise trivial issues are tautological interrogatives such as *Is
everyone identical to themselves?*.

[8]Again, at this point, we gloss over the downward-closedness of sentence meanings.

asking a polar interrogative, as in (16b). However, even though *denn* is syntactically permitted in both sentences, in this context it can only felicitously appear in the wh-interrogative. The reason behind this, Chapter 3 argues, is that when *denn* appears in a polar interrogative, this results in stricter requirements on the context than when it appears in a wh-interrogative.

(16)   [A and B know exactly two people called *Anna*, one from Munich and one from Berlin. This is commonly known among A and B.]

    A: Vorhin hat Anna angerufen.
    A: *Earlier today, Anna called.*

  a. B: Welche Anna meinst du denn?
       B: *Which Anna do you* DENN *mean?*

  b. B: Meinst du (#denn) Anna aus München?
       B: *Do you (#DENN) mean Anna from Munich?*

This contrast can't be captured by treating *denn* as sensitive to merely the resolutions of its containing clause. When modeled in terms of their resolution sets, the meanings of the polar and wh-interrogatives in (16) are indistinguishable in the given context. Since there are exactly two Annas, both question meanings contain exactly two resolutions, one for Anna from Munich, and one for Anna from Berlin. The interrogatives come apart, however, in terms of the semantic objects they highlight. While the polar interrogative highlights a 0-place property, i.e., a proposition, the wh-interrogative highlights a 1-place property. An intuitive way to think about this is that the notion of highlighting divides sentences into those that mention one concrete proposition (declaratives and polar interrogatives) and those that do not (such as wh-interrogatives). What the latter do instead may be conceived as "making available" several propositions, namely several possible instantiations of the highlighted property.

The account in Chapter 3 utilizes this difference to derive a stronger meaning contribution for *denn* in polar interrogatives than in wh-interrogatives, which makes it possible to capture the contrast in (16), as well as related data.

Another example of a highlighting-sensitive expression is the additive particle *also*, which is acceptable in declaratives and polar interrogatives like (17a-b), but marked when associating with the wh-phrase in a wh-interrogative, as in (17c).

(17)   John called.

  a. Mary also called.
  b. Did Mary also call?
  c. #Who also called?

Chapter 4 develops an account that predicts this contrast by treating *also* as sensitive to the property highlighted by its containing clause, just like *denn*, and sensitive to the current question under discussion.

RESOLUTIONS VS. HIGLIGHTING.   What has already been hinted at above and will emerge throughout this dissertation is that the two different notions of unified content considered here allow us to predict different splits in behavior. The notion of resolution allows us to distinguish between declaratives and interrogatives: the former are non-inquisitive, while the latter are non-informative. The notion of highlighting allows us to keep declaratives and polar interrogatives apart from wh-interrogatives: the former highlight a proposition, the latter highlight an n-place property with $n \geq 1$. Figure 2 provides an overview.

There are expressions whose behavior conforms to the split between declaratives and interrogatives: attitudes like *believe* only embed declaratives and attitudes like *wonder* only embed interrogatives. There are also expressions whose behavior patterns with the split between declaratives and polar interrogatives on the one hand and wh-interrogatives on the other hand: *denn* has a more tangible meaning contribution in polar interrogatives than in wh-interrogatives; and *also* is acceptable in declaratives and polar interrogatives, but marked in canonical wh-interrogatives.

Of course, this way of dividing up the empirical picture is not intended to be exhaustive. There might be c-expressions that are sensitive to *both* resolutions and highlighting—the attitude verb *surprise* is a good candidate for this category: it accepts declarative and wh-interrogative complements, but not polar interrogative complements.[9] And there are other levels of semantic content that c-expressions might be able to pick up—such as presuppositions, implicatures, the biases of polar questions, or the expected answers of rhetorical questions.

To conclude this introduction, my overall aim in this dissertation is twofold. First, I hope to provide further evidence that uniform accounts of c-expressions and the clauses they appear with are not only feasible and parsimonious, but also manage to avoid some of the problems faced by non-uniform accounts. Second, I would like to make a case for appreciating the diversity of questions. Different kinds of questions—this includes both different interrogative *forms* and different *uses* of the same form—differ in the semantic content they make available. By treating c-expressions as sensitive to these distinctions, we can predict a finer-grained empirical picture.

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[9]Treating it as sensitive to both highlighting and resolutions might provide us with a way of predicting this selectional restriction. Motivation for treating *surprise* as sensitive to resolutions comes from the fact that the verb is veridical. Motivation for treating it as highlighting-sensitive is discussed by Roelofsen (2017). For different approaches, see also Romero 2015b and others.
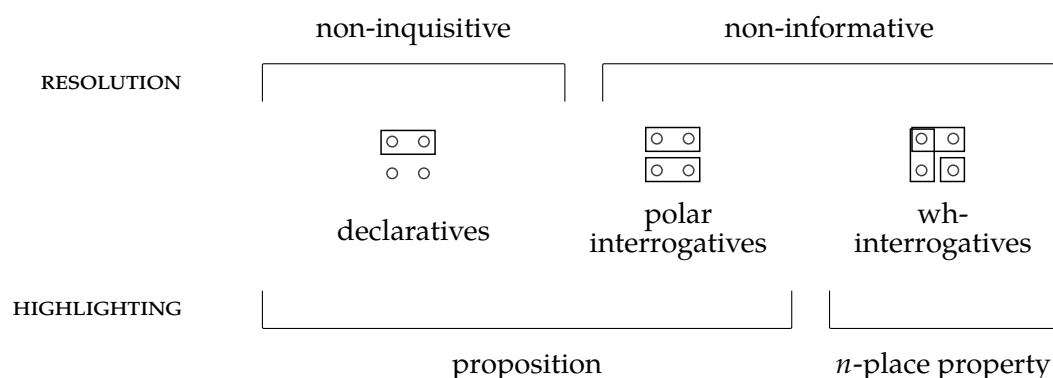
FIGURE 2. Resolution can distinguish between declaratives and interrogatives, while highlighting can distinguish between declaratives/polar interrogatives and wh-interrogatives.

Component papers

The remainder of this dissertation consists of four self-contained papers. The first two of these have been published or are forthcoming as indicated below, the second two have been published in shorter versions, also as indicated below. For co-authored papers, the order of authors reflects their relative contribution.

Chapter 1

Theiler, N., Roelofsen, F., and Aloni, M. (2018). A uniform semantics for declarative and interrogative complements. *Journal of Semantics*, 35(3), 409–466.

This paper develops a semantics for declarative and interrogative complements and for attitude predicates like *know* that can embed both kinds of complements. The proposed account is uniform, in the sense that both kinds of complements denote objects of the same semantic type and a single lexical entry is assumed for the embedding predicate. The paper shows that this approach (i) is flexible enough to derive readings on all levels of exhaustive strength, and (ii) avoids a number of problems for non-uniform theories.

Chapter 2

Theiler, N., Roelofsen, F., and Aloni, M. (2017). Picky predicates: Why *believe* doesn't like interrogative complements, and other puzzles. To appear in *Natural Language Semantics*.

It is a long-standing puzzle why predicates like *believe* embed declarative but not interrogative complements and why predicates like *wonder* embed interrogative but not declarative complements. This paper shows how the selectional restrictions of a range of predicates (neg-raising predicates like *believe*, truth-evaluating predicates like *be true*, inquisitive predicates like *wonder*, and predicates of dependency like *depend on*) can be derived from independently motivated assumptions about the lexical semantics of these predicates.

Chapter 3

Chapter 3 is an expanded version of:

Theiler, N. (2018). The precondition particle: A unified analysis of German *denn*. In S. Hucklebridge and M. Nelson, editors, *Proceedings of NELS 48*, pages 131–144, Amherst, MA. GLSA Publications.

This paper develops an account of the German discourse particle *denn*, capturing the use of this particle in polar questions, wh-questions and certain conditional antecedents in a unified way. It is shown that the behavior of *denn* exhibits an asymmetry between polar and wh-interrogatives, which can naturally be captured by treating the particle as sensitive to the property highlighted by its containing clause. The paper also offers some ideas for how highlighting-sensitivity might be used in the analysis of other discourse particles and extends the account of discourse particle *denn* to additionally cover the use of *denn* as a causal conjunction.

Chapter 4

Chapter 4 is an expanded version of:

Theiler, N. (2019). When additive particles can associate with wh-phrases. To appear in *Proceedings of SuB 23*.

The distribution of certain additive particles is restricted in interesting ways. It has been suggested that in wh-interrogatives they can only associate with the wh-phrase if the interrogative receives a showmaster interpretation (Umbach 2012). This paper presents novel data challenging this generalization and accounts for these data by lifting Beaver and Clark (2008)'s question-under-discussion-based account of additive particles to an inquisitive semantics setting, so that it captures the contribution of additive particles in declaratives, polar interrogatives and wh-interrogatives.

Part One.
Attitudes

Chapter 1.
A uniform semantics for declarative and interrogative complements

1.1. Introduction

So-called *responsive* verbs like *know* and *forget* accept both declarative and interrogative complement clauses as their argument:

(1) a.   Mary knows/forgot that John left.
     b.   Mary knows/forgot who left.

In this paper, we develop a *uniform* theory of clause embedding, i.e., a theory on which declarative and interrogative complements have the same semantic type. On such an account, every responsive verb can be associated with a single lexical entry, applying to declarative and interrogative complements alike.

By contrast, most existing approaches to clausal complements are non-uniform. At least since Karttunen (1977), it is usually assumed that declarative and interrogative complements differ in semantic type, with declaratives denoting propositions and interrogatives denoting sets of propositions. Under this view, it is prima facie unexpected that there are responsive verbs like *know* and *forget*, and non-uniform accounts need to find ways to resolve this tension. The diagram in Figure 1.1 classifies the most influential works on clausal embedding according to how they do this.[1]

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[1]We restrict our attention here to 'propositional' theories of interrogatives, leaving out so-called 'categorial' theories (e.g., von Stechow 1991, Krifka 2001) as well as theories couched in other frameworks, such as situation semantics (e.g., Ginzburg 1995). Categorial theories are not considered here because their main focus is on root interrogatives rather than embedded ones. Various phenomena involving root interrogatives require a more fine-grained notion of question meaning than the one provided by propositional frameworks. These phenomena, however, can also be explained in extensions of propositional frameworks that take dynamic aspects of meaning, i.e., the discourse referents that sentences introduce, into consideration

```
                                        /\
                                       /  \
                                      /    \
                          Non-uniform        Uniform approaches
                          approaches          /\
                            /\               /  \
                           /  \      Partition theory    Present
                          /    \        G&S ('84)        approach
                Reductive    Twin        Inverse
                approaches   relations   reductive
                  /\         approach    approach
                 /  \        George ('11) Uegaki ('15)
```

Type-shifting answer operator	Interrogative raising	Meaning postulates
Heim ('94)	Lahiri ('02)	Karttunen ('77)
Dayal ('96)		Spector & Egré ('15)
Beck & Rullmann ('99)		
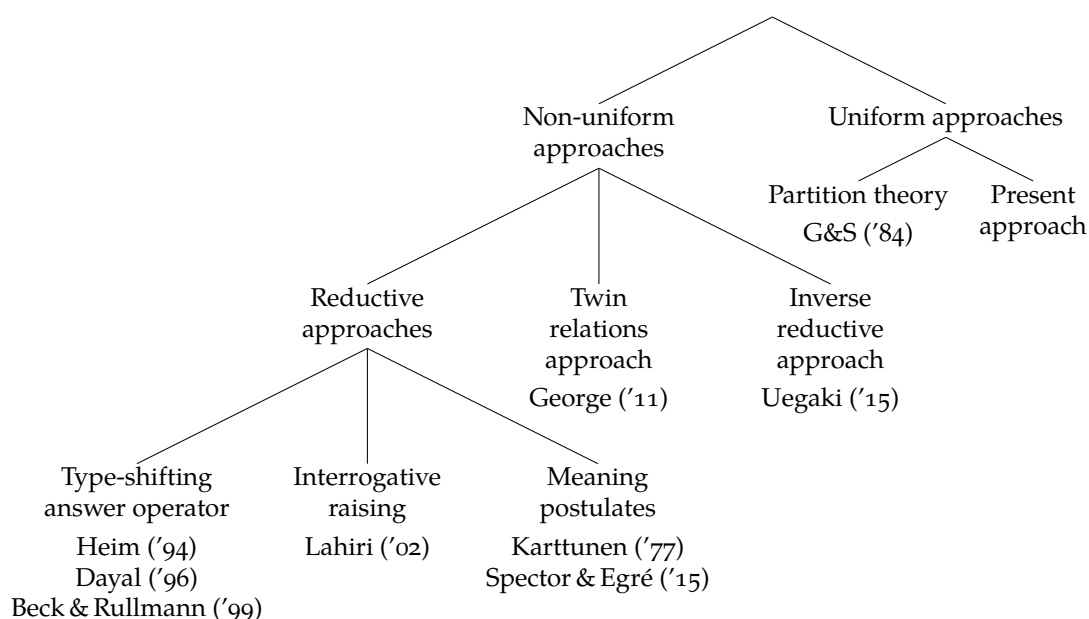
FIGURE 1.1. Different approaches to the semantics of declarative and interrogative complements.

So-called *reductive* approaches take the declarative-embedding use of responsive verbs to be basic, and *reduce* the interrogative-embedding use to the declarative-embedding one. They assume that responsive verbs want a proposition as their input—not a set of propositions. This means that if the complement of the verb is interrogative, a type mismatch arises. Heim (1994), Dayal (1996), and Beck and Rullmann (1999), among others, propose that this type mismatch is resolved by a type-shifting *answer operator*, which compresses the set of propositions generated by the interrogative clause into a single proposition and then feeds this proposition to the verb. Lahiri (2002) proposes that the type mismatch is resolved by raising the interrogative clause to a higher

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(e.g., Aloni *et al.* 2007, Roelofsen and Farkas 2015).

  Ginzburg (1995) specifically addresses embedded interrogatives but his focus is on phenomena of context-sensitivity which are arguably orthogonal to the issues addressed in this article. To explain these cases, Ginzburg proposes to parameterize the 'resolvedness' relation holding between an interrogative and a piece of information with a number of contextual factors including the goals of the conversational participants. Most of the cases of context-sensitivity discussed by Ginzburg can be explained in an extension of the present approach, adopting for example a conceptual cover style of quantification along the lines of Aloni (2001). On this approach, speakers' goals and other contextual factors, rather than being parameters of the resolvedness relation, would play a role in fixing the quantificational domain of wh-phrases.

position in the syntactic structure, leaving a proposition-type variable in the verb's argument slot.

A different variant of the reductive approach, briefly suggested by Karttunen (1977) and elaborated in detail by Spector and Egré (2015), is to assume two lexical entries for every responsive verb, one for each kind of complement. For instance, for *know* we would have the two entries *know$_d$* and *know$_i$*, taking declarative and interrogative complements, respectively. Spector and Egré then formulate a general meaning postulate which, given the declarative entry V_d of a verb V, determines the corresponding interrogative entry V_i.

Two other non-uniform approaches are the *twin relations* approach (George 2011) and the *inverse reductive* approach (also briefly considered in George 2011, but developed in much greater detail in Uegaki 2015b). The *twin relations* approach derives both the declarative-embedding interpretation and the interrogative-embedding interpretation of responsive verbs from a common lexical core. The *inverse reductive* approach reduces the declarative-embedding interpretation of responsive verbs to their interrogative-embedding interpretation, rather than the other way around.

The strategy we will pursue in the present paper diverges from all these approaches in that it treats declarative and interrogative complements uniformly. To our knowledge, the only previous account of clause embedding that follows this strategy is the *partition theory* of Groenendijk and Stokhof (1984).[2] On this theory, both declarative and interrogative complements are treated as denoting propositions. A declarative complement denotes the same proposition in every world, while the proposition denoted by an interrogative complement varies across worlds: in any world w, an interrogative complement denotes that proposition which, in w, is the true exhaustive answer to the question that the complement expresses.

For each of the theories mentioned above, certain problems have been identified in the literature. We will give a quick overview of the relevant issues, which are summarized in Table 1.1.

FLEXIBILITY IN EXHAUSTIVE STRENGTH (SECTIONS 1.3 AND 1.4). Traditionally, three kinds of readings are distinguished for knowledge ascriptions involving interrogative complements. For an impression of what these readings amount

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[2]The idea to treat declaratives and interrogatives uniformly goes further back, at least to Hamblin (1973, p.48). However, Hamblin was exclusively concerned with *root* clauses; he did not consider declarative and interrogative *complements*, and the repercussions of a uniform treatment for the analysis of verbs that take such complements as their argument, which is our main concern here.

	Flexibility			False answer sensitivity	Predicates of relevance	Constraints on verb meanings	Selectional restrictions
	SE	WE/IE	MS				
Reductive theories	+	+	+	–	–	±	–
Twin relations theory	+	–	+	+	–	±	–
Inverse reductive theory	+	+	±	+	+	–	±
Partition theory	+	–	±	–	+	–	–

TABLE 1.1. Pros and cons of existing approaches.

to (a more precise characterization will be given later), consider the following example:

(2)   John knows who called.

Under a *strongly exhaustive* (SE) reading, (2) is true just in case John knows exactly who called and who didn't. Under a *weakly exhaustive* (WE) reading, (2) just requires that John knows of everyone who called that they called (he does not need to know of people who didn't call that they didn't). Finally, under a *mention-some* (MS) reading, it is sufficient for John to know of at least one individual that he or she called. Some existing theories only derive a subset of these readings. In particular, the partition theory is mainly designed to derive SE readings. It needs to invoke additional machinery to derive MS readings and does not derive WE readings at all. Groenendijk and Stokhof argued that this is in fact a desirable feature of their theory, but other authors have disagreed (e.g., Heim 1994, Beck and Rullmann 1999, Spector 2005, Klinedinst and Rothschild 2011).

FALSE ANSWER SENSITIVITY (SECTION 1.3).   Note that according to the traditional characterization of MS and WE readings given above, the truth of (2) does not depend on what John knows or believes about individuals who did *not* call. Spector (2005), George (2011, 2013), and Klinedinst and Rothschild (2011) point out that this is problematic: interrogative knowledge ascriptions like (2) actually require that, of those individuals who did not call, John does not falsely believe that they did. This means that whether someone stands in the

knowledge relation to a certain interrogative does not only depend on her true propositional knowledge, but also on whether she believes any *false answers* to that interrogative. This sensitivity to false answers implies that interrogative knowledge cannot generally be reduced to true propositional/declarative knowledge. George (2011, 2013) shows that capturing false answer sensitivity is a problem for all reductive theories as well as for the partition theory,[3] but not for the inverse reductive theory or the twin relations theory.

PREDICATES OF RELEVANCE (SECTION 1.5). Elliott *et al.* (2017) observe that when so-called *predicates of relevance*, such as **care** and **matter**, take a declarative complement, they carry a certain presupposition that is absent when the complement is interrogative. For instance, (3a) presupposes that John knows that Mary left, while (3b) does not presuppose that John knows or believes of any particular girl that she left.

(3) a. John cares that Mary left.
     b. John cares which girl left.

Elliott *et al.* argue that this is problematic for reductive theories,[4] and Uegaki (2018) shows that it is also problematic for George's twin relations theory. On the other hand, it can easily be accounted for on the inverse reductive approach.

CONSTRAINTS ON VERB MEANINGS (SECTION 1.6). Evidently, the interrogative-embedding and the declarative-embedding interpretation of a responsive verb are related, and it is plausible that not all kinds of relationships between them are permissible. For instance, Spector and Egré (2015) propose that a responsive verb is veridical w.r.t. interrogative complements if and only if it is veridical w.r.t. declarative complements.[5] If Spector and Egré's generalization is correct, this means that, across languages, we will not find any responsive verb that is

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[3]The partition theory correctly captures false answer sensitivity in the case of strongly exhaustive readings. It does not, however, capture false answer sensitivity in the case of mention-some readings.

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

[5]Roughly, a verb is veridical w.r.t. declarative complements if, when used with a declarative complement, it implies that this complement is true, and it is veridical w.r.t. interrogative complements if, when used with an interrogative complement, it expresses a relation between its subject and the true answer to its complement. For instance, *know* is veridical w.r.t. declarative complements because *John knows that Mary left* implies that Mary left, and it is also veridical w.r.t. interrogative complements because *John knows whether Mary left* implies that John knows the true answer to the question whether Mary left. A more precise characterization of veridicality will be given in Section 1.5.

veridical w.r.t. one but not the other kind of complement. George (2011) and Spector and Egré (2015) put forward that a comprehensive theory of clause embedding should predict constraints of this kind. Partition theory and the inverse reductive approach fail to do so. Spector and Egré's reductive theory and George's twin relations theory, on the other hand, do predict the existence of certain general constraints such as the above veridicality constraint. What we will argue is that predicates of relevance form a counterexample to Spector and Egré's generalization and that the veridicality constraint should therefore not follow from a theory of clause embedding as a necessary consequence.[6] We will also suggest how a uniform or inverse reductive theory could account for the fact that most verbs do satisfy the constraint.

Selectional restrictions.   Not all embedding verbs are responsive. As illustrated in (4)–(5), there are also verbs that only take interrogative complements, such as *wonder*, and verbs that only take declarative complements, such as *believe*.

(4) a. *Bill wonders/investigated that John left.
     b.   Bill wonders/investigated who left.

(5) a.   Bill believes/hopes that John left.
     b. *Bill believes/hopes who left.

Most existing theories, with the exception of Uegaki (2015b), have left these selectional restrictions of non-responsive verbs unexplained. For reasons of space, the present paper will do the same, and focus exclusively on responsive verbs. However, in other work (Theiler *et al.* 2017a, Theiler *et al.* 2017b) we argue that it is a general advantage of the uniform approach taken here that the selectional restrictions of verbs like *wonder* and *believe* may in fact be derived in a rather straightforward way from independently motivated features of their lexical semantics. There, we also compare our account with that of Uegaki (2015b), arguing that while his inverse-reductive approach makes it possible to account for the fact that verbs like *wonder* do not take declarative complements (in a way similar to our uniform approach), it does not make it possible to account in an explanatory way for the fact that verbs like *believe* do not take interrogative complements (unlike our uniform approach).

The theory developed in the present paper is like partition theory in that it treats declarative and interrogative complements uniformly. However, build-

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[6]Observe from Table 1.1 that those theories which can deal with predicates of relevance are exactly those that *don't* derive strict constraints on verb meanings like Spector and Egré's veridicality constraint.

ing on recent work in inquisitive semantics (e.g., Ciardelli *et al.* 2015, Ciardelli *et al.* 2017), it also differs from partition theory in crucial respects, overcoming its main limitations. Most fundamentally, declarative and interrogative complements are not treated as denoting propositions, but rather as denoting sets of propositions. In the case of interrogative complements, these propositions do not encode what the true exhaustive answer to the interrogative is in any given world w, but rather what its *truthful resolutions* are in w. Such truthful resolutions need not be exhaustive, and need not even be true in w; they just need to be 'truthful', which means that they should not imply any false information that is directly relevant w.r.t. the issue expressed by the interrogative. This switch from true exhaustive answers to truthful resolutions will allow us to provide a general account of false answer sensitivity, and to derive not only strongly exhaustive readings but also false-answer sensitive mention-some and intermediate exhaustive readings in a straightforward way. Moreover (independently from the move to truthful resolutions), we will show how the special properties of predicates of relevance can be captured, and we will demonstrate how constraints on the space of possible responsive verb meanings can be implemented within a uniform account.

The paper is structured as follows. Section 1.2 briefly reviews the main terminology and notational conventions of inquisitive semantics. Section 1.3 introduces our account of clausal complements, paying special attention to how false answer sensitivity is implemented across the different levels of exhaustivity. Section 1.4 zooms in on the meaning of *know*, while Section 1.5 brings in other responsive verbs, including predicates of relevance. Section 1.6 focuses on capturing constraints on possible responsive verb meanings, and Section 1.7 concludes.

The paper also has two appendices: Appendix 1.A compares our proposal in some detail to the inverse reductive theory of Uegaki (2015b), which, even though it does not assume uniformity, is very close in spirit and empirical reach. Appendix 1.B contains formal proofs for some of the claims made in the paper.

1.2.   *Semantic framework*

Our account will be couched in *inquisitive semantics* (Ciardelli *et al.* 2015). More specifically, we will adopt the type-theoretic inquisitive semantics framework developed in Ciardelli *et al.* 2017. This framework is particularly suitable for our purposes here, because it offers a natural way of treating declarative and interrogative sentences uniformly (cf., Farkas and Roelofsen 2017). In this section, we briefly review the basic features of the framework and introduce some notational conventions that will be useful in later sections.

1.2.1. Sentence meanings in inquisitive semantics

Traditionally, the meaning of a sentence is construed as a *proposition*, i.e., a set of possible worlds. Intuitively, a proposition carves out a region in the space of all possible worlds W, and in asserting a sentence, a speaker is taken to provide the information that the actual world is located within this region. In this way, the proposition expressed by a sentence captures the *informative content* of the sentence.

Inquisitive semantics generalizes this notion of meaning to capture not just informative, but also *inquisitive content*, i.e., the issue raised in uttering a sentence. To achieve this, the meaning of a sentence is construed as a *set of propositions*, namely the set of all those propositions that resolve the issue raised by the sentence. When a speaker utters a sentence with meaning P, she is taken to raise an issue whose resolution requires establishing one of the propositions in P, while at the same time providing the information that at least one of these propositions must be true, i.e., that the actual world is contained in $\bigcup P$.

It is assumed that if a certain proposition p resolves a given issue, then any stronger proposition $q \subset p$ will also resolve that issue. This means that sentence meanings are *downward closed*: if $p \in P$ and $q \subset p$, then $q \in P$ as well. Finally, it is assumed that the *inconsistent* proposition, $\emptyset$, resolves any issue. This means that any sentence meaning has $\emptyset$ as an element and is therefore non-empty. These considerations lead to the following characterization of sentence meanings:

DEFINITION 1 (SENTENCE MEANINGS IN INQUISITIVE SEMANTICS).
A sentence meaning in inquisitive semantics is a non-empty, downward closed set of propositions.

The *maximal elements* of P are referred to as the *alternatives* in P. We will write alt(P) for the set of alternatives in P. In depicting the meaning of a sentence, we will generally only depict the alternatives that it contains. Finally, $\bigcup P$ is referred to as the *informative content* of P, denoted as info(P), and a sentence with meaning P is said to be *true* in a world w just in case $w \in$ info(P).

DEFINITION 2 (ALTERNATIVES, INFORMATIVE CONTENT, AND TRUTH).
For any sentence meaning P and any world w:

- alt$(P) := \{p \in P \mid$ there is no $q \in P$ such that $p \subset q\}$

- info$(P) := \bigcup P$

- A sentence with meaning P is true in w just in case $w \in$ info(P).

(a) Did Amy leave?   (b) Amy left.
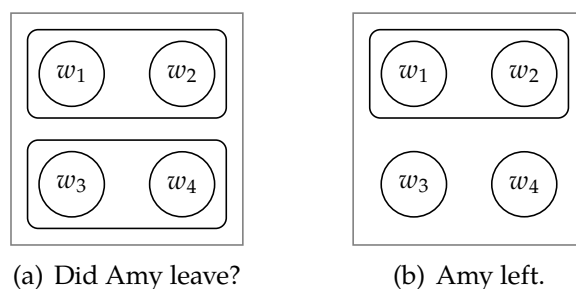
FIGURE 1.2. The meaning a polar interrogative and a declarative sentence in inquisitive semantics.

To illustrate these notions, consider the following two sentences.

(6) a. Did Amy leave?
     b. Amy left.

The polar interrogative in (6a) is taken to have the meaning in Figure 1.2a, where w_1 and w_2 are worlds where Amy left, and w_3 and w_4 are worlds where she didn't leave. The rectangles are the alternatives contained in the given meanings. By downward closure, all propositions contained in one of these alternatives are also included in the meanings of the sentences. The meaning assigned to (6a) captures the fact that, in uttering this sentence, a speaker (i) provides the trivial information that the actual world must be w_1, w_2, w_3, or w_4 (all options are open) and (ii) raises an issue whose resolution requires establishing either that Amy left, or that she didn't leave. Since $\mathsf{info}(\llbracket \textit{Did Amy leave?} \rrbracket) = \{w_1, w_2, w_3, w_4\}$, this sentence is true in all of w_1, w_2, w_3, and w_4. More generally, since the informative content of a non-presuppositional interrogative sentence always covers the entire logical space, such a sentence is always taken to be true in all worlds.

The declarative in (6b) is assigned the meaning in Figure 1.2b, which captures the fact that this sentence (i) conveys the information that the actual world must be either w_1 or w_2, i.e., one where Amy left, and (ii) raises an issue whose resolution requires establishing that Amy left. In this case, the information provided by the speaker is already sufficient to resolve the issue that is raised; no further information is needed from other conversational participants. Furthermore, as expected, *Amy left* is true in worlds w_1 and w_2.

1.2.2.　*Informative and inquisitive sentences*

In the case of the interrogative *Did Amy leave?* the information that is provided is *trivial* in the sense that it does not exclude any candidate for the actual world. Such sentences are called *non-informative*. Conversely, a sentence with meaning P is called *informative* just in case it does exclude at least one candidate for the actual world, i.e., iff $\mathsf{info}(P) \neq W$.

On the other hand, in the case of the declarative *Amy left*, the inquisitive content of the sentence is trivial, in the sense that the issue that is raised in uttering the sentence is already resolved by the information provided; no further information is required. Such sentences are called *non-inquisitive*. Conversely, a sentence with meaning P is called *inquisitive* just in case resolving the issue that it expresses requires more than the information that it provides, i.e., iff $\mathsf{info}(P) \notin P$.

Given a picture of the meaning of a sentence, it is easy to see whether the sentence is inquisitive or not. This is because a sentence is inquisitive just in case its meaning contains at least two alternatives.[7] For instance, the meaning in Figure 1.2a contains two alternatives, which means that the polar interrogative *Did Amy leave?* is inquisitive, while the meaning in Figure 1.2b contains only one alternative, which means that the declarative *Amy left* is not inquisitive. Following Ciardelli *et al.* (2015), Farkas and Roelofsen (2017) and much other work, we will assume that declarative sentences are never inquisitive, i.e., that their meaning always contains a single alternative.[8]

1.2.3.　*Composing meanings*

We adopt a standard two-step approach for composing the meaning of a sentence, summarized in Figure 1.3. In the first step, we *translate* a natural language expression into a type-theoretic language, by translating every lexical item into a certain type-theoretic expression and deriving the translation of complex constituents by means of function application and abstraction. We write $(\alpha)'$ for the translation of a natural language expression α. In the second step, type-theoretic expressions are *interpreted* relative to a model M and an assignment g.

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[7]Strictly speaking, this generalization only holds if any sentence meaning is guaranteed to contain alternatives—which again only holds under the assumption that there are finitely many possible worlds. However, this is a safe assumption to make for all the examples to be considered in this paper.

[8]There is also work in inquisitive semantics that does not make this assumption (e.g., Groenendijk 2009; AnderBois 2012). This requires a view under which uttering an inquisitive sentence does not necessarily involve issuing a request for information. We refer to Ciardelli *et al.* (2012, p.41-43) for further discussion of this point.
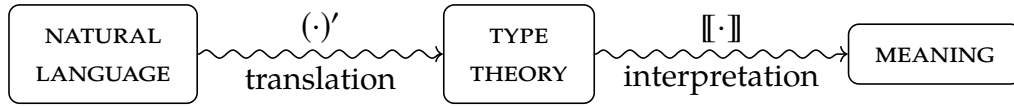
FIGURE 1.3. Two-step setup for deriving sentence meanings

The type theory we assume is two-sorted, with basic types e, s, and t, for individuals, worlds, and truth values, respectively. Since sentence meanings are construed as sets of propositions, sentences are taken to be of type $\langle\langle s, t\rangle, t\rangle$, which we abbreviate as T. From this, one can reverse engineer the types that should be assigned to various kinds of sub-sentential expressions:

(7)
$$
\begin{array}{lll}
\textit{John} : e & \textit{likes} : \langle e, \langle e, T\rangle\rangle & \textit{and} : \langle T, \langle T, T\rangle\rangle \\
\textit{walks} : \langle e, T\rangle & \textit{not} : \langle T, T\rangle & \textit{somebody} : \langle\langle e, T\rangle, T\rangle
\end{array}
$$

For instance, we take the meaning of a sentence like *John walks* to be the set of propositions p such that John walks in every world $w \in p$:

(8) $\quad(\textit{John walks})' = \lambda p.\forall w \in p : W(j)(w)$

This set of propositions is downward closed since, if p is a proposition such that John walks in every world $w \in p$, then the same goes for any $q \subseteq p$. To obtain the above sentence meaning, the verb *walks* should express a function that takes an individual x and yields the set of propositions p such that x walks in every $w \in p$:

(9) $\quad\textit{walks}' = \lambda x.\lambda p.\forall w \in p : W(x)(w)$

This is all we need to know about type-theoretical inquisitive semantics to give a compositional account of the constructions we are interested in here. For a more systematic introduction to this framework, we refer to Ciardelli *et al.* (2017).

1.3. *False answer sensitivity across levels of exhaustive strength*

We now lay out our account of clausal complements. Our initial aim will be to address two of the issues discussed in Section 1.1, namely to implement false answer sensitivity and derive the different levels of exhaustive strength. In doing so we will focus on just one verb, *know*. Other verbs will be considered in Section 1.5. The structure of the current section is as follows. First, Section 1.3.1 explains our main desiderata in some more detail. The rest of the

section spells out our positive proposal. We start by specifying our general assumptions about complement constructions (Section 1.3.2), then provide an account of interrogative complements (Section 1.3.3) and of the verb *know* (Section 1.3.4). Once this is in place, we show how the proposed account captures false answer sensitivity effects across all levels of exhaustivity (Section 1.3.5), and demonstrate that it also makes correct predictions for declarative complements (Section 1.3.6).

1.3.1. *Desiderata*

As mentioned in the introduction, three kinds of readings are traditionally distinguished for knowledge ascriptions involving interrogative complements: *strongly exhaustive* (SE) readings, *weakly exhaustive* (WE) readings, and *non-exhaustive* readings. The latter are also often referred to as *mention-some* (MS) readings, and we follow this custom. We will now make more precise what these readings amount to. Consider again example (2), repeated in (10):

(10)   John knows who called.

Let us assume that John knows what the domain of discourse D is, and let us refer to $A = \{d$ called $\mid d \in D\}$ as the set of answers to the question *who called*. Then the three readings can be characterized as follows:[9]

(11)   a.   Strongly exhaustive reading:
              –for any true answer $a \in A$, John knows that a is true, and
              –for any false answer $a \in A$, John knows that a is false
       b.   Weakly exhaustive reading:
              –for any true answer $a \in A$, John knows that a is true
       c.   Mention-some reading:
              –for at least one true answer $a \in A$, John knows that a is true

Note that in these traditional characterizations of the three different readings, false answers only play a role for SE readings. John's beliefs about false answers do not matter for WE and MS readings. In the recent literature, however, it has been argued that false answers are relevant for these weaker readings as well. In particular, Spector (2005) and Klinedinst and Rothschild (2011) point out their relevance for WE readings, based on sentences like (12).

---

[9]The characterization of strongly exhaustive readings does not correspond completely to that given in Groenendijk and Stokhof (1984). Under the latter, John would be required to know what the extension of the predicate *call* is. The two notions do coincide, however, under our current assumption that John knows what the domain of discourse is.

(12)   John told Mary who passed the exam.

Suppose that only Ann and Bill passed the exam. Then, under what seems to be the most salient reading of (12), the sentence is judged true if John told Mary that Ann and Bill passed the exam and he didn't tell her anything else. On the other hand, it is judged false if John additionally told Mary, erroneously, that Chris and Daniel passed the exam as well.

   George (2011) argues that false answers are relevant for MS readings as well, based on the following scenario. Suppose that there are three stores, Newstopia, Paperworld, and Celluloid City, of which only two, namely Newstopia and Paperworld, sell Italian newspapers. Janna knows, true to fact, that Newstopia sells Italian newspapers and does not have any beliefs concerning the availability of such newspapers elsewhere. Rupert, on the other hand, while also knowing that one can buy an Italian newspaper at Newstopia, falsely believes that Celluloid City sells such newspapers as well. George (2011) observes that there is a salient reading under which sentence (13a) is judged true in this scenario, while (13b) is judged false.

(13)   a.   Janna knows where one can buy an Italian newspaper.
       b.   Rupert knows where one can buy an Italian newspaper.

In order to capture this contrast, the characterization of MS readings should be made sensitive to false answers: it should not just require that the subject knows of at least one true answer to the embedded question that it is true, but also that she does not wrongly believe of any false answer that it is true.

   Xiang (2016a) further observes that the assessment of interrogative knowledge ascriptions is not only sensitive to beliefs concerning completely resolving false answers, but also to false *partial* answers. To see this, consider the same kind of scenario as above but now suppose that only Newstopia sells Italian newspapers. Suppose Rupert knows that Newstopia sells Italian newspapers but also wrongly believes that Paperworld or Celluloid City sells them, although he isn't certain which of the two. Xiang (2016a) observes that (13b) is still judged false in this scenario. Thus, Rupert's belief in the false partial answer 'that Paperworld or Celluloid City sells Italian newspapers' is sufficient to block interrogative knowledge.

   These observations show that false answer sensitivity (FA sensitivity for short) plays a role at all levels of exhaustive strength. For example (10), this yields the following truth conditions, assuming that $A^\vee := \{a_1 \vee \ldots \vee a_n \mid a_i \in A\}$ is the set of partial answers to the question *who called*:

(14)   a.   Strongly exhaustive reading, as before:

       –for any true answer $a \in A$, John knows that a is true, and

       –for any false (partial) answer $a \in A^{\vee}$, John knows that a is false

  b.   FA sensitive weakly exhaustive reading:

       –for any true answer $a \in A$, John knows that a is true

       –for any false (partial) answer $a \in A^{\vee}$, John does not believe that a is true

  c.   FA sensitive mention-some reading:

       –for at least one true answer $a \in A$, John knows that a is true

       –for any false (partial) answer $a \in A^{\vee}$, John does not believe that a is true

We will follow Klinedinst and Rothschild (2011) in referring to FA sensitive WE readings as *intermediate exhaustive* (IE) readings.

When it comes to deriving the different readings, some theories focus exclusively on FA sensitive MS readings (George 2011) while others focus on IE readings (Spector 2005, Klinedinst and Rothschild 2011, Uegaki 2015b, Spector and Egré 2015, Cremers 2016). Like Xiang (2016a), we will aim to give a general account of FA sensitivity that applies uniformly across the different levels of exhaustive strength.

As noted by George (2011), FA sensitivity poses a problem for reductive theories of clause embedding. To see this, observe that in George's scenario above, Janna and Rupert know exactly the same set of relevant propositions. Indeed, the only relevant proposition that they both know is the proposition that Newstopia sells Italian newspapers. Rupert additionally believes the proposition that Celluloid City sells Italian newspapers, but he doesn't *know* this proposition, simply because it is in fact false. This is problematic for reductive theories, because it shows that 'interrogative knowledge' is not always reducible to 'declarative knowledge'. It reveals that interrogative knowledge may not only depend on true declarative knowledge but also on beliefs about false answers to the interrogative at hand. We will see that this is not problematic under a uniform approach to clause embedding.

Finally, we should note that not all interrogative-embedding verbs exhibit FA sensitivity effects. A case in point is the verb *be certain*:

(15)   Rupert is certain where one can buy an Italian newspaper.

In contrast to (13b), where the same complement was embedded under *know*, (15) is saliently judged true in George's scenario. Our account should explain this lack of FA sensitivity effects for verbs like *be certain*.[10]

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[10]In talking about FA sensitivity we will draw a distinction between, on the one hand,

verb phrase
$\langle e, T \rangle$

verb
$\langle \langle s, T \rangle, \langle e, T \rangle \rangle$

complement
$\langle s, T \rangle$ $\rightarrow$ truthful
resolutions

E
$\langle T, \langle s, T \rangle \rangle$

nucleus
T $\rightarrow$ resolutions
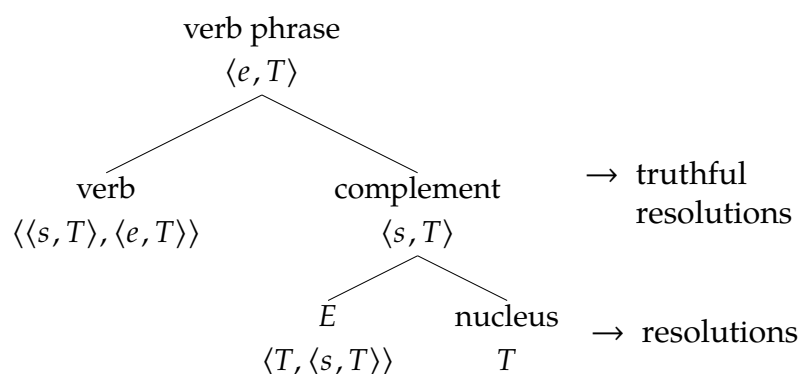
FIGURE 1.4. Global structure of complement constructions

1.3.2. *General assumptions about declarative and interrogative complements*

We now lay out our account of clausal complements, starting with some general syntactic and semantic assumptions which concern both declarative and interrogative complement constructions. We assume that such constructions have the structure in Figure 1.4. For reasons that we will return to in Section 1.3.5, declarative and interrogative complements both involve an *embedding operator E*, which adjoins to a clause that we will call the *nucleus* of the complement. The nucleus has the same semantic properties—for our current purposes—as a declarative respectively interrogative root clause. So, in particular, the semantic type of the nucleus of a complement is T.

The E operator takes the nucleus as its input and returns a function from worlds to sets of propositions. Thus, it is of type $\langle T, \langle s, T \rangle \rangle$. As we will see, this function maps every world w to the set of propositions that can be thought of as *truthful resolutions*, in w, of the issue expressed by the nucleus.

FA sensitivity itself, which is a theoretical property that, on our account, all interrogative-embedding verbs will have, and, on the other hand, FA sensitivity *effects*, which are a possible, but not necessary empirical manifestation of FA sensitivity. What we mean when we say that a verb is FA sensitive is that its semantics is sensitive to answers that are false at some relevant world(s). In the case of *know*, the relevant world is the world of evaluation w_0, and, as we just saw, *know* also exhibits FA sensitivity effects. Later, when considering verbs like *be certain* and *agree*, we will see that the relevant worlds can be different from w_0; in particular, they can be worlds in the epistemic state of the attitude holder (in the case of *be certain*) or another relevant agent (in the case of *agree*). In the case of *be certain*, this will have as a consequence that FA sensitivity effects are absent; in the case of *agree*, FA sensitivity effects will still arise. See footnote 29 for further discussion. Another verb that does not exhibit FA-sensitivity effects, for different reasons, is *surprise*; see Section 1.5.2.3.

Typically a verb and its complement together form a verb phrase that has the same semantic type as an intransitive verb like *walk*, i.e., $\langle e, T \rangle$, expressing a function from individuals to sets of propositions. To achieve this, a verb that takes clausal complements has to be of type $\langle \langle s, T \rangle, \langle e, T \rangle \rangle$. It takes as its input a function from worlds to sets of propositions, generated by its complement, and it yields as its output a function from individuals to sets of propositions.

1.3.3. *Interrogative complements*

In this subsection, we formulate a semantics for interrogative complements, starting at the level of the nucleus (Section 1.3.3.1), then moving on to the level of the complement, where the *E* operator and the notion of truthful resolutions will be introduced (Section 1.3.3.2).

1.3.3.1 *Interrogative nuclei*

We assume that a root wh-interrogative like (16), and thus also the nucleus of the corresponding interrogative complement, has two possible readings, an *exhaustive* and a *non-exhaustive* one.

(16)   Who left?

On the exhaustive reading, the sentence raises an issue whose resolution requires establishing exactly who left and who didn't. Let's assume that there are two individuals in the domain, Amy and Bill. Then, in order to resolve the issue raised by (16), one would have to specify for both Amy and Bill whether they left. On the non-exhaustive reading, on the other hand, the issue can be resolved by establishing either that Amy left, or that Bill left, or that neither of them left. The meaning we take (16) to have on the exhaustive reading is depicted in Figure 1.5a and the one we take it to have on the non-exhaustive reading in Figure 1.5b. As before, w_1 and w_2 in the diagrams are worlds where Amy left, while w_3 and w_4 are worlds where she didn't leave. Furthermore, w_1 and w_3 are worlds where Bill left, and w_2 and w_4 are worlds where he didn't leave.

Depending on the precise nature of the nucleus, either the exhaustive or the non-exhaustive interpretation may be blocked. For instance, the Dutch example in (17) only has an exhaustive interpretation, due to the presence of the exhaustivity marker *allemaal*, while the example in (18), which contains the non-exhaustivity marker *zoal*, only has a non-exhaustive interpretation (Beck and Rullmann 1999).

(a) Who left?$_{[+\text{exh}]}$ (b) Who left?$_{[-\text{exh}]}$
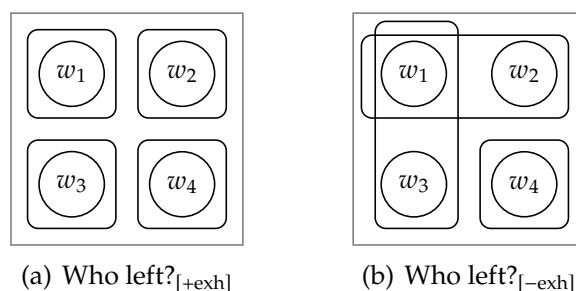
FIGURE 1.5. A wh-interrogative on its exhaustive and non-exhaustive reading.

(17)   Wie zijn er   **allemaal** genomineerd voor een Oscar dit jaar?
        who are there +EXH   nominated   for   a   Oscar this year
        'Who are nominated for an Oscar this year?' (exhaustive)

(18)   Wie zijn er   **zoal** genomineerd voor een Oscar dit jaar?
        who are there −EXH nominated   for   a   Oscar this year
        'Who are nominated for an Oscar this year?' (non-exhaustive)

The existence of such explicit (non-)exhaustivity markers in Dutch and other languages (see Li 1995, for similar data from Mandarin and German) motivates a particular view on the division of labor between semantics and pragmatics. Namely, we assume that the semantic component makes a (possibly restricted) range of possible readings available, and the pragmatic component selects from this range that reading which was most likely intended by the speaker, given the particular context of utterance. On this view, the range of permissible readings of an interrogative clause can be constrained by conventional means, such as the (non-)exhaustivity markers mentioned above. It is difficult to envision how pragmatics, operating at the matrix clause level, could be sensitive to these subsentential, conventional ways of marking exhaustive strength.

Since we will focus on *embedding* here, we will treat the compositional derivation of the nucleus meaning as a blackbox, referring to Champollion *et al.* (2015) for a concrete compositional semantics that is compatible with the account developed here. Our account of embedding is also compatible with other treatments of interrogative nuclei that derive both exhaustive and non-exhaustive interpretations (e.g., Nicolae 2013, Theiler 2014).[11]

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[11] We will largely leave *presuppositional* interrogative nuclei out of consideration in this paper. For instance, a singular *which*-question like *Which student left?* is often taken to presuppose that exactly one student left. The issue of how presuppositions like this should be modeled and derived is complicated, and orthogonal to our main concerns here. We believe that our account

1.3.3.2 The E *operator: from resolutions to truthful resolutions*

As we saw in Section 1.2, in order to count as a resolution of some issue, a proposition has to provide enough information to resolve this issue. Naturally, if a proposition p resolves an issue P, then any more informative proposition $q \subset p$ will resolve P as well. This is the reason why sentence meanings in inquisitive semantics, which are taken to be sets of resolutions, are downward-closed.

However, unlike the meaning of an interrogative nucleus, the meaning of an interrogative *complement* is not represented as a plain set of resolutions, but rather as a function from worlds to sets of *truthful* resolutions. Truthful resolutions are still resolutions, but in addition they have to fulfil two requirements: (i) they need to be consistent, and (ii) they must not provide false information w.r.t. the given issue.

In order to make this more precise, we first introduce some auxiliary notation. We will write $\mathsf{alt}_w(P)$ for the set of alternatives in P that are true in w, and $\mathsf{alt}_{*w}(P)$ for the set of alternatives in P that are false in w. Moreover, we will write $\mathsf{alt}^\cup(P)$ for the set of all unions of alternatives in P, $\mathsf{alt}^\cup_w(P)$ for elements of $\mathsf{alt}^\cup(P)$ that are true in w, and $\mathsf{alt}^\cup_{*w}(P)$ for elements of $\mathsf{alt}^\cup(P)$ that are false in w. Intuitively, $\mathsf{alt}^\cup(P)$ can be thought of as the set of answers and partial answers to P; $\mathsf{alt}^\cup_w(P)$ contains those answers and partial answers that are true in w, while $\mathsf{alt}^\cup_{*w}(P)$ contains those that are false in w. The latter notion is particularly relevant for us, since, as discussed in Section 1.3.1, interrogative knowledge ascriptions require that the subject does not believe an answer or partial answer to the interrogative complement that is false in the world of evaluation.

DEFINITION 3 (TRUE AND FALSE ALTERNATIVE SETS).
For any sentence meaning P and any world w:

- $\mathsf{alt}_w(P) := \{p \in \mathsf{alt}(P) \mid w \in p\}$

- $\mathsf{alt}_{*w}(P) := \{p \in \mathsf{alt}(P) \mid w \notin p\}$

- $\mathsf{alt}^\cup(P) := \{\bigcup Q \mid Q \subseteq \mathsf{alt}(P)\}$

- $\mathsf{alt}^\cup_w(P) := \{p \in \mathsf{alt}^\cup(P) \mid w \in p\}$

- $\mathsf{alt}^\cup_{*w}(P) := \{p \in \mathsf{alt}^\cup(P) \mid w \notin p\}$

Given a sentence meaning P, we can then say that a resolution $p \in P$ provides false information w.r.t. P in w iff it entails some proposition in $\mathsf{alt}^\cup_{*w}(P)$. Con-

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can be extended in various ways to suitably deal with such cases. Whenever we make general claims about interrogative complements, we will indicate in a footnote whether the claim can be expected to hold of presuppositional cases as well.

versely, p provides *no* false information w.r.t. P in w iff it does not entail any proposition in $\mathrm{alt}^{\cup}_{*w}(P)$.

For instance, assume that Amy and Bill are the only individuals in the domain and that only Amy left (in the diagrams in Figure 1.5, this means the actual world is w_2). Consider the sentence meaning $P = [\![\textit{who left}_{[-\mathrm{exh}]}]\!]$, depicted in Figure 1.5b, which contains one alternative that is true in w_2 (Amy left) and two alternatives that are false in w_2 (Bill left; neither Amy nor Bill left). This means that we get:

– $\mathrm{alt}(P) \;\; = \left\{\; \boxed{\text{⬚}}, \boxed{\text{⬚}}, \boxed{\text{⬚}} \;\right\}$

– $\mathrm{alt}_w(P) = \left\{\; \boxed{\text{⬚}} \;\right\}$

– $\mathrm{alt}^{\cup}_{*w}(P) = \left\{\; \boxed{\text{⬚}}, \boxed{\text{⬚}}, \boxed{\text{⬚}} \;\right\}$

Now, let p be the proposition that Amy and Bill left ($\boxed{\text{⬚}}$). Observe that p entails the alternative q that Bill left ($\boxed{\text{⬚}}$). Since q is false in w_2 and q is an alternative in P, $q \in \mathrm{alt}^{\cup}_{*w_2}(P)$. Hence, p provides false information w.r.t. P. As another example, let p' be the proposition that Amy didn't leave ($\boxed{\text{⬚}}$). Now consider the alternatives ($\boxed{\text{⬚}}$) and ($\boxed{\text{⬚}}$), both of which are false in w_2. The union of these two alternatives ($\boxed{\text{⬚}}$) is an element of $\mathrm{alt}^{\cup}_{*w_2}(P)$. Since this union is furthermore entailed by p', we find that p' provides false information w.r.t. P as well.

We hence arrive at the following definition of truthful resolutions. In what follows, we will occasionally make reference to the crucial third clause in this definition as the *no false alternatives (NFA) condition*.[12,13]

DEFINITION 4 (TRUTHFUL RESOLUTION). Let P be a sentence meaning and w a possible world. A proposition p is a truthful resolution of P in w iff:

(i) p is a resolution of P ($p \in P$),

(ii) p is consistent ($p \neq \emptyset$),

(iii) *NFA condition:* p doesn't provide information w.r.t. P that is false in w ($\neg \exists q \in \mathrm{alt}^{\cup}_{*w}(P) : p \subseteq q$).

---

[12]This NFA condition is stronger than the one we assumed in Theiler *et al.* (2016). There, we only excluded propositions which entail false answers, i.e., elements of $\mathrm{alt}_{*w}(P)$. Now, we also exclude propositions which entail false partial answers, i.e., elements of $\mathrm{alt}^{\cup}_{*w}(P)$. See Section 1.3.1 for the motivation behind this stronger formulation, due to Xiang (2016a).

[13]Inquisitive semantics is a support-based rather than a truth-based semantic framework. It would therefore actually be more in the spirit of the framework if we didn't compute truthful resolutions at a specific world of evaluation, but rather relative to a set of worlds, i.e., an information state. For reasons of presentation, we will nonetheless take the former route here.

We further distinguish between truthful resolutions *simpliciter* and *complete* truthful resolutions, which entail all true alternatives.

DEFINITION 5 (COMPLETE TRUTHFUL RESOLUTION).   Let P be a sentence meaning and w a possible world. A proposition p is a complete truthful resolution of P in w iff:

  (i) p is a truthful resolution of P in w,

  (ii) p entails all alternatives in $\text{alt}_w(P)$.

To exemplify the distinction between truthful resolutions simpliciter and complete truthful resolutions, consider a scenario in which there are three people, Amy, Bill and Clara. Assume that in world w Amy and Bill left, but Clara didn't. Again, let $P = [\![\textit{who left}_{[-\text{exh}]}]\!]$. Then, the proposition that Amy left, the proposition that Bill left, and the proposition that both of them left are all truthful resolutions of P in w. The proposition that both of them left is additionally a complete truthful resolution of P in w. The proposition that Amy, Bill and Clara left, on the other hand, is not a truthful resolution of P in w. Observe that, once we make the step from resolutions to truthful resolutions, we are not dealing with downward-closed sets anymore: although the proposition that Amy, Bill and Clara left is a subset of the proposition that Amy left, only the latter is a truthful resolution of P in w.

Crucially, although a truthful resolution r has to entail a true alternative, r itself need not be true. For instance, assume that in the above scenario it is Monday. Consider the proposition r that Amy left and that it is Tuesday. Clearly, r is false. Nonetheless, it counts as a truthful resolution because it only provides true information w.r.t. the issue of who left; the false information that it provides—namely that it is Tuesday—is not relevant w.r.t. the issue of who left. In this sense we may say that truthful resolutions embody a notion of truth radically relativized to a given issue: they must not provide any false information w.r.t. to that issue.

To get a more visual understanding of this concept, let us return to a scenario in which there are just two people who might have left, Amy and Bill. Let $P = [\![\textit{who left}_{[-\text{exh}]}]\!]$. This is depicted in Figure 1.6, where p is the proposition that Amy left and q the proposition that Bill left. Suppose that the actual world, w_0, is located in p, but not in q, as depicted in Figure 1.6. That is, only Amy left in w_0. This means that $q \in \text{alt}^{\cup}_{*w_0}(P)$. Let us now reflect on which propositions in the picture count as truthful resolutions in w_0. Clearly, p itself is a truthful resolution. More interesting, however, is the question which subsets of p are truthful resolutions and which are not. To begin with, all *true* propositions entailing p are automatically truthful resolutions because they are consistent
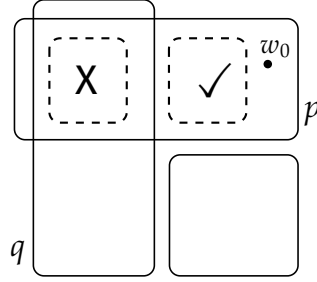
FIGURE 1.6. Illustrating the notion of truthful resolutions.

resolutions and cannot entail any proposition in $\mathsf{alt}^{\cup}_{*w_0}(P)$. On the other hand, with *false* propositions that entail p, we have to distinguish two cases. First, let r be the proposition that both Amy and Bill left (the crossed-out proposition in the diagram). Since r entails q, it does not count as a truthful resolution. Second, let r' be some other consistent proposition such that $r' \subseteq p$, but $r' \not\subseteq q$ (e.g., the one with a tick mark in the diagram). There is no proposition in $\mathsf{alt}^{\cup}_{*w_0}(P)$ that is entailed by r'. Hence, although both r and r' are false, r' counts as a truthful resolution in w_0 whereas r doesn't.

We now turn to defining the E operator. When applied to a nucleus meaning P, this operator yields a function mapping every world w to the set of (complete) truthful resolutions of P in w. Formally, we can characterize E, which comes in a complete and a non-complete variant, as follows.[14]

DEFINITION 6 (THE E OPERATOR).

$$E_{[-cmp]} \quad := \quad \lambda P_T.\lambda w.\lambda p. \left(\begin{array}{c} p \in P \ \wedge \ p \neq \emptyset \ \wedge \\ \neg \exists q \in \mathsf{alt}^{\cup}_{*w}(P) : p \subseteq q \end{array} \right)$$

---

[14]Although at first glance the non-complete and complete variant of E might appear to differ only minimally, formally they actually come apart in a fundamental way. The computation carried out by $E_{[-cmp]}$ is an *innocent* type-shift, in the sense that if we have a function $f = E_{[-cmp]}(P)$, we can retrieve the set P from f, since $P = \bigcup_{w \in W} f(w) \cup \{\emptyset\}$. In contrast, the computation carried out by $E_{[+cmp]}$ is not an innocent type-shift, in the sense that if $f = E_{[+cmp]}(P)$, we cannot retrieve P from f. To see this, consider the following two sets of resolutions: $P_1 = \left\{ \begin{smallmatrix} \boxdot & \circ \\ \circ & \circ \end{smallmatrix}, \begin{smallmatrix} \circ & \circ \\ \boxdot & \circ \end{smallmatrix}, \begin{smallmatrix} \boxdot & \circ \\ \circ & \circ \end{smallmatrix}, \begin{smallmatrix} \circ & \circ \\ \circ & \boxdot \end{smallmatrix} \right\}^{\downarrow}$ and $P_2 = \left\{ \begin{smallmatrix} \boxdot & \circ \\ \circ & \circ \end{smallmatrix}, \begin{smallmatrix} \circ & \boxdot \\ \circ & \circ \end{smallmatrix}, \begin{smallmatrix} \circ & \circ \\ \boxdot & \circ \end{smallmatrix}, \begin{smallmatrix} \circ & \circ \\ \circ & \boxdot \end{smallmatrix} \right\}^{\downarrow}$, where the dow-narrow ($\downarrow$) indicates closure under subsets. Applying $E_{[+cmp]}$ to either P_1 or P_2 yields the same function $f = \left\{ w_1 \mapsto \left\{ \begin{smallmatrix} \boxdot & \circ \\ \circ & \circ \end{smallmatrix} \right\}, w_2 \mapsto \left\{ \begin{smallmatrix} \circ & \boxdot \\ \circ & \circ \end{smallmatrix} \right\}, w_3 \mapsto \left\{ \begin{smallmatrix} \circ & \circ \\ \boxdot & \circ \end{smallmatrix} \right\}, w_4 \mapsto \left\{ \begin{smallmatrix} \circ & \circ \\ \circ & \boxdot \end{smallmatrix} \right\} \right\}$. So, in general it is impossible to retrieve P from $E_{[+cmp]}(P)$.

$$E_{[+cmp]} \ := \ \lambda P_T.\lambda w.\lambda p.\left(\begin{array}{l} p \in P \ \wedge \ p \neq \emptyset \ \wedge \\[4pt] \neg\exists q \in \mathsf{alt}^{\cup}_{*w}(P) : p \subseteq q \ \wedge \\[4pt] \forall q \in \mathsf{alt}_w(P) : p \subseteq q \end{array} \right)$$

For an illustration of the functions that E yields, consider the examples below, which show the result of applying this operator to typical interrogative nucleus meanings.[15]

(19) $\quad E_{[-cmp]}(\boxminus) = \left\{ \begin{array}{rcl} w_1 & \mapsto & \{\; \square, \square, \square, \square, \square \;\} \\[6pt] w_2 & \mapsto & \{\; \square, \square \;\} \\[6pt] w_3 & \mapsto & \{\; \square, \square \;\} \\[6pt] w_4 & \mapsto & \{\; \square \;\} \end{array} \right.$

(20) $\quad E_{[+cmp]}(\boxminus) = \left\{ \begin{array}{rcl} w_1 & \mapsto & \{\; \square \;\} \\[6pt] w_2 & \mapsto & \{\; \square, \square \;\} \\[6pt] w_3 & \mapsto & \{\; \square, \square \;\} \\[6pt] w_4 & \mapsto & \{\; \square \;\} \end{array} \right.$

(21)
$$E_{[-cmp]}(\boxminus) = \left\{ \begin{array}{rcl} w_1 & \mapsto & \{\; \square \;\} \\[6pt] w_2 & \mapsto & \{\; \square \;\} \\[6pt] w_3 & \mapsto & \{\; \square \;\} \\[6pt] w_4 & \mapsto & \{\; \square \;\} \end{array} \right.$$
$$E_{[+cmp]}(\boxminus) = \ \text{(as above)}$$

Observe that, as anticipated, sets of truthful resolutions are not always downward closed. For instance, $E_{[-cmp]}(\boxminus)(w_2)$ contains $\square$, but not $\square$. Further observe that if E applies to an exhaustive nucleus meaning P, as in (21), $E_{[+cmp]}(P)$ and $E_{[-cmp]}(P)$ coincide. This is the case because if P is exhaustive, then $\mathsf{alt}_w(P)$ is a singleton set for every w, which means that any truthful resolution in w is automatically a *complete* truthful resolution in w.

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[15]In these examples, we assume that the four worlds are labelled as in Figure 1.5: w_1 is the world in the upper left corner, w_2 the one in the upper right corner, etcetera.

For easy reference, we will refer below to truthful resolutions that result from applying $E_{[-cmp]}$ to a non-exhaustive nucleus meaning, as in (19), as *mention-some* (MS) truthful resolutions; similarly, when $E_{[+cmp]}$ applies to a non-exhaustive nucleus meaning, as in (20), we will speak of *intermediate exhaustive* (IE) truthful resolutions, and when $E_{[+cmp]}$ or $E_{[-cmp]}$ applies to an exhaustive nucleus meaning, as in (21), we will speak of *strongly exhaustive* (SE) truthful resolutions. This terminology is summarized in the following table.

(22)

	nucleus$_{[-exh]}$	nucleus$_{[+exh]}$
$E_{[-cmp]}$	mention-some	strongly exhaustive
$E_{[+cmp]}$	intermediate exhaustive	strongly exhaustive

This concludes our account of interrogative complements. However, this account only yields concrete predictions when combined with an analysis of the verbs that take such complements as their argument. Instead of diving right into the full range of verbs, though, we will first zoom in on one particular verb, namely *know*. We will see that, when combined with a simple lexical entry for *know*, the above treatment of interrogative complements allows us to derive MS, IE, and SE readings, capturing FA sensitivity effects across these different levels of exhaustivity in a uniform way.

1.3.4. *A basic treatment of 'know'*

We will formally characterize the meaning of *know* in terms of the subject x's *information state* in a world w, which we understand to be the set of worlds compatible with what x takes to be the case in w. We will write DOX_x^w for this set. Crucially, an individual's information state in w does not have to contain w itself, i.e., it does not necessarily hold that $w \in \text{DOX}_x^w$. As is commonplace in doxastic logic, we do assume that DOX_x^w is always consistent (i.e., non-empty) and that x always knows what her own information state is (i.e., $\text{DOX}_x^v = \text{DOX}_x^w$ for all $v \in \text{DOX}_x^w$).

We assume the following basic entry for *know*.[16]

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[16]This entry is a refinement of the treatment of the knowledge modality in *inquisitive epistemic logic* (*IEL*) (Ciardelli and Roelofsen 2015). In *IEL*, DOX_x^w is simply required to coincide with a resolution of the complement. Our entry, on the other hand, requires that DOX_x^w coincides with a *truthful* resolution of the complement in the world of evaluation. As we will see, it is precisely this refinement that allows us to capture FA sensitivity.

(23) *know'* := $\lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p : \text{DOX}_x^w \in f(w)$

In words, *know'* takes a complement meaning f and a subject x as arguments, and yields a set of propositions. Recall that f is a function mapping each world to the set of truthful resolutions of the complement in that world. Hence, the set that *know'* yields contains only propositions p such that for every world $w \in p$ the information state of x in w exactly matches one of the truthful resolutions in $f(w)$.

This entry for *know* differs from classical accounts in two respects. Firstly, on classical accounts, $f(w)$ has a fixed exhaustive strength; i.e., it is the true WE answer in w (Karttunen 1977) or the true SE answer in w (Groenendijk and Stokhof 1984). In comparison, our account is more flexible. Depending on the interpretation of the nucleus of the complement (exhaustive or non-exhaustive) and the E operator (complete or non-complete), $f(w)$ will consist of MS, IE or SE truthful resolutions.

The second difference concerns the relation between DOX_x^w and $f(w)$. Standardly, $f(w)$ is a single proposition rather than a set of propositions and it is required that DOX_x^w is a *subset* of this single proposition. For us, $f(w)$ is a set of propositions and DOX_x^w has to be an *element* of this set—we will see shortly that this is instrumental in accounting for FA sensitivity.

1.3.5. *False answer sensitivity across levels of exhaustivity*

On our account, FA sensitivity is captured by the NFA condition in the definition of truthful resolutions (Definition 4), which says that a proposition p is only a truthful resolution of a sentence meaning P in a world w if it does not entail any proposition in $\text{alt}_{*w}^{\cup}(P)$. Let us see what the consequences of this condition are across the different levels of exhaustive strength.

We begin with George's scenario, involving an MS example. Recall that in the actual world w_0 only Newstopia and Paperworld sell Italian newspapers. Janna and Rupert know that Newstopia sells Italian newspapers. Additionally, Rupert falsely believes that also Celluloid City sells such newspapers. Janna has no beliefs about Celluloid City. Then, under an MS reading, (24) is judged true, while (25) is judged false.

(24) Janna knows where one can buy an Italian newspaper.
(25) Rupert knows where one can buy an Italian newspaper.

This is indeed what we predict. To see why, assume that the above complements each involve $E_{[-\text{cmp}]}$ and the nucleus receives a [–exh] interpretation, resulting in MS readings. Let P be the nucleus meaning. Observe that P contains two

true alternatives, namely the proposition that one can buy an Italian newspaper at Newstopia and the proposition that one can buy an Italian newspaper at Paperworld, and two false alternatives, namely the proposition that one can buy an Italian newspaper at Celluloid City and the proposition that one cannot buy an Italian newspaper at any of the three stores. Janna's information state $\textsc{dox}_j^{w_0}$ is a truthful resolution of the complement since it is consistent, it entails one of the alternatives in $\mathrm{alt}(P)$ and it does not entail any alternative in $\mathrm{alt}_{*w_0}^{\cup}(P)$, while Rupert's information state $\textsc{dox}_r^{w_0}$ is *not* a truthful resolution of the complement since it does entail a proposition in $\mathrm{alt}_{*w_0}^{\cup}(P)$, namely the proposition that one can buy an Italian newspaper at Celluloid City. Thus, (24) comes out as true because $\textsc{dox}_j^{w_0} \in E_{[-\mathrm{cmp}]}(P)(w_0)$, while (25) comes out as false because $\textsc{dox}_r^{w_0} \notin E_{[-\mathrm{cmp}]}(P)(w_0)$.[17]

In the case of IE readings, FA sensitivity arises from exactly the same mechanism. Consider example (26), which is a variant of (12) with *know* rather than *tell*. Pace Groenendijk and Stokhof (1984), we assume here that *know* licenses IE readings, just like *tell*—as will be further discussed in Section 1.4, this assumption is supported by experimental results of Cremers and Chemla (2016).

(26)   John knows who passed the exam.

Suppose that in the actual world w_0 only Anna and Bill, but not Chris and Daniel passed the exam. An IE reading arises on our account if the complement is headed by $E_{[+\mathrm{cmp}]}$ and the nucleus receives a $[-\mathrm{exh}]$ interpretation. In this

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[17]Xiang (2016a) argues that there are two different kinds of false answers relevant in the context of MS readings, namely *over-affirming* and *over-denying* false answers. George (2011) only takes the former into account. To see what the difference is, consider a modified Italian-newspaper scenario. As before, Newstopia sells Italian newspapers, while Paperworld doesn't. In addition, however, there is a third store, Celluloid City, which also sells Italian newspapers. Suppose that Janna believes one can get an Italian newspaper at Newstopia and Paperworld. Since this is a falsely positive belief, Xiang classifies it as over-affirming. Now suppose that Janna correctly believes one can buy an Italian newspaper at Newstopia, that she doesn't have any beliefs about Paperworld, and she wrongly believes one cannot buy an Italian newspaper at Celluloid City. Since this is a falsely negative belief, Xiang classifies it as over-denying.

According to Xiang's experimental results, in a scenario like the one above, sentences like (24) are judged false by a significant number of participants if Janna believes an over-denying answer. This could either be accounted for by assuming that the respective participants are accessing a mention-all reading instead of an MS reading or by making it part of the truth-conditions of the MS reading that over-denying beliefs are not permitted. Xiang pursues the latter strategy. Our account, as presented here, takes the former route: while over-affirming propositions are excluded from the set of truthful resolutions by virtue of the NFA condition, over-denying propositions are included. It would be easy, however, to expand the NFA condition in Definition 4 in such a way that it also rules out over-denying propositions; all we would have to demand is that a truthful resolution in w is consistent with every alternative in $\mathrm{alt}_w(P)$.

case we predict that the following is required for (26) to be true in w_0. John's information state in w_0, $\text{DOX}_j^{w_0}$, has to be an element of $E_{[+\text{cmp}]}(P)(w_0)$, where P is the nucleus meaning. This means that (i) $\text{DOX}_j^{w_0}$ has to be consistent, (ii) it has to entail all true alternatives in P, i.e., it has to entail that Anna and Bill passed the exam, and (iii) in view of the NFA condition, it should not entail any proposition in $\text{alt}_{*w_0}^{\cup}(P)$, i.e., it should not entail that either Chris or Daniel passed. This precisely amounts to the IE reading.

Finally, an SE reading of (26) arises on our account if the nucleus receives a [+exh] interpretation. In this case the alternatives in the nucleus meaning P form a partition of the logical space such that all worlds in any given partition cell agree on who passed the exam and who didn't. Now suppose that the complement is headed by $E_{[-\text{cmp}]}$. In this case we predict that for (26) to be true in w_0 it is required that (i) $\text{DOX}_j^{w_0}$ is consistent, (ii) $\text{DOX}_j^{w_0}$ is a resolution of P, which means that it entails one of the alternatives in P, and (iii) in view of the NFA condition, it should not entail any proposition in $\text{alt}_{*w_0}^{\cup}(P)$. Taken together, requirements (ii) and (iii) imply that $\text{DOX}_j^{w_0}$ has to entail a *true* alternative in P. There is only one true alternative in P, which is the proposition that Anna and Bill passed the exam and Chris and Daniel didn't. It is required, then, that John's information state entails this proposition, which is again precisely what we expect under an SE reading.

If we assume that the complement is headed by $E_{[+\text{cmp}]}$ rather than $E_{[-\text{cmp}]}$ we get an additional completeness requirement, namely, that $\text{DOX}_j^{w_0}$ should entail all true alternatives in P. However, since P forms a partition here, we know that it contains only one true alternative. So the completeness requirement is vacuous in this case, and the end result is exactly the same as with $E_{[-\text{cmp}]}$.

Let us end this subsection with a comment on the division of labor we assume between the E operator and the embedding verb. On our account, the [±cmp] ambiguity is situated at the level of the E operator. One may wonder whether this ambiguity could be incorporated into the meaning of the embedding verb instead. However, coordination data seem to suggest that this would be problematic. To see this, first consider the sentences in (27) and (28) below. As shown experimentally in Cremers and Chemla (2016), sentences like (27) most prominently receive an IE reading.[18] On the other hand, sentences like (28) most prominently receive an MS reading.

(27) John knows which Spanish newspapers are sold at the corner store.

(28) John knows where one can get an Italian newspaper.

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[18]Cremers and Chemla's experiment will be discussed in more detail in Section 1.4 below.

Now consider (29), in which the two interrogative complements from (27) and (28) are conjoined.

(29)   John knows which Spanish newspapers are sold at the corner store and where one can get an Italian newspaper.

The crucial observation is that the most prominent interpretation of (29) seems to be one under which the first complement receives an IE reading, just as in (27), while the second complement receives an MS reading, just as in (28). To derive this interpretation, the first complement needs to bear a [+cmp] feature, while the second complement needs to bear a [–cmp] feature. If completeness were taken to be a feature of the verb, it would be impossible to derive the interpretation, since the complex complement clause could only be interpreted [+cmp] as a whole or [–cmp] as a whole.[19]

This concludes our treatment of interrogative complements embedded under *know*. What we have seen in this subsection is that our notion of truthful resolutions, in particular the NFA condition, captures FA sensitivity in a uniform way across the different levels of exhaustivity. We now turn to declarative complements.

1.3.6. Declarative complements

Even though we focused on interrogative complements so far, our account has been set up in such a way that it can directly be applied to declarative complements as well. Here, we will go into two specific predictions: (i) any truthful resolution of a declarative complement is complete, (ii) the set of truthful resolutions of a declarative complement is always fully downward closed.

1.3.6.1 All truthful resolutions are complete

In order to see what happens when the *E* operator applies to a declarative nucleus, let us look at a concrete example:

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[19]Thanks to Lucas Champollion (p.c.) for pointing this out. The line of reasoning is borrowed from an argument that has been made in connection with distributivity, cf. Dowty (1987).

$$(30) \quad E_{[-\text{cmp}]}(\boxed{\begin{smallmatrix} \circ & \circ \\ \circ & \circ \end{smallmatrix}}) = E_{[+\text{cmp}]}(\boxed{\begin{smallmatrix} \circ & \circ \\ \circ & \circ \end{smallmatrix}}) = \left\{ \begin{array}{lcl} w_1 & \mapsto & \left\{ \boxed{\begin{smallmatrix}\circ&\circ\\\circ&\circ\end{smallmatrix}}, \boxed{\begin{smallmatrix}\circ\\\circ\end{smallmatrix}}\circ, \circ\boxed{\begin{smallmatrix}\circ\\\circ\end{smallmatrix}} \right\} \\ \\ w_2 & \mapsto & \left\{ \boxed{\begin{smallmatrix}\circ&\circ\\\circ&\circ\end{smallmatrix}}, \boxed{\begin{smallmatrix}\circ\\\circ\end{smallmatrix}}\circ, \circ\boxed{\begin{smallmatrix}\circ\\\circ\end{smallmatrix}} \right\} \\ \\ w_3 & \mapsto & \emptyset \\ \\ w_4 & \mapsto & \emptyset \end{array} \right\}$$

In (30), $E_{[\pm\text{cmp}]}$ applies to the nucleus meaning $P = \left\{ \boxed{\begin{smallmatrix}\circ&\circ\\\circ&\circ\end{smallmatrix}} \right\}^{\downarrow}$, which, since it is the meaning of a declarative nucleus, only contains a single alternative. Observe that the complete and the non-complete version of E yield the same result here. This is because any truthful resolution of a declarative complement is automatically also a *complete* truthful resolution. To see why, suppose that p is a truthful resolution. Since a declarative nucleus meaning only contains a single alternative q, we know that p entails q and that q is true. But this means, again because q is the only alternative, that p entails *every* true alternative in the nucleus meaning. Hence, p is also a complete truthful resolution.

As a consequence, while with interrogative complements our account generates multiple readings (MS, IE, and SE), in the case of declarative complements it always generates just one reading.

1.3.6.2 *The set of truthful resolutions is downward closed*

As we have seen in Section 1.3.3.2, when E applies to a non-exhaustive interrogative nucleus, the resulting set of truthful resolutions only exhibits a restricted form of downward closedness. If E applies to a declarative nucleus, however, the resulting set of truthful resolutions is always *fully* downward closed. To see why, consider an arbitrary declarative nucleus meaning P and let q be the unique alternative in P. Then, if $w \in q$, we have that $E(P)(w) = \{q\}^{\downarrow}$, while if $w \notin q$, we have that $E(P)(w) = \emptyset$. As a consequence, the set of truthful resolutions is always fully downward closed.

To illustrate this, consider the following example:

(31)   Rupert knows that one can buy an Italian newspaper at Newstopia.

Let p be the proposition that Newstopia sells Italian newspapers, and r the proposition that both Newstopia and Paperworld sell Italian newspapers. Now, since in the case of a declarative complement, the set of truthful resolutions is downward closed, both p and r are truthful resolutions. This is why it is correctly predicted that (31) is true even if Rupert wrongly believes r.[20]

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[20] For a visual understanding, compare the declarative complement meaning in (30) with the

To take stock, we now have a uniform account of declarative and interrogative complements embedded under *know*. The effects of this semantics depend on whether the complement is declarative or interrogative: (i) in the case of declarative complements, the set of truthful resolutions is fully downward closed, while in the case of interrogative complements it may exhibit a restricted form of downward closedness, which results in FA sensitivity effects; and (ii) the MS, IE and SE reading come apart for interrogative complements, but coincide for declarative complements.

1.4. Do intermediate exhaustive readings for 'know' exist?

In the previous section, we have derived IE readings for interrogative knowledge ascriptions without considering in any detail whether such readings exist. This is, in fact, a controversial issue. In particular, Groenendijk and Stokhof (1982) explicitly argued that they do *not* exist, while recent experimental work by Cremers and Chemla (2016) suggests that they do. In this section, we suggest a way to reconcile these findings with Groenendijk and Stokhof's argument.

1.4.1. Knowledge ascription and introspection

Groenendijk and Stokhof (1982, p.180) argued that *know* does not license IE readings:

> "Suppose that John knows of everyone who walks that he/she does; that of no one who doesn't walk, he believes that he/she does; but that of some individual that actually doesn't walk, he doubts whether he/she walks or not. In such a situation, John would not say of himself that he knows who walks. We see no reason to override his judgement and to claim that in this situation, John does know who walks. This seems to suggest that for John to know who walks, he should not only know of everyone who walks that he/she does, but also of everyone who doesn't that he/she doesn't."

Many authors have found this argument convincing and have therefore assumed, with Groenendijk and Stokhof, that *know* only allows for SE and MS readings.

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interrogative complement meaning in (19). Consider the set of truthful resolutions in w_2. In (30), this includes the proposition ⊡ ∘, but not so in (19). This is because in (19), but not in (30), the proposition in question implies an alternative that is false in w_2.

B	B
R	R

The card that
John looked at

B	B
G	B

John's beliefs
in scenario A

B	B
G	?

John's beliefs
in scenario B
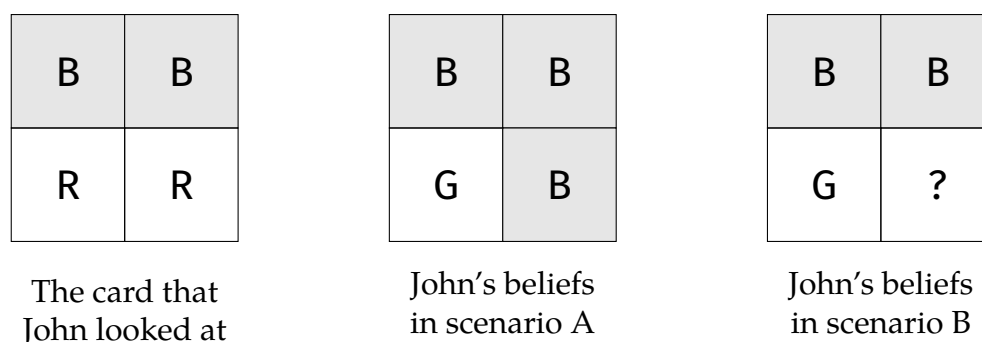
FIGURE 1.7. Scenario from Cremers and Chemla (2016)

However, recent experimental work by Cremers and Chemla (2016) seems to show quite clearly that *know* does license IE readings. Cremers and Chemla asked the participants in their experiment to consider the following context:

> There is a set of cards, each consisting of four squares. Each square can be blue (B), green (G) or red (R). John is playing a game with these cards: he uncovers a card, looks at it briefly and tries to remember which of the squares on the card were blue. In the first round, the card he looked at was the left one in Figure 1.7. Now, consider two different scenarios: in scenario A, John's beliefs about the card he looked at are as represented by the second picture in Figure 1.7; in scenario B, John's beliefs about the card he looked at are as represented by the third picture in Figure 1.7.

Now consider the following sentence:

(32)   John knew which squares were blue.

Cremers and Chemla found that (32) was saliently judged false in scenario A, while it was saliently judged true in scenario B. This can only be the case if the complement in (32) received an IE reading. Under an SE reading the sentence would have been judged false in both scenarios.[21]

How could this experimental result be reconciled with the widely held view, rooted in Groenendijk and Stokhof's argument, that *know* does not license IE readings? What is crucial, we believe,[22] is to recognize that knowledge ascriptions are multiply ambiguous: besides the different readings of the comple-

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[21]An MS reading is in general unavailable for plural *which*-interrogatives with a distributive predicate, such as the one in (32).

[22]We are much indebted to Jeroen Groenendijk for discussion of this issue.

ment, the verb itself also allows for two different interpretations. Groenendijk and Stokhof only considered one of these interpretations, namely the one that requires a strong form of *introspection* on the part of the individual to whom knowledge is ascribed. For Groenendijk and Stokhof it is unwarranted to claim that John knows who walks in a situation in which John would not say of himself that he knows who walks. Another interpretation, however, seems to be made particularly salient in the experimental setting of Cremers and Chemla. Here, it is not really at stake whether John would say of himself that he knew which squares were blue; rather, what is at stake is whether we, as external observers, find that there is a sufficient match between John's beliefs (the second/third picture) and actuality (the first picture).

Thus, Groenendijk and Stokhof assumed an *internal* interpretation of knowledge ascriptions, requiring a strong form of introspection, whereas Cremers and Chemla's experimental setting lends particular salience to what we will call an *external* interpretation of knowledge ascriptions, which does not come with the relevant introspection requirement.

Our aim will be twofold. First, we want to capture the difference between these two interpretations, i.e., the pertinent notion of introspection. And second, we want our theory to derive that the external interpretation is indeed compatible with IE readings, while the internal interpretation (Groenendijk and Stokhof's) is *in*compatible with such readings.

1.4.2. Internal and external interpretation of 'know'

The lexical entry for *know* given in Section 1.3.4 is repeated in (33). This entry captures the external interpretation of *know*.

(33)   *know'* := $\lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p : \text{DOX}_x^w \in f(w)$

We will now strengthen this entry to capture the internal interpretation. This will be done by requiring a certain kind of introspection on the part of the subject, which goes beyond just knowing what her own information state is. There are at least two natural ways to spell out this introspection condition. We will first introduce what we dub *resolution introspection*, then what we call *Heim introspection*, and finally compare the two, concluding in favor of the former.

The idea of *resolution introspection* is very simple: besides requiring that $\text{DOX}_x^w \in f(w)$, i.e., that x's information state in w matches one of the truthful resolutions of the complement in w, we also require that x is fully aware of this match, i.e., that every world she considers possible is one where her information state matches one of the truthful resolutions of the complement

in that world. Formally: $\forall v \in \text{DOX}_x^w : \text{DOX}_x^v \in f(v)$. In other words, under the internal interpretation it is not sufficient if x's information state just *happens* to coincide with a truthful resolution in the world of evaluation; x also has to take herself to know that this is the case. Incorporating this requirement results in the following entry:[23]

(34) $know'_{int} = \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p : (\text{DOX}_x^w \in f(w) \wedge \underbrace{\forall v \in \text{DOX}_x^w : \text{DOX}_x^v \in f(v)}_{\text{resolution introspection}})$

Recall that for all $v \in \text{DOX}_x^w$, $\text{DOX}_x^v = \text{DOX}_x^w$. Thus, $know'_{int}$ can also be formulated as follows, without making reference to DOX_x^v:

(35) $know'_{int} = \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p : (\text{DOX}_x^w \in f(w) \wedge \underbrace{\forall v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v)}_{\text{resolution introspection}})$

We now turn to another way of spelling out the introspection condition in the entry for $know_{int}$. Namely, instead of requiring, as we just did, that the subject has to take herself to know a truthful resolution, we could also proceed along the lines of Heim (1994) and demand that the subject has to take herself to know what the set of truthful resolutions is in the world of evaluation.[24] We will refer to this requirement as *Heim introspection*. Put more loosely, the relevant difference is between taking yourself to know *that you have a truthful resolution* (resolution introspection) and taking yourself to know *what the truthful resolutions are* (Heim introspection). Given a world of evaluation w, Heim introspection amounts to $\forall v \in \text{DOX}_x^w : f(v) = f(w)$. Adding this to our basic entry for $know$, we arrive at the following entry:

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[23]One way to understand the role of this introspection requirement is to compare our system to standard doxastic logic. There, the notion of knowledge is limited to declarative knowledge, and the condition that $\text{DOX}_x^v = \text{DOX}_x^w$ for every $v \in \text{DOX}_x^w$—let's call this condition *information state introspection*—guarantees the validity of the positive and negative introspection principles: $K\varphi \rightarrow KK\varphi$ and $\neg K\varphi \rightarrow K\neg K\varphi$ for all declarative complements φ. By contrast, our account additionally models interrogative knowledge, and while information state introspection still guarantees the validity of the introspection principles w.r.t. declarative complements, it does not guarantee their validity w.r.t. interrogative complements. Once we add resolution introspection, however, the principles do become generally valid. In other words, $know_{int}$ guarantees full introspection w.r.t. declarative and interrogative complements, whereas $know$ only guarantees introspection w.r.t. declarative complements.

[24]It should be noted that Heim (1994) is not concerned with formulating an introspection condition, in fact, but with deriving SE answers from complete answers. To do so, she defines two different notions of answers. Given a question Q and a world w, her answer1$(Q)(w)$ is the true complete answer of Q in w; her answer2$(Q)(w)$ is the set of all worlds v such that answer1$(Q)(v)$ is the same as answer1$(Q)(w)$. Hence, if you take yourself to know answer2$(Q)(w)$, you take yourself to know what answer1$(Q)(w)$ is. Translated into our framework, this amounts to taking yourself to know what the set of truthful resolutions in w is.

(36) $know'_{Heim} = \lambda f_{\langle s,T\rangle}.\lambda x.\lambda p.\forall w \in p : (\text{DOX}_x^w \in f(w) \wedge \underbrace{\forall v \in \text{DOX}_x^w : f(v) = f(w)}_{\text{Heim introspection}})$

In terms of empirical predictions, $know'_{Heim}$ and $know'_{int}$ only come apart when taking an interrogative complement with an MS reading. To see this, consider (37) in George's scenario, which was discussed in Section 1.3.1.

(37) Janna knows where one can buy an Italian newspaper.

It seems to us that Janna, since she takes herself to know that one can buy an Italian newspaper at Newstopia, would say of herself that she knows where one can buy an Italian newspaper—although she is not certain whether other stores sell such newspapers as well. Accordingly, we think (37) should come out true under an internal interpretation of *know* and an MS reading of the complement.

Let us check which predictions the two introspection requirements make. For simplicity, let us assume that the only two relevant stores are Newstopia and Celluloid City (in George's original scenario there is a third store as well, Paperworld, but this can be left out of consideration for our current purposes). Assume that in w_1, Italian newspapers are sold at both stores, in w_2 only at Newstopia, in w_3 only at Celluloid City, and in w_4 at neither of the two stores. Thus, the actual world is w_2. If we assume an MS interpretation of the complement, the complement meaning is $f = E_{[-\text{cmp}]}\left(\begin{smallmatrix}\square&\square\\\square&\square\end{smallmatrix}\right)$. This yields the following sets of truthful resolutions: $f(w_1) = \left\{\begin{smallmatrix}\square&\square\\\circ&\circ\end{smallmatrix}, \begin{smallmatrix}\square&\circ\\\square&\circ\end{smallmatrix}, \begin{smallmatrix}\square&\circ\\\circ&\circ\end{smallmatrix}, \begin{smallmatrix}\circ&\square\\\circ&\circ\end{smallmatrix}, \begin{smallmatrix}\circ&\circ\\\square&\circ\end{smallmatrix}\right\}$ and $f(w_2) = \left\{\begin{smallmatrix}\square&\square\\\circ&\circ\end{smallmatrix}, \begin{smallmatrix}\circ&\square\\\circ&\circ\end{smallmatrix}\right\}$. Janna's information state is $\text{DOX}_j^{w_2} = \begin{smallmatrix}\square&\square\\\circ&\circ\end{smallmatrix}$. Hence, the resolution introspection requirement, $\forall v \in \text{DOX}_j^{w_2} : \text{DOX}_j^{w_2} \in f(v)$, is satisfied since $\begin{smallmatrix}\square&\square\\\circ&\circ\end{smallmatrix} \in f(w_1)$ and $\begin{smallmatrix}\square&\square\\\circ&\circ\end{smallmatrix} \in f(w_2)$. On the other hand, the Heim introspection requirement, $\forall v \in \text{DOX}_j^{w_2} : f(v) = f(w_2)$, is not satisfied since $f(w_1) \neq f(w_2)$. This means that $know'_{Heim}$ predicts (37) to be false in w_2, contra our intuitions, while $know'_{int}$ predicts (37) to be true in w_2, as desired. Thus, we will use resolution introspection rather than Heim introspection in modelling the internal interpretation of *know*.

1.4.3. *Availability of IE readings for 'know'*

Whether a sentence like *John knows who called* is true depends on two factors on our account: whether the verb receives an internal or an external interpretation, and whether the complement gets an MS, IE, or SE reading. Interestingly,

	external		internal
mention some	r_1	=	r_2
intermediate exhaustive	r_3		r_4
			$\parallel$
strongly exhaustive	r_5	=	r_6

TABLE 1.2. The predicted readings of interrogative knowledge ascriptions.

however, these two factors interact in such a way that only *three* distinct readings are predicted (rather than six, as one would expect prima facie). More specifically, as depicted in Table 1.2, we can establish the following two Facts, the proofs of which are given in Appendix 1.B.1.

FACT 1. If the complement receives an MS or an SE interpretation, then the external and the internal interpretation of the verb yield exactly the same reading for the sentence as a whole.

FACT 2. If the verb receives an internal interpretation, then the IE and the SE interpretation of the complement yield exactly the same reading for the sentence as a whole.

In view of Fact 1, we will from now on always assume our basic entry for *know* when the complement receives an MS or SE interpretation.

Fact 2 says that, under an internal interpretation of the verb, what is required for *John knows who called* to be true on an IE reading is exactly the same as what is required on an SE reading. Namely, of all people who called, John needs to know that they called, and moreover he needs to know that nobody else called. Thus, Groenendijk and Stokhof's claim that *know* does not allow for an IE reading is salvaged, though only under an internal interpretation of the verb, the interpretation that they seem to have had in mind.

On the other hand, under an external interpretation of the verb, IE readings are predicted to exist independently of SE ones. This accounts for the findings of Cremers and Chemla (2016), whose experimental setting arguably made the external interpretation of the verb particularly salient.

As Table 1.2 shows, the three readings that we predict for *John knows who called* can all be derived with our basic entry for the verb, *know′*, which was intended to capture the external interpretation. Our second entry, *know′_{int}*, does not yield any additional readings, i.e., it does not overgenerate. Still, these two entries, and the underlying distinction between the internal and the external interpretation of *know*, make it possible to reconcile Groenendijk and Stokhof's argument with Cremers and Chemla's experimental findings.

An additional prediction is that when we consider *self*-ascriptions of knowledge by speakers who can be assumed to comply with the Gricean maxims of cooperative conversational behavior, then the IE reading will coincide with the SE reading even under an external interpretation of the verb. To see why, consider the following example.

(38)   I know who called.

Assume an external interpretation of the verb and an IE interpretation of the complement. Then the sentence is true in w just in case the speaker's information state in w coincides with an IE truthful resolution in w, i.e., just in case $\text{DOX}_x^w \in f_{\text{IE}}(w)$, where x is the speaker and $f_{\text{IE}}(w)$ the set of IE truthful resolutions of the complement in w. Now, we can assume that the speaker is complying with the Gricean maxims, in particular with Quality. This means that she should believe that her information state coincides with an IE truthful resolution of the complement, i.e., every world $v \in \text{DOX}_x^w$ should be such that $\text{DOX}_x^v \in f_{\text{IE}}(v)$. From here we can derive, as is done in the proof of Fact 2 in Appendix 1.B.1, that it must be the case that $\text{DOX}_x^w \in f_{\text{SE}}(w)$, where $f_{\text{SE}}(w)$ is the set of SE truthful resolutions of the complement in w, i.e., it must be the case that the sentence is true under an SE reading.

Thus, we have seen that by distinguishing between an internal and an external interpretation of *know*, we can reconcile the different views on whether interrogative knowledge ascriptions allow for IE readings.

1.5.   *Capturing diversity among responsive verbs*

So far we have restricted our attention to only one verb, *know*. Once we turn to a broader range of responsive predicates, we find interesting differences between them. The aim of this section is to demonstrate that our framework is flexible enough to accommodate these differences. We start out in Section 1.5.1 by defining the notions of veridicality and factivity. On the one hand this will lead to a refinement of our entry for *know*, on the other hand it will help to

appreciate the differences between the responsive predicates. In Section 1.5.2, we then discuss the cases of *be certain, be right/be wrong, be surprised,* and *care*, providing a lexical entry for each of these verbs. Finally, in Section 1.5.3, we point out a number of entailment patterns that are predicted to hold between the various predicates.

1.5.1. *Veridicality and factivity*

The notion of veridicality comes in two flavors, pertaining to declarative and interrogative complements, respectively.

1.5.1.1 *Veridicality w.r.t. declarative complements*

A verb is veridical w.r.t. declarative complements if, when taking a declarative complement, it gives rise to the implication that this complement is true. We will call this a *declarative veridicality implication*. For instance, *know* is veridical w.r.t. declarative complements, as illustrated in (39), while *be certain* is not, as illustrated in (40).

(39) John knows that Mary called.
      ∴ Mary called.

(40) John is certain that Mary called.
      ⫫ Mary called.

Our account already captures the fact that *know* is veridical w.r.t. declarative complements. To see why, suppose that in w Mary didn't call, and let P be the meaning of the declarative nucleus in (40), *that Mary called*. This is the set of propositions which consist exclusively of worlds where Mary called. Thus, P contains exactly one alternative, namely the set q of *all* worlds where Mary called. Since Mary didn't call in w, we find that $\text{alt}^{\cup}_{*w}(P) = \{q\}$. This means, however, that $E_{[\pm\text{cmp}]}(P)(w)$ is empty, since for a proposition p to be included in $E_{[\pm\text{cmp}]}(P)(w)$, it would have to hold that $p \in P$, i.e., $p \subseteq q$, and $p \nsubseteq q$, which is impossible. Hence, John's information state cannot be an element of $E_{[\pm\text{cmp}]}(P)(w)$, and *John knows that Mary called* comes out as false. Conversely, *John knows that Mary called* can only be true in w if *Mary called* is also true in w.

In the case of *know*, the observed veridicality implication is actually a presupposition. As illustrated in (41), it projects under negation. Such veridicality implications are referred to as *factivity presuppositions*, and the verbs that trigger them as *factive* verbs.

(41) John doesn't know that Mary called.

∴ Mary called.

On our account veridicality implications arise from the interaction between the verb and the E operator. Now, if the implication is presuppositional in nature, as in the case of *know*, should this presuppositional nature be determined by the E operator, or rather by the embedding verb? We opt for the latter, for the following reason. If we were to let E earmark veridicality implications as presuppositions, then we would be predicting, at least in the absence of any further stipulations, that all verbs which are veridical w.r.t. declarative complements are factive. As pointed out by Uegaki (2015b) based on Egré (2008), this prediction is too strong. There are a number of verbs triggering veridicality implications that are not presuppositional. As illustrated in (42), *be right* is a case in point. Sentence (42a) implies that Mary called, but this implication clearly doesn't project under the negation in (42b).

(42)   a.   John is right that Mary called.
            ∴ Mary called.
       b.   John isn't right that Mary called.
            ⫫ Mary called.

We will give a lexical entry for *be right* in Section 1.5.2.2. For now, we conclude that it shouldn't fall to the E operator to earmark veridicality implications as presuppositions. Instead, the nature of this implication only gets determined at the level of the embedding verb. For *know*, this can be implemented by means of a definedness restriction in the lexical entry of the verb, as is done in (43).

(43) $know' = \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\underline{\forall w \in p.f(w) \neq \emptyset}. \forall w \in p : \text{DOX}_x^w \in f(w)$

Recall that $f(w) = E(P)(w)$ is non-empty if and only if w is contained in at least one alternative in $\text{alt}(P)$, i.e., if and only if w is contained in $\text{info}(P)$. Also recall that a nucleus with meaning P is *true* in a world w if and only if $w \in \text{info}(P)$. Taken together, this means that a proposition p satisfies the definedness restriction of *know′* just in case the complement nucleus is true in every world in p. In the case of a declarative complement, this amounts to a factivity presupposition. On the other hand, in the case of an interrogative complement, the alternatives in $\text{alt}(P)$ cover the set of all possible worlds, so there will never be a world w such that $f(w) = \emptyset$. Hence, in this case, the definedness restriction of *know′* is trivially satisfied.[25]

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[25]In the case of a presuppositional interrogative nucleus it would also hold that $f(w)$ is never empty, although there may be worlds where $f(w)$ is undefined. For instance, in the case of *which student called*, $f(w)$ would only be defined if exactly one student called in w. As a consequence,

1.5.1.2 Veridicality w.r.t. interrogative complements

The notion of veridicality w.r.t. interrogative complements is not so straightforward. Spector and Egré (2015, footnote 7) provide the following characterization: a responsive verb V is veridical w.r.t. interrogative complements just in case for every interrogative complement Q, every individual x, and every world w, $V(Q)(x)$ is true in w exactly if $V(P)(x)$ is true in w, where P is a declarative complement expressing the true complete answer to Q in w. However, while the intuition behind this characterization seems clear, the exact formulation needs to be made a little more precise. One issue is that whether $V(Q)(x)$ is true in w generally depends on whether Q receives an SE, IE, or MS interpretation. Another issue is that what constitutes a true complete answer to a given interrogative varies between different theories; for instance, for Groenendijk and Stokhof (1984) it is not the same as for Karttunen (1977).

In its existing form, Spector and Egré's characterization wrongly classifies *know* as a non-veridical verb. This is because, as we have already seen, (44) below can very well be true (on an MS reading) even if Rupert doesn't know the true complete answer (either in Karttunen's sense or in Groenendijk and Stokhof's sense) to the question where one can buy an Italian newspaper.

(44)   Rupert knows where one can buy an Italian newspaper.

Unintended results of this kind can be avoided by making an assumption that already seems implicit in Spector and Egré's characterization: to test whether a verb is veridical w.r.t. interrogative complements, one only needs to consider interrogative complements whose SE, IE, and MS interpretation coincide. We will call such complements *exhaustivity-neutral*. There are two kinds of exhaustivity-neutral interrogative complements: polar interrogatives such as *whether it is raining*, and wh-interrogatives such as *who won the Chess World Cup last year*, which involves a property that, in any possible world, applies to a unique individual. For any verb V, individual x, exhaustivity-neutral complement Q, and world w, it is unmistakable whether $V(x, Q)$ is true in w—this doesn't depend on the reading that Q receives. Similarly, if Q is exhaustivity-neutral it is indisputable what the true complete answer is to Q in w—Karttunen's notion and Groenendijk and Stokhof's notion coincide in this case. The complete answers to an exhaustivity-neutral complement always form a partition of the set of all possible worlds.

Using the notion of exhaustivity-neutral complements, we propose the fol-

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John knows which student called'(p) would only be defined if p consisted exclusively of worlds where exactly one student called. This way the existence and uniqueness presuppositions of the nucleus would be projected to the root level.

lowing variant of Spector and Egré's definition of veridicality w.r.t. interrogative complements. We say that V is veridical w.r.t. interrogative complements just in case for every individual x, every world w, every exhaustivity-neutral interrogative complement Q, and every declarative complement P expressing a complete answer to Q, if $V(Q)(x)$ and P are both true in w, then $V(P)(x)$ is true in w as well.

Under this definition, *know* is classified as veridical w.r.t. interrogative complements, as intended, because inferences like (45) are valid.

(45)   Mary knows where John was born.
       John was born in Paris.
       ∴ Mary knows that John was born in Paris.

On the other hand, *be certain* is classified as non-veridical w.r.t. interrogative complements, because inferences like (46) are invalid.

(46)   Mary is certain where John was born.
       John was born in Paris.
       ∴̸ Mary is certain that John was born in Paris.

Our account correctly predicts that *know* is veridical w.r.t. interrogative complements. To see this, assume that *Mary knows where John was born* is true in w. On our account, this means that $\text{DOX}_m^w \in E(\textit{where John was born})(w)$ (whether the E operator is complete or non-complete does not make a difference here as the complement is exhaustivity-neutral). Now, further assume that, in w, John was born in Paris. It follows, then, that $E(\textit{where John was born})(w) = E(\textit{that John was born in Paris})(w)$. Thus, we find that $\text{DOX}_m^w \in E(\textit{that John was born in Paris})(w)$, which means that *Mary knows that John was born in Paris* is true in w.

1.5.2.   *Other verbs*

We have seen that *know* is veridical w.r.t. both declarative and interrogative complements, that it triggers a factivity presupposition when taking declarative complements, and that it exhibits FA sensitivity effects when taking interrogative complements. Below, we will consider *be certain* (which is non-veridical and non-factive), *be right* and *be wrong* (which are veridical but not factive), *be surprised* (which is veridical and factive but does not exhibit FA sensitivity effects), and *care* (which is veridical w.r.t. declarative complements but not w.r.t. interrogative complements). We will show how these differences can be

captured on our account.

1.5.2.1 *'be certain'*

Clearly, *be certain* is close in meaning to *know*. However, we propose that there are two differences between the verbs. First, we take *be certain* to be sensitive to truthful resolutions of the complement in those worlds that the subject considers possible, not necessarily in the world of evaluation (only if this happens to be a world that the subject considers possible). For instance, *John is certain who called* can be true in a world w even if John's information state in w does not coincide with a truthful resolution of *who called* in w; as long as it does coincide with a truthful resolution of *who called* in some world that John considers possible. This is captured by the preliminary entry for *be certain* in (47). For comparison, we repeat the non-presuppositional version of our basic (external) entry for *know* in (48).

(47)   *be certain'* $= \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p : \exists v \in \mathrm{DOX}_x^w : \mathrm{DOX}_x^w \in f(v)$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (preliminary)

(48)   *know'* $\quad = \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p : \qquad\qquad \mathrm{DOX}_x^w \in f(w)$

Just like *know*, our preliminary entry for *be certain* takes a function f from worlds to sets of propositions as its first argument, an individual x as its second argument, and yields a set of propositions. Different from *know*, however, there is a layer of existential quantification over worlds in x's information state DOX_x^w, and f is fed worlds $v \in \mathrm{DOX}_x^w$, rather than the world of evaluation w.

Notice the subtle, but crucial change that this world shift brings: in order to determine whether *John is certain who called* is true in w, we don't have to compute the set of truthful resolutions of *who called* in w itself, but rather in worlds $v \in \mathrm{DOX}_x^w$. We will see below that, as a consequence *be certain* is not veridical and doesn't exhibit FA sensitivity effects.

We now turn to a second difference between *know* and *be certain*. Recall that we argued that *know* has both an *internal* interpretation, which requires resolution introspection, and an *external* interpretation, which does not require such introspection. We propose that *be certain* only has an internal interpretation, requiring resolution introspection. In order for *John is certain who called* to be true in w, it is not sufficient if John's information state in w just *happens* to match a truthful resolution of *who called* in some world that John considers possible; rather, in any world that is compatible with John's information state such a match must obtain.[26]

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[26]Thus, in Cremers and Chemla's experimental setting, if John's beliefs about the card he

Our preliminary entry for *be certain* needs to be strengthened in order to ensure resolution introspection. This can be done in the same way as we did earlier with our basic entry for *know*.

(49)   *be certain′* $= \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p :$
$$(\exists v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v) \wedge \underbrace{\forall v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v)})$$

resolution introspection

Now, since DOX_x^w is assumed to be consistent, i.e., non-empty, the first conjunct is implied by the second. So we can simplify, and our final entry for *be certain* is the following:

(50)   *be certain′* $= \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\forall w \in p : \forall v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v)$

Our entry for *be certain* is very similar to that proposed by Uegaki (2015b) (though the latter is formulated in a different framework). Uegaki makes two observations in support of his proposal. First, it predicts that *be certain* does not give rise to IE readings, unlike *know*. Our treatment also makes this prediction. Moreover, going one step beyond Uegaki's proposal, it also offers an intuitive explanation for what is responsible for this contrast between *be certain* and *know*. Namely, *be certain* lacks an external interpretation: it is only true to say that an individual x is certain of something if x would say of herself that she is certain. On an internal interpretation, both *be certain* and *know* require resolution introspection, which is incompatible with IE readings. It is only on the *external* interpretation of *know* that it does not require resolution introspection and therefore permits IE readings.[27]

Uegaki's second observation is that his entry makes desirable predictions about presupposition projection. For instance, *John is certain which student left* is predicted to presuppose that John believes that exactly one student left. A detailed account of presupposition projection in our framework is beyond the scope of the present paper, but it seems that under reasonable assumptions, Uegaki's result would carry over to our treatment.[28]

Turning now to veridicality, our account correctly predicts that *be certain* is

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saw are as depicted in the third picture in Figure 1.7, we would say that the sentence *John is certain which squares were blue* is *false*.

[27]Another advantage of our treatment of *be certain* in comparison with Uegaki's is that, even though it blocks IE readings, it does allow us to derive FA sensitive MS readings as well as SE readings in a uniform way. On Uegaki's account, SE readings are readily obtained, but deriving MS readings requires additional assumptions. We refer to Appendix 1.A for a more general and more detailed comparison between our account and Uegaki's.

[28]The main assumption that we would have to make is that $E(\textit{which student left})(w)$ is undefined whenever there is not a unique student who left in w. See also footnote 11.

non-veridical, both w.r.t. declarative and w.r.t. interrogative complements. For instance, the argument in (40), repeated here in (51), is predicted to be invalid, because *John is certain that Mary called* may well be true in w if Mary did in fact not call in w. The only requirement is that Mary called in all worlds that make up John's information state in w, which may not include w itself. Similarly, the argument in (46), repeated here in (52), is also predicted to be invalid, because even if w is a world in which *Mary is certain where John was born* and *John was born in Paris* are both true, it may still be a world in which *Mary is certain that John was born in Paris* fails to hold. After all, if Mary is certain that John was not born in Paris but, say, in London, we predict that *Mary is certain where John was born* is true, even if in fact John was born in Paris. Again, the only requirement is that John was born in London in all worlds that make up Mary's information state.

(51)   John is certain that Mary called.
       ∴. Mary called.

(52)   Mary is certain where John was born.
       John was born in Paris.
       ∴. Mary is certain that John was born in Paris.

Finally, our account predicts that *be certain* does not exhibit FA sensitivity effects. For instance, (53) is correctly predicted to be true on an MS reading even if Rupert mistakenly believes that one can buy an Italian newspaper at Paperworld.

(53)   Rupert is certain where one can buy an Italian newspaper.

To see that this is predicted, suppose that the complement clause in (53) contains an $E_{[-\mathrm{cmp}]}$ operator and that the nucleus receives a [–exh] interpretation, which gives us an MS reading. Then (53) comes out as true even if Rupert mistakenly believes that both Newstopia and Paperworld sell Italian newspapers. This is the case because all the worlds in Rupert's information state are ones where both Newstopia and Paperworld indeed sell Italian newspapers. This means that in all of these worlds, DOX_r^w is a truthful resolution of the complement.[29]

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[29] At first glance, it might seem that this lack of FA sensitivity effects follows from the fact that *be certain* is non-veridical. However, there are verbs, such as *agree*, which are non-veridical but do exhibit FA sensitivity effects. To see this, assume that Rupert believes both Newstopia and Paperworld sell Italian newspapers, while Rachel believes that only Newstopia sells such newspapers. In this context, (i) below is false, meaning that whether Rupert agrees with Rachel depends on an answer that is *false according to Rachel's beliefs*.

(i)   Rupert agrees with Rachel about where one can buy an Italian newspaper.

1.5.2.2 'be right' and 'be wrong'

As mentioned in Section 1.5.1, *be right* is veridical w.r.t. declarative complements. This is illustrated in (54). It is also veridical w.r.t. interrogative complements, as illustrated in (55).

(54) John is right that Mary called.
      ∴ Mary called.

(55) John is right about where Mary was born.
      Mary was born in Paris.
      ∴ John is right that Mary was born in Paris.

We also observed in Section 1.5.1 that the declarative veridicality implication of *be right* is not a presupposition, unlike in the case of *know*.

(56) John isn't right that Mary called.
      ↛ Mary called.

What *is* presupposed by both (54) and (56) is that John *believes* that Mary called.

(57) John is right that Mary called.
      ∴ John believes that Mary called.

(58) John isn't right that Mary called.
      ∴ John believes that Mary called.

To capture this, we take *be right* to presuppose that the subject's information state DOX_x^w coincides with a truthful resolution of the complement in all worlds that she considers possible, and to assert that DOX_x^w coincides with a truthful resolution in the world of evaluation w. The assertive component of *be right* is hence the same as that of *know*.

A rough first approximation of a lexical entry for *agree* that would account for this is the following (for a more detailed discussion of this verb, see Chemla and George 2016, Uegaki 2018).

(ii)   *agree'* $= \lambda f_{\langle s,T\rangle}.\lambda y.\lambda x.\lambda p.\forall w \in p : \forall v \in \text{DOX}_y^w : \text{DOX}_x^w \in f(v)$

Recall from footnote 10 that we understand FA sensitivity not as sensitivity to answers that are false *in the world of evaluation* but rather as sensitivity to answers that are false *in some relevant world*. Under this perspective, both *agree* and *be certain* must be classified as FA sensitive: the former is sensitive to answers that are false according to the object's information state, the latter to those that are false according to the subject's information state. As we just saw, the FA sensitivity of *agree* does give rise to FA sensitivity effects, while that of *be certain* never manifests itself empirically since DOX_x^w cannot entail any answer that is false according to DOX_x^w.

(59)   *be right′* $= \lambda f_{\langle s,T \rangle}.\lambda x.\lambda p.\underline{\forall w \in p : \forall v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v)}.$
$$\forall w \in p : \text{DOX}_x^w \in f(w)$$

Now let us turn to *be wrong*. We first observe that this verb is non-veridical, both w.r.t. declarative complements and w.r.t. interrogative complements, as witnessed by the invalid inferences in (60) and (61).

(60)   John is wrong that Mary called.
       ∤. M called.

(61)   John is wrong about where Mary was born.
       Mary was born in Paris.
       ∤. John is wrong that Mary was born in Paris.

In fact, *be wrong* is what we may call *anti*-veridical w.r.t. declarative complements:

(62)   John is wrong that Mary called.
       ∴ Mary *didn't* call.

The anti-veridicality implication of *be wrong* is an entailment, not a presupposition, just like the declarative veridicality implication of *be right*:

(63)   John isn't wrong that Mary called.
       ∤. Mary *didn't* call.

Both (62) and (63) do presuppose that John *believes* that Mary called, again just as in the case of *be right*. Thus, we arrive at the following entry:

(64)   *be wrong′* $= \lambda f.\lambda x.\lambda p.\underline{\forall w \in p : \exists v \in \text{DOX}_x^w : \text{DOX}_x^w \in f(v)}.$
$$\forall w \in p : \text{DOX}_x^w \notin f(w)$$

The only difference between *be right* and *be wrong* is that the former requires $\text{DOX}_x^w \in f(w)$, whereas the latter requires the opposite, $\text{DOX}_x^w \notin f(w)$. This captures all the entailment patterns exemplified above.

1.5.2.3   *'be surprised'*

Emotive factives like *be surprised* show that veridicality is not a sufficient condition for FA sensitivity effects.[30] To see this, first note that *be surprised* is veridical w.r.t. both declarative and interrogative complements:

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[30] In footnote 29 above it is shown that it is not a necessary condition either.

(65) Mary is surprised that John was born in Paris.
∴ John was born in Paris.

(66) Mary is surprised at where John was born.
John was born in Paris.
∴ Mary is surprised that John was born in Paris.

Turning to FA-sensitivity effects, however, consider the following sentence:

(67) Rupert is surprised at where one can buy an Italian newspaper.

For (67) to be true on an MS reading, there has to be at least one store x such that Rupert correctly believes but did not expect that x sells Italian newspapers. What Rupert believes or expected about stores that do *not* sell Italian newspapers seems immaterial. So, *be surprised* does not exhibit FA-sensitivity effects. A simple lexical entry that would achieve this is given in (68), where we write EXP_x^w for the set of worlds compatible with x's previous expectations at w.[31]

(68) *be surprised*$' = \lambda f.\lambda x.\lambda p.\forall w \in p : \exists q \in \text{alt}(f(w)) : \text{DOX}_x^w \subseteq q \wedge \text{EXP}_x^w \subseteq \overline{q}$

Note what happens here: the entry makes specific reference to the set of truthful resolutions of the complement in the world of evaluation, $f(w)$, but then only the maximal elements of the set, $\text{alt}(f(w))$, are taken into account. It is required that there exists an alternative q such that x believes q in w, $\text{DOX}_x^w \subseteq q$, but q is incompatible with x's previous expectations in w, $\text{EXP}_x^w \subseteq \overline{q}$. So, explicit reference is made to the set of truthful resolutions in the world of evaluation (which captures the veridical nature of the verb), but then exactly the part of this set that would be needed to generate FA-sensitivity effects is disregarded.[32]

1.5.2.4 *'care'*

As mentioned in Section 1.1, Elliott *et al.* (2017) argue that predicates of relevance, such as *care*, *matter* and *be relevant* pose a problem for reductive theories

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[31]The entry given here is merely meant to illustrate that it is possible in our framework to deal with verbs that are veridical but do not exhibit FA sensitivity effects. It is not meant as a fully realistic treatment of *be surprised*, which involves several complexities that are orthogonal to our present concerns. In particular, our entry does not account for the fact that *be surprised* and other emotive factives do not license polar and disjunctive interrogative complements. We refer to Guerzoni and Sharvit (2007), Sæbø (2007), Nicolae (2013), Spector and Egré (2015), Romero (2015b) for recent work in this area. See in particular Herbstritt (2014); Roelofsen *et al.* (2016); Roelofsen (2017) for an approach that is compatible with the present proposal.

[32]See Xiang (2016a) for another possible account of the fact that emotive factives like *be surprised* do not exhibit FA sensitivity effects. A detailed comparison between the two accounts must be left for another occasion.

of question embedding. They observe that what is presupposed by these predicates depends on whether they take a declarative or an interrogative complement. With a declarative complement, they presuppose that the complement is true and that the subject knows this. For instance, (69a) presupposes that Mary left and that John knows this. With an interrogative complement, on the other hand, predicates of relevance don't carry an analogous presupposition. For instance, (69b) doesn't presuppose that John believes any answer to the embedded interrogative.

(69)   a.   John cares that Mary left.
        b.   John cares which girl left.

This is problematic for standard reductive theories, because they predict that a sentence like (69b) is true if and only if John cares that p, where p is a proposition that counts as an answer to the interrogative in (69b). Thus, (69b) is wrongly predicted to presuppose that John believes p, for some answer p. Uegaki (2018) shows that this problem arises on George's twin relations theory as well.

Predicates of relevance are also interesting for another reason. Namely, they are veridical w.r.t. declarative complements but not w.r.t. interrogative complements. That is, inferences like (70) are valid, but ones like (71) are not.

(70)   Mary cares that John was born in Paris.
        ∴ John was born in Paris.

(71)   Mary cares where John was born.
        John was born in Paris.
        ∤. Mary cares that John was born in Paris.

In particular, even if both premises of the inference in (71) are true, the conclusion may still not be true due to presupposition failure, i.e., Mary might not know that John was born in Paris. This is particularly problematic for the proposal of Spector and Egré (2015), which aims to derive the empirical generalization that verbs which are veridical w.r.t. declarative complements are also veridical w.r.t. interrogative complements.[33]

On our account, it is straightforward to define a lexical entry for *care* that captures the above observations. In particular, both the differences in presuppositions and those in veridicality naturally fall out from the semantic properties of declarative and interrogative complements. We propose the following lexical entry, where $\text{\sc bou}_x^w$ is the bouletic state of x in w, i.e., the set of all those worlds that are compatible with what x desires in w.

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[33]This generalization will be discussed in more detail in Section 1.6.

(72) $care' := \lambda f.\lambda x.\lambda p.\underline{\forall w \in p : (f(w) \neq \emptyset \wedge \forall v \in \text{DOX}_x^w : f(v) \neq \emptyset)}.$

$$\forall w \in p : \exists v \in W : \exists q \in \text{alt}(f(v)) : (\text{BOU}_x^w \subseteq q \vee \text{BOU}_x^w \cap q = \emptyset)$$

In words, it is presupposed that the set of truthful resolutions is non-empty in the world of evaluation and that it is non-empty in all worlds in the subject's information state. It is asserted that, among the minimally informative possible resolutions of the complement, there is at least one which the subject either desires to be true or to be false.

If *care* takes an interrogative complement, its presupposition is trivially satisfied since the meaning of an interrogative nucleus covers the entire logical space and $f(w)$ will therefore be non-empty for all worlds w. In contrast, with declarative complements, there are usually worlds w such that $f(w)$ is empty and, in that case, the presupposition of *care* is non-trivial. This pattern is already familiar from our discussion of *know* in Section 1.5.1.

Assume that *care* takes a declarative complement and that q is the unique alternative in the nucleus meaning. Then, the second conjunct of the presupposition amounts to q being true in all worlds in the subject's information state. Combined with the first conjunct, which requires that q is true in the world of evaluation, this amounts to demanding that the subject knows q.

Turning to veridicality, we find that by virtue of the factivity presupposition of *care*, declarative veridicality inferences like (70) indeed come out as valid. In contrast, interrogative veridicality inferences are not predicted to go through. In order for the conclusion in, e.g., (71) to hold, it would have to be the case that Mary knows that John was born in Paris—this, however, is not guaranteed by the given premises.[34]

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[34]Two side notes. First, our lexical entry predicts that the SE and IE reading of *care* coincide. More precisely, for any nucleus α, if $f_{SE} = E_{[+cmp]}(\alpha_{[+exh]})$ and $f_{IE} = E_{[+cmp]}(\alpha_{[-exh]})$, then $care(f_{SE}) = care(f_{IE})$. Secondly, our analysis predicts that when *care* takes an interrogative complement, the MS reading entails the IE/SE reading. Thus, when *care* takes an interrogative complement, we only find two distinct readings, namely MS and SE/IE, and of these two the former entails the latter. It appears that with non-negated statements like (ia), there is a preference for the MS interpretation, while with negated statements like (ib) the IE/SE interpretation is prefered.

(i)   a.   John cares who left.
      b.   John doesn't care who left.

Since this means that in either case the stronger one of the two readings is favored, this pattern could be explained by appealing to the strongest meaning hypothesis (Dalrymple *et al.* 1998).

1.5.3. *Some predicted connections between embedding verbs*

Many of the lexical entries we introduced in the preceding sections are built up from similar ingredients. For instance, $know'_{ext}$ and *be right'* have the same assertive component, and $know'_{int}$ is built up from $know'_{ext}$ and an additional introspection requirement. Taking these similarities into account, it is not surprising that we can identify multiple connections that obtain between the embedding verbs. Figure 1.8a and 1.8b display an interesting subset of those connections. The former shows the relations that obtain between the verbs on their declarative-embedding use and the latter those that obtain between the verbs on their interrogative-embedding use.

The solid black arrows are to be understood as implications. For instance, in both figures, we have an arrow from $know_{int}$ to *be certain*, meaning that, if an individual x stands in a $know'_{int}$ relation to some complement meaning f, then x is predicted to also stand in a *be certain'* relation to f. Also note that the visualization does not distinguish between whether an implication holds due to the asserted meaning components of the lexical entries or due to a presupposition. For example, on its declarative-embedding use, *be wrong* implies *be certain*, but this is only the case because, whenever *be wrong'$(f)(x)$* is true, the definedness restriction of *be wrong'* is satisfied, and this definedness restriction amounts to *be certain$(f)(x)$*.

The dashed double arrows, labelled with *not*, are to be read as *true iff not true*. For instance, in Figure 1.8b, *be wrong* and $know_{int}$ are connected with such an arrow because, whenever *be wrong'$(f)(x)$* holds, $know'_{int}(f)(x)$ doesn't hold and vice versa. Note, however, that this does not indicate that $know_{int}$ simply amounts to *not be wrong*. Rather, $know'_{int}(f)(x)$ can fail to hold because x is wrong *or* because x doesn't satisfy the resolution introspection requirement. Furthermore, just as the solid arrows, the *not*-arrows don't distinguish between asserted or presuppositional content. For example, if *be wrong'$(f)(x)$* is true, $know_{int}'(f)(x)$ cannot be true because of presupposition failure.

A couple of observations are worth making here. Firstly, once we restrict our attention to declarative complements, as in Figure 1.8a, the meanings of many verbs are Strawson-equivalent, e.g., that of $know_{int}$, $know_{ext}$ and *be right*. On the other hand, moving to interrogative complements, not all of these Strawson-equivalences obtain anymore. Instead, Figure 1.8b nicely reflects the distinction between internal, i.e., resolution-introspective, and external verbs. The external verbs $know_{ext}$ and *be right* are still Strawson equivalent. Furthermore, by combining internal *be certain* and external *be right*, we obtain a meaning that is equivalent to $know_{int}$: *be certain* contributes the resolution introspection condition of $know_{int}$, and *be right* contributes its "truthfulness condition".
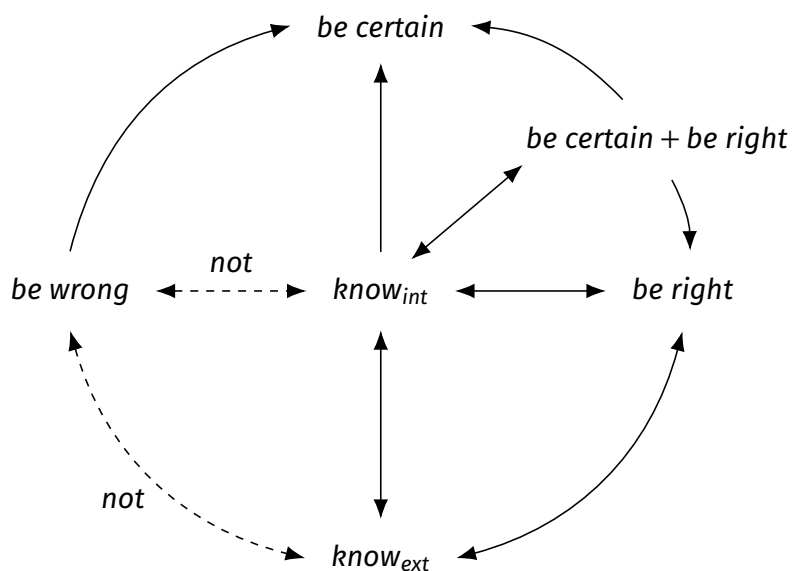
(a) Declarative-embedding use of the verbs
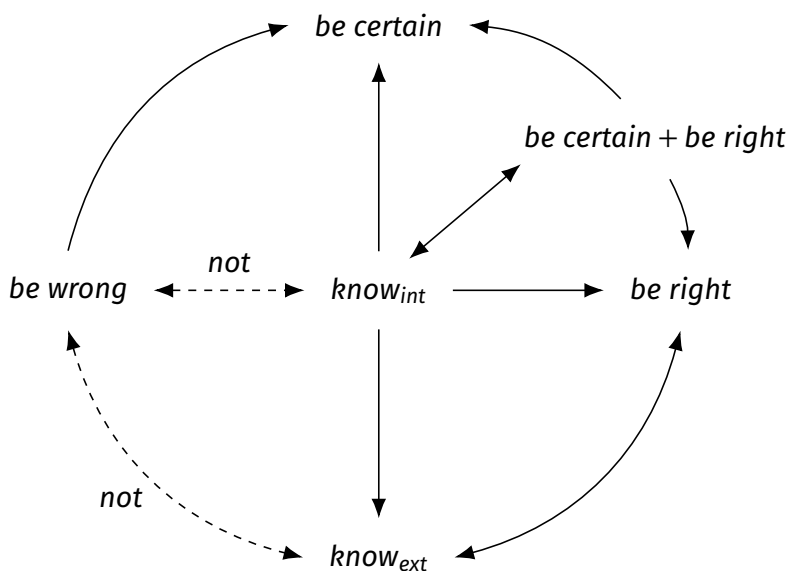
(b) Interrogative-embedding use of the verbs

FIGURE 1.8. Predicted connections between responsive verbs.

1.6.   Constraints on responsive verb meanings

In the previous section we have seen that our framework is flexible enough to formulate lexical entries for a variety of verbs. In particular, we saw that we have a great amount of freedom when it comes to capturing the different properties that verbs may have: declarative veridicality, interrogative veridicality, factivity, and FA sensitivity. In this section, we take a more critical perspective, asking whether the flexibility we have is really only a virtue, or whether it has a downside as well. We do this in light of arguments by George (2011) and Spector and Egré (2015) that a comprehensive theory of clause-embedding should predict certain general constraints on responsive verb meanings. Spector and Egré give empirical arguments for one particular such constraint, which involves the distinction between veridical and non-veridical verbs. We discuss the first part of this constraint in Section 1.6.1 and propose an account of it in Section 1.6.2. In Section 1.6.3 and 1.6.4, we do the same for the second part of the constraint.

1.6.1.   *Spector and Egré's interrogative veridicality generalization*

Spector and Egré (2015) hold that a responsive verb is veridical w.r.t. declarative complements exactly if it is veridical w.r.t. interrogative complements. We will refer to the "$\Rightarrow$"-direction of this generalization as the *interrogative veridicality generalization*, and to the "$\Leftarrow$"-direction as the *declarative veridicality generalization*. In this subsection, we focus on the former; in Section 1.6.3 we will turn to the latter.

First off, we would like to point out a counterexample to the interrogative veridicality generalization. Predicates of relevance like *care* and *matter*, as already discussed above, are veridical w.r.t. declarative complements but not w.r.t. interrogative complements. That is, inferences like (73) are valid, but ones like (74) aren't.

(73)   It matters to Mary that John was born in Paris.
        ∴ John was born in Paris.

(74)   It matters to Mary where John was born.
        John was born in Paris.
        ∴̸ It matters to Mary that John was born in Paris.

Even if both premises of the inference in (74) are true, the conclusion may still

not be true due to presupposition failure, i.e., Mary might not know that John was born in Paris. Thus, the veridicality generalization does not hold in full generality. This is problematic for Spector and Egré's reductive theory, where the assumed connection between declarative and interrogative veridicality is a direct and inescapable consequence of the meaning postulates that connect the interrogative-embedding interpretation of responsive verbs to their declarative-embedding interpretation.

Still, it seems fair to say that the vast majority of responsive verbs complies with the generalization, at least in English and related languages.[35] Our aim will be to show how this tendency can be accounted for within a uniform theory of clause-embedding, without ruling out occasional counterexamples such as *care* and *matter*.

1.6.2. *Accounting for the interrogative veridicality generalization*

Why would only a subset of the space of possible responsive verb meanings be lexicalized in natural languages? Before coming to address this question, let us note that the same question has arisen in other empirical domains as well, and in some cases it has already received a lot of attention. Consider the case of determiners. In the standard generalized quantifier framework, there is a huge space of meanings that determiners could in principle have, but in practice there seem to be certain constraints on which of these possible meanings are actually lexicalized in natural languages. For instance, a well-known empirical generalization in this area is that all natural language determiners are *conservative* (Barwise and Cooper 1981, Keenan and Stavi 1986). A determiner D is conservative if for every two set-denoting expressions A and B, $D(A, B)$ is equivalent with $D(A, A \cap B)$. Only a small portion of the entire space of possible determiner meanings is conservative. For instance, in a universe with just two objects, there are $2^{16} = 65,536$ possible determiner meanings, but only $2^9 = 512$ of these are conservative (Keenan and Stavi 1986).

Whether the conservativity generalization is a strict universal or rather a 'soft constraint' with occasional counterexamples is a matter of ongoing debate. For instance, Cohen (2001) argues that *many* and *few* have a reading under which

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[35] As far as we can tell, all responsive verbs in these languages, including predicates of relevance like *care* and *matter*, comply with a somewhat weaker version of the generalization, which holds that any responsive verb that is veridical w.r.t. declarative complements is also *Strawson* veridical w.r.t. interrogative complements. Here, Strawson veridicality is defined just like plain veridicality, but then making use of Strawson entailment rather than entailment simpliciter.

they are not conservative, but Romero (2015a) suggests a decompositional analysis of these determiners under which their 'core semantics' *is* conservative.

It is also an open question *why* natural language determiners are generally conservative. It seems plausible that such an explanation may be given in computational terms. Indeed, it may well be that the cognitive load of verifying whether a determiner D applies to two sets A and B can be kept relatively low as long as D is conservative, because in this case we only need to consider objects in A; we don't need to look at objects in $B \setminus A$ or in $\overline{A \cup B}$. Another (not necessarily causally independent) reason may be that the meaning of conservative determiners is easier to learn from examples: it has been shown experimentally that children exposed to a novel conservative determiner show significant understanding of it after having been told the truth value of a number of example sentences in a number of contexts, while children exposed to an imaginary non-conservative determiner do not come to grasp its meaning at all after having received such information (Hunter and Lidz 2013).

Given that natural language determiners are, or at least tend to be conservative, it is natural to expect that similar properties may be identified in other domains, in particular in the domain of clause-embedding predicates. Below we will formulate such a property of clause-embedding predicates, which we will call *clausal distributivity* (c-distributivity for short), and we will show that all c-distributive responsive verbs must satisfy Spector and Egré's interrogative veridicality generalization.

Roughly, we will say that a verb V is c-distributive if for any complement meaning f that can be decomposed into a set of simpler complement meanings $\{f_1, f_2, \ldots\}$, and for every individual x, $V(f)(x)$ holds if and only if $V(f_i)(x)$ holds for some f_i. Informally, c-distributivity says that, whenever f can be decomposed into simpler parts, $V(f)(x)$ is fully determined by those simpler parts, i.e., in computing $V(f)(x)$ we don't have to look at f as a whole but only at its parts.

To make this more precise, we have to define the relevant notion of *decomposition*. Recall that a complement meaning f is always obtained in our framework by applying E to a nucleus meaning P. We define the decomposition of a nucleus meaning as follows.

DEFINITION 7 (DECOMPOSING NUCLEUS MEANINGS). A nucleus meaning P can be decomposed if there is a set of nucleus meanings $\mathcal{D}$ such that:

1. $P = \bigcup \mathcal{D}$

2. Every two distinct elements $P', P'' \in \mathcal{D}$ are mutually inconsistent, i.e., $P' \cap P'' = \{\emptyset\}$

3. Every $P' \in \mathcal{D}$ is non-inquisitive.

For any P, there is at most one set $\mathcal{D}$ satisfying these requirements. If there is indeed one, we refer to it as the decomposition of P, and denote it as $\texttt{decomp}(P)$. Otherwise the decomposition of P is undefined.

Notice that the first two requirements should be part, in some form or other, of any reasonable notion of decomposition.[36] The first requires that putting the elements of $\texttt{decomp}(P)$ together leads us back to the original P. The second requires that the elements of $\texttt{decomp}(P)$ have to be mutually independent, which is made precise here in terms of mutual inconsistency.[37] The third requirement, on the other hand, specifies that the elements of a decomposition must be 'elementary' nucleus meanings, which in the present setting means that they must be non-inquisitive. In other words, while P itself may be inquisitive and thus contain multiple alternatives, every element of $\texttt{decomp}(P)$ must contain a unique alternative. This is a natural requirement for 'elementary' nucleus meanings, because it ensures that such nucleus meanings cannot be further decomposed. That is, for any non-inquisitive nucleus meaning P, $\texttt{decomp}(P) = \{P\}$. Vice versa, $\texttt{decomp}(P) = \{P\}$ also implies that P is non-inquisitive. So there is a one-to-one connection between non-inquisitiveness and non-decomposability.

FACT 3. A nucleus meaning P is non-inquisitive if and only if $\texttt{decomp}(P) = \{P\}$.

Now note that under our notion of decomposition, $\texttt{decomp}(P)$ is only defined if P does not contain any overlapping alternatives. To see this, suppose that P does contain two alternatives p and q that overlap, i.e., such that $p \cap q \neq \emptyset$. Then, by the first requirement, there must be some $P' \in \texttt{decomp}(P)$ such that $p \in P'$ and some $P'' \in \texttt{decomp}(P)$ such that $q \in P''$. But then, since both P' and P'' are downward closed, we have that $p \cap q \in P'$ and $p \cap q \in P''$. This means that $P' \cap P'' \neq \{\emptyset\}$, in violation of the second requirement.

On the other hand, if P does *not* contain any overlapping alternatives, then $\texttt{decomp}(P)$ is always well-defined, and moreoever, its elements correspond precisely to the alternatives in P: $\texttt{decomp}(P) = \{\{p\}^{\downarrow} \mid p \in \texttt{alt}(P)\}$.

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[36]For a concrete example of a notion of decomposition that has precisely these two components, consider the notion of vector decomposition in linear algebra: a decomposition of a vector v is a set of vectors $\texttt{decomp}(v)$ such that (i) the sum of all vectors in $\texttt{decomp}(v)$ is v itself, and (ii) the vectors in $\texttt{decomp}(v)$ are all linearly independent.

[37]There is another natural way to construe independence in our framework as well. Namely, instead of inconsistency we could also just require non-entailment, i.e., $P' \not\subseteq P''$. Note that this requirement is weaker than inconsistency. Thus, we could refer to decompositions as defined in Definition 7 as *strict* decompositions, and to ones that only require non-entailment between components as *soft* decompositions. The fact that strict decompositions are of primary interest to us here will become clear below, see in particular footnote 38.

FACT 4 (DECOMPOSITION AND ALTERNATIVES).

- decomp(P) is defined if and only if P does not contain any overlapping alternatives.

- Whenever defined, decomp(P) amounts to $\{\{p\}^{\downarrow} \mid p \in \mathsf{alt}(P)\}$.

Finally, we note that whenever decomp(P) is defined, i.e., whenever P does not contain overlapping alternatives, applying $E_{[+\text{cmp}]}$ or $E_{[-\text{cmp}]}$ to P gives exactly the same results. Thus, below, whenever it is assumed that decomp(P) is defined, we simply write $E(P)$ rather than $E_{[+\text{cmp}]}(P)$ or $E_{[-\text{cmp}]}(P)$.

We can now give a precise formulation of c-distributivity. For expository purposes we formulate the property for predicates that have one clausal and one individual argument slot—it will be clear how it can be generalized to predicates with zero or more than one individual argument slots.

DEFINITION 8 (C-DISTRIBUTIVITY).
A predicate V with one clausal and one individual argument slot is c-distributive if and only if for any individual x, any world w, and any nucleus meaning P such that decomp(P) is defined:

$V(E(P))(x)$ is true in w iff $V(E(P'))(x)$ is true in w for some $P' \in$ decomp(P)

Informally, c-distributivity says that we should be able to evaluate whether the verb applies to a certain complement by checking whether it applies to one of the elements of the complement's decomposition, in case such a decomposition exists.

Now we are ready to state the main result of this subsection: all c-distributive responsive verbs comply with Spector and Egré's interrogative veridicality generalization. A proof of this fact is given in Appendix 1.B.2.

FACT 5.   A c-distributive responsive verb that is veridical w.r.t. declarative complements is also veridical w.r.t. interrogative complements.

Most responsive verbs in English are c-distributive. Indeed, the only exceptions that we have been able to identify are predicates of relevance like *care* and *matter*, which are exactly the ones which violate Spector and Egré's interrogative veridicality generalization.[38] The fact that so many responsive verbs are c-distributive may possibly be explained in computational terms, just like the

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[38]Recall from footnote 37 that the strict notion of decomposition that we assume here has a natural alternative, which is 'softer' in that it does not require the components of a decomposition to be mutually inconsistent, but just that they do not entail one another. Under this notion of decomposition, the class of c-distributive responsive verbs would be much smaller. For in-

fact that determiners are generally conservative. That is, it seems reasonable to hypothesize that the cognitive load of verifying whether a verb applies to a certain complement can be kept relatively low as long as it is guaranteed that this can be done by verifying whether the verb applies to the elements of the decomposition of the given complement, in case such a decomposition exists.

What is most important for our present purposes is that we have seen how general constraints on responsive verb meanings, such as Spector and Egré's interrogative veridicality generalization, can be captured within a uniform theory of clause-embedding. This addresses the main concern that George (2011) and Spector and Egré (2015) raised for the uniform approach, as well as the inverse reductive approach.[39] The particular way in which we have proposed to capture Spector and Egré's interrogative veridicality generalization also seems to have some advantages over their own account. First, it allows for counterexamples, which is needed to accommodate verbs like *care* and *matter*. And second, it allows us to draw parallels with other domains—e.g., that of determiners—and paves the way for possible explanations of the generalization in terms of minimizing cognitive processing load.[40]

1.6.3. *Spector and Egré's declarative veridicality generalization*

Recall that Spector and Egré do not only hold that every responsive verb which is veridical w.r.t. declaratives is also veridical w.r.t. interrogatives, but also the reverse, i.e., that every responsive verb which is veridical w.r.t. interrogatives is veridical w.r.t. declaratives as well. We called this the declarative veridicality generalization.

As discussed by Spector and Egré, many previous authors have rejected this generalization (e.g., Groenendijk and Stokhof 1984, Berman 1991, Higginbotham 1996, Lahiri 2002) based on Karttunen's (1977, p.11) observation that communication verbs like *tell* appear to be veridical w.r.t. interrogative complements, but non-veridical w.r.t. declarative complements. That is, inferences

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stance, *know* would not be c-distributive, exactly because it exhibits FA sensitivity effects when the nucleus of its complement is not a partition. This is why the strict notion of decomposition is most relevant for our purposes.

[39] As far as we can tell, the strategy we have taken here could also be adopted on the inverse reductive approach.

[40] We conjecture that, when formulated at a sufficiently abstract level, a property similar to c-distributivity may actually hold not just of most predicates that take declarative and/or interrogative clauses as their argument, but of most predicates in general, also ones that take atomic and/or plural individuals as their argument. However, we must leave the formulation of such a more general property for further work.

like (75) appear to be valid, while inferences like (76) seem invalid.

(75)   Mary told Alice where John was born.
         John was born in Paris.
         ∴ Mary told Alice that John was born in Paris.

(76)   John told Mary that it was raining.
         ⫫. It was raining.

However, these judgements have been challenged by Tsohatzidis (1993) and more elaborately by Spector and Egré (2015), who point out that, with communication verbs, inferences like (75) are in fact defeasible.

(77)   Old John told us whom he saw in the fog, but it turned out that he was mistaken (the person he saw was Mr. Smith, not Mr. Brown). (Tsohatzidis 1993, p.272)

(78)   Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong. (Spector and Egré 2015, p.1737)

This clearly contrasts with the behavior exhibited by verbs like *know*, whose veridicality implications are indefeasible:

(79)   #Mary knew where John was born, but she turned out to be wrong.

On the other hand, while *tell* is typically interpreted as non-veridical w.r.t. declarative complements, Spector and Egré hold that there are also cases where it receives a veridical interpretation. For instance, they hold that (80a-b) both presuppose, and thus imply, that Mary is pregnant.[41]

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[41]We should note that the veridical readings of declarative-embedding communication verbs seem to surface only when these verbs are embedded under entailment-canceling operators. This observation isn't explained by assuming a lexical ambiguity as Spector and Egré do. Rather, one might take it to indicate that some independent mechanism is at work here. One possible line of explanation can be found in recent QUD-based approaches to presupposition projection. Drawing on Beaver (2010), Tonhauser (2016) and Simons *et al.* (2017) propose that the projection of factivity presuppositions depends on the placement of focus. More specifically, they maintain that if the embedding verb is focused, the presupposition projects, while if some element in the embedded clause is focused, the presupposition doesn't project. The former is the case in (ia), the latter in (ib). Indeed, we can infer from (ia) but not from (ib) that Sue is pregnant.

(i)   a.   Sue hasn't TOLD anyone that she is pregnant. She was going to wait until Christmas.
              ⤳ $P(s)$
        b.   Sue hasn't told anyone that she is PREGNANT. She only said that they are TRYING.
              ⤳̸ $P(s)$

(80) a. Sue didn't tell anyone that she is pregnant.
      b. Did Sue tell anyone that she is pregnant?

Based on these empirical observations, Spector and Egré suggest that communication verbs like *tell* are ambiguous. On one reading they are veridical w.r.t. both declarative and interrogative complements; on another reading they are not veridical w.r.t. either type of complement.[42] Under this assumption, communication verbs no longer form a counterexample to the declarative veridicality generalization. Spector and Egré thus conclude that the generalization is valid after all.

1.6.4. Accounting for the declarative veridicality generalization

Spector and Egré are mainly driven by the interrogative veridicality generalization. They don't explicitly show that their account derives the declarative veridicality generalization, and it seems to us that this is in fact impossible. That is, the account does not rule out responsive verbs that are veridical w.r.t. interrogative complements but not w.r.t. declarative complements. Consider, for instance, a fictitious verb *trueifbelieve* with the following basic 'declarative' lexical entry (recall that on Spector and Egré's account every responsive verb has a basic declarative entry which applies when the verb combines with a declarative complement, and an interrogative entry which is derived from this basic declarative entry via existential quantification; moreover, note that Spector and Egré take a declarative complement to denote a single proposition and an interrogative complement to denote a set of propositions).

(81) $\textit{trueifbelieve}'_{\text{decl}} := \lambda p.\lambda x.\lambda w.(\text{DOX}_x^w \subseteq p \rightarrow w \in p)$

This entry says that when the verb *trueifbelieve* combines with a proposition p

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Crucially, Simons *et al.*'s reasoning does not only apply to factive verbs but also to notoriously non-factive verbs like *believe*: from (ii), we can infer that the car is parked in the parking garage.

(ii) Polly: Why is it taking Phil so long to get here?
      Amy: He didn't believe that the car's parked in the parking garage.

(Simons *et al.* 2017, p.203)

If this account is correct, there seems to be no reason why it should not apply to non-veridical communication verbs. But then there would be no reason either to assume that declarative-embedding communication verbs are lexically ambiguous.

[42]Uegaki (2015b, pp.158f) provides a possible explanation of why the veridical reading of communication verbs is preferred with interrogative, but not with declarative complements.

and an individual x, it returns the set of worlds w such that, when x believes p in w, then p is true in w. Using Spector and Egré's general recipe for deriving the interrogative entry of a responsive verb from its declarative entry, we get the following interrogative entry for *trueifbelieve*:

(82)   *trueifbelieve*$'_{\text{int}}$:= $\lambda Q_{\langle\langle s,t\rangle,t\rangle}.\lambda x.\lambda w.\exists p \in Q : (\text{DOX}^w_x \subseteq p \to w \in p)$

Now, let us consider whether this verb is veridical w.r.t. declarative and interrogative complements. First, consider the inference in (83):

(83)   Mary trueifbelieves where John was born.
         John was born in Paris.
         ∴ Mary trueifbelieves that John was born in Paris.

Such inferences are valid, because the second premise alone already ensures that the conclusion holds, irrespectively of Mary's information state. Thus, *trueifbelieve* is veridical w.r.t. interrogative complements.

    Now consider the following inference, which is invalid:

(84)   John trueifbelieves that it is raining.
         ⫫. It is raining.

The inference is invalid because the premise can be true even if it is not raining, as long as John does not believe that it is raining. Thus, *trueifbelieve* is not veridical w.r.t. declarative complements. This means that Spector and Egré's theory does not rule out verbs that fail to comply with the declarative veridicality generalization.

    In our own framework, it can be proven that all c-distributive predicates which have a certain natural property that we will call the *choice property* comply with the generalization. Informally, we say that a predicate has the choice property just in case, for any two declarative complements that are mutually inconsistent, the verb cannot be true of both complements at once—it can only be true of one of them in any given world. More formally:

DEFINITION 9 (CHOICE PROPERTY).
We say that a declarative-embedding verb V has the choice property just in case for any two declarative nucleus meanings P and P' such that $\text{info}(P')\cap\text{info}(P') = \emptyset$, and any world w, $V(E(P))(x)$ and $V(E(P'))(x)$ cannot both be true at w.

This property applies to a large class of verbs, which in particular contains all *factive* verbs. After all, if V is factive and $V(E(P))(x)$ and $V(E(P'))(x)$ are both true at a world w, then P and P' must also both be true at w, which means that

$\mathsf{info}(P') \cap \mathsf{info}(P')$ cannot be empty.

Any c-distributive responsive verb with the choice property complies with the declarative veridicality generalization. A proof of this fact is given in Appendix 1.B.3.

FACT 6. *Any c-distributive responsive verb that has the choice property and is veridical w.r.t. interrogative complements must also be veridical w.r.t. declarative complements.*

1.7. Conclusion

We have proposed a uniform account of declarative and interrogative complements, and the verbs that take both kinds of complement as their argument. The account overcomes a problem for reductive approaches concerning false answer sensitivity (pointed out in George 2011), as well as a problem both for reductive theories and for the twin relations theory concerning predicates of relevance (pointed out in Elliott *et al.* 2017, Uegaki 2018). It also addresses the limitations of Groenendijk and Stokhof's uniform partition theory; in particular, it straightforwardly derives MS and IE readings as well as SE ones. Finally, it addresses a concern raised by George (2011) and Spector and Egré (2015) for uniform and inverse reductive theories, showing that it is possible to capture general constraints on responsive verb meanings within a uniform framework. In Appendix 1.A our approach is compared in some detail with the inverse reductive theory of Uegaki (2015b).

Appendices to Chapter 1

1.A.   *Comparison with Uegaki (2015)*

In Section 1.1 we situated the present proposal w.r.t. a range of previous approaches in rather general terms. Here, we will offer a more detailed comparison with one of these approaches, namely that of Uegaki (2015b), which in our view constitutes the most comprehensive previous account of the issues that we have been concerned with in this paper (see Table 1.1 on page 18).[43] The core of our proposal and that of Uegaki were developed independently, as witnessed by preliminary presentations of the two accounts (Theiler 2014, Roelofsen *et al.* 2014, Uegaki 2014). However, in further developing our initial proposal we have crucially benefited from some of the insights in Uegaki's work. The two resulting proposals are very much in the same spirit, but there are also some significant differences, which we will highlight below.

The discussion will center on two main themes: variability in the exhaustive strength of interrogative complements (Section 1.A.1) and the connection between veridicality, factivity, and extensionality (Section 1.A.2). These themes correspond to two of the core chapters in Uegaki (2015b). The third core chapter in Uegaki (2015b) is concerned with the selectional restrictions of clause-embedding verbs. As mentioned earlier (see p.20), our own account of these selectional restrictions is presented in a separate paper. There, it is also compared with Uegaki's proposal.

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[43]To be sure, neither our own proposal nor that of Uegaki (2015b) covers all the issues that have been discussed in previous work on declarative and interrogative complements and the verbs that embed them. For instance, quantificational variability effects (e.g., Berman 1991, Lahiri 2002, Beck and Sharvit 2002, Cremers 2016), the *de re/de dicto* ambiguity (e.g., Groenendijk and Stokhof 1984, Sharvit 2002), the licensing of negative polarity items (e.g., Guerzoni and Sharvit 2007, Guerzoni and Sharvit 2014, Nicolae 2013), homogeneity effects (Kriz 2015, Cremers 2016), and perspective sensitivity (e.g., Aloni 2005) are not explicitly accounted for. We are hopeful that our proposal can be extended to do so, incorporating insights from the work cited here, but a full implementation must be left for future work.

1.A.1. Variability in exhaustive strength

As discussed in Section 1.3.1, sentences with interrogative complements usually exhibit variability in exhaustive strength. With certain verbs, however, this variability is restricted. For instance, *be certain* is incompatible with an IE reading, and our theory accounts for this fact. Uegaki aims to predict more generally which readings are available for any responsive verb and to derive these predictions from the lexical properties of the verb. It has to be noted that such predictions—while clearly desirable—will only be explanatory to the extent that the involved mechanisms are independently motivated. This means in particular that it should be possible to provide reasons for assuming the relevant properties of the embedding verbs that are *not* connected to deriving the observed levels of exhaustive strength.

   We will first consider the general architecture that Uegaki assumes and the distinction between extensional and intensional verbs that is relevant for his account. We then turn to the 'baseline' readings that are predicted for different embedding verbs and finally to the non-baseline readings, which are obtained by additional semantic operations.

GENERAL ARCHITECTURE AND EXTENSIONAL/INTENSIONAL RESPONSIVE VERBS. Uegaki decomposes every responsive verb V into a *core predicate* R_V, which is the proposition-taking counterpart of V, plus an answer operator. The answer operator, Ans_d, has the denotation in (85). It takes a world w and a question denotation Q as arguments and delivers the true WE answer to Q in w.

(85) $\mathrm{Ans}_d = \lambda w'.\lambda Q_{\langle\langle s,t\rangle,t\rangle}.$

$$\begin{cases} \iota p \in Q. \left(\begin{array}{c} p(w') \wedge \forall p' \in Q. \\ (p'(w') \rightarrow p \subseteq p') \end{array} \right) & \text{if } \exists! p \in Q. \left(\begin{array}{c} p(w') \wedge \forall p' \in Q. \\ (p'(w') \rightarrow p \subseteq p') \end{array} \right) \\ \text{undefined} & \text{otherwise} \end{cases}$$

The difference between *extensional* and *intensional* responsive verbs is the following on Uegaki's account. The world argument of Ans_d can get bound either by the core predicate R_V or by an exhaustification operator, X. Intensional verbs like *be certain* or *tell*$_{[-\mathrm{ver}]}$[44] have a core predicate that binds the world argument of Ans_d, as in (86a), while extensional verbs like *know* do *not* bind this argument themselves, but leave it to be bound by the exhaustification operator, as in (86b).

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[44]Following Spector and Egré (2015), Uegaki assumes that *tell* is ambiguous between a veridical and a non-veridical interpretation. We use *tell*$_{[-\mathrm{ver}]}$ to denote the non-veridical version of the verb.

(86) a. intensional verb:
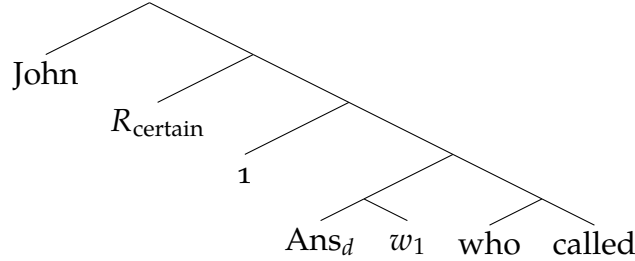
  b. extensional verb:
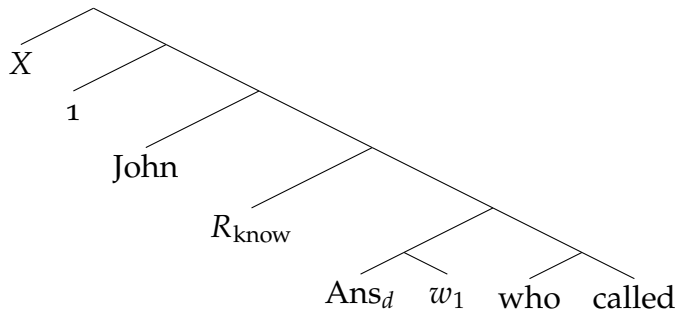
This contrast between extensional and intensional verbs can also be observed from the lexical entries in (87): the intensional verbs in (87a) and (87b) take a world-sensitive argument $\mathcal{P}$, which they evaluate in some possible world (in the case of *tell*) or all possible worlds that are compatible with the subject's beliefs (in the case of *be certain*). The extensional verb in (87c) on the other hand takes a simple proposition p as its argument.

(87) a. $[\![R_{\text{certain}}]\!]^w = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}.\lambda x.\forall w' \in \text{DOX}_x^w : \text{DOX}_x^w \subseteq \mathcal{P}(w')$

  b. $[\![R_{\text{tell}[-\text{ver}]}]\!]^w = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}.\lambda x.\lambda y.\exists w'.\textbf{tell}(x, y, \mathcal{P}(w'), w)$

  c. $[\![R_{\text{know}}]\!]^w = \lambda p_{\langle s, t \rangle}.\lambda x.\text{DOX}_x^w \subseteq p$

BASELINE READINGS. In Uegaki's system, each verb comes with a baseline reading, which is the reading it has in the absence of further semantic operations such as exhaustification. In the case of extensional verbs like *know*, the baseline reading is WE. To see why, consider again the lexical entry in (87c) for the knowledge relation R_{know} and the entry in (85) for the answer operator Ans_d. As can be seen from the structure in (86b), the propositional argument p that R_{know} takes in the semantic derivation is delivered by Ans_d. Since, given a world w and a question meaning Q, $\text{Ans}_d(w)(Q)$ is the true WE answer to Q in w, we find that for a subject x to *know* Q in w, x's belief state in w, DOX_x^w, has to be a subset of the true WE answer in w. This amounts to a WE reading.

The semantics of intensional verbs, on the other hand, is expressed in terms of quantification over possible worlds, and the strength of their baseline reading

depends on the kind of quantification that is used. For instance, as can be seen from the entries in (87a) and (87b), a universal semantics is assumed for *be certain*, while an existential semantics is assumed for *tell*$_{[-\text{ver}]}$, the non-veridical variant of *tell*.[45]

The propositional concept $\mathcal{P}$ that these verbs take as an argument is a function mapping every world to the true WE answer at that world. If *be certain* is applied to a propositional concept $\mathcal{P}$ that has been computed from the meaning Q of an interrogative complement, then the semantics in (87a) amounts to requiring that the subject's belief state DOX_x^w is homogeneous with respect to every answer to Q—or, in other words, that the subject has to believe an SE answer to Q. In comparison, the unrestricted existential quantification in the semantics of *tell*$_{[-\text{ver}]}$ is much weaker: it is only required that the subject stands in a *tell*-relation to the true WE answer at some world w'. However, since for every proposition p that is an MS answer at w', there also exists a world w'' such that p is a WE answer at w'', this condition boils down to requiring that the subject stands in a *tell*-relation to some possible MS answer. Hence, the baseline reading for *be certain* is an SE reading, whereas that for *tell*$_{[-\text{ver}]}$ is an MS reading. As far as we can see, however, the choice for universal as opposed to existential quantification in the case of *be certain* does not receive an independent motivation and is therefore tantamount to hardcoding the baseline exhaustive strength into the lexical entry. In comparison, on our account, the unavailability of IE readings for *be certain* follows from the assumption that this verb only permits an internal, i.e., resolution-introspective interpretation.

INTERMEDIATE EXHAUSTIVITY. Turning to intermediate exhaustivity, for extensional verbs this reading is derived by applying the exhaustification operator X at the root level, i.e., above the embedding verb.[46] Roughly, if this operator applies to a sentence, it asserts the proposition expressed by the sentence and negates all strictly stronger alternatives of this proposition.

(88) $[\![X]\!]^w = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}. \mathcal{P}(w)(w) \wedge \forall v : (\{w' \mid \mathcal{P}(w')(v)\} \subset \{w' \mid \mathcal{P}(w')(w)\} \rightarrow \neg \mathcal{P}(w)(v))$

As can be seen from the structure in (86b), the propositional concept $\mathcal{P}$ that X takes as its argument is the result of first computing the meaning of the sentence

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[45]The entry in (87b) is only a preliminary version; Uegaki's final entry for *tell* has an exluded-middle presupposition, which we will turn to below.

[46]This operator may be regarded as a refinement of the EXH operator in Klinedinst and Rothschild (2011). However, in contrast to Uegaki, Klinedinst and Rothschild are only concerned with deriving IE readings of *non-factive* verbs. Their account fails to derive such readings for factive verbs—which to us seem to be the prime case of FA sensitivity effects.

to which *X* applies, and then lambda-abstracting over the world argument of the answer operator in that sentence. For example, in the semantic derivation of (89a), *X* applies to the propositional concept in (89b).

(89) a. Mary told$_{[+ver]}$ John who called.
      b. $\mathcal{P} = \lambda w_1.[\![\text{Mary} \, [\, \text{told}_{[+ver]} \, [\, \text{John} \, [\, [\text{Ans}_d \, w_1] \, [\, \text{who called} \,]]]]]\!]$

To see that this gives *X* access to the relevant set of alternatives, assume, e.g., that in the world of evaluation w Ann and Bill called, but Chris didn't, whereas in v all of Ann, Bill and Chris called. Then, $\{w' \mid \mathcal{P}(w')(v)\}$ is the set of all those worlds in which Mary told John the true WE answer to *who called?* in v, i.e., she told him that Ann, Bill and Chris called. In contrast, $\{w' \mid \mathcal{P}(w')(w)\}$ is the set of all those worlds in which Mary told John the true WE answer to *who called?* in w, i.e., she told him that Ann and Bill called. Observe that $\{w' \mid \mathcal{P}(w')(v)\} \subset \{w' \mid \mathcal{P}(w')(w)\}$. Hence, what *X* asserts is that Mary told John that Ann and Bill called and she didn't tell him that Ann, Bill and Chris called. This is exactly the IE reading of (89).

This is the way in which IE readings *can* in principle be derived on Uegaki's account. When it comes to *restricting* their availability, a certain feature of the exhaustivity operator becomes crucial: this operator interacts with the monotonicity properties of the embedding verb in such a way that, if the verb is upward-monotonic, IE is derived, whereas, if the verb is not upward-monotonic, the contribution of *X* is vacuous. To see why, consider again the definition of *X* in (88). In the case of a predicate that is not upward-monotonic, the implication in the second conjunct is vacuously satisfied because it will never be the case that $\{w' \mid \mathcal{P}(w')(v)\} \subset \{w' \mid \mathcal{P}(w')(w)\}$. For upward-monotonic predicates, on the other hand, $\{w' \mid \mathcal{P}(w')(v)\} \subset \{w' \mid \mathcal{P}(w')(w)\}$ can become true; it holds for all worlds v and w such that $\text{Ans}_d(v)(Q) \subset \text{Ans}_d(w)(Q)$. Hence, for these verbs the second part in the definition of *X* applies non-vacuously.

Uegaki's account thus establishes a connection between the monotonicity properties of embedding verbs and the availability of IE readings. More specifically, by assuming that emotive factives like *be happy* and *be surprised* are non-monotonic, these verbs are predicted to lack IE readings. The only predicted reading for emotive factives is their baseline reading, i.e., WE. On the other hand, epistemic attitude verbs like *know* and the veridical variants of communication verbs like *tell*, which are assumed to be upward monotonic, are predicted to have IE readings.

While we find the approach ingenious, we have four reservations. First, as also noted by Uegaki himself, the non-monotonicity of emotive factives, on

which his analysis crucially relies, is debatable (von Fintel 1999, Crnič 2011). Second, the assumed unavailability of SE readings for emotive factives has been contradicted by recent experimental work (Cremers and Chemla 2017). Third, as argued by Xiang (2016b), it seems difficult to extend the account to derive FA-sensitive MS readings. Fourth, Uegaki's account only derives a connection between monotonicity properties and exhaustive strength for extensional verbs. For intensional verbs, essentially, exhaustive strength must still be encoded in the individual lexical entries. In sum, this means that Uegaki's theory of exhaustive strength is explanatory only for extensional verbs and, for these verbs, only to the extent that their monotonicity properties indeed correlate with the presence/absence of IE readings; more experimental work is needed to determine conclusively whether such a correlation exists (cf., Cremers and Chemla 2017).

STRONG EXHAUSTIVITY. An SE reading can be derived in two different ways on Uegaki's account, depending on whether the verb is extensional or intensional. In either case, however, SE arises from an excluded-middle assumption, which is encoded in the lexical entry of the embedding verb as a soft presupposition (Gajewski 2007, Abusch 2010).

To begin with, consider an intensional verb like *tell*$_{[-ver]}$, whose lexical entry including the relevant presupposition is given in (90). According to Uegaki, *tell* comes with an excluded-middle assumption stating that, for every possible answer p to the embedded interrogative, the subject x has either told the addressee y that p or told her that $\neg p$. It is easy to see that this condition gives rise to an SE reading. Uegaki thus predicts that for intensional verbs like *tell* the SE reading can directly arise from their excluded-middle presupposition. Under this view, in order for the SE reading *not* to arise, on the other hand, the presupposition needs to be suspended.

(90) $[\![R_{\text{tell}[-\text{ver}]}]\!]^{w} = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}.\lambda y.\lambda x.$

$$\begin{cases} \exists w'.\textbf{tell}(x, y, \mathcal{P}(w'), w) & \text{if } \forall w'. \left(\begin{array}{l} \textbf{tell}(x, y, \mathcal{P}(w'), w) \vee \\ \textbf{tell}(x, y, \neg\mathcal{P}(w'), w) \end{array} \right) \\ \text{undefined} & \text{otherwise} \end{cases}$$

Turning to extensional verbs, the situation becomes slightly more complex. Here, it is not the verb itself that is relevant for the excluded-middle presupposition, but its non-factive counterpart. For example, in the case of *know*, Uegaki encodes the excluded-middle presupposition in terms of *believe*, i.e., in terms of the subject's doxastic state:

(91) $[\![R_{\text{know}}]\!]^w = \lambda p_{\langle s,t\rangle}.\lambda y.\lambda x. \begin{cases} \text{DOX}_x^w \subseteq p & \text{if } p(w) \land \left(\begin{array}{c} \text{DOX}_x^w \subseteq p \ \lor \\ \text{DOX}_x^w \subseteq \neg p \end{array} \right) \\ \text{undefined} & \text{otherwise} \end{cases}$

Note that, in contrast to the intensional verb, here the excluded-middle pre-supposition is not formulated with respect to *every* possible answer; instead it only concerns a specific proposition p. If p is the true WE answer in the world of evaluation, for example, the excluded-middle presupposition in (91) does not itself amount to an SE reading. However, as soon as this presupposition is combined with an IE reading, SE follows. To see why, recall that an IE reading, derived by applying the X operator, would assert that for every answer p, if p is true then the subject x believes p, and if p is false then x does not believe p. Now, since the excluded-middle assumption tells us that for every p, x either believes p or believes $\neg p$, it follows from the IE reading that, for every false answer p, x believes $\neg p$. This gives us an SE reading.

In the case of extensional verbs, SE readings are thus parasitic on IE readings on Uegaki's account. In particular, this means that emotive factives, which are predicted to lack IE readings, are predicted not to have SE readings either. For extensional verbs that do permit IE readings on the other hand, and for intensional verbs, the availability of SE readings depends on whether the verb comes with an excluded-middle presupposition, which Uegaki assumes to be the case exactly if it licenses neg-raising.

As far as we can see, the main problem for this analysis is that, in order to derive SE readings, excluded-middle presuppositions need to be assumed even for verbs for which it is very debatable whether such presuppositions exist. For instance, if Uegaki wants to derive SE readings for intensional communication verbs like *tell*[−ver]—and it seems that he does (p.156)—then an excluded-middle presupposition needs to be assumed for such verbs, although they do not readily seem to license neg-raising:[47]

(92) Ann didn't tell Bill that it is raining.
      ⫫. Ann told Bill that it is not raining.

A further problem arises in connection with *know*. Since R_{know} carries an excluded-middle presupposition that is formulated in terms of the subject's doxastic state, the inference in (93) is predicted to go through. This 'pseudo

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[47]Uegaki distinguishes between a *literal* and a *deductive* reading of communication verbs (Theiler 2014). This distinction, however, does not appear to have a bearing on the licensing of excluded-middle inferences: *tell* seems to license such inferences neither on the literal nor on the deductive reading.

neg-raising' effect is clearly undesirable.

(93)   Ann doesn't know that it is raining.
       ∴ Ann believes that it is not raining.

1.A.2.   Veridicality, factivity, and extensionality

Uegaki's account differs from ours in that it predicts a one-to-one connection between factivity and extensionality. We will see that, as a result, non-factive veridical verbs like *be right* have to be treated as intensional verbs—which has a number of undesirable consequences.

In Uegaki's system, there are two reasons why a verb can come out as veridical: either because the verb is extensional, i.e., the answer operator is evaluated in the root evaluation world, or because the verb meaning is decomposed into an inherently veridical core predicate plus an answer operator. Let us consider both in turn.

First, recall that extensional verbs do not bind the world argument of Ans_d themselves, but leave it to the exhaustivity operator X to bind this argument. This operator, whose definition is repeated in (94) below, takes a propositional concept $\mathcal{P}$ and, among other things, asserts that the result of evaluating $\mathcal{P}$ at the root world of evaluation w holds at w. Since X obligatorily applies in the case of extensional verbs, for these verbs Ans_d thus gets evaluated in w. This means that, if extensional verbs take an interrogative complement, Ans_d delivers the true WE answer in the world of evaluation. If they take a declarative complement, whose meaning Uegaki represents as a singleton set containing the proposition that the complement is standardly taken to express, the definedness restriction of Ans_d amounts to a factivity presupposition. Crucially, for Uegaki, extensionality thus always entails both veridicality with respect to interrogative complements *and* factivity with respect to declarative complements.

(94) $[\![X]\!]^w = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}.\mathcal{P}(w)(w) \wedge \forall v : (\{w' \mid \mathcal{P}(w')(v)\} \subset \{w' \mid \mathcal{P}(w')(w)\} \rightarrow$
      $\neg \mathcal{P}(w)(v))$

The second way in which a verb can be veridical is by virtue of the inherent veridicality of its core predicate. For example, Uegaki assumes the following core predicate for *prove*.

(95) $[\![R_{\text{prove}}]\!]^w = \lambda \mathcal{P}_{\langle s, \langle s, t \rangle \rangle}.\lambda x.\exists w'.\textbf{prove}(x, \mathcal{P}(w'), w)$

The format of this predicate does not by itself differ from that of other intensional verbs with an existential semantics such as *tell*$_{[-\text{ver}]}$. However, Uegaki

additionally assumes by way of a meaning postulate that the implication in (96) holds.

(96) $\forall p.\forall x.\forall w.(\mathbf{prove}(x,p,w) \rightarrow p(w))$

This means that *prove* comes out as veridical with respect to both interrogative and declarative complements: if $\mathcal{P}$ is the meaning of an interrogative complement, $R_{\mathrm{prove}}(\mathcal{P})(x)$ is only true in w if there exists a w' such that $\mathcal{P}(w')$ is a true answer in w and $\mathbf{prove}(x,\mathcal{P}(w'),w)$. If $\mathcal{P}$ is the meaning of a declarative and it holds in w that $R_{\mathrm{prove}}(\mathcal{P})(x)$, then it follows that the information conveyed by the declarative complement is true in w.

Note that, different from those verbs for which veridicality arises from extensionality, intensional verbs like *prove,* for which veridicality results from the inherent veridicality of their core predicate, are not predicted to be *factive.* This means that the only way in which a verb can be factive on Uegaki's account is by virtue of its extensionality. Hence, under this analysis, there is a one-to-one connection between extensionality and factivity.

This connection has consequences for which verbs get classified as extensional and which as intensional on Uegaki's approach. In particular, verbs like *prove* and *be right* have to be treated as intensional since they don't give rise to factivity presuppositions. Different from garden-variety intensionals, however, such verbs are veridical. As we will see below, their treatment as intensionals has a number of undesirable consequences: they are predicted to exhibit no FA sensitivity effects, to have no WE/IE readings, and to have SE readings only in so far as they trigger an excluded-middle presupposition. Let us examine these predictions in some more detail.

Recall that intensional verbs, unlike extensional ones, bind the world argument of the answer operator. Hence, while in the case of extensionals this argument remains free and can be bound by the exhaustivity operator *X*, in the case of intensionals *X* does not have a world to bind. As a consequence, *X* cannot apply to sentences with intensional embedding verbs. However, in Uegaki's system the *X* operator is used to derive FA sensitivity effects.[48] This means that intensional verbs are predicted not to exhibit FA sensitivity effects. While this indeed seems to be a correct prediction for prima-facie intensional verbs like *be certain* or *tell*[−ver], it appears to be wrong for veridical verbs like *prove* and *be right,* as illustrated by the following example. Assume that Ann and Bill, but not Chris were at a party. Mary believes that Ann and Bill were

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[48]To be more concrete, the IE reading is derived via application of *X*, and Uegaki also suggests a way to derive FA sensitive MS readings, namely by expressing the verb phrase in terms of a disjunction and then applying *X* to each of the disjuncts.

there, but has no beliefs about Chris' presence at the party. In this scenario, (97) can be judged true. This means that readings other than the SE reading need to be available for (97), because under the SE reading (97) is false. Now assume instead that Mary believes Ann, Bill *and* Chris were at the party. In this scenario, it seems that (97) would be judged false. This means that an IE reading, i.e., an FA sensitive reading is needed for (97)—but this reading is unavailable for *be right* on Uegaki's account.

(97)   Mary is right about who was at the party.

On the other hand, whether intensional verbs have SE readings on Uegaki's account depends on whether they carry an excluded-middle presupposition. For *be right* and *prove*, however, this does not seem to be the case, as illustrated by (98) and (99). Hence, *be right* and *prove* would come out as lacking SE readings.

(98)   Ann isn't right that it is raining.
        ɟ. Ann is right that it's not raining.

(99)   Ann didn't prove that 3 is prime.
        ɟ. Ann proved that 3 is not prime.

In terms of exhaustive strength, Uegaki's analysis thus predicts intensional verbs to be limited to their baseline reading (unless they carry excluded-middle presuppositions, in which case also the SE reading is available). As discussed above using the example of *tell*$_{[-ver]}$, if an existential semantics is assumed, the baseline reading is an MS reading. Since Uegaki proposes an existential semantics for *be right* and *prove*, the only reading these verbs are predicted to have is a non-FA-sensitive MS reading.

To sum up, Uegaki's account makes a number of problematic predictions for non-factive veridical verbs like *be right* and *prove*, which arise from the treatment of such verbs as intensionals. This treatment, however, is unavoidable for Uegaki since on his account extensionality and factivity cannot be teared apart. In comparison, on our account these problems do not arise since there is no comparable connection between extensionality and factivity.

1.B. Formal proofs

1.B.1. Internal/external interpretation of 'know'

Here, we provide proofs of Fact 1 on page 48 and of Fact 2 on page 48, both repeated below.

FACT 1.   If the complement receives an MS or a SE interpretation, then the external and the internal interpretation of the verb yield exactly the same reading for the sentence as a whole.

PROOF 1.   (Sketch) Consider the sentence *John knows who called* and assume that the complement receives an MS reading. Then, under an external interpretation of the verb, the sentence is true in w just in case $\text{DOX}_j^w \in f_{\text{MS}}(w)$, where $f_{\text{MS}}(w)$ is the set of MS truthful resolutions of the complement in w. Now, it follows straightforwardly from the definition of MS truthful resolutions that if a proposition p is an MS truthful resolution in some world w, then it is also an MS truthful resolution in any world in which it is true, i.e., in any $v \in p$. But this means that $\forall v \in \text{DOX}_j^w : \text{DOX}_j^w \in f_{\text{MS}}(v)$. Thus, the resolution introspection requirement is automatically satisfied, and the sentence is not only true in w under an external interpretation of the verb but also under an internal interpretation. A similar argument can be given in case the complement receives an SE reading.

FACT 2.   If the verb receives an internal interpretation, then the IE and the SE interpretation of the complement yield exactly the same reading for the sentence as a whole.

PROOF 2.   Suppose that in a world w, x knows who called under an internal interpretation of the verb and an IE interpretation of the complement. Then we do not only have that $\text{DOX}_x^w \in f_{\text{IE}}(w)$, where $f_{\text{IE}}(w)$ is the set of IE resolutions of the complement in w, but also, by resolution introspection, that $\text{DOX}_x^w \in f_{\text{IE}}(v)$ for every $v \in \text{DOX}_x^w$.

Now, towards a contradiction, assume that DOX_x^w does *not* coincide with an SE resolution of the complement in w, i.e., that $\text{DOX}_x^w \notin f_{\text{SE}}(w)$. Then there must be an individual y such that y did not call in w but x doesn't know this, i.e., DOX_x^w must contain at least one world w_y where y did call. On the other hand, DOX_x^w cannot consist exclusively of worlds where y called, because y did not call at w and $\text{DOX}_x^w \in f_{\text{IE}}(w)$. Now, since $w_y \in \text{DOX}_x^w$, we must have, by the introspection requirement above, that $\text{DOX}_x^w \in f_{\text{IE}}(w_y)$. But all IE truthful

resolutions at w_y must be propositions that establish that y called. So DOX_x^w must establish that y called as well, i.e., it must consist exclusively of worlds in which y called. This is in contradiction with what we derived earlier. So we can conclude that DOX_x^w must coincide, after all, with an SE resolution of the complement in w, i.e., that $\text{DOX}_x^w \in f_{\text{SE}}(w)$.

It remains to be shown that $\text{DOX}_x^w \in f_{\text{SE}}(v)$ for all $v \in \text{DOX}_x^w$. Suppose that $v \in \text{DOX}_x^w$. Then, since we have just established that $\text{DOX}_x^w \in f_{\text{SE}}(w)$, we have that $v \in f_{\text{SE}}(w)$ as well. But then, given the partition-inducing nature of SE resolutions, it follows that $f_{\text{SE}}(v) = f_{\text{SE}}(w)$. Thus, we can conclude that $\text{DOX}_x^w \in f_{\text{SE}}(v)$, as desired.

1.B.2. *Veridicality and c-distributivity*

Here we provide a proof of Fact 5 on page 68, repeated below.

FACT 5. A c-distributive responsive verb that is veridical w.r.t. declarative complements is also veridical w.r.t. interrogative complements.

In order to prove this connection between c-distributivity and veridicality, we first give fully explicit definitions of veridicality w.r.t. declarative and interrogative complements, respectively. We start with veridicality w.r.t. declarative complements, which is a straightforward notion.

DEFINITION 10 (VERIDICALITY W.R.T. DECLARATIVE COMPLEMENTS).
A declarative-embedding verb V is veridical w.r.t. declarative complements if and only if for any individual x, any world w and any declarative nucleus meaning P:

If $V(E(P))(x)$ is true in w, then P is true in w.

Veridicality w.r.t. interrogative complements is a more complex notion. In the framework that we have developed an interrogative complement meaning is always obtained by applying E to an interrogative nucleus meaning Q, and a declarative complement meaning is obtained by applying E to a declarative nucleus meaning P. Furthermore, Q is exhaustivity-neutral if and only if the alternatives in $\text{alt}(Q)$ form a partition of the set of all possible worlds, and P constitutes a 'complete answer' to such an exhaustivity-neutral Q if and only if the informative content of P coincides precisely with one of the cells in the partition induced by Q, i.e., $\text{info}(P) \in \text{alt}(Q)$. Given these notions, veridicality w.r.t. interrogative complements is defined as follows.

DEFINITION 11 (VERIDICALITY W.R.T. INTERROGATIVE COMPLEMENTS).
A responsive verb V is veridical w.r.t. interrogative complements if and only if for any individual x, any world w, any interrogative nucleus meaning Q such that $\mathsf{alt}(Q)$ is a partition of W, and any a declarative nucleus meaning P such that $\mathsf{info}(P) \in \mathsf{alt}(Q)$:

> If $V(E(Q))(x)$ is true in w and P is true in w, then $V(E(P))(x)$ is true in w as well

With these definitions in place, we are ready to prove Fact 5.

PROOF OF FACT 5.   Let V be a c-distributive responsive verb that is veridical w.r.t. declarative complements. Towards establishing that V is veridical w.r.t. interrogative complements, let Q be an interrogative nucleus meaning such that $\mathsf{alt}(Q)$ forms a partition of W, let x be an individual, and w a world such that $V(E(Q))(x)$ is true in w. Furthermore, let P be a declarative nucleus meaning such that $\mathsf{info}(P) \in \mathsf{alt}(Q)$ and such that P is true in w. We have to show that $V(E(P))(x)$ is true in w as well.

Since $V(E(Q))(x)$ is true in w and V is c-distributive, it must be the case that $V(E(P'))(x)$ is true in w for some $P' \in \mathsf{decomp}(Q)$ (we know that $\mathsf{decomp}(Q)$ exists because $\mathsf{alt}(Q)$ forms a partition of W). Now, towards a contradiction, suppose that $P' \neq P$. Then, since both $\mathsf{info}(P')$ and $\mathsf{info}(P)$ are elements of $\mathsf{alt}(Q)$, and $\mathsf{alt}(Q)$ forms a partition of W, $\mathsf{info}(P')$ and $\mathsf{info}(P)$ must be disjoint. Since P is true in w, it follows that P' cannot be true in w. But then, since V is veridical w.r.t. declarative complements, it follows that $V(E(P'))(x)$ cannot be true in w either, contrary to what we assumed. Thus, we can conclude that $P' = P$. It follows that $V(E(P))(x)$ is true in w, which is precisely what we needed to show in order to establish that V is veridical w.r.t. interrogative complements.   □

1.B.3. *Veridicality and choice property*

Here we provide a proof of Fact 6 on page 73, repeated below.

FACT 6.   Any c-distributive responsive verb that has the choice property and is veridical w.r.t. interrogative complements must also be veridical w.r.t. declarative complements.

PROOF OF FACT 6.   We will prove that any c-distributive verb that has the choice property and is *not* veridical w.r.t. declarative complements is *not* veridical w.r.t. interrogative complements either. Let V be a c-distributive responsive verb that has the choice property and is not veridical w.r.t. declarative complements. This

means that there is a declarative nucleus meaning P, an individual x, and a world w such that $V(E(P))(x)$ is true in w but P itself is not true in w.

Towards establishing that V cannot be veridical w.r.t. interrogative complements in this case, let Q be the interrogative nucleus meaning $P \cup \neg P$. We can think of Q as the question 'whether P'. Note that $\mathsf{alt}(Q)$ forms a partition of W, and $\mathsf{info}(\neg P) \in \mathsf{alt}(Q)$. Now, since $V(E(P))(x)$ is true in w and since V is c-distributive, it follows that $V(E(Q))(x)$ is true in w as well. We also have that $\neg P$ is true in w. This means that, if V were veridical w.r.t. interrogative complements, it should be the case that $V(E(\neg P))(x)$ is true in w as well. This cannot be the case, because $V(E(P))(x)$ is true in w and V has the choice property. So, V cannot be veridical w.r.t. interrogative complements. □

Chapter 2.
Picky predicates: Why 'believe' doesn't like interrogative complements, and other puzzles

2.1. Introduction

Certain clause-embedding predicates take both declarative and interrogative complements, as shown in (1) for *know*. Others take only declarative complements, as illustrated in (2) for *believe,* or only interrogative complements, as seen in (3) for *wonder*.

(1)   Bill knows that/whether/what Mary has eaten.

(2)   Bill believes that/*whether/*what Mary has eaten.

(3)   Bill wonders whether/what/*that Mary has eaten.

Verbs like *know* are referred to as *responsive* predicates, predicates like *wonder* as *rogative* predicates, and predicates like *believe* as *anti-rogative* predicates. Any account that aims at explaining the distribution of clausal complements will have to capture both the selectional *restrictions* of rogative and anti-rogative predicates and the selectional *flexibility* of responsive predicates. Most accounts of clausal complements assume a type distinction between declarative and interrogative complements (e.g. Karttunen 1977, Heim 1994, Dayal 1996, Lahiri 2002, Spector and Egré 2015, Uegaki 2015b). Usually, declarative complements are taken to have type $\langle s, t \rangle$, while interrogative complements are taken to have type $\langle \langle s, t \rangle, t \rangle$. The selectional restrictions of (anti-)rogative predicates can then be captured by postulating that rogative predicates take arguments of type $\langle \langle s, t \rangle, t \rangle$, while anti-rogative predicates take arguments of type $\langle s, t \rangle$. On the other hand, to capture the selectional flexibility of responsive predicates, these accounts assume an operator that shifts the type of interrogatives into that of declaratives, or vice versa.

This approach, however, has its limitations. First, as soon as we admit type-shifting, we lose part of the account of selectional restrictions. This is because if we introduce an operator that adapts the type of interrogatives to that of declaratives (as in, e.g., Heim 1994), then this operator would also resolve the type conflict when anti-rogative predicates like *believe* take interrogative complements. Thus, in this case, we lose the account of the selectional restrictions of anti-rogatives. On the other hand, for analogous reasons, if the type-shifter adapts the type of declaratives to that of interrogatives (as in Uegaki 2015b), the account of the selectional restrictions of rogative predicates is lost. Thus, type-distinction-based accounts do not directly capture the selectional restrictions of both rogative and anti-rogative predicates at once. The selectional restrictions of one of these predicate classes need to be derived from factors other than the postulated type distinction between declaratives and interrogatives. Of course one may attempt to overcome this limitation by assuming that the type-shifter can only apply in certain configurations. The point here is that, *without* such additional assumptions, type-distinction-based accounts cannot capture selectional restrictions and selectional flexibility at the same time.

Moreover, if one wants to account for the selectional restrictions of rogative or anti-rogative predicates in terms of a type mismatch, one has to assume differences in semantic type between certain predicates which seem difficult to motivate independently. For instance, if one wants to account in this way for the fact that rogative predicates do not accept declarative complements while responsive predicates do, one has to assume a difference in semantic type between *be curious* (which is rogative; e.g., *I'm curious who left / *that Bill left*) and *be of interest* (which is responsive; e.g., *Who left / that Bill left is of interest to me*). Similarly, if one wants to explain the fact that anti-rogatives, unlike responsives, do not take interrogative complements in terms of a type mismatch, then one has to assume a difference in semantic type between predicates like *assert* and *claim* (which are anti-rogative) and ones like *announce* and *state* (which are responsive). In the absence of independent motivation for such type distinctions, the approach is stipulative to a certain degree.[1] An account which derives the selectional restrictions of (anti-)rogatives from semantic assumptions about these predicates which can be independently motivated would be preferable.

The present paper assumes a *uniform* account of clausal complements, introduced in Theiler *et al.* 2018. The account is uniform in the sense that it assigns the same semantic type to declarative and interrogative complements,

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[1]It must be noted that such motivation is not completely absent: Uegaki (2015a) provides an explicit argument for his assumption that predicates like *believe* require an argument of type $\langle s, t \rangle$ while predicates like *know* require an argument of type $\langle \langle s, t \rangle, t \rangle$. However, this argument does not seem entirely conclusive; see Appendix 2.A.2 for discussion.

namely $\langle\langle s,t\rangle,t\rangle$, and assumes that all clause-embedding predicates take arguments of this type. On such an account, the selectional flexibility of responsive predicates is directly predicted, without any type-shifting operations. On the other hand, the selectional restrictions of (anti-)rogatives need to be explained based on independently observable properties of the relevant predicates. Such an explanation has recently been given for *wonder* and some closely related rogative predicates (Ciardelli and Roelofsen 2015, Uegaki 2015b).[2] The present paper does so for another class of rogative predicates, namely predicates of dependency like *depend on* and *be determined by*, as well as two classes of anti-rogative predicates, namely (i) neg-raising predicates like *believe* and *think* and (ii) truth-evaluating predicates like *be true* and *be false*. Independently of the present paper, Mayr (2017) and Cohen (2017a,b) have also recently proposed ways to explain the anti-rogativity of neg-raising predicates.[3] These accounts, while building on the same idea as ours, are more limited in scope and less explicit. We will discuss them in Appendix 2.A.

The paper is structured as follows. Section 2.2 briefly lays out our uniform account of clausal complements, and exemplifies our treatment of responsive predicates. Section 2.3 is concerned with the selectional restrictions of anti-rogative predicates, Section 2.4 with those of rogative predicates, and Section 2.5 discusses an empirical and more general methodological issue. Section 2.6 concludes. Appendix 2.A discusses related work in some detail, Appendix 2.B spells out some technical details of the proposed account, and Appendix 2.C presents an extension of the core account to presuppositional complements.

2.2.   *A uniform treatment of clausal complements*

Our treatment of clausal complements is couched in inquisitive semantics (Ciardelli *et al.*, 2013, 2015).[4] In this framework, declarative and interrogative clauses are taken to have the same kind of semantic value, namely a set of propositions. The conceptual motivation behind this uniform notion of sentence meaning is as follows. While traditionally the meaning of a sentence φ is taken to capture just the information conveyed by φ, in inquisitive semantics it is taken to addi-

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[2]The proposals of Ciardelli and Roelofsen (2015) and Uegaki (2015b) are very much in the same spirit. For discussion of the subtle differences between them, see Appendix 2.A.2.

[3]A first version of the present account started circulating in the Spring of 2016.

[4]As will become clear in the course of the paper, this choice of framework is an integral part of the proposed account. In particular, as will be laid out in Section 2.3.1.3, in deriving the selectional restrictions of neg-raising predicates, we make crucial use of inquisitive negation as well as the fact that sentence meanings in inquisitive semantics are not arbitrary sets of propositions, but always downward closed.

tionally capture the *issue* expressed by φ as well. We call the information that is conveyed by a sentence its *informative content*, and the issue expressed by it its *inquisitive content*. To encode both kinds of content at once, the meaning of a sentence is construed as a set of propositions, no matter whether the sentence is declarative or interrogative.

By uttering a sentence φ with meaning $[\![\varphi]\!]$, a speaker is taken to do two things at the same time. Firstly, she is taken to raise an issue whose resolution requires establishing one of the propositions in $[\![\varphi]\!]$. These propositions are called *resolutions*. Secondly, she is taken to provide the information that the actual world is contained in the union of all resolutions, $\bigcup[\![\varphi]\!]$. $\bigcup[\![\varphi]\!]$ is the informative content of φ, written as $\mathsf{info}(\varphi)$.

2.2.1. *Downward closure, alternatives, and truth*

Sentence meanings in inquisitive semantics are *downward closed*: if $p \in [\![\varphi]\!]$ and $q \subset p$, then also $q \in [\![\varphi]\!]$. This captures the intuition that, if a proposition p resolves a given issue, then any stronger proposition $q \subset p$ will also resolve that issue. As a limit case, it is assumed that the inconsistent proposition, $\emptyset$, trivially resolves all issues, and is therefore included in the meaning of every sentence. The maximal elements in $[\![\varphi]\!]$ are referred to as the *alternatives* in $[\![\varphi]\!]$ and the set of these alternatives is denoted as $\mathsf{alt}(\varphi)$. Alternatives are those propositions that contain precisely enough information to resolve the issue expressed by φ. Finally, from the meaning of a sentence in inquisitive semantics, its truth conditions are derived in the following way: φ is true in a world w just in case w is compatible with $\mathsf{info}(\varphi)$, i.e., $w \in \mathsf{info}(\varphi)$.

For example, consider the sentence meaning $[\![\varphi]\!] = \{\, \{w_1, w_2\}, \{w_1\}, \{w_2\}, \emptyset\,\}$. This meaning contains exactly four resolutions, namely $\{w_1, w_2\}$, $\{w_1\}$, $\{w_2\}$, and $\emptyset$. It contains exactly one alternative, namely $\{w_1, w_2\}$. That is, $\mathsf{alt}(\varphi) = \{\, \{w_1, w_2\}\,\}$. Since $[\![\varphi]\!]$ is downward closed, it additionally contains all subsets of $\{w_1, w_2\}$, i.e., $\{w_1\}$, $\{w_2\}$, and $\emptyset$. The informative content of φ is $\mathsf{info}(\varphi) = \{w_1, w_2\}$. This means that φ is true in w_1 and w_2 and false in all other worlds.

2.2.2. *Informative and inquisitive sentences*

The informative content of φ can be trivial, namely iff the propositions in $[\![\varphi]\!]$ cover the entire logical space W, i.e., iff $\mathsf{info}(\varphi) = W$. In this case, we call φ *non-informative*. Conversely, we call φ *informative* iff $\mathsf{info}(\varphi) \neq W$. Not only the informative content, but also the inquisitive content of a sentence can be

(a) Ann left.   (b) Did Ann leave?   (c) Who left?
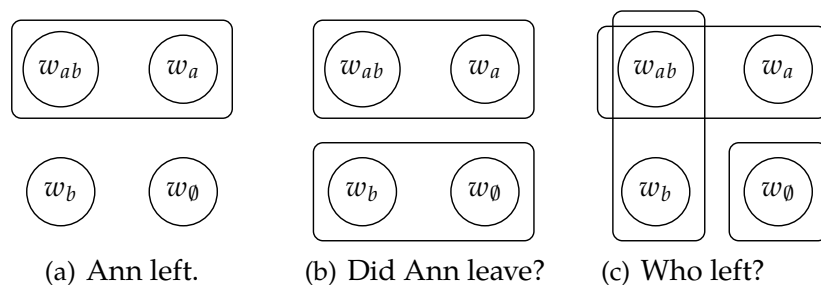
FIGURE 2.1. Examples of complement clause meanings in inquisitive semantics.

trivial. This is the case iff the issue expressed by φ is already resolved by the information provided by φ itself, i.e., iff $\mathsf{info}(\varphi) \in [\![\varphi]\!]$. In this case, we call φ *non-inquisitive*. Conversely, φ is called *inquisitive* iff $\mathsf{info}(\varphi) \notin [\![\varphi]\!]$. If φ is non-inquisitive, its meaning contains a unique alternative, namely $\mathsf{info}(\varphi)$. Vice versa, if $[\![\varphi]\!]$ contains multiple alternatives, it is inquisitive.

2.2.3. *Declarative and interrogative complements*

Following Ciardelli *et al.* (2015) and much earlier work in inquisitive semantics, we assume that a declarative complement or matrix clause φ is never inquisitive.[5] That is, its meaning $[\![\varphi]\!]$ always contains a single alternative, which coincides with its informative content, $\mathsf{info}(\varphi)$. For example:

(4)   alt(that Ann left) = $\big\{ \ \{w \mid \text{Ann left in } w\} \ \big\}$

Conversely, we assume that an interrogative complement or matrix clause is never informative. This means that the alternatives associated with an interrogative clause always completely cover the set of all possible worlds.[6] For example, if the domain of discourse consists of Ann and Bob, we assume the following sets of alternatives for the interrogative complements *whether Ann left* and *who left*.[7]

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[5] There is also work in inquisitive semantics that does not make this assumption (e.g. AnderBois 2012). This requires a view under which uttering an inquisitive sentence does not necessarily involve issuing a request for information. See Ciardelli *et al.* (2012) for discussion.

[6] For simplicity we leave the presuppositions of complement clauses out of consideration here; Appendix 2.C discusses how the proposed account can be extended to deal with such presuppositions.

[7] The alternatives assumed here for wh-interrogatives only allow us to derive non-exhaustive (mention-some) readings. Our account can be refined to derive intermediate and strongly exhaustive readings as well (see Theiler *et al.*, 2018). This refinement doesn't affect any of the

(5)   alt(whether Ann left) = $\left\{ \begin{array}{l} \{w \mid \text{ Ann left in } w\}, \\ \{w \mid \text{ Ann didn't leave in } w\} \end{array} \right\}$

(6)   alt(who left) = $\left\{ \begin{array}{l} \{w \mid \text{ Ann left in } w\}, \\ \{w \mid \text{ Bob left in } w\}, \\ \{w \mid \text{ nobody left in } w\} \end{array} \right\}$

The alternative sets in (4)–(6) are also depicted in Figure 2.1, where w_{ab} is a world in which both Ann and Bill left, w_a one in which only Ann left, w_b one in which only Bill left, and $w_\emptyset$ one in which neither Ann nor Bill left.

2.2.4. *Responsive predicates: a brief illustration*

Before dealing with the selectional restrictions of anti-rogative predicates, let us first briefly specify a basic lexical entry for the responsive predicate *be certain*, showing that its selectional flexibility is immediately captured.[8] In the entry below, P is the meaning of the clausal complement, its semantic type $\langle\langle s, t \rangle, t \rangle$ is abbreviated as T, and DOX_x^w is the doxastic state of the subject x in world w.[9]

(7) $[\![\text{be certain}]\!]^w = \lambda P_T.\lambda x.\,\text{DOX}_x^w \in P$

As illustrated by the following examples, this entry uniformly handles declarative and interrogative complements, which are both of type T.

(8)   Mary is certain that John left.
      $\rightsquigarrow$ True in w iff $\text{DOX}_m^w \subseteq \{w \mid \text{John left in } w\}$

(9)   Mary is certain who left.
      $\rightsquigarrow$ True in w iff $\exists p \in \left\{ \begin{array}{l} \{w \mid \text{ Ann left in } w\}, \\ \{w \mid \text{ Bob left in } w\}, \\ \{w \mid \text{ nobody left in } w\} \end{array} \right\}$ s.t. $\text{DOX}_m^w \subseteq p$

The present approach thus yields a more economical treatment of responsive predicates than approaches that assume a type distinction between declarative

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results presented here.

    [8]For a full account of *be certain* this basic entry needs to be refined. For instance, the given entry does not capture the fact that when taking a wh-complement *be certain* only permits a strongly exhaustive reading (Uegaki 2015b, Theiler *et al.* 2018), nor the fact that when taking a polar interrogative complement, the predicate is degraded in plain episodic, positive sentences, while completely fine under negation (Mayr 2017, van Gessel *et al.* 2018). These empirical facts are left out of consideration here.

    [9]For simplicity, we give truth-conditional entries here. For a full-fledged compositional inquisitive semantics, these can easily be transformed into support-conditional entries; see Appendix 2.B.

and interrogative complements. It is not necessary here to assume a type-shifting operation (or multiple lexical entries for each responsive predicate). Moreover, as discussed in Theiler *et al.* 2018, the approach avoids certain thorny problems, brought to light in George 2011, Elliott *et al.* 2017, Roberts 2018, and Uegaki and Roelofsen 2018, for mainstream theories which assume a type-shifting operation from sets of propositions to propositions. It should be noted, however, that these problems are also avoided by the approach of Uegaki (2015b), which assumes a type-shifting operation in the opposite direction.[10]

2.3. *Anti-rogative predicates*

We will now turn our attention to anti-rogative predicates, which include attitude predicates like *think* and *believe*,[11] likelihood predicates such as *seem* and *be likely*, speech-act predicates like *claim* and *assert*, truth-evaluating pred-

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[10] A general argument that has been made against the uniform approach taken here is that it does not impose any constraints on the space of possible responsive predicate meanings (George 2011, Spector and Egré 2015). In defense of the approach, Theiler *et al.* (2018) point out that the same situation exists in other empirical domains, and that the solutions proposed there may be applied in the domain of responsive predicates as well. For instance, generalized quantifier theory leaves the space of possible determiner meanings highly unconstrained. Only a small subset of these meanings can be expressed by lexical determiners in natural languages. It has been argued that this may be rooted in the fact that certain types of determiner meanings are significantly harder to learn and/or process than others (see, e.g., Steinert-Threlkeld and Szymanik, 2018). Steinert-Threlkeld (2019) and Theiler *et al.* (2018) suggest that the same approach may be taken in the domain of responsive predicates, and take some concrete steps in this direction.

[11] In this paper, we will set aside the observation that in certain constructions *believe* does in fact take interrogative complements. Two examples are given in (ia-b):

(i)   a.   You won't believe who won!
        b.   He just wouldn't believe me who I was.
        c.   *You won't think who won!
        d.   *You won't believe whether Mary won!
        e.   *You won't believe who called in ages!

Note that, as illustrated in (ic), other anti-rogative predicates do not seem to exceptionally license interrogative complements in these configurations, and as illustrated in (id), while *believe* exceptionally licenses wh-interrogatives in these cases, polar interrogative complements are still unacceptable. Interestingly, when *believe* felicitously embeds an interrogative complement, it becomes factive. This means that *believe* in these constructions shares many properties with emotive factive predicates like *be surprised*. Finally, it was pointed out by an anonymous reviewer that *believe* in these configurations is not neg-raising. This can be observed from the ungrammaticality of (ie): if *believe* was neg-raising, it would license the strong NPI *in ages* (Gajewski 2007). Since we will derive the anti-rogativity of *believe* from the fact that it is neg-raising, this last observation might be taken to corroborate our account. Further investigation of this peculiar construction must be left for another occasion, though.

icates like *be true* and *be false*, and non-veridical preferential predicates like *hope* and *fear*. We won't account for the anti-rogativity of all these different predicate classes here, but instead will focus on just two classes, namely *neg-raising* predicates such as *believe, think, seem,* and *be likely* (Sect. 2.3.1) and the *truth-evaluating* predicates *be true* and *be false* (Sect. 2.3.2).

2.3.1. *Neg-raising predicates*

2.3.1.1 *Zuber's observation: all neg-raising predicates are anti-rogative*

It has been observed that—diverse as the class of anti-rogative predicates may be—there is something that many of them have in common: namely, many of them are neg-raising. This means, at first pass, that they license the following kind of inference:[12]

(10)   Mary does **not** believe that Ann left.
       ∴ Mary believes that Ann did **not** leave.

Zuber (1982) claims that *all* neg-raising predicates are anti-rogative. Indeed, examining the class of neg-raisers, it doesn't seem possible to find a counterexample to this generalization. Some anti-rogative neg-raisers are given in (11).

(11)   *believe, think, feel, expect, want, seem, be likely*

We will show that once we add a treatment of neg-raising to our present account of clausal embedding, then, indeed, anti-rogativity will follow. In our discussion we will focus on the case of *believe,* and indicate how the account can be extended to other neg-raising predicates.

Note, however, that Zuber's generalization does not hold in the other direction; there are several anti-rogative predicates that are not neg-raising:

(12)   a.   Truth-evaluating predicates: *be true, be false*[13]
       b.   Non-veridical preferential predicates: e.g., *desire, fear*
       c.   Speech act predicates: e.g., *claim, assert*

---

[12]See, e.g., Horn 1989 and Gajewski 2007 for a characterization of neg-raising predicates in terms of strict NPI licensing, which is arguably more reliable but would take us a bit far afield here.

[13]*Be true/false* aren't categorized as neg-raising here, although they do license neg-raising inferences. This is because, as illustrated in (i), negated *be true/false* don't license strict NPIs, unlike predicates like *think* and *believe*; see also footnote 12 above.

(i)   a.   *It isn't true that Mary will leave until June.

This means that an analysis which derives anti-rogativity from neg-raising will not cover all anti-rogative predicates. As mentioned above, we will consider the truth-evaluating predicates *be true* and *be false* in Section 2.3.2, and will briefly return to the anti-rogativity of the remaining predicates in (12) in Section 2.6.

2.3.1.2 *Deriving neg-raising from an excluded-middle presupposition*

We start with a preliminary entry for *believe*, which is identical to the basic entry for *be certain* given in Section 2.2.4 and which doesn't yet capture the fact that *believe* is neg-raising.

(13) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x. \text{DOX}_x^w \in P$ (preliminary entry)

We adopt a presuppositional account of neg-raising, which was originally proposed by Bartsch (1973) and further developed by Gajewski (2007).[14] On this account, neg-raising behavior results from a so-called *excluded-middle (EM) presupposition*, carried by all neg-raising predicates. For instance, sentence (14) presupposes that Mary is opinionated as to whether Ann left: she either believes that Ann left or she believes that Ann didn't leave.

(14) Mary believes that Ann left.
      Presupposition: M believes that A left or M believes that A didn't leave.

In (14), the presupposition easily goes unnoticed, though, since it is weaker than the asserted content. On the other hand, if we negate (14), presupposed and asserted content become logically independent. Taken together, they imply that Mary believes that Ann didn't leave—which accounts for the neg-raising effect.

(15) Mary doesn't believe that Ann left.
      Presupposition: M believes that A left or M believes that A didn't leave.
      ∴ Mary believes that Ann didn't leave.

It should be noted, as Bartsch does herself, that neg-raising is defeasible: if

---

b.   John doesn't think that Mary will leave until June.

As we will discuss in a moment, we will assume that neg-raising predicates involve a so-called *excluded-middle presupposition* (Bartsch 1973, Gajewski 2007). Assuming that *be true/false* involve such a presupposition would (i) make wrong predictions about the licensing of strict NPIs, and (ii) amount to assuming a tautological presupposition for these predicates (since it is true for any proposition p that p is true or that $\neg p$ is true).

[14]Besides the presuppositional account of neg-raising, there are also accounts based on implicatures (e.g., Romoli 2013) or homogeneity (Gajewski 2005, Križ 2015); see Križ (2015, Ch.6) for a recent overview and comparison. We leave open at this point whether the generalization that neg-raising predicates are anti-rogative can also be derived on these other accounts.

the opinionatedness assumption is suspended, as in (16), *believe* receives a non-neg-raising reading. This behavior sets neg-raising predicates apart from certain other presupposition triggers, such as *it*-clefts, whose presuppositions are hard to cancel or to locally accommodate under sentential negation.

(16) Bill doesn't know who killed Caesar. He isn't even sure whether or not Brutus and Caesar lived at the same time. So, naturally. . .

Bill doesn't believe that Brutus killed Caesar.
$\not\rightsquigarrow$ Bill believes that Brutus didn't kill Caesar.

One might think that the easy defeasibility of neg-raising makes it more attractive to treat the EM inference as a conversational implicature. This option, however, was convincingly rejected by Horn (1978), who argued that there is no obvious semantic property determining whether a predicate is neg-raising or not. For instance, while *want* is neg-raising, the closely related *desire* is not.

We therefore maintain a presuppositional account like that of Bartsch, and additionally assume, following Gajewski (2007), that the excluded-middle presupposition is locally accommodated in cases like (16) in order to obtain an interpretation that is consistent with the contextually given information.[15]

2.3.1.3 *A generalized EM presupposition*

If we want to add the EM presupposition to our uniform lexical entry for *believe*, repeated in (17), there is one more thing to take into account.

(17) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x. \text{DOX}^w_x \in P$ \hfill (preliminary entry)

The semantic object P that *believe* takes as its argument on our account is not a single proposition but a downward-closed set of propositions. If we compute its negation simply by taking its set-theoretical complement, this does not yield the desired result.[16] We will therefore use the negation operation from inquisitive

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[15]Gajewski (2007) emphasizes that the excluded-middle presupposition of neg-raising predicates, because of its defeasibility, should be regarded as a *soft presupposition* in the sense of Abusch (2002, 2010). However, his actual account of their defeasibility is in terms of local accommodation and does not seem to explicitly rely on the assumption that they are soft presuppositions in Abusch's sense. It does assume, of course, that their local accommodation under negation is relatively unproblematic, in contrast with presuppositions contributed by other triggers, such as *it*-clefts.

[16]To see this, consider again a model with $W = \{w_{ab}, w_a, w_b, w_\emptyset\}$. In this model, the meaning of the declarative complement *that Ann left* is $[\![\text{that Ann left}]\!] = \{\{w_{ab}, w_a\}, \{w_{ab}\}, \{w_a\}, \emptyset\}$, as depicted in Figure 2.2a. We expect of a suitable negation operation that, when applied to this sentence meaning, it yields the meaning of *that Ann didn't leave*, i.e., $[\![\text{that Ann didn't leave}]\!] = \{\{w_b, w_\emptyset\}, \{w_b\}, \{w_\emptyset\}, \emptyset\}$, depicted in Figure 2.2b. However, if we implement negation as

(a) that Ann left   (b) that Ann didn't leave   (c) whether Ann left
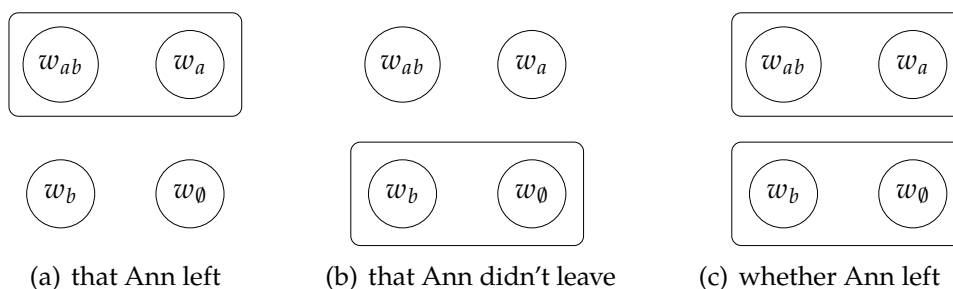
FIGURE 2.2. Example illustrating inquisitive negation.

semantics, written as $\neg$. When applied to a sentence meaning P, inquisitive negation returns the set of those propositions that are inconsistent with every member of P:[17]

(18) $\neg P \;:=\; \{p \mid \forall q \in P : q \cap p = \emptyset\}$

This operation may be thought of as a generalized negation that can be applied to both declarative and interrogative clauses. For declarative clauses, the result corresponds to what we would expect from a classical negation operation. For instance, take the sentence meaning $P = [\![\text{that Ann left}]\!] = \{\,\{w_{ab}, w_a\}, \{w_{ab}\}, \{w_a\}, \emptyset\,\}$, depicted in Figure 2.2a. Applying inquisitive negation to this sentence meaning yields:

$$
\begin{aligned}
\neg P \;&=\; \{p \mid \forall q \in P : q \cap p = \emptyset\} \\
&=\; \{p \mid \{w_{ab}, w_a\} \cap p = \emptyset \text{ and } \{w_{ab}\} \cap p = \emptyset \text{ and } \{w_a\} \cap p = \emptyset \\
&\qquad \text{and } \emptyset \cap p = \emptyset \,\} \\
&=\; \{p \mid \{w_{ab}, w_a\} \cap p = \emptyset \,\} \\
&=\; \{\,\{w_b, w_\emptyset\}, \{w_b\}, \{w_\emptyset\}, \emptyset \,\}
\end{aligned}
$$

Observe that, as expected, this result corresponds to the meaning of *that Ann didn't leave*, depicted in Figure 2.2b.

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set-theoretic complementation, we don't get this result. Rather, $[\![\text{that Ann didn't leave}]\!]$ would contain every proposition that is not an element of $[\![\text{that Ann left}]\!]$, including, e.g., the trivial proposition W and the proposition that Bob didn't leave, $\{w_a, w_\emptyset\}$.

[17]There is both conceptual and empirical support for this way of treating negation in inquisitive semantics. Conceptually, it can be characterized in terms of exactly the same algebraic properties as the standard truth-conditional negation operator (Roelofsen 2013a). Empirical support comes, for instance, from sluicing constructions (AnderBois 2014). Note also that an analogous treatment of negation has been proposed in alternative semantics (Kratzer and Shimoyama 2002).

For interrogative clauses, applying inquisitive negation always yields the inconsistent sentence meaning, $\{\emptyset\}$. To see why, recall from Section 2.2 that interrogative clauses are never informative: the alternatives in the meaning of an interrogative complement, taken together, always cover the entire logical space.[18] As a consequence, there can be no non-empty proposition that is inconsistent with every proposition in an interrogative sentence meaning. For a concrete example, consider the interrogative sentence meaning $Q = [\![\text{whether Ann left}]\!] = \{\{w_{ab}, w_a\}, \{w_{ab}\}, \{w_a\}, \{w_b, w_\emptyset\}, \{w_b\}, \{w_\emptyset\}, \emptyset\}$, depicted in Figure 2.2c. Applying inquisitive negation to Q yields:

$$
\begin{aligned}
\neg Q \; &= \; \{p \mid \forall q \in Q : q \cap p = \emptyset\} \\
&= \; \{p \mid \{w_{ab}, w_a\} \cap p = \emptyset \text{ and } \{w_{ab}\} \cap p = \emptyset \text{ and } \{w_a\} \cap p = \emptyset \text{ and} \\
&\qquad \{w_b, w_\emptyset\} \cap p = \emptyset \text{ and } \{w_b\} \cap p = \emptyset \text{ and } \{w_\emptyset\} \cap p = \emptyset \text{ and} \\
&\qquad \emptyset \cap p = \emptyset\} \\
&= \; \{p \mid \{w_{ab}, w_a\} \cap p = \emptyset \text{ and } \{w_b, w_\emptyset\} \cap p = \emptyset\} \\
&= \; \{\emptyset\}
\end{aligned}
$$

Using inquisitive negation, we can now formulate a lexical entry for *believe* including the EM presupposition. We will refer to the EM presupposition in this setting as the *generalized EM presupposition*, as it applies to both declarative and interrogative complements.

(19) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in P \vee \text{DOX}_x^w \in \neg P} \, . \, \text{DOX}_x^w \in P$

What will be crucial for our account of the selectional restrictions of neg-raising predicates is that the effect of the generalized EM presupposition depends on whether the complement is declarative or interrogative.

DECLARATIVE COMPLEMENTS.   As discussed in Section 2.2, we assume that declarative complements are never inquisitive. This means that if P is the meaning of a declarative complement, it contains only one alternative p. Then, the first disjunct in the presupposition amounts to $\text{DOX}_x^w \subseteq p$ (x believes that p), while the second disjunct amounts to $\text{DOX}_x^w \cap p = \emptyset$ (x believes that $\neg p$). Hence, for declarative complements, our generalized rendering of the EM presupposition boils down to the ordinary version of this presupposition.

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[18]Recall that we leave presuppositional complement clauses out of consideration here; see Appendix 2.C for an extension of the core account developed here that deals with such complements.

INTERROGATIVE COMPLEMENTS. On the other hand, as discussed above, interrogative complements are never informative, as a result of which the inquisitive negation of an interrogative complement meaning P is always $\neg\!\!\neg P = \{\emptyset\}$. Hence, the second disjunct of the presupposition can only be satisfied if $\text{DOX}_x^w = \emptyset$. Under the standard assumption that doxastic states are consistent, this is impossible. In other words, the second disjunct is redundant.

However, what if we are not willing to make the assumption that doxastic states, or more generally, *modal bases* are consistent? After all, our eventual aim will be to account for the anti-rogativity of *all* neg-raising predicates, not only for that of *believe*, and different neg-raising predicates have different modal bases. Taking it for granted that all of these modal bases are necessarily consistent would be too strong an assumption. Fortunately, even without this assumption, the second disjunct in the presupposition turns out to be redundant. To see this, assume that the second disjunct is true, i.e., that $\text{DOX}_x^w = \emptyset$. Then, the first disjunct amounts to the condition that $\emptyset \in P$. Since P is an interrogative complement meaning, the propositions that it contains together cover the entire logical space. Therefore, since sentence meanings are downward closed, the condition that $\emptyset \in P$ is always satisfied.[19] More generally, whenever the second disjunct is true, the first is true as well. Thus, the second disjunct in the presupposition is redundant, and this is the case with or without the assumption that doxastic states are consistent. As a consequence, if *believe* takes an interrogative complement, its lexical entry reduces to (20).

(20) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in P}.\ \text{DOX}_x^w \in P$

The presupposed and the asserted content in (20) are exactly the same. This means that when *believe* combines with an interrogative complement, its assertive component is trivial relative to its presupposition. Prima facie, we would expect triviality like this to make itself felt as logical deviance. But this is not what we find in this case: when *believe* combines with an interrogative complement, we perceive the result as ungrammatical. Can we explain ungrammaticality in terms of logical deviance? Gajewski (2002) argues that this is indeed possible for certain cases of systematic triviality. In the following sections we will show that the triviality observed above is indeed a case of such systematic triviality, and we will spell out in detail how Gajewski's theory can be applied to explain the anti-rogative nature of neg-raising predicates.

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[19]Note that at this point one particular feature of inquisitive semantics, namely the downward-closedness of sentence meanings, is crucial for the proposed account.

2.3.1.4 L-analyticity

What we mean here by *systematic* triviality is that the meaning of a sentence in which a neg-raising predicate embeds an interrogative complement comes out as trivial independently of the exact lexical material that appears in the sentence. In particular, it doesn't matter which exact predicate is used—the triviality only depends on the fact that the predicate is neg-raising—and it doesn't matter which lexical material appears in the complement—the triviality only depends on the fact that the complement is interrogative.

In contrast, there are also cases of non-systematic triviality such as the tautology in (21), which does rely on the presence of specific lexical material.

(21)   Every tree is a tree.

Gajewski (2002) suggests that cases of systematic triviality can be delineated from cases of non-systematic triviality in terms of the notion of *logical analyticity* (for short, *L-analyticity*). If a sentence is L-analytical, we do not perceive its triviality as logical deviance, as we do in cases of non-systematic triviality such as (21). Rather, according to Gajewski, L-analyticity manifests itself at the level of grammar: L-analytical sentences are perceived as being ungrammatical. An example of a phenomenon that Gajewski accounts for using this line of argument is the definiteness restriction in existential statements, exemplified in (22). Below we will see how he recasts a prominent analysis of this restriction, originally due to Barwise and Cooper (1981), in terms of L-analyticity.

(22)   *There is every tall tree.

Logical words.   The notion of L-analyticity builds upon the distinction between *logical* and *non-logical* vocabulary. Intuitively, this distinction is easy to grasp; it runs along the lines of words that have lexical content versus words that don't. Among the logical words are quantifiers like *a* or *every*, connectives like *and* or *if*, and copulas like *is*. Among the non-logical words, on the other hand, are predicates like *tree*, *run*, and *green*. There is no general agreement in the literature on a single definition of the class of logical words. Abrusán (2014) provides an overview of definitions that have been proposed, most of them based on invariance conditions. For the purposes of this paper, we will assume that a suitable definition of logical words can in principle be given. As far as we can see, the items that we will classify as logical are uncontroversially so, meaning that they should come out as logical under any suitable definition of logicality.

LOGICAL SKELETON. To determine whether a given sentence is L-analytical, we first compute its *logical skeleton* (LS) using the algorithm from Gajewski (2002). Let α be the logical form (LF) of the sentence. Then we obtain the LS from α by (i) identifying the maximal constituents of α that don't contain any logical items, and (ii) replacing each such constituent β with a fresh constant of the same type as that of β. For example, the LFs and LSs of *Every tree is a tree* and *There is every tall tree* are given in (23) and (24). In (23), the maximal constituents of the LF not containing any logical items are the two instances of *tree*. In (24), the only maximal non-logical constituent of the LF is the phrase *tall tree*.

(23)   Every tree is a tree.
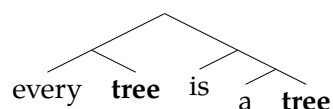
    Logical form: *Logical skeleton:*
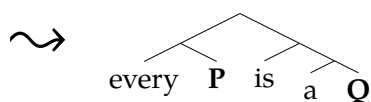
(24)   *There is every tall tree.
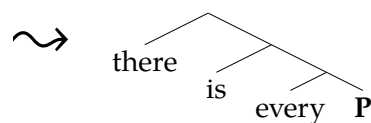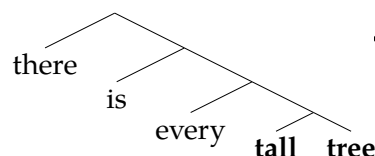
L-ANALYTICITY AND UNGRAMMATICALITY. We adopt the following assumptions about L-analyticity and ungrammaticality from Gajewski (2009).

ASSUMPTION 1 (L-ANALYTICITY).
A sentence S is L-analytical just in case S's LS receives the denotation 1 (or 0) for all interpretations in which its denotation is defined.

ASSUMPTION 2 (UNGRAMMATICALITY).
A sentence is ungrammatical if it contains an L-analytical constituent.

For example, consider the interpretation of the LS in (23):

(25) $[\![\text{every } \mathbf{P} \text{ is a } \mathbf{Q}]\!]^{\langle D, I \rangle} = [\![\text{every}]\!]^{\langle D, I \rangle}(I(\mathbf{P}))(I(\mathbf{Q}))$

It is possible to find two interpretations I_1 and I_2 such that $[\![\text{every } \mathbf{P} \text{ is a } \mathbf{Q}]\!]^{\langle D, I_1 \rangle} \neq [\![\text{every } \mathbf{P} \text{ is a } \mathbf{Q}]\!]^{\langle D, I_2 \rangle}$. Hence, (23) does not come out as L-analytical. This is expected, as this sentence is a non-systematic tautology.

    On the other hand, consider the interpretation of the LS in (24), given in (26) below. Following Barwise and Cooper (1981), it is assumed that *there* simply

denotes the domain of individuals D_e.

(26) $[\![\text{there is every } \mathbf{P}]\!]^{\langle D, I \rangle} = [\![\text{every}]\!](I(\mathbf{P}))([\![\text{there}]\!]^{\langle D, I \rangle})$

$= [\![\text{every}]\!]^{\langle D, I \rangle}(I(\mathbf{P}))(D_e)$

It isn't possible to find an interpretation I such that $[\![\text{there is every } \mathbf{P}]\!]^{\langle D, I \rangle} = 0$, because $I(\mathbf{P}) \subseteq D_e$ for all I. This means that, as expected, (24) comes out as L-analytical, which accounts for its ungrammaticality.

2.3.1.5 *Capturing the anti-rogativity of neg-raising predicates in terms of L-analyticity*

Let us now return to the selectional restrictions of neg-raising predicates and see how the account sketched in Section 2.3.1.3 can be made fully explicit by phrasing it in terms of L-analyticity. In order to do so, two assumptions about the structure of interrogative clauses and neg-raising predicates are needed.

INTERROGATIVE CLAUSES ARE HEADED BY A QUESTION OPERATOR.   Firstly, we asssume that interrogative clauses are headed by a question operator, written as '?'. Semantically, this operator takes the semantic value of its prejacent P as its input, and yields $P \cup \neg P$ as its output:

(27) $[\![?]\!]^w = \lambda P_T.P \cup \neg P$

In terms of alternatives, ? adds to the alternatives already contained in P one additional alternative, which is the set-theoretic complement of the union of all the alternatives in P. This is a standard operation in inquisitive semantics (see, e.g., Ciardelli *et al.*, 2015). Note that it always results in a set of alternatives which together cover the entire logical space, i.e., a sentence meaning that is non-informative.[20]

LEXICAL DECOMPOSITION OF NEG-RAISING PREDICATES.   Secondly, we assume that a neg-raising predicate V is decomposed at LF into two components, R_{EM} and $\mathcal{M}_V$, the former of which but not the latter is a logical item in the relevant sense. While R_{EM} is common to all neg-raising predicates, $\mathcal{M}_V$ is specific

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[20]The exact treatment of the question operator does not really matter for our purposes. The only thing that is crucial is that it always results in non-informativity. In particular, our account is also compatible with a treatment of the question operator under which it (i) only adds an additional alternative if its input P is not yet inquisitive, and (ii) adds a presupposition to the effect that at least one of the alternatives in its output is true (Roelofsen 2013b).

to the predicate V.[21] An LF in which *believe* is decomposed into these two
components is given in (28).

(28)
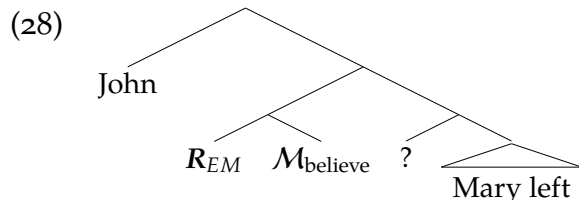
The non-logical component, $\mathcal{M}_V$, is a function that maps an individual x to a
modal base. Which modal base this is gets determined by the predicate V. In
the case of, e.g., *believe*, it is x's doxastic state, while in the case of *want* it is x's
bouletic state:

(29)   a. $[\![\mathcal{M}_{\mathrm{believe}}(x)]\!]^w = \mathrm{DOX}_x^w$
       b. $[\![\mathcal{M}_{\mathrm{want}}(x)]\!]^w \;\;= \mathrm{BOUL}_x^w$

The logical component, R_{EM}, does two things: it triggers the EM presupposi-
tion and acts as compositional glue by connecting $\mathcal{M}_V$ to the subject and the
complement:

(30) $[\![R_{\mathrm{EM}}]\!] = \lambda \mathcal{M}_{\langle e,st\rangle}.\lambda P_{\langle st,t\rangle}.\lambda x : \underline{\mathcal{M}(x) \in P \;\vee\; \mathcal{M}(x) \in \neg P}. \,\mathcal{M}(x) \in P$

R_{EM} takes the function $\mathcal{M}_V$, the complement meaning P, and the subject x as
arguments; it contributes the EM presupposition (the modal base $\mathcal{M}_V(x)$ has to
be a resolution either of P or of the negation of P); and it asserts that $\mathcal{M}_V(x)$ is a
resolution of P. Intuitively, R_{EM} is a logical item because it does not contribute
any "contingent content" of its own: its denotation, in contrast to that of $\mathcal{M}_V$,
does not vary between models.

L-ANALYTICITY.   We now have all the ingredients needed to show that the trivial
sentence meanings we identified in Section 2.3.1.3 are L-analytical. There, we
had found that whenever a neg-raising attitude predicate like *believe* combines
with an interrogative complement, as in (31), its asserted content is trivial
relative to its presupposition.

(31)   *John believes whether Mary left.

Let's start by constructing the LS for (31): the subject, the complement clause,
and the function $\mathcal{M}_{\mathrm{believe}}$ each get substituted by a fresh constant, while both

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[21]Bošković and Gajewski (2011) propose a very similar decomposition of neg-raising predi-
cates, motivated on independent grounds.

R_{EM} and the interrogative marker remain untouched.

(32)
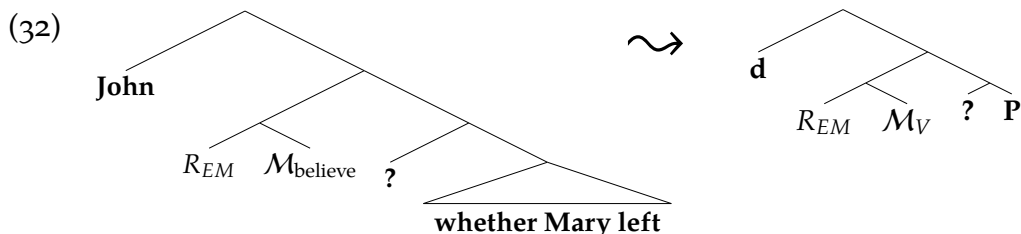
The denotation of this LS is given in (33a), its presupposition in (33b).

(33)   a.   Asserted content: $[\![\mathcal{M}_V(\mathbf{d})]\!] \in [\![\mathbf{?P}]\!]$
       b.   Presupposition: $[\![\mathcal{M}_V(\mathbf{d})]\!] \in [\![\mathbf{?P}]\!]$ or $[\![\mathcal{M}_V(\mathbf{d})]\!] \in [\![\neg\,\mathbf{?P}]\!]$

First, we note that the first disjunct in the presupposition is identical with the asserted content. Next, let's look at the second disjunct in the presupposition. We find that, no matter what $\mathbf{P}$ is, the set of propositions in $[\![\mathbf{?P}]\!]^{\langle D,I \rangle}$ covers the entire logical space. Hence, we also know that $[\![\neg\,\mathbf{?P}]\!]^{\langle D,I \rangle} = \{\emptyset\}$ for all I. The second disjunct in the presupposition is thus only satisfied if $[\![\mathcal{M}_V(\mathbf{d})]\!]^{\langle D,I \rangle} = \emptyset$. But observe that, whenever this holds, then the first disjunct is also satisfied. This is because every sentence meaning contains the inconsistent proposition, which means that $[\![\mathbf{?P}]\!]^{\langle D,I \rangle}$ contains $\emptyset$, regardless of what $\mathbf{P}$ is. Thus, whenever the second disjunct holds, the first one holds as well, or, in other words, whenever the presupposition is satisfied, the first disjunct is true.

Now, since the first disjunct, as noted initially, is identical with the asserted content, this in turn means that, for all interpretations in which the denotation of the LS is defined, this denotation will be 1. Sentence (31) hence comes out as L-analytical, which is what we set out to show.

ANTI-ROGATIVITY AND THE DEFEASIBILITY OF NEG-RAISING.   Finally, let us return to a case in which the neg-raising inference is suspended, repeated in (34) below.

(34)   Bill doesn't know who killed Caesar. He isn't even sure whether or not Brutus and Caesar lived at the same time. So, naturally. . .

       Bill doesn't believe that Brutus killed Caesar.
       ↝̸ Bill believes that Brutus didn't kill Caesar.

One might expect that in such contexts, since the neg-raising inference of the predicate does not really surface, the incompatibility with interrogative complements will also be lifted. This is not the case, however. As witnessed by (35), interrogative complements are still unacceptable in such configurations.

(35) Bill doesn't know who killed Caesar. He isn't even sure whether or not Brutus and Caesar lived at the same time. So, naturally. . .

*Bill doesn't believe **whether** Brutus killed Caesar.

This is correctly predicted. Recall that according to Gajewski's (2009) theory of L-analyticity, for a sentence to be perceived as ungrammatical it is sufficient that a *constituent* of its logical form is L-analytical. This is indeed the case in (35): even though the full sentence is not L-analytical (assuming that the EM presupposition is locally accommodated), the clause that gets negated (*Bill believes whether Brutus killed Caesar*) *is* L-analytical. This is sufficient to account for the perceived ungrammaticality.

2.3.2. *Truth-evaluating predicates: 'be true' and 'be false'*

We have seen above how the selectional restrictions of a substantial class of anti-rogative predicates, namely those that are neg-raising, can be derived. We now turn to another, much smaller class of anti-rogatives consisting of the truth-evaluating predicates *be true* and *be false*.

Recall that the basic entry for *believe* requires that $\text{DOX}_x^w \in P$, where x is the subject of the predicate, w the world of evaluation, and P the semantic value of the complement. The requirement says that DOX_x^w, the information state of x in w, should be a resolution of P. Many other attitude predicates can be treated similarly, replacing DOX_x^w by another appropriate modal base associated with the individual x.

At first sight, *be true* and *be false* do not fit this mold, since they do not involve an individual subject, let alone make reference to any modal base associated with such an individual. Yet it is possible to view *be true* and *be false* in a way that is quite similar to the above view on *believe* and other attitude predicates. Namely, even though it does not make sense to explicate the semantics of *be true* and *be false* in terms of a modal base associated with a particular individual, it *is* natural to think of these predicates in terms of a modal base that depends only on the world of evaluation w. Let us denote this modal base as TRUE^w. Given a world w, what should TRUE^w be? In view of the truth-evaluating function of *be true* and *be false*, it is natural to require that TRUE^w should determine exactly what is true and what is false in w. But this simply means that TRUE^w should be the singleton set $\{w\}$. Viewed as a doxastic state, this is a state of complete information, according to which the only candidate for the actual world is w.

Using TRUE^w as the relevant modal base, we can now give lexical entries for *be true* and *be false* which are structurally parallel to our basic entry for *believe*. As expected, the only difference is that *be true* and *be false* do not take

an individual subject as one of their arguments, and accordingly the modal base that they rely on does not depend on such an individual.

(36)   a. $[\![\text{be true}]\!]^w = \lambda P_T.\text{TRUE}^w \in P$
       b. $[\![\text{be false}]\!]^w = \lambda P_T.\text{TRUE}^w \notin P$

When combined with a declarative complement, these entries give the expected results. For instance, $[\![\text{It is true that Ann left}]\!]^w = 1$ just in case $\{w\} \in [\![\text{Ann left}]\!]$, which means that w must be a world in which Ann left. Similarly, $[\![\text{It is false that Ann left}]\!]^w = 1$ just in case $\{w\} \notin [\![\text{Ann left}]\!]$, which means that w must be a world in which Ann didn't leave.

   Now, what happens when *be true* and *be false* take an interrogative complement? We have seen in Section 2.2 that if P is the semantic value of an interrogative complement, its elements cover the entire logical space, i.e., $\bigcup P = W$. Since sentence meanings are downward closed, this means that $\{w\} \in P$ for any $w \in W$. This makes sense: a question is always resolved by a doxastic state that contains full information as to what the world is like. But this means that, if P is the semantic value of an interrogative complement, $[\![\text{be true}]\!]^w(P) = 1$ and $[\![\text{be false}]\!]^w(P) = 0$ for any $w \in W$. Hence, when taking interrogative complements, *be true* and *be false* systematically yield a tautology and a contradiction, respectively. Assuming that *be true* and *be false* constitute logical vocabulary, these are again cases of L-analyticity. This provides an explanation for why truth-evaluating predicates don't accept interrogative complements.

2.4.   *Rogative predicates*

We now turn to rogative predicates. This class includes predicates such as *wonder* and *be curious*, which Karttunen (1977) calls 'inquisitive predicates', as well as predicates of dependency such as *depend on* and *be determined by*, and speech act predicates such as *ask* and *inquire*. We focus here on the first two subclasses and will briefly remark on the third in the conclusion.

2.4.1.   *Inquisitive predicates*

Ciardelli and Roelofsen (2015) and Uegaki (2015b) offer an account of the selectional restrictions of *wonder*. The former is couched within the same general approach to clause embedding that we are assuming here, i.e., one in which declarative and interrogative complements are assumed to be of the same semantic type. We briefly review this account here, adapting it to our current terminology. The account can, with small modifications, be extended to other

inquisitive predicates such as *be curious* and *investigate*.[22] For discussion of the subtle differences between the accounts of Ciardelli and Roelofsen (2015) and Uegaki (2015b), respectively, we refer to Appendix 2.A.2.

To model what it means for an individual to *wonder*, we first need a representation of the issues that she entertains. Ciardelli and Roelofsen call this her *inquisitive state*. Formally, an individual's inquisitive state in w, INQ_x^w, is a downward-closed set of consistent propositions which together cover her doxastic state, i.e., $\bigcup \text{INQ}_x^w = \text{DOX}_x^w$. The propositions in INQ_x^w are those that are informative enough to resolve the issues that x entertains. They correspond to extensions of her current doxastic state in which all her questions are settled one way or another.

Informally, x wonders about a question, e.g., about *who called*, just in case (i) x isn't certain yet who called, and (ii) she wants to find out who did. This is the case exactly if (i) x's current doxastic state does not resolve the question, and (ii) every doxastic state in x's inquisitive state is one that does resolve the question:

(37) $[\![\text{wonder}]\!]^w = \lambda P_T . \lambda x . \underbrace{\text{DOX}_x^w \notin P}_{x \text{ isn't certain yet}\dots} \quad \wedge \quad \underbrace{\text{INQ}_x^w \subseteq P}_{\text{but wants to find out}}$

This entry yields desirable results when the predicate takes an interrogative complement. Now let us consider what happens when it takes a declarative complement:

(38)   *John wonders that Mary called.

Recall that if P is the meaning of a declarative complement it always contains a single alternative α. Since complement meanings are downward-closed, this means that P amounts to the powerset of α, $\wp(\alpha)$. Now suppose that the first conjunct in (37) holds: $\text{DOX}_x^w \notin P$. Then it must be that $\text{DOX}_x^w \nsubseteq \alpha$. But then, since $\bigcup \text{INQ}_x^w = \text{DOX}_x^w$, it must also be that $\bigcup \text{INQ}_x^w \nsubseteq \alpha$. It follows that there is at least one $s \in \text{INQ}_x^w$ such that $s \nsubseteq \alpha$. But if $s \nsubseteq \alpha$, then since α is the unique alternative in P, we have that $s \notin P$. So the second conjunct in the lexical entry must be false. Hence, whenever *wonder* takes a declarative complement, this results in a contradictory sentence meaning.

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[22]Crucially, *be curious* is like *wonder* and unlike the closely related (but responsive) predicate *be of interest* in that it implies ignorance.

(a) Full dependency   (b) Trivial dependency   (c) Partial dependency
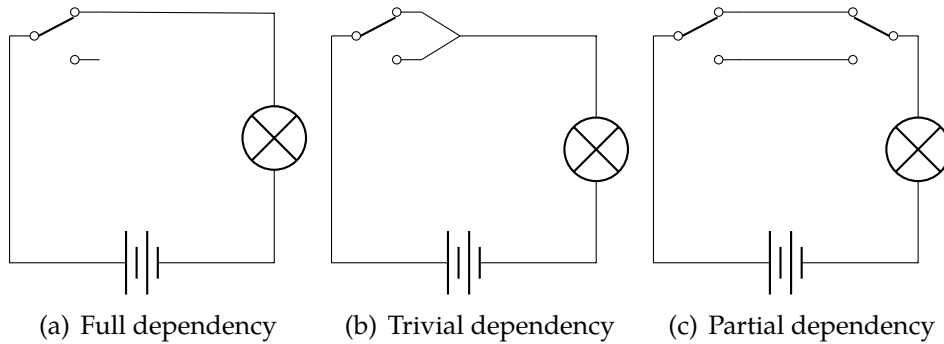
FIGURE 2.3. Full, trivial, and partial dependency between (left) switch and light.

2.4.2. *Verbs of dependency*

We now turn to rogative predicates of dependency, such as *depend on* and *be determined by* (on one of its interpretations). We will concentrate on *depend on*, but it seems that the account we will present could be straightforwardly extended to other predicates of dependency.

Our treatment of *depend on* builds on that of Ciardelli (2016, p.243), who argues that dependency statements are *modal* statements. One can only sensibly say that one thing depends on another relative to some specific range of relevant possible worlds, i.e., a *modal base*. This modal base can either be explicitly given, as in (39), or inferred from the context, as in (40), where, roughly, it is construed as 'given the laws of nature and the electrical circuit under discussion'.

(39)   According to Dutch law, one's income tax rate depends on one's age.

(40)   Whether the light is on depends on whether the switch is up.

To form an intuition about what it means for one thing to depend on another, let us focus on example (40) and consider the electrical circuit in Figure 2.3a. Let w_1 be the actual world, in which the switch is up and the light on, and let w_2 be a world in which the switch is down and the light off. The modal base σ_{w_1} consists of all worlds in which the laws of nature are the same as in w_1 and in which the circuit is exactly as given in Figure 2.3a. That is, $\sigma_{w_1} = \{w_1, w_2\}$. Let P_{light} be the meaning of the first argument of the predicate in (40), *whether the light is on*, and P_{switch} the meaning of the second argument, *whether the switch is up*. What does it mean for P_{light} to depend on P_{switch} relative to σ_{w_1}?

On a first approximation, it means that whenever we rule out enough possible worlds in our modal base to establish some alternative in P_{switch}, we also

automatically establish some alternative in P_{light}. That is, whenever we determine whether the switch is up or down, it is also determined whether the light is on or off. More generally, we could say that P depends on P' relative to a modal base σ if and only if there is a function f that maps each alternative $\alpha \in \text{alt}(P')$ to an alternative $f(\alpha) \in \text{alt}(P)$ such that for all $p \subseteq \sigma$, if $p \subseteq \alpha$ for some $\alpha \in \text{alt}(P')$ then $p \subseteq f(\alpha)$ as well. This is the logical notion of dependency that Ciardelli (2016) proposes and investigates.

We will further refine this basic notion, however, in order to rule out *trivial* dependencies, i.e., cases in which the function f maps every alternative in $\text{alt}(P')$ that is compatible with σ to the *same* alternative in $\text{alt}(P)$. To see that such cases need to be ruled out, suppose that the light is always on, no matter whether the switch is up or down, as in the circuit in Figure 2.3b. Let w_3 be the actual world in this scenario—i.e, the world in which the switch is up and the light on—and let w_4 be a world in which the switch is down but the light still on. Then we have that $\sigma_{w_3} = \{w_3, w_4\}$. In this scenario, it is certainly still possible to find a function f mapping every alternative α in $\text{alt}(P_{\text{switch}})$ to some alternative $f(\alpha)$ in $\text{alt}(P_{\text{light}})$ such that for all $p \subseteq \sigma_{w_3}$, if $p \subseteq \alpha$ for some $\alpha \in \text{alt}(P')$ then $p \subseteq f(\alpha)$ as well. Just let f map both alternatives in $\text{alt}(P_{\text{switch}})$ to the same alternative in $\text{alt}(P_{\text{light}})$, namely the alternative 'that the light is on'. But we would not say that sentence (40) is true in this scenario. Whether the light is on does not depend on whether the switch is up. It's just always on. So, we should require that the function f does not map all the alternatives in $\text{alt}(P_{\text{switch}})$ that are compatible with σ_{w_3} to the same alternative in $\text{alt}(P_{\text{light}})$. This leads us to the following entry for *depend on*:[23]

(41) $[\![\text{depend on}]\!]^w = \lambda P'_T.\lambda P_T.\exists f \in \text{alt}(P)^{\text{alt}(P')}$ such that:

   (i) $\forall p \subseteq \sigma_w.\forall \alpha \in \text{alt}(P').(p \subseteq \alpha \rightarrow p \subseteq f(\alpha))$ and

   (ii) $\exists \alpha, \alpha' \in \text{alt}(P').\alpha \cap \sigma_w \neq \emptyset \wedge \alpha' \cap \sigma_w \neq \emptyset \wedge f(\alpha) \neq f(\alpha'))$

Now let us examine whether this lexical entry accounts for the selectional restrictions of the predicate. What happens if either the first or the second argument of the predicate is a declarative clause? First consider the following case:

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[23]This entry may be further refined in order to allow for *partial* dependencies. For instance, in the circuit in Figure 2.3c, whether the light is on only partially depends on the position of the switch on the left. The position of the switch on the right now also matters. On a first approximation, we could say that P partially depends on P' if we can find a third sentence meaning P'' such that P fully depends on $P' \cap P''$ but not on P'' alone (cf., Karttunen 1977, fn.6). We do not explicitly work out this refinement here, because it would not yield different predictions about the selectional restrictions of *depend on*.

(42)   *That the light is on depends on whether the switch is up.

In this case, P contains a single alternative. This means that it will be impossible to find a function $f \in \mathsf{alt}(P)^{\mathsf{alt}(P')}$ that satisfies condition (ii) in the entry above, i.e., one that does not map every element of $\mathsf{alt}(P')$ onto the same element of $\mathsf{alt}(P)$. Thus, (42) comes out as a contradiction, and this will always be the case if the first argument of the predicate is a declarative clause.

Now consider a case in which the second argument is a declarative clause:[24]

(43)   *Whether the light is on depends on that the switch is up.

In this case, P' contains a single alternative. This again means that it will be impossible to find a function $f \in \mathsf{alt}(P)^{\mathsf{alt}(P')}$ that satisfies condition (ii) in the entry of the predicate. So (43) also comes out as a contradiction, and the same result obtains if the predicate takes other declarative clauses as its second argument. This systematic contradictoriness explains why *depend on* cannot take declarative complements.[25]

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[24]As noted by an anonymous reviewer, the reader might wonder whether the ungrammaticality of (43) isn't rooted in syntax rather than semantics. After all, declarative complements generally do not combine with prepositions in English (unlike interrogative complements). However, as the same reviewer notes, a semantic explanation does seem to be needed, for at least two reasons. First, movement (e.g., topicalization) generally resolves the incompatibility between declarative complements and prepositions, as in (i), but this is not the case for *depend on*, as seen in (ii):

(i)   a.   *They complained about that Mary left.
      b.   That Mary left is what they complained about.

(ii) a.   *Your salary depends on that you have a PhD.
      b.   *That you have a PhD is what your salary depends on.

Second, looking beyond English, there are languages in which declarative complements *can* in principle combine with prepositions, but are still ungrammatical under *depend on*. A case in point is Spanish, as illustrated in (iii) and (iv).

(iii) Estoy convencido de que podemos trabajar juntos.
       I-am convinced of that we-can   work   together
       'I am convinced that we can work together.'

(iv) *Si   podemos trabajar juntos   depende de que tenemos la   misma ética.
      Whether we-can   work   together depends on that we-have the same   ethics
      'Whether we can work together depends on that we have the same ethics.'

[25]Notice that there is an interesting similarity between our entry for *depend on* and that for *wonder*: the first condition in the entry for *depend on* is similar to the 'entertain' condition in the entry for *wonder,* and the second condition in the entry for *depend on* is similar to the 'ignorance' condition in the entry for *wonder.*

2.5. *Empirical and methodological challenges*

In this final section we will identify an empirical challenge for the account laid out above. We will show that, at least in the case of neg-raising predicates, this challenge can be addressed. However, doing so will bring out a general methodological issue for semantic accounts of ungrammaticality.

2.5.1. *Empirical challenge: mixed complements*

The account presented above makes incorrect predictions for the case of *mixed complements*, i.e., complex complements formed by conjoining a declarative and an interrogative clause. As illustrated in (44), anti-rogative and rogative predicates do not accept mixed complements. Our account, however, predicts the examples in (44) to be grammatical.

(44) a. *John believes/thinks that Mary left and when she did.
      b. *It is true that Mary left and when she did.
      c. *John wonders that Mary left and when she did.

To see why we make these predictions, recall that a declarative clause is usually informative, i.e., $\text{info}(\varphi) \subset W$, and that an interrogative clause is usually inquisitive, i.e., $\text{info}(\varphi) \notin [\![\varphi]\!]$. To compute the meaning of two conjoined clauses, we simply take their intersection, i.e., $[\![\varphi \wedge \psi]\!] = [\![\varphi]\!] \cap [\![\psi]\!]$. This means that, if one of the conjoined clauses is informative, then so is the conjunction as a whole, and if one of the conjuncts is inquisitive, then the conjunction as a whole is typically inquisitive as well. For example, the mixed complement in (44), *that Mary left and when she did*, is both informative and inquisitive.

Now, let's focus on the case of neg-raising predicates. On our account, it is the non-informativity of interrogative complements that leads to systematic triviality whenever these complements appear under neg-raising predicates. Declarative complements don't give rise to such systematic triviality because they are typically informative. More concretely, recall that if *believe* (its lexical entry is repeated below in (45)) takes an interrogative complement P, then the second disjunct of the EM presupposition makes a vacuous contribution to the disjunction as a whole, since $\neg P = \{\emptyset\}$. By contrast, if *believe* takes a declarative complement with meaning P, the second disjunct makes a non-vacuous contribution, since $\neg P \neq \{\emptyset\}$. A mixed complement, because it is informative, behaves just like a declarative complement in this respect, hence averting triviality. This means that *believe* is wrongly predicted to accept mixed complements.

(45) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in P \lor \text{DOX}_x^w \in \neg P} \,.\, \text{DOX}_x^w \in P$

Below we suggest an alternative way of formulating the EM presupposition, which makes correct predictions for mixed complements.

2.5.2. *Projection operators*

To formulate a suitable version of the EM presupposition, we first introduce a number of operators on sentence meanings, familiar from inquisitive semantics as *projection operators*. The !-operator eliminates inquisitiveness: $!P$ is always non-inquisitive. The ?-operator, already familiar from our treatment of interrogative complements in Section 2.3, eliminates informativity: $?P$ is always non-informative. Finally, we introduce the $\langle?\rangle$-operator from Roelofsen (2015), which can be thought of as a conditional variant of the ?-operator: if P is inquisitive, then $\langle?\rangle$ has no effect, but if P is not inquisitive, then $\langle?\rangle P = ?P$.

(46) $!P = \bigcup P$

$?P = P \cup \neg P$

$\langle?\rangle P = \left\{ \begin{array}{ll} ?P & \text{if } P \text{ is not inquisitive} \\ P & \text{otherwise} \end{array} \right\}$

The $\langle?\rangle$-operator *ensures inquisitiveness* while preserving other semantic properties of its prejacent, in particular its informative content and its decision set,[26] as much as possible. In Roelofsen (2015) and Ciardelli *et al.* (2018) this operator is taken to play an important role in the interpretation of interrogative clause type marking.

2.5.3. *Reformulating the EM presupposition*

We will now first formulate the EM presupposition in terms of the ?-operator. This will be just a notational variant of our old formulation. In a second step, we will then formulate the EM presupposition in terms of the $\langle?\rangle$-operator. This re-formulation will yield the same results for declarative and interrogative complements, but will make a difference for mixed complements.

Note that, for any proposition p and sentence meaning P, the condition that $p \in P \lor p \in \neg P$ is equivalent to $p \in ?P$. Using this equivalence, we can reformulate our lexical entry for *believe* as follows:

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[26]The decision set of a sentence φ with meaning P is the set of propositions that either resolve the issue expressed by φ or establish that this issue cannot be truthfully resolved, i.e., the set of propositions $P \cup \neg P$.

(47) $\llbracket \text{believe} \rrbracket^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in ?P} . \text{DOX}_x^w \in P$

Now, let's see what happens if we define the EM presupposition in terms of the $\langle ? \rangle$-operator instead of the ?-operator:

(48) $\llbracket \text{believe} \rrbracket^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in \langle ? \rangle P} . \text{DOX}_x^w \in P$

If *believe* takes a declarative complement, then P is not inquisitive. This means that the $\langle ? \rangle$-operator contributes the same meaning as the ?-operator, and the lexical entry for *believe* amounts to (49). As we have just seen, this formulation is equivalent to our original lexical entry for *believe*. So, in the case of declarative complements, nothing has changed.

(49) $\llbracket \text{believe} \rrbracket^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in ?P} . \text{DOX}_x^w \in P$
 [with non-inquisitive complement]

If *believe* takes an interrogative complement, then P is inquisitive. This means that the $\langle ? \rangle$-operator doesn't have any effect and the lexical entry for *believe* reduces to (50). In other words, the presupposition and the asserted content are identical. So, in the case of interrogative complements we derive the same triviality as before.

(50) $\llbracket \text{believe} \rrbracket^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in P} . \text{DOX}_x^w \in P$
 [with inquisitive complement]

Finally, if *believe* takes a mixed complement, then P is also inquisitive, and with the same reasoning as for interrogative complements, this configuration results in triviality. With the modified version of the EM presupposition, we hence correctly predict that *believe* doesn't accept mixed complements.

Note that while this modification of our account solves the mixed complement problem for neg-raising predicates, the problem persists for other anti-rogative and rogative predicates.[27]

2.5.4. *A methodological note*

As we have just seen, one way of formulating the EM presupposition made the right predictions for mixed complements, while another formulation didn't.

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[27]In the case of truth-evaluating predicates, there is a natural way to address the problem. Namely, if such predicates take a mixed complement, the interrogative conjunct will always be *redundant*, in the sense that leaving it out would not affect the interpretation of the sentence as a whole. Such redundancy is known to manifest itself as unacceptability (see, e.g., Schlenker 2009, Katzir and Singh 2013, Mayr and Romoli 2016).

This brings out a general limitation of semantic accounts of ungrammaticality. The problem, as we see it, is that we cannot distinguish between the two formulations of the EM presupposition on independent grounds. This is because they make exactly the same predictions for declarative complements—and the case of declarative complements is the only one where we can check whether our account derives the correct meaning. In all the other cases, we cannot check this because the sentences are ungrammatical and therefore simply have no "observable" semantic properties. So, while for neg-raising predicates we have independent motivation for assuming an EM presupposition per se (namely, we can observe that these predicates are neg-raising), there is no independent motivation for preferring any particular formulation of the EM presupposition. Thus, it cannot be said that the account given here fully *derives* the selectional restrictions of predicates like *believe* and *think* from independently observable semantic properties of these predicates, i.e., the fact that they are neg-raising. Rather, we have shown that making one particular assumption about the lexical semantics of these predicates, namely that they involve an EM presupposition formulated in terms of $\langle ? \rangle$, accounts both for their neg-raising property and for their selectional restrictions.

As far as we can see, this is a principled limitation affecting all semantic accounts of ungrammaticality. All such accounts have to rely on specific lexical entries for the expressions involved. It is often possible to motivate these lexical entries on independent grounds, in the sense that they make good predictions for grammatical cases. However, it is often difficult, if not impossible, to show that these entries could not be altered in such a way that the good predictions about the grammatical cases would be preserved while the ungrammatical cases would no longer come out as trivial.

2.6.   Conclusion

There are two kinds of approaches to the semantics of clausal complements, one that assumes different types for declarative and interrogative complements and one that assumes uniform typing. On the first approach, the selectional restrictions of clause-embedding predicates can to some extent be accounted for in terms of a type mismatch, but in the absence of independent motivation for the assumed type distinction and the type requirements of the relevant predicates, such an account remains stipulative.

On the second approach, the selectional restrictions of clause-embedding predicates have to be explained entirely based on semantic properties of the relevant predicates. Extending initial work of Ciardelli and Roelofsen (2015)

and Uegaki (2015b), we have seen in this paper that such an explanation can be given for several important classes of rogative and anti-rogative predicates, namely neg-raising predicates, truth-evaluating predicates, inquisitive predicates, and predicates of dependency.

Cases that we have not treated here include rogative speech act predicates such as *ask* and *inquire*, anti-rogative speech act predicates such as *assert* and *claim*, as well as non-veridical preferential predicates like *fear* and *desire*. The selectional restrictions of this last class of predicates have been addressed elegantly in recent work by Uegaki and Sudo (2017).

For rogative speech act predicates such as *ask* and *inquire*, we might attempt a simple explanation along the following lines. It is natural to assume that part of what a sentence like *x asked φ* conveys is that *x* uttered a sentence φ which was *inquisitive* w.r.t. the common ground in the context of utterance. Arguably, this is necessary in order to satisfy the *sincerity conditions* of the speech act of asking, and similarly for inquiring. This requirement cannot be met if φ is a declarative, because in that case it is bound to be non-inquisitive w.r.t. the common ground.

For anti-rogative speech act predicates like *assert* and *claim*, we believe that an explanation is harder to find. This is because there are closely related speech act predicates such as *announce, state,* and *tell* which are responsive. If we tried to appeal to a similar reasoning as with rogative speech act predicates, we would have to motivate why this reasoning applies to predicates like *assert*, but not to predicates like *announce*. Instead, following White and Rawlins (2016), we conjecture that the relevant factor determining whether an 'assertive' speech act predicate is responsive or anti-rogative might lie in the predicate's event structure. Further exploring this hypothesis, however, must be left for another occasion.

Moreover, while all predicates we discussed here could easily be classified as either responsive or (anti-)rogative, not all embedding predicates fall so neatly into one of these categories. One complication stems from the fact that the selectional restrictions of some predicates appear to be polarity sensitive (Mayr 2017). For instance, as illustrated in (51) and (52), *say* and *be certain* seem to allow *whether*-complements when appearing under negation, but not when appearing in positive episodic sentences.

(51) a. Mary didn't say whether Bill had eaten.
      b. *Mary said whether Bill had eaten.

(52) a. Mary isn't certain whether Bill has eaten.
      b. *Mary is certain whether Bill has eaten.

Mayr (2017) proposes that the environments in which verbs like *say* and *be certain* accept *whether*-complements are exactly the same environments in which NPIs are licensed. In recent experimental work, van Gessel *et al.* (2018) found confirmation for the polarity sensitivity of *be certain whether*, but could not confirm Mayr's hypothesis that this construction is acceptable exactly in those environments that license NPIs: acceptability judgments for *be certain whether* do not correlate with judgments on NPIs.

Another complication, illustrated in (53), is that certain predicates, namely emotive factives like *surprise* and *amaze*, only accept wh-interrogatives as complements, but not polar interrogatives.

(53) a.   It is amazing what Bill had for breakfast.
      b.   *It is amazing whether Bill had breakfast.

Several accounts of this phenomenon have been suggested (d'Avis 2002, Abels 2004, Guerzoni 2007, Sæbø 2007, Nicolae 2013, Romero 2015b). For a detailed overview of this literature, as well as a proposal that is directly compatible with the account developed in the present paper, we refer to Roelofsen *et al.* 2016 and Roelofsen 2017.

Appendices to Chapter 2

2.A. Related work

This appendix discusses some work that is, like the present paper, concerned with the selectional restrictions of rogative and/or anti-rogative predicates. In particular, we will consider the work of Zuber (1982), Egré (2008), Mayr (2017), and Cohen (2017a,b) on the connection between anti-rogativity and neg-raising (Sect. 2.A.1), and the work of Uegaki (2015b) on the selectional restrictions of *wonder* and possible independent motivation for a type distinction between anti-rogatives on the one hand and rogatives and responsives on the other (Sect. 2.A.2).

2.A.1. On the connection between anti-rogativity and neg-raising

Evidently, the discussion of anti-rogativity in the present paper is greatly indebted to Zuber (1982), who observed the connection between anti-rogativity and neg-raising. Zuber's work was brought to our attention through the insightful discussion of clausal embedding in Egré (2008). However, neither Zuber (1982) nor Egré (2008) succeeded in *deriving* anti-rogativity from neg-raising in a principled way.

Independently of the present paper, Mayr (2017) and Cohen (2017a,b) have also recently proposed ways to explain the connection between anti-rogativity and neg-raising.[28] While these accounts are largely in the same spirit as ours, they are more limited in scope and less explicit in some important regards. We will discuss each account in some more detail below.

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[28]As mentioned, a first version of the present account started circulating in the spring of 2016.

2.A.1.1   Mayr 2017

Mayr (2017) assumes the following lexical entry for *believe*:

(54) $[\![believe]\!] = \lambda p_{st}.\lambda x_e.\lambda w_s : \underline{\mathrm{DOX}_x^w \subseteq p \vee \mathrm{DOX}_x^w \subseteq \overline{p}}. \mathrm{DOX}_x^w \subseteq p$

That is, just as we did, he incorporates an excluded-middle presupposition to capture the fact that *believe* is neg-raising, following Gajewski (2007). However, he assumes that anti-rogative predicates like *believe* and responsive predicates like *know* and *be certain* all take a single proposition as their first input, while we take them to apply to sets of propositions.

   Mayr takes a declarative complement to denote a single proposition, so such a complement can straightforwardly combine with *believe,* as well as with *know* and *be certain.* A polar interrogative complement on the other hand, is taken to denote a kind of type-raised existential quantifier over sets of propositions. For instance, *whether Mary smokes* is interpreted as follows:[29]

(55) $[\![whether\ Mary\ smokes]\!] = \lambda Q_{\langle st,st\rangle}.\lambda w_s.\exists p \in Q'.Q(p)(w) = 1$

       where $Q' = \{\lambda w'.\text{Mary smokes in } w', \lambda w'.\text{Mary doesn't smoke in } w'\}$

Given this treatment, neither *believe* nor *know* can directly take a polar interrogative like *whether Mary smokes* as its complement, since the latter does not denote a proposition. Mayr (2017) assumes that this type clash can be resolved by letting the polar interrogative take sentential scope, leaving behind a trace of type $\langle s, t\rangle$. Thus, the logical form of such a construction is as follows:

(56)   [whether Mary smokes] λp [John believes p]

In order to determine what the interpretation of this logical form is, we need to specify how the excluded-middle presupposition projects out of the scope of an existential quantifier. Mayr (2017) does not specify this, but writes that the following interpretation is obtained:

(57) $\lambda w_s.\exists p \in Q' : \underline{\mathrm{DOX}_j^w \subseteq p \vee \mathrm{DOX}_j^w \subseteq \overline{p}}. \mathrm{DOX}_j^w \subseteq p$

Note that it is not quite clear how this formula should be read. In particular, the underlined part cannot be read as usual, namely as restricting the domain of application of a certain function, because it does not come right after a lambda operator but rather appears in the scope of a quantifier which binds into it.

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[29]This interpretation actually differs slightly from the interpretation given in (17) of Mayr (2017). This is because, as confirmed by Mayr (p.c.), the latter contained a typo. The interpretation given here is the one that was intended.

Mayr (2017, p.871) says the following about this:

> "What is the presupposition of [(57)]? Taking the first of the propositions in Q' and setting it for p in [(57)] gives the presupposition that John either believes that Mary smokes or that she does not smoke. Taking the second proposition in Q', however, yields exactly the same. As a consequence, the presupposition of [(57)] is that John either believes that Mary smokes or that she does not smoke. Given the existential quantification in the assertive component of [(57)], the assertion is equivalent to the presupposition. This means that whenever [(57)] has a defined truth value, it is true. It is a tautology. Therefore [(56)] has a trivial literal meaning and is degraded..."

To determine whether this informal line of reasoning is tenable, we need a more general and precise specification of the assumed presupposition projection mechanism. Mayr (p.c.) has suggested that the desired results can be obtained by assuming a three-valued Strong Kleene logic, in which the truth value of $\exists x.\varphi(x)$ is defined just in case the truth value of $\varphi(x)$ is defined for at least one value of x, and $\exists x.\varphi(x)$ is true just in case $\varphi(x)$ is true for at least one value of x. Under this assumption, (57) is indeed true whenever it has a defined truth value. However, it remains to be seen whether a Strong Kleene logic is compatible with all the other parts of Mayr's proposal (concerning *be certain*, *know*, and other predicates).

Moreover, the account of Mayr (2017) is restricted to *polar* interrogative complements (the case of wh-interrogatives is explicitly left for future work), and it does not explicitly show that embedding polar interrogative clauses under *believe* and other neg-raising predicates always gives rise to *logical* analyticity (rather than just a tautology).

2.A.1.2 *Cohen 2017a, 2017b*

Cohen (2017a,b) has proposed two different ways of explaining the connection between anti-rogativity and neg-raising. We will not explicitly present these proposals here, for two reasons. First, they are cast in a different logical framework, which we would need to introduce in some detail before spelling out the proposals themselves. And second, the proposals are still rather preliminary at this point. One exists in the form of a 7-page handout, and the other in the form of a 5-page squib. Several important aspects have not been fully specified yet. For these reasons, we will restrict ourselves here to pointing out some challenges for the two proposals in their current form. A more comprehensive comparison must wait until the proposals have been worked out in more detail.

The proposal sketched in Cohen (2017a) wrongly predicts that under negation, neg-raising predicates do take interrogative complements. Moreover, it assumes that the EM presupposition of neg-raising predicates is pragmatic rather than semantic. As noted by Horn (1978), EM presuppositions are expected to arise much more widely under this assumption than they actually do. In particular, it becomes difficult, if not impossible, to account for the fact that predicates like *believe* trigger an EM presupposition while closely related predicates like *be certain* don't.

On the proposal sketched in Cohen (2017b) EM presuppositions are semantic in nature and neg-raising predicates are no longer predicted to license interrogative complements under negation. However, the account is, like that of Mayr (2017), restricted to polar interrogative complements. Moreover, it seems difficult to extend the account in a principled way to wh-interrogatives, because it relies on a non-compositional treatment of *believing whether*. This construction is, as a whole, viewed as a modal operator which comes with an EM presupposition. That is, the semantic contribution of *believing whether* is not derived from an independently motivated lexical entry for *believe* and an independently motivated treatment of interrogative complements. Finally, the proposal relies on a non-standard account of neg-raising, whose empirical coverage seems to be narrower than the account of neg-raising that we adopted, which is due to Gajewski (2007) building on much previous work. For instance, the account of Cohen (2017b) does not seem to account for the fact that negated neg-raising predicates license strong NPIs (e.g., *Bill doesn't believe/*know that Mary has been back to England in years*), a core empirical fact about neg-raising predicates (for discussion, see Gajewski 2007 and Križ 2015).

2.A.2. Uegaki 2015

We have shown that the selectional restrictions of some important classes of rogative and anti-rogative predicates can be derived from semantic assumptions about these predicates that can be independently motivated, and we argued that such an account is to be preferred over one that relies on a difference in semantic type between declarative and interrogative complements, at least as long as such a difference in type is not independently motivated.

Uegaki (2015b) assumes that declarative complements denote propositions, that interrogative complements denote sets of propositions, and that there is a type-shifting operation that transforms single propositions into sets of propositions if needed to avoid a type mismatch. This type-shifting operation,

denoted Id, simply turns any proposition p into the corresponding singleton set $\{p\}$.[30]

(58) $[\![\mathsf{Id}]\!]^w = \lambda p.\{p\}$

Thus, type-shifting is not needed when a responsive predicate like *know* takes an interrogative complement, as on the standard reductive approach (e.g., Heim 1994), but rather when such a predicate takes a declarative complement. For instance, *John knows that Mary left* is rendered as follows:

(59) John knows [Id [that Mary left]]

In this setup, the selectional restrictions of anti-rogative predicates like *believe* can be seen as resulting from a type mismatch, under the assumption that such predicates require a single proposition as their input. On the other hand, the selectional restrictions of rogative predicates like *wonder* have to be given a different kind of explanation, because in terms of semantic type they do not differ from responsive predicates like *know*.

Uegaki provides such an explanation, as well as independent motivation for the assumed type distinction between anti-rogative predicates on the one hand and responsive and rogative predicates on the other. We will consider these aspects of Uegaki's proposal in Sections 2.A.2.1 and 2.A.2.2, respectively, in each case drawing comparisons with our own approach.

2.A.2.1 Rogative predicates

SUMMARY OF UEGAKI'S ACCOUNT. The fact that *wonder* does not license declarative complements is accounted for by Uegaki (2015b, Sect. 2.3.3) in a way that is quite close in spirit to the account adopted in the present paper from Ciardelli and Roelofsen (2015), but different in implementation and empirical predictions. Uegaki proposes to decompose *wonder* into *want to know* and to derive the incompatibility with declarative complements from independently motivated assumptions about the lexical semantics of *want*. In particular, in line with earlier work on *want*, Uegaki (2015b, p.66) takes *x wants p* to presuppose (i) that x believes that the presuppositions of p are satisfied, and (ii) that x does not believe that p is true.

(60) Uegaki's entry for *want*:
$[\![want]\!]^w(p)(w)$ is defined only if:

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[30]In discussing Uegaki's proposal we adopt his convention to specify the denotation of each expression α at a specific world w, $[\![\alpha]\!]^w$, rather than the full meaning of the expression, $[\![\alpha]\!]$, which would be the function $\lambda w.[\![\alpha]\!]^w$.

    (i) $\sigma_x^w \subseteq \{w' \mid p(w') = 1 \text{ or } p(w') = 0\}$ 'x believes presupposition of p'

    (ii) $\sigma_x^w \nsubseteq \{w' \mid p(w') = 1\}$ 'x does not believe that p is true'

Now consider a case where *wonder* takes a declarative complement.

(61)   *John wonders that Mary left.

If *wonder* is analyzed as *want to know*, then the truth value of (61) is only defined if (i) John believes that the presuppositions of *John knows that Mary left* are satisfied, i.e., he believes that Mary left, and (ii) John does not believe that *John knows that Mary left* is true. Assuming that *x believes p* generally entails *x believes that x knows p*, these two conditions are contradictory. Thus, it is predicted that the presuppositions of (61) can never be satisfied. This explains the fact that *wonder* does not license declarative complements, and Uegaki suggests that the account can be extended to other rogative predicates as well, assuming that all these predicates have *want to know* as a core component.

Problems and comparison.   We see two problems for this proposal, one concerning the treatment of *wonder* itself, and one concerning the extension to other rogative predicates. Let us first consider the predictions of the account for a case where *wonder* takes an interrogative complement:

(62)   John wonders whether Mary left.

It is predicted that this sentence presupposes that John does not believe that *John knows whether Mary left* is true. Assuming that John is introspective, this is just to say that the sentence presupposes that John doesn't know whether Mary left. Since presuppositions under *want* project to the belief state of the subject (Karttunen 1973, 1974), it is therefore also predicted that (63) presupposes that John believes Mary doesn't know where he is.

(63)   John wants Mary to wonder where he is.

This is a problematic prediction, because (63) can very well be true in a situation in which John believes that Mary already knows where he is. We take this to show that the 'ignorance component' of *wonder* is an entailment rather than a presupposition, and this is indeed how it is modeled on our account. As a result, we do not predict that (63) implies that John believes Mary is ignorant as to where he is.

    Now let us turn to the possibility of extending Uegaki's account of *wonder* to other rogative predicates. It is indeed natural to assume that *investigate* and *be*

curious are, just like *wonder*, very close in meaning to *want to know*. However, we do not think that this assumption is justifiable for predicates of *dependency*. It is clear that a sentence like (64) does not make reference to any agent's knowledge or desires, and can therefore not be paraphrased in terms of *want to know*.

(64)   Whether the light is on depends on whether the switch is up.

Thus, we think that the present proposal improves on Uegaki's account both in its treatment of *wonder* and in covering a broader range of predicates.

2.A.2.2   *Anti-rogative predicates*

SUMMARY OF UEGAKI'S ACCOUNT.   As mentioned above, Uegaki assumes that anti-rogative predicates like *believe* require a single proposition as their input, while responsive and rogative predicates require sets of propositions. Moreover, he assumes that a declarative complement denotes a single proposition, while an interrogative complement denotes a set of propositions. This immediately accounts for the fact that anti-rogative predicates cannot take interrogative complements. Further assuming that a single proposition can be transformed into a set of propositions using the type-shifter Id, it is also predicted that responsive predicates can take both declarative and interrogative complements.

Uegaki motivates the assumption that anti-rogative predicates like *believe* and responsive predicates like *know* require different types of input by highlighting a contrast that arises when these two types of predicates are combined with so-called 'content DPs', like *the rumor that Mary left*. The contrast, first noted by Vendler (1972) and also discussed by Ginzburg (1995), King (2002), and Moltmann (2013), is illustrated in (65).

(65)   a.   John believes the rumor that Mary left.
             ∴ John believes that Mary left.
       b.   John knows the rumor that Mary left.
             ⫫ John knows that Mary left.

In general, *x believes the rumor that p* entails *x believes that p*, whereas *x knows the rumor that p* does not entail *x knows that p*, and the same is true if *rumor* is replaced by *story, claim, hypothesis,* et cetera.

Now, Uegaki claims that all anti-rogative predicates behave just like *believe* in this respect, while all responsive predicates behave just like *know*. He then provides an account of the contrast in (65) which relies on the assumption that *believe* requires a single proposition as its input, while *know* requires a set of propositions. Thus, to the extent that the account makes correct predictions

for other anti-rogative and responsive predicates as well, it indeed provides independent motivation for the type distinction that Uegaki assumes to account for the selectional restrictions of anti-rogative predicates.

Problem and comparison.   The problem for this approach is that there are counterexamples to the claim that all anti-rogative predicates behave like *believe* when combined with content DPs, and that all responsive predicates behave like *know* in this respect. First, there are anti-rogative predicates, such as *think* and *want*, which, unlike *believe*, cannot be combined with content DPs at all.[31]

(66)   *John thinks/wants/feels/supposes the rumor that Mary left.

While this does not directly counter Uegaki's account of the fact that *believe* is anti-rogative, it does show that the scope of the account is restricted; it certainly does not cover the full range of anti-rogative predicates.

A more drastic problem is that there are also responsive predicates that do not behave like *know* when combined with content DPs. Such predicates include *hear* and *prove*, as illustrated in (67)-(68).[32]

(67)   John heard the rumor that Mary left.
       ∴ John heard that Mary left.

(68)   John proved the hypothesis that every positive integer has a unique prime factorization.

---

[31]As an anonymous reviewer points out, these predicates *can* be combined with DPs like *something* and *several things*, expressions that Moltmann (2013) calls *special quantifiers*. With these expressions the relevant entailment is licensed:

(i)   John thinks something—namely that Mary left.
       ∴ John thinks that Mary left.

However, as discussed above, we are interested here in the contrast between predicates like *know* and predicates like *believe* that arises with content nouns like *rumor*. With special quantifiers, on the other hand, there is no contrast between *know* and *believe*: as shown in (ii), if *know* combines with *something* the relevant inference is licensed (while with *rumor* it wouldn't be licensed). Hence, special quantifiers are not part of Uegaki's generalization, and therefore not a counterexample to our criticism.

(ii)   John knows something—namely that Mary left.
       ∴ John knows that Mary left.

[32]Uegaki (2015b, pp. 49, 61) remarks that certain responsive predicates allow for a so-called *entity-relating* reading (such as the *acquaintance reading* of *know*), and that his theory leaves open the possibility that under this reading, these predicates do license inferences like those in (67)-(68). However, to the extent that such readings exist for *hear* and *prove*, they don't seem to be necessary for the inferences in (67)-(68) to go through.

∴ John proved that every positive integer has a unique prime factorization.

On Uegaki's account these predicates are thus predicted to be anti-rogative, just like *believe*, contrary to fact. This means that the independent motivation that Uegaki provides for his account of the selectional restrictions of anti-rogative predicates in terms of a type mismatch collapses. As a result, the account loses its explanatory force.

In comparison, we have shown that the selectional restrictions of two important classes of anti-rogative predicates can be derived from independently motivated semantic assumptions about these predicates, without the need to assume a mismatch in semantic type.

2.B. *Support-conditional lexical entries*

In the main text, we have given *truth-conditional* lexical entries for a number of predicates. For instance, according to our entry for *be certain*, repeated in (69) below, the predicate denotes a function which takes a complement meaning P and an individual x as its input, and delivers a truth value, either 1 or 0, as its output, depending on the world of evaluation w.

(69) $[\![\text{be certain}]\!]^w = \lambda P_T.\lambda x.\,\text{DOX}_x^w \in P$

Another, equivalent formulation of the entry is given in (70) below. This formulation makes clear that, when given a complement meaning P and an individual x as its input, the predicate yields a function from possible worlds to truth values. This kind of function can be identified with a set of possible worlds, namely those that are mapped to 1. Such a set of worlds, a proposition, is taken to encode the meaning of a sentence in standard possible worlds semantics.

(70) $[\![\text{be certain}]\!] = \lambda P_T.\lambda x.\lambda w.\,\text{DOX}_x^w \in P$

In inquisitive semantics, however, as discussed in Section 2.2, the meaning of a sentence is not a single proposition, but rather a set of propositions (non-empty and downward closed), encoding both the informative and the inquisitive content of the sentence. Thus, in inquisitive semantics, predicates like *be certain* should, when given a complement meaning P and an individual x as their input, not yield a set of worlds as their output, but rather a set of propositions—or equivalently, a function mapping every proposition p either to 1 or to 0. Schematically, the entries for such predicates should therefore be of the following form:

(71) $[\![\cdot]\!] = \lambda P_T.\lambda x.\lambda p_{\langle s,t \rangle} \ldots$

In this way, a complete sentence like *Bill is certain that Ann left* is associated with a set of propositions, as desired. Each of these propositions is said to *support* the sentence. Thus, lexical entries that fit the scheme in (71) are called *support-conditional*, rather than truth-conditional, entries.

Now, what are the support-conditional entries of the predicates that we have discussed? We propose that they can be derived from their truth-conditional entries in a straightforward way. Namely, we assume that for every predicate V under consideration, $[\![V]\!](P)(x)(p)$ is defined just in case $[\![V]\!](P)(x)(w)$ is defined for all $w \in p$, and $[\![V]\!](P)(x)(p) = 1$ just in case $[\![V]\!](P)(x)(w) = 1$ for all $w \in p$. Concretely, this yields the following entries:

(72) $[\![\text{be certain}]\!] = \lambda P_T.\lambda x.\lambda p. \forall w \in p. \text{DOX}_x^w \in P$

(73) $[\![\text{believe}]\!] = \lambda P_T.\lambda x.\lambda p. \dfrac{\forall w \in p. (\text{DOX}_x^w \in P \vee \text{DOX}_x^w \in \neg P).}{\forall w \in p. \text{DOX}_x^w \in P}$

(74) $[\![\text{be true}]\!] = \lambda P_T.\lambda p. \forall w \in p. \text{TRUE}^w \in P$

(75) $[\![\text{be false}]\!] = \lambda P_T.\lambda p. \forall w \in p. \text{TRUE}^w \notin P$

(76) $[\![\text{wonder}]\!] = \lambda P_T.\lambda x.\lambda p. \forall w \in p. (\text{DOX}_x^w \notin P \wedge \text{INQ}_x^w \subseteq P)$

(77) $[\![\text{depend on}]\!] = \lambda P_T'.\lambda P_T.\lambda p. \forall w \in p. \exists f \in \text{alt}(P)^{\text{alt}(P')}$ such that:

   (*i*) $\forall q \subseteq \sigma_w. \forall \alpha \in \text{alt}(P'). (q \subseteq \alpha \rightarrow q \subseteq f(\alpha))$ and

   (*ii*) $\exists \alpha, \alpha' \in \text{alt}(P'). \alpha \cap \sigma_w \neq \emptyset \wedge \alpha' \cap \sigma_w \neq \emptyset \wedge f(\alpha) \neq f(\alpha'))$

To briefly illustrate what these entries deliver, consider the following sentence:

(78) John wonders whether Mary called.

According to the entry in (76), a proposition p belongs to $[\![(78)]\!]$ just in case every world $w \in p$ is one in which (i) John isn't certain yet whether Mary called, but (ii) every extension of his current doxastic state in which the issues that he entertains are resolved is one in which he has learned whether Mary called. Note that $[\![(78)]\!]$ contains a single maximal element, i.e., a single alternative, which is the set of *all* worlds in which conditions (i) and (ii) above are satisfied. Thus, it is correctly predicted that (78) is not inquisitive, and that the sentence is true in w, i.e., $w \in \text{info}([\![(78)]\!])$, exactly when it is true according to our truth-conditional entry for *wonder* in (37).

More generally, our support-conditional entries predict for any predicate V under consideration, and any declarative sentence φ in which V takes a clausal complement and an individual subject (or two clausal complements in the case

of *depend on*), that (i) φ is non-inquisitive, and (ii) φ is true in a world w, i.e., $w \in \text{info}(\varphi)$, just in case it is true in w according to our truth-conditional entries.

Indeed, because of this tight connection between the support and truth conditions of sentences involving the predicates in question, we felt justified in concentrating only on the latter in the main text of the paper. For more details concerning type-theoretic inquisitive semantics, we refer to Ciardelli *et al.* (2017).

2.C. *Extending the account to presuppositional questions*

In this appendix we demonstrate how our account can be extended to presuppositional questions. Such questions are problematic for our account in its current form because it derives the selectional restrictions of anti-rogatives from the fact that the meaning of an interrogative complement always covers the entire logical space W. Presuppositional questions, however, do not cover W, but only a subset of W.

2.C.1. *Presuppositional questions*

Let us consider the example of a polar question containing the presupposition trigger *stop*:

(79)   Did John stop smoking?

As before, we model presuppositions via definedness restrictions: e.g., ⟦Did John stop smoking?⟧(p) is defined only if John used to smoke in all worlds $w \in p$:

(80)   ⟦Did John stop smoking?⟧

$$= \lambda p. \begin{cases} \forall w \in p : S(w)(j) \vee \forall w \in p : \neg S(w)(j) & \text{if } \forall w \in p : U(w)(j) \\ \text{undefined} & \text{otherwise} \end{cases}$$

In line with this, we define the *presupposition* $\pi(P)$ of a sentence meaning P as the set of all those propositions p for which $P(p)$ is defined.

DEFINITION 12 (PRESUPPOSITION).
The presupposition $\pi(P)$ of a sentence meaning P is $\pi(P) = \{p \mid P(p) \text{ is defined}\}$.

2.C.2. *Presupposition projection*

NEGATION.   It is well known that presuppositions project through negation. We modify the definition of the inquisitive negation operator to model this fact.

(81) $\neg = \lambda P.\lambda p. \begin{cases} \forall q \in P : p \cap q = \emptyset & \text{if } P(p) \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$

As before, when $\neg$ is applied to a sentence meaning P, it again yields a sentence meaning, i.e., a set of propositions. Now, however, $\neg P(p)$ is only defined if $P(p)$ is. As a consequence, for any sentence meaning P, it holds that $\pi(P) = \pi(\neg P)$.

EMBEDDING PREDICATES.   Next, we turn to the embedding predicate *believe*. As observed by Karttunen (1973, 1974), a sentence like (82) presupposes not that John used to smoke, but that Mary *believes* that he used to smoke. That is, *believe* and other non-factive attitude predicates project the presupposition of their complement clause by attributing it to the attitude holder as a belief.

(82)   Mary believes that John stopped smoking.
        Presupposition: Mary believes that John used to smoke.

The support-conditional version of the existing lexical entry for *believe* is repeated in (83) (see Appendix 2.B). Recall that the definedness restriction of this entry serves to model the excluded-middle (EM) presupposition. In what follows, we will refer to the disjunction modelling the EM presupposition ($\forall w \in p : \text{DOX}_x^w \in P$ or $\forall w \in p : \text{DOX}_x^w \in \neg P$) as the *EM condition*.

(83) ⟦believe⟧

$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \text{DOX}_x^w \in P & \text{if } \forall w \in p : \text{DOX}_x^w \in P \\ & \text{or } \forall w \in p : \text{DOX}_x^w \in \neg P \\ \text{undefined} & \text{otherwise} \end{cases}$

In order to also model the presupposition projection behavior of *believe*, we may add another condition to the existing definedness restriction. What we require for ⟦believe⟧$(P)(x)(p)$ to be defined is that, in every world $w \in p$, the subject's doxastic state, DOX_x^w, satisfies the presuppositions of the complement meaning P. That is, for every $w \in p$, $P(\text{DOX}_x^w)$ should be defined. A lexical entry for *believe* including this additional condition is given in (84).

(84)   ⟦believe⟧

$$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \text{DOX}_x^w \in P & \text{if } (\forall w \in p : \text{DOX}_x^w \in P \\ & \text{or } \forall w \in p : \text{DOX}_x^w \in \neg\, P) \\ & \textbf{and } \forall w \in p : \text{DOX}_x^w \in P \textbf{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

However, because presuppositions project through negation, we find that whenever p satisfies the EM condition, it is of course also defined for all $w \in p$ whether $\text{DOX}_x^w \in P$. This means that we may also just omit the additional definedness condition and stick with the entry in (83).

2.C.3. *Relativizing non-informativity*

Recall that we assume that interrogative complements are never informative. We had taken a sentence φ to be non-informative iff its informative content is trivial—by which we meant *trivial w.r.t. the logical space W*. That is, we called φ non-informative iff $\text{info}(\varphi) = W$. Now that we are also considering presuppositional questions, it is natural to relativize the definition of non-informativity to the presuppositional content of a sentence. We say that a sentence φ with presupposition $\pi(\llbracket\varphi\rrbracket)$ is non-informative w.r.t. its presupposition iff $\text{info}(\varphi) = \bigcup \pi(\llbracket\varphi\rrbracket)$. This is the case iff the alternatives in $\llbracket\varphi\rrbracket$ together cover $\bigcup \pi(\llbracket\varphi\rrbracket)$. Intuitively, we can think of this along the following lines. Suppose that $\text{info}(\varphi) = \bigcup \pi(\llbracket\varphi\rrbracket)$ and consider the doxastic state of someone who hears φ. Then, whenever this doxastic state is one that satisfies the presupposition of φ, i.e., an element of $\pi(\llbracket\varphi\rrbracket)$, it will also already contain all the information encoded by $\text{info}(\varphi)$, i.e., φ will not add any information to the given doxastic state.

Using this relativized notion, we now assume that interrogative complements are always non-informative w.r.t. their presupposition. In case an interrogative does not carry a presupposition, this simply boils down to normal non-informativity.

At this point, we can already see from the definition of inquisitive negation in (81) that, just as before, the inquisitive negation of an interrogative complement meaning P with presupposition $\pi(P)$ is always $\neg\, P = \{\emptyset\}$. This is because there can be no non-empty proposition $p \in \pi(P)$ such that p is inconsistent with every $q \in P$.

Also as before, this means that if *believe* takes an interrogative complement, the second disjunct of the EM condition can only be true if $\text{DOX}_x^w = \emptyset$. It follows that the second disjunct can only be true if the first disjunct is true as well,

since $\emptyset$ is contained in any complement meaning P. In other words, the second disjunct in the EM condition is redundant. Thus, if *believe* takes an interrogative complement, its lexical entry reduces to (85).

(85) $[\![\text{believe}]\!]$

$$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \text{DOX}_x^w \in P & \text{if } \forall w \in p : \text{DOX}_x^w \in P \\ \text{undefined} & \text{otherwise} \end{cases}$$

Note that the definedness condition in (85) entails the support condition. In other words, when *believe* combines with an interrogative complement, its support condition is trivial relative to its presupposition. We will now again show that this triviality is a case of L-analyticity.

2.C.4. *L-analyticity*

It is straightforward to translate the notion of L-analyticity into our support-conditional framework:

ASSUMPTION 3 (L-ANALYTICITY, SUPPORT-BASED VERSION). A sentence S with logical skeleton χ is L-analytical just in case either (i) or (ii) holds.

  (i) For all interpretations, if it is defined whether a proposition p supports χ, then p supports χ.

 (ii) For all interpretations, if it is defined whether a proposition p supports χ, then p does not support χ.

We now show that the meaning of (86) still comes out as L-analytical on the presuppositional account.

(86)   *Mary believes whether John stopped smoking.

We again start by constructing the logical skeleton (LS). As before, we assume that *believe* decomposes at LF into $\mathcal{M}_{\text{believe}}$ and R_{EM}. The lexical entries of these items need to be modified slightly to fit the support-conditional setting.

(87) $[\![\mathcal{M}_{\text{believe}}(w)(x)]\!] = \text{DOX}_x^w$

(88) $[\![R_{\text{EM}}]\!] = \lambda \mathcal{M}_{\langle s,\langle e,st \rangle \rangle}.\lambda P.\lambda x.\lambda p.$

$$\begin{cases} \forall w \in p : \mathcal{M}(w)(x) \in P & \text{if } (\forall w \in p : \mathcal{M}(w)(x) \in P \text{ or} \\ & \quad \forall w \in p : \mathcal{M}(w)(x) \in \neg P) \\ \text{undefined} & \text{otherwise} \end{cases}$$

The LS for (86) is given in (89).

(89)
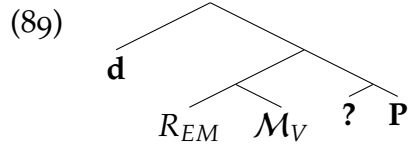
Now, let p be a proposition. We want to determine whether $p \in [\![(89)]\!]$. Whether this is the case, though, is only defined if p supports the presupposition $\pi([\![(89)]\!])$. This means it has to hold that either (a) $[\![\mathcal{M}]\!](w)([\![\mathbf{d}]\!]) \in [\![\mathbf{?P}]\!]$ for all $w \in p$, or (b) $[\![\mathcal{M}]\!](w)([\![\mathbf{d}]\!]) \in [\![\neg\,\mathbf{?P}]\!]$ for all $w \in p$. We already know that, no matter what $\mathbf{P}$ is, the set of propositions in $[\![\mathbf{?P}]\!]$ covers the presupposition of $\mathbf{?P}$, $\pi([\![\mathbf{?P}]\!])$. That is, $\mathsf{info}(\mathbf{?P}) = \bigcup \pi([\![\mathbf{?P}]\!])$. Hence, we also know that $[\![\neg\,\mathbf{?P}]\!] = \{\emptyset\}$.

The second disjunct in the EM condition, (b), can thus only be true if $[\![\mathcal{M}]\!](w)([\![\mathbf{d}]\!]) = \emptyset$ for all $w \in p$. But if this holds, then the first disjunct is also true, since $[\![\mathbf{?P}]\!]$ always contains $\emptyset$. This means that whenever the second disjunct holds, the first one holds as well, or, in other words, whenever the EM condition holds, the first disjunct is true.

Now, let's assume that the p we were considering indeed supports the presupposition $\pi([\![(89)]\!])$. Then we know that the first disjunct of the EM condition holds. But note that this disjunct is identical to the support condition for p, namely $[\![\mathcal{M}]\!](w)([\![\mathbf{d}]\!]) \in [\![\mathbf{?P}]\!]$ for all $w \in p$. This in turn means that, for all interpretations in which it is defined whether $p \in [\![(89)]\!]$, it is indeed the case that $p \in [\![(89)]\!]$. Hence, (89) comes out as L-analytical.

Part Two.
Particles

Chapter 3.
On 'denn' and other highlighting-sensitive particles

3.1. Introduction

Discourse particles are small words that are tremendously useful in conversation. They help interlocutors organize and navigate a discourse by overtly signaling what otherwise would have to be inferred by hearers. They can signal how a given utterance fits into the overall structure of the discourse (Rojas-Esponda 2015) or how the content conveyed by an utterance relates to the epistemic states of the interlocutors (Zimmermann 2011). More generally, we may characterize discourse particles as commenting on the semantic content of their containing utterance by expressing a relation between this content and some property of the discourse or of the interlocutors. Under this view, if we want to describe the meaning of a discourse particle, we need to specify *which* comment the particle makes on the semantic content of its containing utterance. I argue that in addition we have to specify another, often overlooked component, namely, *which notion of semantic content* is the pertinent one here.

Most work in formal semantics has focused on discourse particles occurring in declarative sentences.[1] For these particles, the relevant notion of semantic content is straightforward: declaratives convey information, and this information is classically modeled as a proposition. So, we may think of discourse particles in declaratives as connecting the propositional content expressed by the declarative to some property of the discourse or the interlocutors. A prominent example of a particle fitting this perspective is German *ja*. Roughly, by using *ja* in a sentence with propositional content p, the speaker connects p to the epistemic states of the interlocutors by indicating that either p is already

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[1]Some notable exceptions are Grosz 2011; Kaufmann and Kaufmann 2012; Rojas-Esponda 2014; Csipak and Zobel 2014 and Gutzmann 2015.

common knowledge of speaker and hearer or it is verifiable on the spot (Kratzer 2004).

   This paper is concerned with discourse particles that occur in interrogative sentences. For these particles, identifying a suitable notion of semantic content is less straightforward. Since questions request information, rather than conveying it, they aren't taken to express propositional content. Instead, the meaning of a question is often taken to reside in its *answerhood conditions*—those conditions under which a statement counts as an answer to the question (Hamblin 1958). An influential implementation of this idea can be found in *alternative semantics*, which models the meaning of a question as the set of answers to this question (Hamblin 1973, Karttunen 1977). As a reasonable first attempt, one might therefore treat discourse particles in questions as sensitive to the question's semantic content qua answerhood conditions. Whatever such an account would look like concretely, however, we will see shortly that it wouldn't be able to capture the meaning of a number of particles—including the one that is the main subject of this paper, German *denn*.[2,3]

   Denn is a discourse particle that appears predominantly in questions. It is licensed both in polar questions such as (1) and wh-questions such as (2) (Thurmair 1989). Moreover, it can appear in certain conditional antecedents, as in (3) (Brauße 1994, Csipak and Zobel 2016).

(1) **Polar questions:**

   a. Kann Tim denn schwimmen?
      Does Tim DENN *know how to swim?*

   b. Ist dir denn gar nicht kalt?
      Are you DENN *not cold at all?*

(2) **wh-questions:**

   a. Warum lachst du denn?
      Why are you DENN *laughing?*

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[2]Any theory that implements the pre-theoretical notion of answerhood classifies propositions into answers and non-answers. Hamblin 1973 and Karttunen 1977 are mentioned here because readers are likely to be familiar with these works, not because I want to suggest we should adopt their particular division into answers and non-answers. Rather, the point I will try to make is more general: take *any* suitable implementation of answerhood—by 'suitable' I mean that it has to track our intuitions about which propositions resolve a question—and this implementation will be insufficient to capture the semantics of certain discourse particles.

[3] The framework of *inquisitive semantics* is closely related to alternative semantics, but adopts a slightly different perspective: it takes the meaning of both declaratives and interrogatives to reside in their *resolution conditions* (Ciardelli *et al.* 2013, Ciardelli *et al.* 2015). For the purposes of the current paper, the difference between answerhood conditions and resolution conditions isn't relevant.

b. Wie schaltet man dieses Ding denn aus?
How does one DENN *switch this thing off?*

(3) **Conditional antecedents:**

a. Kritik ist willkommen, wenn sie denn konstruktiv ist.
Criticism is welcome if it DENN *is constructive.*

b. Sie kann gewinnen, wenn sie das denn will.
She can win if she DENN *wants to.*

For now, we will focus on *denn* in questions. Even without going into any details about the semantic contribution of this particle, we can show that *denn* is insufficiently captured by treating it as sensitive to only answerhood conditions. To begin with, observe that in the following scenario *denn* is felicitous in the wh-question (4a), but not in the polar question (4b).

(4) [Two ANNAS: A and B know exactly two people called Anna. One of them lives in Munich, the other one in Berlin. This is commonly known among A and B.]

A: Vorhin hat Anna angerufen.

A: Earlier today, Anna called.

a. B: Welche Anna meinst du denn?

B: Which Anna do you DENN *mean?*

b. B: #Meinst du denn Anna aus München?

B: #Do you DENN *mean Anna from Munich?*

The scenario in (4) is set up in such a way that the wh-question in (4a) and the polar question in (4b) have the same answerhood conditions: because there are exactly two Annas and we know that exactly one of them called, either question can be resolved by stating that Anna from Munich called or that she didn't call (in which case it was Anna from Berlin who called). So, if *denn* was only sensitive to answerhood conditions, it wouldn't be able to distinguish between (4a) and (4b) and should therefore be felicitous either in both questions or in neither of them. What we find, though, is that *denn* is felicitous in the wh-question, but not in the polar question. We conclude that there must be a difference between these two kinds of questions to which *denn* is sensitive.[4]

Indeed, while there are many straightforward examples of polar questions that disallow the use of *denn*, it is difficult (but not impossible) to find examples of infelicitous *denn*-marked wh-questions. Intuitively, this is because *denn*

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[4]Arguments of this format, utilizing the answer-conditional equivalence of a polar question and a wh-question, can be found in much recent work in question semantics (e.g., Csipak and Zobel 2014, Iatridou and Tatevosov 2016, Roelofsen 2017).

in wh-questions doesn't seem to add much to the original meaning of the question—an observation reflected in the fact that much previous work ascribes a rather weak meaning contribution to *denn*: many accounts agree that the particle merely marks its containing question as somehow "relevant" for the speaker (e.g., König 1977, Thurmair 1989, Bayer 2012) or, similarly, that it signals a heightened interest of the speaker (Csipak and Zobel 2014).

While these characterizations might be accurate for wh-questions, they do not capture the more tangible contribution of *denn* in polar questions. I suggest that the missing piece in accounting for this asymmetry is a suitable notion of semantic content which sets polar questions apart from wh-questions. The notion of *highlighted content* by Roelofsen and Farkas (2015) serves this purpose. It models which semantic objects a sentence makes salient. Concretely, Roelofsen and Farkas assume that every sentence—regardless whether it is a declarative, a polar interrogative, or a wh-interrogative—highlights an n-place property, where $n \geq 0$ is the number of wh-elements in the sentence. Declaratives and polar interrogatives highlight 0-place properties, i.e., propositions, while wh-interrogatives highlight n-place properties with $n \geq 1$. For instance, both the declarative in (5a) and the polar interrogative in (5b) highlight the proposition that Mary read Frankenstein, while the wh-question in (5c) highlights the 1-place property of having read Frankenstein.

(5)   a. Mary read Frankenstein.
      b. Did Mary read Frankenstein?
      c. Who read Frankenstein?

I propose that the meaning of *denn* and a range of other particles should be captured by treating them as sensitive to highlighted content.[5] This way, the

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[5]The central idea of this approach is similar to that put forward by Csipak and Zobel (2014). For them, the difference between a polar and a wh-question is that the former but not the latter has an *explicitly identified answer* (*EIA*) (the prejacent of the polar questions). I find much to agree with in their approach. There are, however, some fundamental differences between Csipak and Zobel's view and the one presented here:

1. Csipak and Zobel explicitly treat *denn* as *not* sensitive to EIAs. I disagree with this assumption, on the basis of examples like (4) above and others to be discussed in Section 3.2.

2. For Csipak and Zobel, only polar questions have EIAs. By contrast, following Roelofsen and Farkas (2015), I treat highlighting as a uniform notion that is applicable to both declarative and interrogative clauses (both polar and wh-interrogatives).

3. Most importantly, Csipak and Zobel assume that if a particle is sensitive to EIAs, it can't appear in wh-questions. I disagree with this view, on the basis of particles like *denn* and others that will be discussed in Section 3.5. I suggest that using the uniform notion of highlighted content allows us to account for particles that are sensitive to EIAs but that

observed asymmetry in meaning between polar and wh-questions falls out naturally.

The paper is structured as follows. In Section 3.2 we introduce the two central properties of *denn*, its discourse anaphoricity and its sensitivity to highlighted content. In Section 3.3 we develop an account of *denn* that implements these properties, and in Section 3.4 we walk through the predictions that this account makes for various sentence types. Section 3.5 offers ideas for how to integrate highlighted content in the analysis of some other discourse particles. Section 3.6 extends the account from Section 3.3 to also cover the use of *denn* as a causal conjunction. Section 3.7 concludes.

3.2. *Properties of 'denn'*

This section illustrates two central properties of *denn*, discourse anaphoricity and sensitivity to highlighted content, and discusses their treatment in extant accounts.

3.2.1. *Discourse anaphoricity*

It has been known for a long time that whether *denn* is felicitous in a question *Q* depends in some way on the discourse leading up to *Q* (e.g., König 1977, Thurmair 1991). In truly out-of-the-blue contexts like (6), *denn* is infelicitous. But if we modify the scenario by adding a suitable previous discourse move, as in (7), the same *denn*-marked question becomes felicitous.

(6) [A approaches a stranger on the street.]
    A: Entschuldigen Sie, ist heute (#denn) Montag?
    A: Excuse me, is it (#DENN) Monday today?

(7) [Garbage gets collected on Mondays. A and B, two housemates, are talking over breakfast.]
    A: Kannst du nachher die Mülltonne rausstellen?
    A: Can you put out the garbage later today?
    B: Ist heute (denn) Montag?
    B: Is it (DENN) Monday today?

For a related example from the literature, consider (8) and (9) by König (1977).

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can also appear in wh-questions.

König (1977) observes that in the scenario in (8), where A wakes B in the middle of the night, it is infelicitous for A, the waker, to follow her action up by asking (8). By contrast, in the scenario in (9), where it is B that wakes A, it is acceptable for A, the wakee, to ask the same question.

(8)   [EARLY WAKING 1: A wakes B in the middle of the night.]
      A: #Wie spät ist es denn?
      A: #What is the time DENN*?*

(9)   [EARLY WAKING 2: B wakes A in the middle of the night.]
      A: Wie spät ist es denn?
      A: What is the time DENN*?*

According to a common position in the literature (a.o., Franck 1980, Hentschel and Weydt 1983, Thurmair 1991, Kwon 2005, Gutzmann 2015), *denn* indicates that the questioning act is in some way externally motivated. For instance, according to Thurmair (1991, p.378), *denn* signals that the reason why the speaker is asking the question can be found in the immediate utterance context. Under this view, the question in EARLY WAKING 1 is infelicitous because the context doesn't supply a reason why A would want to know the time. By contrast, the question in EARLY WAKING 2 is felicitous because in that context it is natural to assume that A is looking for an explanation for being woken; learning the time might indeed provide her with such an explanation.

To my knowledge, the only formal implementation of the external-motivation view on *denn* can be found in Gutzmann 2015. Abstracting away from the details of his framework, Gutzmann assumes that *denn* contributes the following felicity condition:

(10)   Felicity condition for *denn* by Gutzmann (2015):
       It is felicitous for a speaker to utter a *denn*-question Q only if the hearer knows the reason why the speaker is asking Q.

Under this account, the EARLY WAKING examples receive an explanation similar to the one sketched above: the wakee can't be assumed to know why the waker would want to know the time, whereas the waker can reasonably infer why the wakee wants to know the time. The felicity condition is thus only met if (9) is asked by the wakee.

So, the external-motivation view on *denn* in general and Gutzmann's account in particular capture the basic discourse anaphoricity of *denn*. As we will see in the following section, however, the meaning contribution they assume is too weak: not just *any* reason for asking a question is sufficient for licensing *denn*,

even if that reason emerges from the utterance context.

3.2.2. *Sensitivity to highlighted content*

For a simple example, where the external-motivation account is too permissive, consider (11). The reason why a pollster would ask a passerby to participate in a poll is evident: it's their job. It's safe to assume that the hearer in (11) knows this as well. So, Gutzmann's account, and more generally, any account based on the external-motivation view, would predict *denn* to be licensed. Yet, we find that the pollster's question is infelicitous with *denn*, but completely felicitous without.

(11) [Pollster, holding a clipboard, approaching a passerby:]
      Guten Tag! Ich führe im Auftrag von Ideopoll eine Umfrage durch. Möchten Sie (#denn) teilnehmen?
      Hello! I'm carrying out a poll on behalf of Ideopoll. Would you (#DENN) like to participate?

The problem with the external-motivation view is that it takes *denn* to establish a connection between the utterance context and the questioning act *as a whole*. I argue that this view isn't fine-grained enough: what *denn* establishes is a connection between the context and the highlighted content of the question.

   For an example that illustrates this point, consider (12). Here, again, the infelicity of the question is due to the presence of *denn*. If *denn* is omitted, B's reply becomes acceptable.

(12) [PARTY: Peter is very fond of Sophie but not so fond of parties: usually, he only goes to a party if she goes as well. Peter's feelings aren't returned by Sophie, though. So, she won't go to a party just because Peter is there. All of this is commonly known. Right now, A and B are talking at a big, difficult to overview party, wondering which of their friends are there.]

      A: Da drüben ist Sophie!
      A: Sophie is over there!

      B: Ist (#denn) Peter auch hier?
      B: Is (#DENN) Peter also here?

Given the scenario in (12), the reason for B's question emerges clearly from the context: A has just spotted Sophie, and A and B both know that, whenever Sophie is there, chances are good Peter will show up as well. So, A knows (i) that B's question continues their discussion about which of their friends might be

at the party, and (ii) that this question has been prompted by seeing Sophie. In other words, A knows the motivation for the questioning act. This means that external-motivation accounts, including Gutzmann's account, would predict *denn* to be licensed in (12), contrary to what we find empirically.

It is also worth noting that we find a certain asymmetry here: if A spots Peter instead of Sophie, and B asks about Sophie instead of Peter, *denn* becomes felicitous:[6]

(13)   [Same scenario as in (12).]

       A: Da drüben ist Peter!
       A: Peter is over there!

       B: Ist denn Sophie auch hier?
       B: Is DENN Sophie also here?

To foreshadow a bit, we will explain asymmetries like this by assuming that *denn* is sensitive to the content highlighted by the question. B's question in (12) highlights the proposition that Peter is at the party, while B's question in (13) highlights the proposition that Sophie is at the party. Roughly, in these examples, *denn* marks the highlighted proposition as an explanation for the information asserted by A. That is, in (13), it marks Sophie's being at the party as an explanation for Peter's being there. Since, in the given scenario, it is commonly known that Peter only goes to parties if Sophie is there, Sophie's presence would indeed explain Peter's presence and *denn* is acceptable in (13). By contrast, in (12), *denn* marks Peter's presence as an explanation for Sophie's presence. Since Sophie's presence is known *not* to depend on Peter's presence, though, Peter's presence can't be construed as an explanation for Sophie's presence and *denn* is not acceptable in (12).

Later, in order to account for a wider range of uses, we will generalize the meaning contribution of *denn* and assume that the particle marks learning the highlighted proposition as a *necessary precondition* for what we will call *proceeding in discourse*. In the party scenario, for interlocutor B to proceed in discourse, she has to accept the information asserted by A—and the *denn*-marked question specifies a necessary precondition for doing so. In (13), B

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[6]Relatedly, it is felicitous to mark B's question in (12) with *dann* 'then' instead of *denn*, as shown in (i). We won't return to *dann* in this paper; see Biezma (2014) for an analysis of the relevant use of English *then*.

(i)   [Same scenario as in (12).]

     A: Sophie is over there!

     B: Ist dann Peter auch hier?
     B: Is Peter also here, then?

expresses that she will have to learn that Sophie is at the party in order to "integrate" the fact that Peter is at the party with her existing beliefs. In this sense, *denn* in (13) marks learning that Sophie is there as a necessary precondition for B to accept the previous utterance.[7] In the given scenario, it's warranted to regard learning that Sophie is at the party as a precondition for integrating that Peter is there, whereas it's not warranted to regard learning that Peter is at the party as a precondition for integrating that Sophie is there. This is why *denn* is acceptable in (13) but not in (12).

Before we make these ideas more precise in the next section, let's consider one more example to familiarize ourselves with the notion of necessary precondition:

(14)   [FROZEN LAKE: A loves ice skating and wants to do it as often as possible. B knows this. A and B are walking by a lake that usually doesn't freeze. A notices that the lake is frozen.]

    a.   A: Schau mal! War es denn diesen Winter kälter als normal?
        A: Look! Was this winter DENN colder than usual?

    b.   A: Schau mal! Sollen wir (#denn) Schlittschuh laufen gehen?
        A: Look! Shall we (#DENN) go ice skating?

Intuitively, *denn* is felicitous in (14a) because learning that it was unusually cold can easily be seen as a necessary precondition for integrating the information that the lake is frozen.[8,9] On the other hand, the particle is infelicitous in (14b)

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[7]The notion of a necessary precondition can also be found in Csipak and Zobel (2016)'s work on *denn* in conditional antecedents. Csipak and Zobel suggest that this kind of *denn* requires, among other things, that the prejacent of the conditional antecedent be "a necessary precondition for the validity of the content of a previous utterance" (p.15). However, in that paper, Csipak and Zobel are explicitly not concerned with the meaning of *denn* in questions since they don't take a unified analysis of conditional *denn* and question *denn* to be possible. We will discuss their arguments in Section 3.4.4.2.

[8]The notion of necessity that is relevant here—as well as in many other instances of human reasoning—is defeasible. When faced with new evidence (e.g., that somebody is artificially cooling the lake), A would not insist on having to learn that this winter was colder before she can integrate that the lake is frozen.

[9]Going by PARTY and FROZEN LAKE, the reader might wonder why I talk about the *learning* of an instantiation p being a precondition for *accepting* a proposition q. Doesn't this amount to the same as saying p is a precondition for q? In the examples so far, it does indeed, but more generally, p being a precondition for q is only one possible way in which learning p can be a precondition for accepting q. For another way, consider (i). We wouldn't want to regard fever as a precondition for the flu, but learning that someone has fever might indeed be a precondition for accepting that they have the flu. Often, however, we will discuss examples where p is indeed a precondition for q, and in those cases I will switch to the easier formulation.

(i)   [Parent after their son unconvincingly announces he can't go to school today because he has the flu:]

because there is no salient contextual information such that the plan to go ice skating could reasonably be construed as a precondition for integrating this information. However, for both (14a) and (14b) it is clear from the context why A is asking the question, which means that Gutzmann's condition would predict *denn* to be felicitous in both questions.

To sum up, we have discussed two important properties of *denn*, its discourse anaphoricity and its sensitivity to highlighted content. In the following section, we will formulate an account of *denn* that implements these properties.

3.3.   *A precondition account of 'denn'*

We first define the notion of *highlighted content* (Section 3.3.1), and then provide a felicity condition for *denn* (Section 3.3.2). Some concepts used in this condition will require further clarification. We discuss the role that extralinguistic context plays in our model of discourse (Section 3.3.3) as well as the notion of *proceeding in discourse* (Section 3.3.4).

3.3.1.   *Highlighted content*

Asking a question or making an assertion changes the context in which the subsequent utterance is interpreted. For instance, if the polar question or the assertion in (15) gets answered by *yes*, this conveys that the door is open, whereas if the polar question or the assertion in (16) is answered by *yes*, this conveys that the door is closed. In response to the wh-question *Which book did John read?* in (17), *yes* and *no* are meaningless. But if (17) receives the term answer *Middlemarch*, this conveys that John read Middlemarch. In response to a polar question or an assertion, by contrast, this term answer is not licensed.

(15)   Is the door open? / The door is open.

    a. Yes.   ↝   open
    b. No.   ↝   closed
    c. *Middlemarch.

(16)   Is the door closed? / The door is closed.

    a. Yes.   ↝   closed
    b. No.   ↝   open
    c. *Middlemarch.

So, so. Hast du denn auch Fieber?
Well, well. Do you ᴅᴇɴɴ *have a fever?*

(17) Which book did John read?

    a. *Yes./*No.

    b. Middlemarch.   ⤳   John read Middlemarch.

One way of modeling these discourse effects is to assume that the utterance of a question or an assertion brings certain semantic objects into salience, which then become available for subsequent anaphoric reference (Groenendijk and Stokhof 1984, von Stechow 1991, Krifka 2001, Aloni *et al.* 2007). Here we will use Roelofsen and Farkas (2015)'s implementation of this idea, which is applicable to both assertions and questions. Roelofsen and Farkas assume an additional level of semantic representation, dubbed *highlighted content*. The highlighted content of polar interrogatives and declaratives is a proposition, whereas that of wh-questions is an n-place property with $n \geq 1$. For example, both the polar interrogative in (18a) and the declarative in (18b) are taken to highlight the proposition that Mary read Frankenstein, i.e., $\lambda w.R(f)(m)(w)$. The single-wh-question in (18c) is taken to highlight the unary property of having been read by Mary, i.e., $\lambda x.\lambda w.R(x)(m)(w)$, and the multiple-wh-question in (18d) is taken to highlight the binary relation $\lambda y.\lambda x.\lambda w.R(x)(y)(w)$.

(18)
a.	Mary read Frankenstein.	⤳ $\lambda w.R(f)(m)(w)$	0-place property
b.	Did Mary read Frankenstein?	⤳ $\lambda w.R(f)(m)(w)$	0-place property
c.	What did Mary read?	⤳ $\lambda x.\lambda w.R(x)(m)(w)$	1-place property
d.	Who read what?	⤳ $\lambda y.\lambda x.\lambda w.R(x)(y)(w)$	2-place property

Roelofsen and Farkas generalize over these different cases by viewing propositions as 0-place properties. All of the above sentence types then highlight an n-place property, where $n \geq 0$ is the number of wh-elements in the sentence.

    The current paper suggests that this way of generalizing over different sentence types supplies a suitable notion of semantic content for the analysis of certain discourse particles, such as *denn*. Though related notions have played a role in recent work on discourse particles (Rojas-Esponda 2014, Csipak and Zobel 2014), the concepts of highlighting used in these accounts are limited to polar questions. The current proposal relies crucially on a unified conception of highlighted content.

Instantiations of a property. In our account of *denn*, we will refer to the *instantiations* of a highlighted property. Given an n-place property f and individuals $d_1, \ldots, d_n$, we call the proposition $f(d_1, \ldots, d_n)$ an instantiation of f. What will be important for us is the following contrast. If f is a proposition, i.e., a 0-place property, it has exactly one instantiation, namely f itself. This means that the highlighted property of a declarative or a polar question has

exactly one instantiation. By contrast, if f is an n-place property with $n \geq 1$, it has several different instantiations. This means that the highlighted property of a wh-question has several different instantiations.

3.3.2. *A felicity condition for 'denn' in questions*

We are now ready, at least modulo some conceptual details, to formulate our positive proposal. Following an influential position on the meaning contribution of discourse particles, we assume that what *denn* contributes is expressive or use-conditional content (Kratzer 1999; Potts 2005, 2007; Gutzmann 2015; cf. also McCready 2012; Grosz 2016), which can be specified in the form of a felicity condition.

(19) **Felicity condition for *denn*:**
      Given a salient previous discourse act A_{-1}, it is felicitous for a speaker s to use *denn* in a clause with highlighted property f iff s considers learning an instantiation of f a necessary precondition for herself to proceed from A_{-1}.

Parts of this condition need further clarification. I first try to give the reader a quick impression of the concepts used here, then discuss some of them in more depth in the following subsections.

The 'salient previous discourse act A_{-1}'. The discourse-anaphoricity of *denn* is implemented in the felicity condition by making reference to a salient previous discourse act A_{-1}. The term *discourse act*, which will be discussed in Section 3.3.3, is used to refer to a wider notion of discourse moves, encompassing speech acts as well as gestures and other kinds of non-verbal acts performed by interlocutors.

The 'clause'. The felicity condition is intended to apply both to *denn* in questions and in conditional antecedents—hence the underspecified term *clause* instead of *interrogative*. The predictions that the condition makes for *denn* in conditional antecedents are discussed in Section 3.4.4.

To 'proceed from A_{-1}'. In a nutshell, for an interlocutor x to *proceed* from a discourse act A_{-1} is for x to act in line with what A_{-1} has indicated would be a preferred reaction. For instance, if A_{-1} was an imperative, then x has to carry out the given instructions; if A_{-1} was an assertion, x has to accept and integrate

the asserted information; and so on. We will have much more to say about this notion of proceeding in Section 3.3.4.

To 'LEARN' AN INSTANTIATION OF A PROPERTY. An instantiation of a property is a proposition. Hence, to *learn* an instantiation of a property is to learn a proposition.

For a quick illustration, let's now see how the above felicity condition can account for the TWO ANNAS example from Section 3.1, repeated in (20).

(20) [TWO ANNAS: A and B know exactly two people called Anna. One of them lives in Munich, the other one in Berlin. This is commonly known among A and B.]

    A: Vorhin hat Anna angerufen.
    A: Earlier today, Anna called.

  a. B: Welche Anna meinst du denn?
       B: Which Anna do you DENN mean?

  b. B: #Meinst du denn Anna aus München?
       B: #Do you DENN mean Anna from Munich?

First we determine which properties the *denn*-containing clauses highlight. The wh-interrogative in (20a) highlights the unary property f_a of being the referent that A intended:

$$f_a = \lambda x.\lambda w.\text{intended-referent}(x)(w)$$

The polar interrogative in (20b) highlights the proposition f_b that A meant Anna from Munich:

$$f_b = \lambda w.\text{intended-referent}(\textbf{munich-anna})(w)$$

While there are multiple possible instantiations of f_a (namely, that A meant Anna from Berlin, that A meant Anna from Munich), there is only one possible instantiation of f_b (namely, that A meant Anna from Munich).

Now, the previous discourse act A_{-1} was A's assertion that Anna called. So, for B to proceed from A_{-1} is to accept that Anna called. In order to do so, however, B first needs to interpret A's assertion—and this B can only do if she knows the referent for 'Anna'. So, what *denn* in (20a) conveys is that, in order to interpret (and thus ultimately accept) A's assertion, B first has to learn which Anna was the intended referent. In other words, B has to learn a true instantiation of f_a. Since this is in line with the given scenario, *denn* is acceptable in (20a). By contrast, what *denn* in (20b) conveys is that to interpret A's assertion, B has to learn that A meant Anna from Munich. This is not in line with the

given scenario: if B learned that Anna from Berlin was the intended referent, this would just as well enable her to interpret A's assertion and suitably react to it. In this sense, learning f_b is *not* a necessary precondition for proceeding from A_{-1}. Hence, *denn* is correctly predicted to be infelicitous in (20b).

We will return to the Two Annas case in Section 3.4.3 when discussing the differences between wh- and polar questions. For now, let's try to make two central notions used in the felicity condition more precise, namely, discourse acts and proceeding in discourse.

3.3.3. *Discourse acts*

In Section 3.2.1 we saw evidence for *denn*'s discourse anaphoricity. Whether the particle is felicitous in a question Q depends not only on Q itself, but also on the discourse preceding Q. How broad is the relevant notion of discourse events? In particular, in how far is *denn* sensitive to non-linguistic context?

Authors subscribing to the external-motivation view on *denn* (e.g., Thurmair 1991, Kwon 2005) generally acknowledge that the external motivation for the questioning act need not stem from the linguistic context. Rather, it can be supplied by some non-linguistic act by one of the interlocutors or even just by a piece of contextually available evidence. We have already seen an example of this happening: In the Frozen Lake case, *denn* signaled that an unusually low temperature is a precondition for the speaker to make sense of the lake being frozen. The fact that the lake is frozen is something that the interlocutors observed from extralinguistic evidence. For another example, consider (21). Here, *denn* conveys that it being past midnight is a precondition for the speaker to make sense of the fact that a night bus drove by. Again, the interlocutors observe the fact that the bus drove by from extralinguistic contextual evidence.

(21)   [Night Bus: A and B are walking home from a bar, when a bus, clearly recognizable as a night bus, drives by. As both A and B know, night buses run every day from midnight to 6am.]

A: Oh! Ist es denn schon so spät?
A: Oh! Is it denn *already that late?*

We may take these discourses to show that *denn* is indeed sensitive to non-linguistic contextual evidence. However, what seems to me like a more tenable approach is to view *denn* as sensitive merely to all communicative acts performed by interlocutors, no matter whether these acts are verbal or non-verbal. This excludes non-linguistic contextual evidence like frozen lakes or passing buses.

Why prefer this approach? It seems that in all relevant examples, such as NIGHT BUS or FROZEN LAKE, for a piece of non-linguistic evidence to serve as an antecedent for *denn*, it is not sufficient if this evidence is salient (in the sense of real-world salience). Rather, the interlocutors need to mediate between non-linguistic context and discourse by "importing" the non-linguistic evidence into the discourse, and they do so by using a small set of conventional *demonstration acts*. In face-to-face conversations, this set includes, e.g., a suggestive nod, a noticeable gaze accompanied by an utterance of *oh!* or *look!*, or a pointing gesture. Without such mediating demonstration acts, examples like NIGHT BUS and FROZEN LAKE would be infelicitous.[10]

I assume that demonstration acts like these are in fact linguistic in nature, that is, governed by conventional rules (cf., Stojnić *et al.* 2013, Stojnić *et al.* 2017). For our purposes, it will suffice to assume that they draw attention to some object, with the aim of updating the common ground with saliently observable facts about this object. For example, by pointing at the frozen lake, an interlocutor draws attention to the lake, with the aim of updating the common ground with the fact that the lake is frozen. I use the term *discourse act* to refer to all acts in discourse, including classic speech acts like assertions, questions and imperatives, non-verbal demonstration acts such as pointing and its analogs, and expressive acts like laughing, frowning or crying. We can then say that the antecedent picked up by *denn* is always a discourse act—when it appears that *denn* picks up non-linguistic evidence, it only picks up the information that gets imported into the discourse *via the demonstration act*.

Finally, there are certain uses of *denn* in wh-questions that don't seem to require an overt antecedent at all. I will postpone an explanation of these cases to Section 3.4.3.

3.3.4. *Proceeding*

So far, we have seen only a relatively narrow range of examples for what proceeding in discourse can amount to. In Two ANNAS, proceeding amounted to accepting some asserted information. What kept the interlocutor from doing so was her inability to interpret the assertion. In PARTY and FROZEN LAKE, proceeding also meant accepting information—asserted in the former case and

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[10]This is reminiscent of the role that demonstration acts play for determining the reference of pronouns. If a pronoun is used deictically in a discourse-initial utterance, no linguistic antecedent for the pronoun is available. Yet, as pointed out by Stojnić *et al.* (2017), the pronoun doesn't simply pick up that individual which is most salient in the given non-linguistic context, e.g., someone jumping up and down next to the interlocutors. What is needed to make this individual the referent of the pronoun is still some demonstration act, e.g., gazing at the individual.

demonstrated via contextual evidence in the latter case. But here, 'accepting' was used in a stronger sense: when describing what kept the speaker from proceeding, I resorted to saying that she can't 'make sense of' some piece of information or that she can't 'integrate' this information. It's now time to (a) give a definition of proceeding that covers a wider range of cases, and (b) to get more concrete on what exactly it means to integrate information.

3.3.4.1 *Proceeding from a discourse act*

By asking a *denn*-question, a speaker signals that something is keeping her from continuing with the discourse in the most straightforward or most desirable way. We say that something is keeping her from *proceeding*. But what exactly does it mean to continue in the most straightforward way? That depends on the preceding discourse act.[11]

Proceeding. Let A_{-1} be the preceding discourse act, h_{-1} the hearer/addressee of A_{-1} and s_{-1} the speaker of A_{-1}.

1. If A_{-1} is an **imperative**, then for h_{-1} to proceed from A_{-1}, h_{-1} has to accept that the felicity conditions of the imperative speech act are met and carry out the given instructions or commit to doing so at a later point.

2. If A_{-1} is a **question**, then for h_{-1} to proceed from A_{-1}, h_{-1} has to accept that the felicity conditions of the question speech act are met, and

   (a) if A_{-1} is a **wh-question**, h_{-1} has to answer this question,

   (b) if A_{-1} is a **polar question**, h_{-1} has to answer this question **positively**.

3. If A_{-1} is an **assertion**, then for h_{-1} to proceed from A_{-1}, h_{-1} has to accept that the felicity conditions of the assertion speech act are met and accept the information that is conveyed by A_{-1}.

4. If A_{-1} is an **expressive act**, then for h_{-1} to proceed from A_{-1}, h_{-1} has to accept the information that is conveyed by A_{-1}.

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[11] The notion of proceeding is defined here in terms of the *form* of a discourse act—imperative, question, et cetera—rather than in terms of the *force* that these acts can have—command, permission, inquiry, et cetera. By doing this, we are essentially assuming that every imperative issues a command, every question raises an issue, and every assertion provides information. This assumption is of course well known to be false (Davidson 1979, Bach and Harnish 1979): an utterance's linguistic form doesn't determine but merely constrains the utterance's force. At the same time, the assumption is pervasive in modern semantic work on discourse dynamics (Roberts 1996, Portner 2004, Farkas and Bruce 2010, Murray 2010)—and we won't deviate from it here.

5. If A_{-1} is a **demonstration act**, then for h_{-1} /s_{-1} to proceed from A_{-1}, h_{-1} /s_{-1} has to accept the information that is conveyed by A_{-1}.

6. If h_{-1} /s_{-1} transparently **entertains the plan** to perform an action, then, to proceed, h_{-1} /s_{-1} has to carry out this plan.

Observe that for those discourse acts that correspond to classic speech acts (imperatives, questions and assertions), proceeding always involves accepting that the felicity conditions of the speech act are met. These are simply felicity conditions in the sense of Austin (1962) and Searle (1969).[12] For instance, the felicity conditions for an assertion of p are often taken to include the speaker knowing p (Williamson 2002). If a speaker feels that this condition might not be met, he can make this the subject of a *denn*-question like (22). According to our felicity condition for *denn*, what the particle expresses in (22) is that B considers A's knowing the asserted content a necessary precondition for B to accept this content.

(22)   A: ⟨arbitrary assertion⟩

   B: Weißt du das denn auch sicher?
   B: Do you DENN *know this for sure?*

More generally, any of the above components of proceeding can be taken up in a *denn*-question with suitable highlighted content. Let's run through a number of examples. If A_{-1} is an imperative, the hearer may signal that she can't carry out the instructions, e.g., because she's missing some information for doing so, as in (23).

(23)   A: Hol heute Nachmittag bitte Karl vom Bahnhof ab!
   A: This afternoon, please pick up Karl from the station!

   B: Wann genau kommt er denn an?
   B: When exactly is he DENN *arriving?*

If A_{-1} is a wh-question, the hearer may signal that she can't answer the question, e.g., because the answer depends on some information she doesn't yet have. In (24), this missing information is A's income. If A_{-1} is a polar question, the hearer may ask whether a precondition for a positive answer to this question holds. In (25), being younger than eighteen is a precondition for getting a

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[12]For those discourse acts that don't correspond to speech acts (demonstration acts and expressive acts), proceeding doesn't involve accepting felicity conditions. This treatment is chosen mostly for simplicity. It seems plausible that demonstration acts—and conceivably also many expressive acts—do have felicity conditions. However, this is a complex topic, and I don't have anything to contribute to it here.

discount.

(24) A: Welche Steuerklasse habe ich?
      A: Which tax bracket am I in?

      B: Wie viel verdienst du denn?
      B: How much do you DENN earn?

(25) [Only people younger than eighteen can buy discounted tickets.]
      A: Gilt die Ermäßigung auch für mich?
      A: Am I eligible for the discount?

      B: Bist du denn noch unter achtzehn?
      B: Are you DENN below eighteen?

If A_{-1} is an assertion, the hearer may be unable to accept the asserted information because it clashes with her existing beliefs, as in Frozen Lake or Party. We will discuss this case in more detail in the next subsection.

   If an interlocutor is transparently entertaining a plan, but can't go through with this plan because she is missing some information, she may use a *denn*-question to convey this, as in (26).

(26) A: Ich schau mal gerade den Weg zu Lisas Party nach.
      A: I'm just gonna look up how to get to Lisa's party.

      [Takes out his phone.]

      A: Oh, wo wohnt sie *denn* nochmal?
      A: Oh, where does she DENN live again?

Finally, no matter whether A_{-1} is an imperative, a question or an assertion, the hearer can always fail to proceed because she can't interpret A_{-1}, as in Two Annas, or because she refuses to accommodate a presupposition of A_{-1}, as in (27).[13]

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[13]As brought to my attention by Julian Schlöder (p.c.), there is a striking counterexample to the rule that *denn*-questions can be used to request information needed to interpret A_{-1}. Namely, *denn* is infelicitous in the question *What did you say?* when this question is used for re-eliciting the previous utterance:

(i) Was hast du (#denn) gesagt?
     What did you (#DENN) say?

This is unexpected on the proposed account, since knowing what was said is a precondition for proceeding. I believe that to find an explanation we have to pay attention to the focus structure of the question. *What did you say?* in its re-eliciting use is unusual in that focus-marking on the wh-element seems to be obligatory although the wh-element appears ex-situ:

(ii) a.   WAS hast du gesagt?
      b.   #Was hast du GESAGT?

(27)   A: Kommt Anton's Freundin auch mit?
       A: Is Anton's girlfriend coming too?

       B: Hat er denn eine Freundin?
       B: Does he DENN have a girlfriend?

Although the proposed analysis is not implemented in any specific formal model of discourse, there are of course some points of contact with such models. Readers familiar with the Table model by Farkas and Bruce (2010) might prefer to think of proceeding from a question or proceeding from an assertion as reaching one of the states in the *projected set* (a set of privileged possible future common grounds). This view could also be extended to imperatives, e.g., by representing the common ground as a preference order over alternatives (Starr 2016) and letting imperatives project privileged future common grounds. However, turning to the remaining kinds of discourse acts (demonstration acts and expressive acts), it is much less clear how proceeding from these acts could be translated into the Table model. For instance, do expressive acts like laughing or subtle demonstration acts like gazing steer the conversation to any particular privileged future that should be represented in the discourse model? Do expressive acts provide expressive content, and does this expressive content enter the common ground at all? I don't know the answers to questions like these, and will not suggest any particular formal representation of demonstration acts and expressive acts here.

3.3.4.2 Integrating information

We still need to clear up what exactly it means to *integrate* information and in how far integrating information is important in a discourse at all. To begin with, consider once more the FROZEN LAKE case, a shortened version of which

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As illustrated in (iii), *denn* seems generally incompatible with focused wh-phrases, which are characteristic of echo questions (broadly construed), i.e., questions whose answer has been given in the immediately preceding utterance (for a recent account, see, e.g., Beck and Reis 2018). Moreover, if we provide a context for *What did you say?* that allows for focusing a non-wh-element, as in (iv), *denn* is acceptable.

(iii) *A: I invited Maria and Peter.*
       B: Ich hab gerade nicht zugehört. WEN hast du (#denn) eingeladen?
       B: I wasn't listening. WHO did you (#DENN) invite?

(iv)   *A: Hey there! I'm waiting for an answer.*
       B: Oh! Was hast du denn GESAGT?
       B: Oh! What did you DENN SAY?

I take these data to suggest that the infelicity of *denn* in (i) stems from a general incompatibility with echo questions. I will leave it for future work to identify the source of this incompatibility.

is repeated in (28).

(28) [Frozen Lake: A and B are walking by a lake that usually doesn't freeze. A notices the lake is frozen.]

A: Schau mal! War es denn diesen Winter kälter als normal?
A: Look! Was this winter DENN *colder than usual?*

To explain the felicity of *denn* here, I suggested that A can't make sense of the lake being frozen. Adopting our new terminology, we would say that A can't proceed because she can't *accept* the fact that the lake is frozen. Clearly, 'accept' is used in a technical sense here: A doesn't actually doubt the fact that the lake is frozen—after all she can see it with her own eyes. Rather, what is meant is that A can't *integrate* this fact with her existing beliefs. In particular, given her belief that the winters aren't cold enough for the lake to freeze, it's unexpected for A that the lake is frozen. If she tried to update her doxastic state with this fact, this would trigger belief revision: she would have to drop her belief about the local winter temperatures. What she does is to check whether the current winter has been unusually cold, i.e., whether adjusting her belief would be justified.[14] *After* learning that it indeed has been unusually cold, A would be able to update her beliefs with the fact that the lake is frozen without this causing belief revision. In this sense, again, learning the highlighted proposition of the *denn*-question is a necessary precondition for proceeding in discourse.

Note, however, that for A to react the way she does, is entirely optional. Faced with a surprising observation, an interlocutor might either decide to call attention to her surprise and try to resolve it, or she might simply let it pass. In the latter case, however, we would still want to say that she accepted the new information and thus proceeded in discourse. So, we have a tension here: sometimes, not being able to integrate information can keep an interlocutor from proceeding, but at other times, integrating seems to be optional for proceeding. We will sketch one possible way around this tension, by saying that these differences are due to differences in *conversational tone*. Conversational tone is a notion proposed by Yalcin (2007, p.1008) to capture which status the interlocutors ascribe to the propositions in the common ground:

Conversational tone. An attitude is the *conversational tone* of a group of interlocutors just in case it is common knowledge in the group that everyone is to strike this attitude towards the propositions which are common ground.

For instance, if the conversational tone is belief, interlocutors will take the

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[14]Cf. the related observations reported by Bublitz (1978, p.60) and Kwon (2005, p.114).

propositions in the common ground to be commonly believed. But the conversational tone could as well be supposition, just-going-along-with-whatever, pretense, ironic non-belief, and so on. Often, the purpose of the discourse will determine the conversational tone. A theater play might be associated with a conversational tone of pretense and a small talk conversation with a conversational tone of just-going-along-with-whatever, while a scientific discourse should usually have a conversational tone of at least justified belief.[15]

Using this notion, we can now give a definition of accepting in terms of conversational tone.

Accepting information. An interlocutor x *accepts* a proposition p just in case:
  (i) x comes to hold the current conversational tone towards p, and
 (ii) condition (i) can be satisfied without making any additional changes to x's doxastic state.

Let's say the conversational tone is belief. Then, for x to accept a proposition p, x has to come to believe p and, in order to come to believe p, x must not have given up any of her existing beliefs and she must not have added any new beliefs other than p. This could be the appropriate kind of setting for the FROZEN LAKE case, where inconsistency between new and old information prevents x from proceeding.

Sometimes, though, interlocutors seem to be even more ambitious in that they don't only want to avoid inconsistencies, but also want new information to follow from or be explained by old information. This is the kind of conversational tone that might be behind why-questions with *denn*. These questions, illustrated in (29), can follow virtually any assertion or imperative.

(29) Warum denn?
      Why DENN?

Here, the conversational tone might be something like understanding. Then, for x to accept a proposition p, x has to come to understand p and, in order to come to understand p, x must not have given up any of her existing beliefs and she must not have added any new beliefs other than p.

By contrast, if the conversational tone is the kind of going-along-with-everything attitude often employed in small talk conversations, then proceeding becomes much easier. For x to accept a proposition p, x might only have to acknowledge having heard p. Clause (ii) of the definition still requires that,

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[15]There are some shortcomings of this notion. In particular, as discussed in Murray and Starr 2018, assuming that conversational tone has to be common knowledge is problematic. For the current account, we will not pursue any alternative to Yalcin's notion, though.

in order to do so, x must not have given up any of her existing beliefs and she must not have added any new beliefs other than p—but this requirement is inconsequential in this case, since acknowledging having heard p will not involve any such changes to x's belief state.

So, the degree to which integrating new information is necessary for proceeding depends on how closely common ground and private doxastic states are connected. If they are relatively closely connected, they need to stay in sync, which means it's important for the discourse that interlocutors call attention to their problems with integrating new information. Integrating, in this case, is obligatory for proceeding. If, however, common ground and private doxastic states are only loosely connected, it's not as important to keep them in sync. Integrating, in this case, is only optional for proceeding.

Now that we have a better understanding of what it means to accept information, we can also appreciate cases of "intra-speaker" *denn*-questions. If a speaker x uses *denn*, the discourse act picked up by *denn* doesn't need to have been performed by another interlocutor—it can have been performed by x herself. For instance, this is the case in the Frozen Lake example, where the speaker uses a demonstration act. However, she might as well have asserted that the lake is frozen, with *denn* picking up this assertion, as in (30).

(30) A: Der See ist gefroren! War es denn diesen Winter kälter als normal?
   A: The lake is frozen! Was this winter denn colder than usual?

This would be suprising if the requirements for asserting p and proceeding from an assertion of p were the same. For example, it would be a reasonable assumption that asserting p and proceeding from this assertion both require believing p. Then, however, the speaker in (30) couldn't have any problem with proceeding. However, in order to explain the felicity of (30), we could say that, given certain conversational tones, proceeding has more demanding conditions than asserting. For example, believing p might be sufficient for asserting p, but in order to proceed from this assertion, it might be required that the speaker can also explain p.

3.4. *Predictions*

While the previous section had a rather conceptual flavor at times, we will now focus on linguistic data, spelling out some predictions that our account makes for *denn* in polar questions (Section 3.4.1), alternative questions (Section 3.4.2), wh-questions (Section 3.4.3), and conditional antecedents (Section 3.4.4).

3.4.1. Predictions for polar questions

To recap, if *denn* appears in a polar question, the highlighted property f is a 0-place-property, i.e., a proposition. Since there is only one instantiation of a proposition, namely the proposition itself, learning an instance of f amounts to learning f itself. So, according to our felicity condition from Section 3.3.2, *denn* can appear in a polar question just in case the speaker considers learning the highlighted proposition f a necessary precondition for herself to proceed from the preceding discourse act. But this is just to say that the speaker considers the truth of f itself a necessary precondition for proceeding.

A basic prediction following from this is that, given two polar questions that are indistinguishable in terms of their answerhood conditions, but differ in their highlighted propositions, *denn* might be acceptable in one of them but not the other. This is the case in (31). In (31a), f is the proposition that B doesn't need a key to open the door. What B conveys by using *denn* is that she can follow A's instruction only if she doesn't need a key. This question is felicitous with or without *denn*. In contrast, by using (31b), B conveys she has to learn that she *needs* a key. Since this can't reasonably be construed as a precondition for B to open the door, *denn* is degraded in (31b). Without *denn*, the question is completely fine.

(31) [OPENING DOORS: Only A has keys to open the door.]

A: Mach schon mal die Tür auf! Ich komm' gleich nach.
A: You go on and open the door! I'm coming in a minute.

a. B: Brauche ich (denn) keinen Schlüssel?
B: Do I (DENN) not need a key?

b. B: Brauche ich (??denn) einen Schüssel?
B: Do I (??DENN) need a key?

3.4.2. Predictions for alternative questions

Alternative questions are disjunctive questions with falling intonation on the final disjunct, as in (32). This intonational pattern sets them apart from polar disjunctive questions such as (33), which have a final-rise intonation (Pruitt and Roelofsen 2013).

(32) Are you arriving on Monday↑ or Tuesday↓?

(33) Do you have a loyalty card or a student ID↑?

We find that *denn* can appear both in alternative questions, as illustrated in (34),

and in polar disjunctive questions, as illustrated in (35).

(34)   A: Kannst du mich vom Bahnhof abholen?
       A: Can you pick me up from the station?

       B: Kommst du denn am Montag↑ oder am Dienstag↓?
       B: Are you DENN *coming on Monday↑ or Tuesday↓?*

(35)   [At the ticket counter.]
       A: Ein ermäßigtes Ticket bitte.
       A: One discounted ticket please.

       B: Haben Sie denn eine Kundenkarte oder einen Studentenausweis↑?
       B: Do you DENN *have a loyalty card or a student ID↑?*

To account for these data, we have to extend our definition of highlighted content, which so far doesn't cover alternative questions. Following Roelofsen and Farkas (2015), we assume that alternative questions highlight several propositions. By contrast, polar disjunctive questions highlight only a single proposition.[16] For instance, the alternative question (34) highlights both the proposition that A will arrive on Monday and the proposition that A will arrive on Tuesday. By contrast, the polar disjunctive question (35) highlights the proposition that A has a loyalty card or a student ID.

To generalize over the different sentence types, we will say that every sentence highlights n m-place properties. For alternative questions, $n > 1$, and for all other sentence types, $n = 1$.

We also need to adapt our felicity condition to this extended notion of highlighted content. Rather than presupposing, as we did before, that there is exactly one highlighted property, we now say that *denn* marks learning an instantiation of one of the possibly many highlighted properties as a necessary precondition:

(36)   **Felicity condition for *denn* (alternative-question version):**
       Given a salient previous discourse act A_{-1}, it is felicitous for a speaker s to use *denn* in a clause with highlighted properties $F = \{f_1, \ldots, f_n\}$ iff s considers learning an instantiation of at least one $f \in F$ a necessary precondition for herself to proceed from A_{-1}.

This condition predicts *denn* to be felicitous in (34) and (36). The alternative question (34) highlights two propositions (that A will arrive on Monday, that

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[16]Roelofsen and Farkas motivate this difference by appealing to the specific *yes/no*-responses licensed by alternative questions and polar disjunctive questions. The reader is referred to their paper for details.

A will arrive on Tuesday). By using *denn*, the speaker conveys that she has to learn one of these propositions before committing to pick up A from the station. The polar disjunctive question (36) highlights the proposition that A has a loyalty card or a student ID. By using *denn*, the speaker indicates that she can only sell a discounted ticket to A after learning that A has a loyalty card or a student ID.

This concludes our treatment of alternative questions. For all other sentence types, the more complex notion of highlighted content and the felicity condition boil down to their simpler versions. For readability, I will therefore use the simpler condition in the remainder of the paper.

3.4.3. *Predictions for wh-questions*

Let's now take a closer look at *denn* in wh-questions, and try to explain why *denn* in these questions can seem so different from *denn* in polar questions. To recap, for a wh-question, the highlighted property f is an n-place-property, with $n \geq 1$. So, according to our felicity condition, *denn* can appear in a wh-question just in case the speaker considers learning an instantiation of f a necessary precondition for herself to proceed from the previous discourse act.

3.4.3.1 *The asymmetry between polar questions and wh-questions*

We mentioned in the introduction that wh-questions are much more permissive than polar questions when it comes to licensing *denn*. In fact, it is rather difficult to find infelicitous examples of *denn* in wh-questions at all. The only clearly unacceptable cases are set in very sparse, unambiguous contexts such as the first Early waking context in Section 3.2.1. By contrast, it is relatively easy to find infelicitous occurrences of *denn* in polar questions.

The proposed account provides a natural explanation for this asymmetry. *Denn* in a wh-question merely signals that the informational request expressed by the question needs to be satisfied for the speaker to proceed. In a coherent discourse, this doesn't add much to the existing question meaning. By contrast, if a speaker uses *denn* in a polar question, she signals that the truth of a specific proposition is a precondition for proceeding—and this is a very clear addition to the existing meaning of a polar question.

When discussing the Two Annas case in Section 3.3.2, we already saw a concrete example, where the contribution of *denn* in a polar question renders this question infelicitous, while the weaker contribution of *denn* in the corresponding wh-question is perfectly acceptable.

3.4.3.2   'Denn' without antecedent

The permissiveness of *denn* in wh-questions goes even further. There are
some striking examples, where *denn* is licensed in a wh-question although this
question doesn't seem to be preceded by any suitable discourse act to which
denn could be anaphoric:

(37)   [Host asking guest at a dinner party:]
       Welchen Wein möchtest du denn?
       Which wine would you DENN *like?*

(38)   [Someone asking a passerby:]
       Wie komme ich denn von hier zum Bahnhof?
       How do I DENN *get to the station from here?*

(39)   [Katja is a common friend of A's and B's. A to B discourse-initially:]
       Sag mal... warum geht Katja denn nie ans Telefon?
       Say... why does Katja DENN *never answer her phone?*

I suggest that to make sense of data like these, we need to take the not-at-issue
meaning contributions of the relevant questions into account. Wh-questions
are often taken to presuppose that at least one of their answers is true (e.g.,
Horn 1972, Abusch 2010). For example, (37) presupposes that the hearer wants
wine. *Why*-questions additionally have a factivity presupposition (e.g., Katz
and Postal 1965): (39) presupposes that Katja never answers her phone. Finally,
by asking a how-question, such as (38), a speaker often conversationally impli-
cates that she desires the situation described in the question to come true: by
asking (38), the speaker implicates that she wants to reach the station.

   It seems that the above not-at-issue contributions play a role in providing
suitable antecedents for *denn* in various ways. Let's start with example (38). Re-
call from Section 3.3.4 that one of the ways in which an interlocutor can proceed
in discourse is by carrying out a plan that she has transparently been entertain-
ing. We may now say that the speaker in (38)—in particular by implicating that
she wants to reach the station—is transparently entertaining the plan of going
to the station. What is keeping her from carrying out that plan is her lack of
knowledge about how to get there. Hence, here it is the *denn*-question itself
that provides a context for the interpretation of *denn*.

   In example (37), the presupposition might act in concert with the social
protocol of having a dinner party. The host presupposes that the hearer wants
wine, and, being the host, she is thus trying to see to it that the hearer gets
wine. Again, she is transparently entertaining a plan. What is keeping her
from going through with this plan is her lack of knowledge about which exact

wine the guest would like to have.

Finally, in example (39), it seems to be the information provided by the presupposition itself that gets taken up by *denn*.

The speaker draws attention to the fact that Katja never answers her phone, and by asking a why-question, she signals that she can't integrate this fact yet. This is somewhat similar to the demonstration acts in FROZEN LAKE and NIGHT BUS. There, the speaker made some particular fact salient and then indicated that she can't integrate this fact. Just as in (39), this doesn't suggest that the speaker fails to *believe* this fact—after all, the fact is observable in FROZEN LAKE and NIGHT BUS and even presupposed in (39).

Why- and how-questions might be particularly suited to license *denn* without any contextual help. In part this might be owing to their not-at-issue contributions, in part because their question meaning links in so well with these contributions: how-questions seem to say, 'I want to *X*, but I can't proceed because I don't know how to *X*', and why-questions, 'I know that *p*, but I can't proceed because I can't make sense of *p*.'

3.4.4. Predictions for conditionals

The distribution of *denn* isn't limited to questions. As illustrated by (40), the particle can also appear in certain conditional antecedents (Brauße 1994, Csipak and Zobel 2016).

(40)   Caro kann gewinnen, wenn sie das denn will.
       Caro can win if she DENN wants to.

Denn-marked antecedents can also occur as bare antecedents, reacting to the preceding assertion by another interlocutor, as in (41).

(41)   A: Caro kann gewinnen.
       A: Caro can win.
       B: Wenn sie das denn will.
       B: If she DENN wants to.

We see that in both (40) and (41), the material picked up by *denn* precedes the particle. This is in line with the discourse-anaphora view on *denn* adopted in this paper. Indeed, a corpus study by Zobel and Csipak (2016) found that most occurrences of conditional *denn* follow this pattern. However, Zobel and Csipak also identified a number of other, significantly less frequent configurations. In particular, they found examples like (42), where *denn* doesn't seem to be anaphoric but rather cataphoric: its referent is provided by the consequent and

the consequent comes after the antecedent. Constructions like these show that the question of which material in a discourse can serve as a referent for *denn* is much more complex than assumed in the present paper, and also seems to be subject to syntactic factors.

(42)   Wenn sie denn nicht vermeidbar ist, wie sollte eine Kündigung kommu-
        niziert werden?
        If it_i DENN *can't be avoided, how should a dismissal_i be communicated?*
                                                        (Zobel and Csipak 2016, p.352)

I won't try to give an account of how conditional *denn* finds its referent, but focus on cases like (40) and (41) in which *denn* is clearly anaphoric. However, this still leaves open the question *what kind of* discourse move conditional *denn* is anaphoric to. For simplicity, let's assume that it picks up an assertion of the consequent. The property *f* highlighted by a conditional antecedent is simply the proposition expressed by the antecedent. Our felicity condition then predicts *denn* to be felicitous just in case the speaker considers the antecedent a necessary precondition for accepting the consequent. For example, in (40), *denn* signals that the speaker will only accept that Caro can win if the speaker learns that Caro wants to win. This condition is indeed very close to one of the felicity conditions that Csipak and Zobel (2016) provide for conditional *denn*.

3.4.4.1   *Conditional perfection*

The above treatment immediately leads us to an additional prediction: conditional *denn* turns its containing conditional into a biconditional. This happens because *denn* marks the proposition expressed by the antecedent as a *necessary* precondition for the consequent. From the at-issue meaning of the conditional, we already know that the antecedent is a *sufficient* condition for the consequent. So, taken together, this means the antecedent is necessary and sufficient for the consequent—in other words, the conditional is a biconditional. We hence predict *denn* to be a conventional means of expressing conditional perfection.

   We find that this prediction is indeed borne out. In (43a), *denn* is felicitous, while in (43b), where conditional perfection is canceled, *denn* is infelicitous. Similarly, *denn* is felicitous in (44a), while in (44b), where the antecedent is disjunctive, it is infelicitous for *denn* to occur in one or both of the disjuncts.[17] This is because (44b) supplies two sufficient conditions. If there are two sufficient conditions, neither of them can be necessary.

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[17]If *denn* only appears in the first disjunct, the infelicity is less pronounced, presumably because it can be understood as taking scope over the disjunction as a whole.

(43)   a.   Kritik ist willkommen, wenn sie denn konstruktiv ist.
          Criticism is welcome if it DENN is constructive.
      b.   Kritik ist willkommen, wenn sie (#denn) konstruktiv ist—und auch
          wenn sie nicht konstruktiv ist.
          *Criticism is welcome if it (#DENN) is constructive—and also if it isn't con-
          structive.*

(44)   a.   Wir gehen morgen Squash spielen, wenn denn Court 1 frei ist.
          We'll play squash tomorrow if DENN court 1 is free.
      b.   Wir gehen morgen Squash spielen, wenn (?denn) Court 1 frei ist oder
          wenn (#denn) Court 2 frei ist.
          *We'll play squash tomorrow if (?DENN) court 1 is free or if (#DENN) court 2
          is free.*

As a final note, however, recall that the meaning contribution of *denn* isn't
truth-conditional. There also is a truth-conditional way of expressing a bicon-
ditional, namely with *only if*. If conditional perfection gets canceled in an *only
if* biconditional, the resulting infelicity is more pronounced than that of (43)
and (44):

(45)   Kritik ist (#nur) willkommen, wenn sie konstruktiv ist—und auch wenn
      sie nicht konstruktiv ist.
      Criticism is welcome (#only) if it is constructive—and also if it isn't constructive.

3.4.4.2   *Possibility of a unified account*

To conclude this section on conditional *denn*, let us try to diffuse an argument
that Csipak and Zobel (2016) give against a unified account of *denn* in questions
and in conditional antecedents.

   Csipak and Zobel (2016) argue that *denn* in conditional antecedents (hence-
forth $denn_C$) but not *denn* in questions (henceforth $denn_Q$) carries what we might
describe as an *epistemic unassertability bias*: if a speaker uses a *denn*-antecedent,
she considers the proposition expressed by the antecedent too unlikely to as-
sert it. Csipak and Zobel (2016) implement this as a not-at-issue contribution
of $denn_C$:

(46) $[\![denn_C]\!](p) : \lambda w.\text{prob}(w, p) < T$, where T is at or below the threshold
      for assertability

In support of this analysis, they report that the continuation in (47) is infelicitous

in combination with *denn*, while without *denn* it is fine.[18]

(47)   Wir machen morgen ein Picknick, wenn (#denn) die Sonne scheint—und
das ist laut Wetterbericht sehr wahrscheinlich.
We are having a picnic tomorrow if (#DENN) the sun is shining—which the
weather report says is likely.   (after Csipak and Zobel 2016)

On Csipak and Zobel's account, *denn*$_C$ conventionalizes a meaning contribution
that is already present as a conversational implicature: if a speaker uses a con-
ditional, then, by standard Gricean reasoning, she conversationally implicates
that she considers the antecedent proposition unassertible. In order to find
out whether this unassertability bias is part of the conventional meaning of
denn, we have to consider contexts in which the conversational implicature is
suspended. If using *denn* in these contexts is acceptable and doesn't convey
an unassertability bias, we know that the unassertability bias can be canceled
and is thus pragmatic in nature. Otherwise, the bias can't be canceled and is
semantic. Consider (48).

(48)   [5-year-old Tina just learned there's a minimal age for becoming German
president. Now she wants to know which relatives are old enough to
become president.]
Tina: Can Grandpa Erich become president?
Father: I know the answer, but I want you to come up with it yourself. After all
you roughly know how old Grandpa Erich is. So, think about it:

Er kann Bundespräsident werden, wenn er denn mindestens 40 Jahre
alt ist.
He can become president if he DENN is at least 40 years old.

The context makes it clear that the father *could* assert the antecedent—he
chooses not to for pedagogical reasons. To me it seems that *denn*$_C$ is felici-
tous in (48) and no unassertability bias is conveyed. If this is right, the bias
can't be part of the conventional meaning of *denn*$_C$. I conclude that a unified
account of *denn*$_C$ and *denn*$_Q$ is in principle possible.

The oddness observed with the picnic example in (47) might stem from the

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[18]Notice that (46) doesn't explain the infelicity of (47) though. If we follow Csipak and Zobel
in assuming a threshold T for asserting a proposition, then it also makes sense to assume a
threshold for calling a proposition likely. I will refer to the latter as L. It is natural to assume
that $L < T$ (otherwise we would make undesirable predictions; e.g., *It is raining* would be
predicted to follow from *It it likely that it is raining*). Now, according to (46), *denn*$_C$ contributes
the condition that $\text{prob}(w, p) < T$, and the continuation in (47) contributes the condition that
$\text{prob}(w, p) > L$. In order to explain the infelicity of *denn*$_C$ in (47), these conditions would have
to be incompatible, but they are not: they are met if $L < \text{prob}(w, p) < T$.

fact that the antecedent (*if the sun is shining*) and the continuation (*which is very likely*) stand in a contrastive discourse relation. Standing in a contrastive discourse relation isn't the same as being inconsistent, though. If we insert a suitable contrastive discourse marker like *but*, the acceptability of *denn* improves:

(49) Wir machen morgen ein Picknick, wenn denn die Sonne scheint—aber das ist laut Wetterbericht sehr wahrscheinlich.
      We are having a picnic tomorrow if DENN the sun is shining—but the weather report says that that's likely.

Interestingly, in the absence of a contrastive discourse marker, a similar kind of oddness seems to arise if we use an *only if* conditional:

(50) Wir machen morgen (??nur dann) ein Picknick, wenn die Sonne scheint— und das ist laut Wetterbericht sehr wahrscheinlich.
      We are having a picnic tomorrow (??only) if the sun is shining—which the weather report says is likely.

I take these observations to indicate that the epistemic effect we can observe with conditional *denn* might be derivable from the discourse effect of asserting a biconditional.

3.5. *Lessons for other discourse particles*

So far, we have seen how an analysis of one specific discourse particle, namely *denn*, can profit from assuming that this particle is sensitive to the highlighted content of its containing clause. Concretely, this assumption allowed us to capture a certain asymmetry between *denn* in polar and wh-questions. There are some other particles, such as German *überhaupt* and closely related English *even*, that can appear in both polar and wh-questions, and which show a similar asymmetry in meaning. This section won't work out full accounts for any of these expressions. It will, however, offer some ideas for how highlighted content might be useful in their analysis.

3.5.1. *'überhaupt'*

German *überhaupt* comes in a stressed and an unstressed version. Here, we will focus on the unstressed version because it is most similar to both *denn* and English *even*. This kind of *überhaupt* can appear in polar interrogatives, as illustrated in (51), and wh-interrogatives, as illustrated in (52). In both cases it

might be translated as *even*. The polar question in (51) roughly translates as *Do you even drink alcohol?* and the wh-question in (52) as *Where are we even?*.

(51)   A: Möchtest du ein Glas Wein?   *A: Would you like a glass of wine?*
       B: Nein, Danke.   *B: No, thank you.*
       A: Hättest du gerne ein Bier?   *A: Would a beer appeal to you?*
       B: Nein.   *B: No.*
       A: TRINKST du überhaupt   *A: Do you ÜBERHAUPT DRINK alco-*
          Alkohol?   *hol?*
                                                        (Rojas-Esponda 2014, p.5)

(52)   [A and B are tourists in NYC, travelling on the subway.]
       A: In welche Linie müssen wir gleich umsteigen?
       A: Which train do we have to change to?
       B: Hmm... Wo SIND wir überhaupt gerade?
       B: Hmm... Where ÜBERHAUPT ARE we right now?

Überhaupt is also licensed in declaratives, as shown in (53), where the *überhaupt*-statement roughly translates as *I actually don't drink alcohol.*[19]

(53)   A: Möchtest du ein Glas Wein?   *A: Would you like a glass of wine?*
       B: Nein, Danke.   *B: No, thank you.*
       A: Hättest du gerne ein Bier?   *A: Would a beer appeal to you?*
       B: Nein. Ich trinke überhaupt   *B: No. I drink ÜBERHAUPT no alcohol.*
          keinen Alkohol.
                                                        (Rojas-Esponda 2014, p.3)

Rojas-Esponda (2014) gives an elegant unified account of *überhaupt* in polar interrogatives and declaratives, both in its stressed and unstressed version. Her account is formulated in terms of a certain kind of *Question under Discussion* tree (*QUD* tree), which represents hierarchical relations between questions: more general questions are higher in the tree, whereas more specific questions are lower. Simplifying from the details of her account, Rojas-Esponda analyzes unstressed *überhaupt* as a marker of *doubting moves*. These are moves which show that the current QUD (a higher node in the tree) is not answerable or which ask whether this QUD is answerable. For instance, (51) asks whether the QUD *What is the alcohol you want?* is answerable, and (53) shows it is not answerable.

Rojas-Esponda's account has two main shortcomings. First, it doesn't account for *überhaupt* in wh-questions. Second, it misses certain facts about

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[19]In order to get the reading corresponding to this translation, it's important that *überhaupt* doesn't bear any stress. If it was focused (*Ich trinke ÜBERHAUPT keinen Alkohol*), then the statement would mean *I don't drink any alcohol at all.* See Rojas-Esponda 2014.

highlighting in polar questions. I suggest that both problems can be solved by treating *überhaupt* as sensitive to highlighted content.

Let's first take a look at the restrictions that *überhaupt* imposes on highlighted content. In example (51), repeated in (54a), the *überhaupt*-marked polar question highlights the proposition that B drinks alcohol. Note that *überhaupt* isn't felicitous if instead the proposition that B doesn't drink alcohol gets highlighted, as in (54b). Crucially, though, the given context supplies contextual evidence for B not drinking alcohol, and does therefore license highlighting the negative alternative (Büring and Gunlogson 2000). This is evidenced by the felicity of (54) without *überhaupt*. We conclude that it must be the presence of *überhaupt* that dictates the conditions on highlighting here.

(54)   [Same beginning of the discourse as in (51).]
    a. A: Trinkst du überhaupt Alkohol?
       A: Do you ÜBERHAUPT drink alcohol?
    b. A: Trinkst du (#überhaupt) keinen Alkohol?
       A: Do you (#ÜBERHAUPT) drink no alcohol?

Now, how should we approach a highlighting-sensitive semantics of *überhaupt*? I suggest that the contributions of *denn* and unstressed *überhaupt* in questions are actually very similar. Intuitively, *überhaupt* is something like a QUD-sensitive version of *denn*: from the perspective of *denn*, discourse seems to be merely a linear list of utterances, whereas from the perspective of *überhaupt* discourse is organized hierarchically. More concretely, I propose the following felicity condition for *überhaupt* in questions. It doesn't capture the contribution of *überhaupt* in assertions. Therefore, it isn't intended to replace Rojas-Esponda's full account, but just to give a quick impression of how highlighted content could be integrated.

(55)   **Felicity condition for *überhaupt* (building on Rojas-Esponda 2014):**
    It is felicitous for a speaker s to use *überhaupt* in a question with highlighted property f iff s considers learning an instantiation of f a <u>necessary precondition</u> for answering the current QUD.

This condition is almost exactly like the one for *denn*, the only difference being that it talks about a precondition for answering the QUD rather than for proceeding in discourse. It predicts that *überhaupt*-marked polar questions ask whether the precondition for answering the QUD holds—that is, whether the QUD is answerable. The condition also captures *überhaupt* in wh-questions. *Überhaupt* in (52), for example, is predicted to signal that learning the location is a precondition for answering the QUD. This is in

line with our intuitions for (52).

Finally, let's check whether our felicity condition predicts the correct highlighting patterns. I think it's helpful at this point to observe that the felicity condition for *denn* and that for *überhaupt* sometimes coincide. They do so exactly if proceeding in discourse (as defined in Section 3.3.4) is the same as answering the current QUD. This again is the case whenever the QUD gets explicitly asked in the preceding discourse move, as in (52) or (56). In discourses like that, *überhaupt* and *denn* can be used interchangeably (modulo a slight difference in tone). For instance, in (52) the question *Which train do we have to change to?* is both the QUD and the preceding discourse move. Hence, knowing where A and B are can be construed as a precondition both for proceeding in discourse and for answering the QUD. Similarly with (56), where Peter's having kids is a precondition both for answering the QUD and for proceeding.

(56)   A: Wie heißen Peters Kinder?
       A: What are Peter's kids called?

       B: Hat er denn/überhaupt Kinder?
       B: Does he ÜBERHAUPT have kids?

However, proceeding in discourse and answering the QUD don't always coincide. They can come apart whenever the QUD is not explicitly asked in the preceding discourse move. This is the case in (51), where the QUD is *What is the alcohol you want?*, whereas the preceding discourse move is B's assertion of *No* (=*I don't want a beer.*). We find that *überhaupt* but not *denn* is acceptable in A's final question, as shown in (57a). This is correctly predicted by our felicity condition, since B drinking alcohol can be construed as a precondition for answering the QUD, but not for accepting the assertion that B doesn't want a beer. By contrast, if the polar question highlights the negated alternative, as in (57b), the pattern is reversed: *denn* but not *überhaupt* is acceptable. This is also predicted by our felicity condition: B not drinking alcohol is not a precondition for answering the QUD, but can be construed as a precondition for integrating the fact that B turned down A's offers of wine and beer.

(57)   [Same beginning of the discourse as in (51).]
       a. A: Trinkst du überhaupt/#denn Alkohol?
           A: Do you ÜBERHAUPT/#DENN drink alcohol?
       b. A: Trinkst du #überhaupt/denn keinen Alkohol?
           A: Do you #ÜBERHAUPT/DENN drink no alcohol?

3.5.2. English 'even'

The English focus particle *even* leads a double life as a discourse particle, whose usage and contribution seem very similar to that of unstressed *überhaupt*, described in the last subsection.[20] In fact, we can replace all occurrences of *überhaupt* in the relevant interrogative examples above by *even* without changing the meaning in any obvious way.

Iatridou and Tatevosov (2016) account for discourse particle *even*, exploring its commonalities with focus particle *even*. Their analysis builds on the idea that discourse particle *even*, just like focus particle *even* has a scalar semantics: it marks its containing question as that question among a group of possible questions that is least likely to be asked. While their approach is attractive, it is rather different from mine and that by Rojas-Esponda (2014), and I won't discuss its details here.

I suggest, however, that Iatridou and Tatevosov's account might profit from incorporating highlighted content. This is because, as shown in (58), *even* exhibits the same restrictions with respect to highlighted content as *überhaupt*. As argued in the previous subsection, these restrictions don't correspond to those imposed by the context, and therefore should be attributed to the particle.

(58)   A: Would you like a glass of wine?
        B: No, thank you.
        A: Would a beer appeal to you?
        B: No.

   a.   A: Do you (even) drink alcohol?
   b.   A: Do you (#even) drink no alcohol?

Though Iatridou and Tatevosov's account doesn't capture the data in (58), they foreshadow the usefulness of highlighting in a very accurate way. When comparing *even* in polar questions and in wh-questions, they describe the exact asymmetry in meaning that we have been tracking for *denn*:

> "[With] a wh-question [. . .], there may be an intuition of an "epistemic" prerequisite. **I need to know** where it is **before I can** tell you if I can go there. But in the Y/N case we are talking about an additional prerequisite effect. There the effect [. . .] is that **the world has to be a certain way** (an affirmative answer to the [. . .] question), for the issue/proposal in the QUD to be possible."
>
> (Iatridou and Tatevosov 2016, f.n.41, my emphasis)

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[20]The main difference is that, unlike *überhaupt*, *even* can't appear in declaratives. Furthermore, stressed *überhaupt* doesn't seem to bear any resemblance to *even*.

Rather than making the prerequisite effect the primary meaning contribution of the particle, as we did with *denn*, Iatridou and Tatevosov (2016) derive it from the general discourse function of polar questions. If I understand correctly, for Iatridou and Tatevosov, the prerequisite effect stems from the fact that a polar question Q needs to receive a positive answer to allow the discourse to continue with a "subquestion" of Q. For example, in (59), B's question whether the creature is warm-blooded needs to receive a positive answer in order to allow A and B to continue the discourse by pursuing a subquestion of B's question. In particular, a positive answer will allow them to pursue the subquestion *Is the creature a mammal?*. This is because a negative answer to B's question would in one fell swoop resolve all subquestions negatively—among them also the question whether the creature is a mammal.

(59)   A: Is this creature a mammal, you think?
       B: Is it even warm-blooded?   (Iatridou and Tatevosov 2016, p.322)

I don't find this argument convincing. I grant that it is indeed a commonly employed discourse strategy to ask a polar question whose highlighted alternative expresses a precondition. Crucially, however, it is not the only discourse strategy available to interlocutors. Instead of inquiring about the warm-bloodedness of the creature, B could react, e.g., by asking (60a), which, unlike the warm-bloodedness question, is a "subquestion" of *Is this creature a mammal?* (if the creature is a platypus, it's also a mammal). However, being a platypus certainly isn't a precondition for being a mammal. Therefore, as expected, discourse particle *even* is infelicitous in this question, (60b).

(60)   a. B: Is it perhaps a platypus?
       b. #B: Is it even a platypus?

To clarify, I don't deny that interlocutors tend to follow certain general discourse strategies and that these strategies can impose certain restrictions on highlighted content. However, I think that speakers have a choice between a range of such strategies. The view put forward in this paper is that what *even* and related particles do is to *conventionally* signal one specific discourse strategy, namely the "precondition" one. This perspective is in line with the data in (60), as well as with the highlighting patterns in (58).
This concludes our discussion of discourse particles in general and discourse particle *denn* in particular. In the remainder of the paper, we will turn to the use of *denn* as a causal conjunction.

3.6. Causal conjunction 'denn'

Discourse particles often lead double lives as members of other word classes. For instance, the German discourse particle *ja* is homonymous with a response particle; the English discourse particle *even* is homonymous with a focus particle; and there are many more examples. Discourse particle *denn* is homonymous with a conjunction that expresses, roughly, a causal or precondition-like relationship between two sentences (Pasch *et al.* 2003). The closest English equivalent of this kind of *denn* is the (archaic) conjunction *for*. In this section we will explore how our account of discourse particle *denn* can be extended to also cover causal conjunction *denn*.

3.6.1. Data

In many contexts, causal *denn* is synonymous with the standard causal conjunction *weil* 'because':

(61) a. Die Straße ist ganz nass, denn es hat geregnet.
   b. Die Straße ist ganz nass, weil es geregnet hat.
      The street is wet DENN/WEIL *it rained.*

However, *denn* can express a wider range of semantic relationships than *weil*. In particular, *denn*-clauses but not *weil*-clauses can be used to provide justifications for assertions:

(62) a. Es hat geregnet, denn die Straße ist ganz nass.
   b. #Es hat geregnet, weil die Straße ganz nass ist.
      It rained DENN/#WEIL *the street is wet.*   (Scheffler 2005)

Moreover, and this is particularly relevant for us, *denn* can be used to express a precondition relationship, whereas *weil* cannot:

(63) a. Das Streichholz entzündete sich, denn es war genügend Sauerstoff in der Luft.
   b. #Das Streichholz entzündete sich, weil genügend Sauerstoff in der Luft war.
      The match lit DENN/#WEIL *there was enough oxygen in the air.*

Finally, different from *weil*-clauses, *denn*-clauses can't answer why-questions:

(64) *Why is Sophie relieved?*
   a. Weil sie ihre letzte Prüfung hinter sich hat.

move	speaker	hearer/addressee
question	recipient	source
assertion	source	recipient

<small>TABLE</small> 3.1.   Connections between hearer/speaker and recipient/source roles

b. *Denn sie hat ihre letzte Prüfung hinter sich.
   *WEIL/*DENN she is done with her last exam.*

Scheffler (2005) explains this last contrast by treating the causal relationship conveyed by *denn* as a conventional implicature and that expressed by *weil* as asserted.[21]

3.6.2. *Predictions for causal conjunction 'denn'*

With our treatment of question *denn*, we have already made some headway towards a unified account. We took *denn* to signal that the speaker considers learning an instantiation of the highlighted property f a necessary precondition for proceeding in discourse. Among other things, this can mean that an instantiation of f is an explanation for the preceding discourse act: in this case, by using a *denn*-question, a speaker demands an explanation before she is willing to proceed (cf. the discussion in Section 3.3.4). The most general example of this are *denn*-marked bare why-questions:

(65)   Warum denn?
       Why DENN?

Overall, this perspective seems to fit well with the fact that causal conjunction *denn* can also convey that its prejacent is an explanation or a cause for the content expressed by the preceding sentence. If we look more closely, though, there are still a few issues to solve.

3.6.2.1 *Interrogative flip*

Recall that with question *denn*, the speaker considers learning an instantiation of the highlighted property f a precondition *for herself* to proceed. On the other

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[21]For a similar observation and treatment of English *since*, see Charnavel (2017).

hand, with causal conjunction *denn*, the speaker doesn't ask for information, but rather provides information *for the hearer*, in the hope that this will convince her. We can capture this role reversal by treating *denn* as subject to so-called *interrogative flip* (Fillmore 1975, Mitchell 1986).

In a discourse, there are several ways of assigning roles to interlocutors. If we assign them based on who makes a discourse move, the roles are those of speaker and hearer/addressee. But if we focus on the direction of information transfer, i.e., if we take a more "evidential" perspective, we arrive at the roles of *recipient* and *source*, where the source is the interlocutor providing information and the recipient the interlocutor receiving information. If the speaker asks a question, she is the recipient, while the hearer/addressee is the source. On the other hand, if the speaker makes an assertion, she is the source, while the hearer/addressee is the recipient. These connections between the different roles are summarized in Table 3.1.

Perspective shifts that depend on illocutionary force are not uncommon in natural language: there are many perspective-dependent expressions that make the speaker the relevant perspective-holder when they occur in assertions, and make the hearer/addressee the relevant perspective-holder when they occur in questions. For example, whereas illocutionary adverbs like *honestly* are anchored to the speaker in assertions, in questions they are anchored to the hearer (Faller 2006). This perspective shift is usually called *interrogative flip* or *evidential flip* (Fillmore 1975, Mitchell 1986).

(66) a. Honestly, it was Mary who ate the biscuits.
      b. Honestly, who has eaten the biscuits?

Adopting the distinction between recipient and source, we arrive at the below felicity condition, which is applicable to both question *denn* and causal conjunction *denn*. It predicts that with question *denn*, it is the speaker who needs to learn an instantiation of f, whereas with causal conjunction *denn* it is the hearer.

(67) **Felicity condition for *denn* (interrogative-flip version):**
      Given a salient previous discourse act A_{-1}, it is felicitous for a speaker s to use *denn* in a clause with highlighted property f iff s considers learning an instantiation of f a necessary precondition for the recipient to proceed from A_{-1}.

3.6.2.2 *Necessary precondition vs. possible explanation*

There is (at least) one remaining problem when we try to apply this felicity condition to causal conjunction *denn*. Given two sentences with the same

highlighted proposition f, our felicity condition would predict that *denn* is either felicitous in both sentences or in neither sentence. This isn't always the case, however. For instance, *denn* is felicitous in the assertion in (68) but not in the corresponding polar question in (69) (unless B believes that selling drugs is the only possible explanation for why Karl has to go to jail).

(68)   Karl muss ins Gefängnis, denn er hat Drogen verkauft.
       Karl has to go to jail, DENN he sold drugs.

(69)   *A: Karl has to go to jail.*
       B: #Hat er denn Drogen verkauft?
       B: #Did he DENN sell drugs?

Intuitively, *denn* in (69) is unacceptable because Karl having sold drugs can't be construed as necessary in the relevant sense—there could have been other reasons for him going to jail. On the other hand, Karl having committed a crime can easily be understood as a necessary precondition, as shown by the felicity of *denn* in (70). The problem then seems to be that question *denn* marks learning an instantiation of f as necessary, while causal conjunction *denn* introduces explanations that are often merely possible, not necessary.

(70)   B: Hat er denn ein Verbrechen begangen?
       B: Did he DENN commit a crime?

In order to capture this difference, we introduce one more level of modality into the felicity condition: instead of requiring that the speaker considers learning an instantiation of f necessary, we now only require that the speaker considers it *possible* that learning an instantiation of f is necessary.

(71)   **Felicity condition for *denn* (modalized interrogative-flip version):**
       Given a salient previous discourse act A_{-1}, it is felicitous for a speaker s to use *denn* in a clause with highlighted property f iff s considers it possible that learning an instantiation of f is a necessary precondition for the recipient to proceed from A_{-1}.

In a modal logic, this nesting of modalities would be expressed as $\Diamond_S \Box_R \varphi$ (it is possible for the speaker S that it is necessary for the recipient R that φ). The effect of $\Box_R$ depends on whether the recipient R is the speaker or the hearer.

   In questions, the speaker is the recipient. This means that for questions the above felicity condition requires the speaker to consider it possible that learning an instantiation of f is a necessary precondition *for herself* (= recipient) to proceed in the discourse. That is, $\Diamond_S \Box_R \varphi$ amounts to $\Diamond_S \Box_S \varphi$. We make the

natural assumption that agents are fully introspective with respect to their own preconditions for proceeding in discourse (i.e., we assume that $\Diamond_x \Box_x \varphi \Leftrightarrow \Box_x \varphi$ for all x and φ). Under this assumption, considering it possible that f is a precondition for oneself simply boils down to considering f a precondition. It follows that for questions the new, modalized felicity condition simply boils down to the old one.

Let's now turn to assertions. In assertions, the hearer is the recipient. This means that for assertions the above felicity condition requires the speaker to consider it possible that learning an instantiation of f is a necessary precondition *for the hearer* to proceed. That is, $\Diamond_S \Box_R \varphi$ amounts to $\Diamond_S \Box_H \varphi$. While we do assume that agents are introspective with respect to their own preconditions for proceeding, we don't assume that they are introspective with respect to other agents' preconditions for proceeding. This means that we cannot reduce the felicity condition any further. There is, however an intuitive way of understanding the nested modalities here. We may think of a speaker who makes a *denn*-marked assertion as preemptively answering a *denn*-marked polar question that she thinks the hearer might ask.

This perspective allows f to be any proposition that a hearer might need confirmed in order to accept a discourse move or a piece of information. For instance, f could explicitly reconfirm a presupposition, as in (72), or some other precondition, as in (73). Moreover, f could be a cause as in (68) above and in (74) below; it could be a justification for an assertion as in (62) or a justification for an order as in (75).

(72) Ist dir gar nicht aufgefallen, dass du viel zu schnell fährst? Denn das tust du.
Haven't you noticed that you are driving way too fast? Denn *you are.*

(73) Geh schon mal vor! Denn du kennst ja den Weg.
You go ahead! Denn *you know the way.*

(74) Der See ist gefroren, denn es war diesen Winter kälter als normal.
The lake is frozen. Denn *this winter was colder than usual.*

(75) Ich gebe Ihnen ausdrücklich den Befehl, es so und so zu machen, denn ich bin Ihr Vorgesetzter.[22]
I explicitly order you to do so-and-so, denn *I'm your superior.*

To wrap up, this section identified a common semantic core of causal *denn* and particle *denn*. We have seen what the main semantic parallels and differences

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[22]Example from `https://dict.leo.org/forum/viewUnsolvedquery.php?idThread=1149521`, accessed on Aug 8, 2018.

between them are, and how they might be captured in a unified account.

3.7. *Conclusion*

This paper developed a unified semantic account of the German discourse particle *denn* that captures the use of this particle in polar questions, wh-questions and certain conditional antecedents. The starting point was the observation that *denn* exhibits an asymmetry in meaning, depending on whether it appears in polar questions or wh-questions. I argued that we can naturally capture this asymmetry by treating *denn* as sensitive to the property highlighted by its containing clause. More specifically, I suggested that *denn* connects this highlighted property to the preceding discourse: it expresses that learning an instantiation of the highlighted property is a necessary precondition for the speaker to proceed in discourse.

Finally, this paper offered some ideas for how highlighting-sensitivity might be used in the analysis of discourse particles other than *denn*, and extended the account of discourse particle *denn* to also cover the use of *denn* as a causal conjunction.

Chapter 4.
When additive particles can associate with wh-phrases

4.1. Introduction

English has several additive particles, which differ in their distribution across sentence types. This paper will focus on *also*, which is a common choice to express additivity in assertions and polar questions:

(1)   a. Mary also danced.
      b. Did Mary also dance?

In wh-questions the choice of additive particle depends on the phrase with which the particle associates. If it associates with a non-wh-phrase, as in (2), then the use of *also* is acceptable; but if it associates with the wh-phrase, as in (3a), then the use of *also* is marked—we will discuss how exactly it is marked in the following section.[1] In order to express additivity in this latter case, speakers typically employ *else*, as in (3b).

(2)   Lots of people danced the WALTZ. But who also danced the JIVE?

(3)   JOHN danced the waltz.

      a. #Who also danced the waltz?
      b. Who else danced the waltz?

This paper investigates under which circumstances it is acceptable for *also* to associate with a wh-phrase. We will derive the basic distributional properties

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[1]To be precise, in assertions and polar questions, the acceptability of *also* depends on the associated phrase as well: e.g., *also* cannot associate with negative universal quantifiers (*#Bob also called NOBODY*). Although data points like this aren't the main focus of the present paper, they will be predicted by the account to be proposed here.

of this additive particle and discuss how these properties interact with certain non-canonical questioning scenarios.

The paper is structured as follows. Section 4.2 introduces the key data. Section 4.3 provides some background on additive presuppositions and the question-under-discussion model in which the account will be formulated. In Section 4.4, a generalized additive presupposition is proposed, and in Section 4.5, it is demonstrated how this presupposition accounts for the distribution of *also* in assertions, polar questions and different kinds of wh-questions. Section 4.6 concludes.

4.2.   'Also' in showmaster and summoning questions

There are several recent papers that discuss the differences between the two German additive particles *auch* and *noch* (Umbach 2012; Grubic 2017, see also Eckardt 2006).[2] Though these accounts are concerned with data from German, they are immediately relevant for us, since, as we will see, the pertinent differences between *auch* and *noch* correspond to those between *also* and *else*. Here I discuss a generalization about *auch* due to Umbach (2012) and challenge it on the basis of previously unnoticed data.

4.2.1. Showmaster questions

Umbach (2012) maintains that *auch* can only associate with the wh-phrase in a wh-question if the question is interpreted as a *showmaster question*, i.e., a question the speaker asks while already knowing the answer. Typically, a speaker will ask a showmaster question in order to prompt the hearer to say the answer out aloud. As an illustration, Umbach provides the example in (4), which involves three people, little Lisa, Lisa's mother, and Auntie. Since Auntie has been to the zoo with Lisa, she knows the answer to the question in (4); she is merely trying to prompt Lisa to tell her mother the answer too.

(4)   [Lisa tells her mom what happened when she visited the zoo with Auntie.]
       Auntie to Lisa: Und was ist im Zoo auch passiert?
       Auntie to Lisa: And what also happened at the zoo?   (Umbach 2012, p.1845)

Observe that *auch* is acceptable in (4), although it associates with the wh-phrase. English *also* patterns with *auch*: the English translation of (4) receives

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[2]For a recent investigation into the semantics of additive particles in questions, albeit with a different focus than that of the current paper, see also Schmitt 2018.

a showmaster interpretation and it seems to be this interpretation that makes *also* acceptable.

Other possible scenarios for showmaster questions include oral examinations, as in (5), or lively narrative discourses like (6). Again, both *auch* and *also* are acceptable in these examples.

(5) [Examiner after student has given an incomplete answer:]

Gut, aber was ist 1776 auch passiert?
Good, but what also happened in 1776?

(6) Ich stand vor dem Eingang, und wer stand da plötzlich auch?
I was standing in front of the entrance, and who also stood there all of a sudden?
(Reis and Rosengren 1997, quoted from Umbach 2012, p.1850)

4.2.2. *Extant accounts of 'also' in showmaster questions*

Umbach (2012) herself and Grubic (2017) have suggested explanations for why *auch* triggers a showmaster interpretation when it appears in wh-questions. I critically discuss both accounts, starting with Grubic's proposal.

4.2.2.1 *Grubic (2017)*

Grubic's account is formulated in a *question-under-discussion* (*QUD*) framework and treats *auch* as signaling that a previously addressed QUD gets re-opened with respect to a larger wh-domain.[3] According to Grubic, the showmaster effect is pragmatic and stems from Gricean reasoning along the following lines. A speaker will only re-open a QUD with respect to a larger wh-domain if she has a reason to do so. A plausible reason is that the speaker thinks that in the previously given answer relevant alternatives were forgotten or ignored.

A problem I see with this line of explanation is that it only derives a relatively weak implicature, namely that the speaker considers the existing answer incomplete—not that she already knows the answer to the *auch*-question. This is problematic because a scenario in which the speaker merely thinks the answer is incomplete doesn't seem to license *auch*. For instance, in (7), if B merely considers A's answer incomplete but doesn't know which exact books A read over the summer, then it isn't acceptable for B to use *also*.

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[3]I summarize only those features of Grubic's proposal that are relevant for the showmaster effect. Her full account uses situation semantics (Kratzer 2011) and captures a range of differences between *auch* and *noch*. It treats *auch* as signaling that the QUD gets re-opened with respect to the same *topic situation* but a different *resource situation*. Since Grubic additionally assumes that QUDs cannot get re-opened with respect to the same topic situation and a smaller domain, this means that for her *auch* signals a re-opening of a QUD with a larger domain.

(7) [Over the summer, every student has to read two books of their choice.
     Back at school, A is reporting what she read:]
     A: On vacation, I read Emma.
     B: Okay, cool. #Und was hast du auch gelesen?
     B: Okay, cool. #And what did you also read?

4.2.2.2 Umbach (2012)

Umbach's explanation for the showmaster interpretation is based on the following reasoning. If additive particles associate with a wh-phrase, they follow their associated phrase rather than preceding it. This configuration—an additive particle following its associated phrase—shows up not only in questions, but also in assertions (Altmann 1976), as illustrated in (8).

(8) Mary danced, and John ALSO danced.

Krifka (1998) argues that if an additive particle appears in this configuration, its associated phrase is a *contrastive topic* (cf., Jackendoff 1972, Büring 2003). Now, since *auch* in the relevant questions associates with the wh-phrase, Umbach concludes that the wh-phrase must be a contrastive topic. According to Umbach, contrastive topics need to be referential and wh-phrases are not referential in a suitable way. She concludes that if *auch* associates with the wh-phrase, it coerces a referential interpretation of the wh-phrase, and that this is the cause of the showmaster interpretation:[4]

> "...The wh-word is, as a rule, unsuited to serve as a contrastive topic because it is not referential. However, in showmaster questions the need for a contrastive topic imposes a referential interpretation on the wh-word, which is why these questions presuppose that the speaker is familiar with the answer."   (Umbach 2012, p.1858)

This means that Umbach's account predicts a showmaster interpretation to arise whenever *auch* associates with the wh-phrase. We are now going to see some novel data not in line with this prediction.

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[4]Umbach provides too little detail to judge how plausible this argument is. It remains unclear, e.g., what exactly a referential interpretation of the wh-phrase is, and why familiarity with the answer follows from such an interpretation. However, it is indeed an interesting question whether wh-phrases can be contrastive topics (CTs), and if so, how this may be derived in a theory of CTs. The problem might be similar to that posed by generalized quantifiers acting as CTs (Rooth, 2005; Constant, 2014; Chapter 4). Also see the remarks in Section 4.6.

4.2.3. *Summoning questions*

Umbach's prediction is too strong. Not all questions in which *auch* associates with the wh-phrase receive a showmaster interpretation. A case in point are a certain class of questions, which to my knowledge have not been discussed in the literature so far. I will refer to them as *summoning questions*. A summoning question is a question that typically is posed directly to a group of people, with the aim of finding out who of these people have a certain property. The summoning question in (9), for instance, could be posed by an instructor to a class of students at the beginning of a semester.

(9)   Who here is taking this course for credit? Raise your hands!

As shown in (10), summoning questions can host *auch/also*, and they do so without triggering a showmaster effect. In (10a) and its English translation, for instance, the question of who wants an ice cream is genuine: the speaker doesn't have anybody particular in mind, contrary to what Umbach's account would predict.

(10)   a.   Wer will auch ein Eis?
              Who also wants an ice cream?
        b.   Wer ist auch dafür, zu gehen?
              Who is also in favor of leaving?
        c.   Wer von euch ist auch bei Snapchat?
              Who here is also on Snapchat?

Finally, note that by default the speaker will act as the antecedent for the additive particle in summoning questions. In (10a), for example, the speaker is presupposing that she herself wants an ice cream.[5] However, as illustrated in (11), it doesn't seem necessary for licensing *auch/also* that the speaker is the antecedent.

(11)   Ich geh gleich ein Eis für Maria holen. Wer von euch will auch eins?
        I'm getting an ice cream for Mary. Who of you guys also wants one?

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[5]It's an interesting question, though probably orthogonal to our purposes here, why additive presuppositions in summoning questions can be accommodated so easily, whereas they have been observed to resist accommodation in other environments (Kripke 1991/2009).
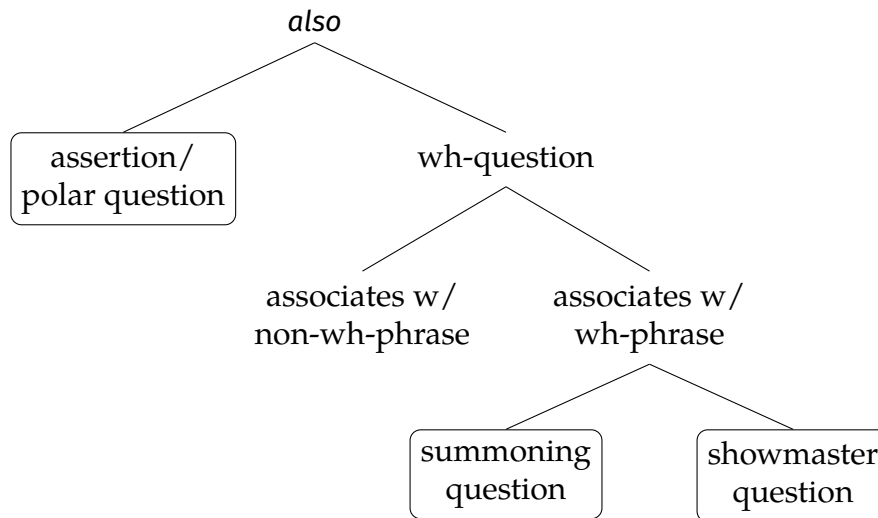
FIGURE 4.1. Distribution of *also*/*auch*

4.2.4. *Summary of the data*

Let's recap the empirical picture. We have seen that, while *also* can easily appear in assertions and polar questions, the particle is only acceptable in canonical wh-questions if it doesn't associate with the wh-phrase. If it does associate with the wh-phrase, *also* is only acceptable if the containing question is a summoning question or a showmaster question. This distribution is summarized in Figure 4.1.

In this paper, we will only account for a subset of these data, leaving aside for now the case where *also* appears in a wh-question but associates with a non-wh-phrase (that is, we will account for all the boxed cases in Figure 4.1).

4.3. *Background on additive presuppositions*

Before turning to the positive proposal in the next section, we will review some basic properties of additive particles and see how these properties can be captured in a QUD framework.

4.3.1. *Focus sensitivity*

Additive particles are focus-sensitive. Their presupposition depends on the focus structure of their containing sentence. For example, (12a), where *dog* is

focused, presupposes that John gave something other than a dog to Mary, while (12b), where *Mary* is focused, presupposes that John gave a dog to someone other than Mary.

(12) a. John also gave a [dog]$_F$ to Mary.
         $\rightsquigarrow$ John gave something other than a dog to Mary.
      b. John also gave a dog to [Mary]$_F$.
         $\rightsquigarrow$ John gave a dog to somebody other than Mary.

This focus sensitivity can easily be implemented in alternative semantics (Rooth 1992): if *also* appears in a sentence S, then it presupposes that there is a true alternatives p in the focus semantic value of S such that p is different from the ordinary semantic value of S. We will refer to the first part of this presupposition as the EXISTENCE condition and to the second part as the NON-IDENTITY condition. For example (12b) above, these conditions amount to the following.

(13) John also gave a dog to MARY.
      $\rightsquigarrow$ There's a true $p \in [\![$John gave a dog to MARY$]\!]^F$ EXISTENCE
      such that $p \neq [\![$John gave a dog to MARY$]\!]^0$ NON-IDENTITY

It has been suggested in the literature that this formulation falls short, though: both EXISTENCE and NON-IDENTITY have been argued to be too weak to capture the empirical picture.

4.3.2. EXISTENCE *is too weak*

Kripke (1991/2009) points out that additive presuppositions are different from many other presuppositions: they can't be accommodated or satisfied by common ground knowledge. If they could be, then we would expect (14) to be acceptable out of the blue—after all, it is well known that, any given night, several million people have dinner in New York. So, if the EXISTENCE condition was just an existential statement, as in (13), the additive presupposition could easily be accommodated.

(14) Sam is having dinner in New York tonight, too.   (Kripke 1991/2009)

Kripke suggests that additive particles, rather than contributing a simple existential statement, are anaphoric: in (14), *too* seems to require that, of some particular individual other than John, it has been saliently established in the discourse that they are having dinner in New York tonight.

4.3.3. *Focus sensitivity via Current Question*

There are different ways of capturing the discourse anaphoricity and focus sensitivity of additive particles. Beaver and Clark (2008) use a question-under-discussion-based framework (Roberts 1996) for this purpose, and we will follow them. In this framework, focus sensitivity can be modeled without directly making reference to focus semantic values. Instead, it is assumed that every assertion addresses a so-called *Current Question* (*CQ*). This CQ can either be an explicitly asked question or it can remain implicit. In the latter case, it can be deduced from the focus structure of the assertion. This is possible because of *question-answer congruence*: if an assertion *A* answers a question *Q*, then *A* has focus marking on that constituent that corresponds to the wh-phrase in *Q*. For example, (15) is taken to be associated with the CQ *What did Mary give John?*, whereas (16) is taken to be associated with the CQ *Who gave John a dog?*.

(15)   [CQ: What did Mary give John?]
       Mary gave John a [dog]$_F$.

(16)   [CQ: Who gave John a dog?]
       [Mary]$_F$ gave John a dog.

This connection between focus marking and CQ allows Beaver and Clark to capture the EXISTENCE condition in terms of the CQ. Roughly, they take an additive particle to signal that a positive partial answer to the CQ has saliently been established in the discourse. For example, *also* in (17) is taken to mark that a positive partial answer to *What did John read?* has saliently been established.

(17)   [CQ: What did John read?]
       John also read [Middlemarch]$_F$.

4.3.4. NON-IDENTITY *is too weak*

The NON-IDENTITY condition as formulated in Section 4.3.1 has also been subject to criticism, with both Jasinskaja and Zeevat (2009) and Beaver and Clark (2008) proposing a strengthened version of this condition. Beaver and Clark require that the already established partial answer, i.e., the antecedent, is not entailed by the prejacent of the additive particle. To motivate this decision, they point to the oddness of discourses like those in (18).

(18)   a.   Sam is [happy]$_F$. #He's also [ecstatic]$_F$. (after Beaver and Clark 2008)

       b.   I called [Alice]$_F$. #I also called [Alice and Mary]$_F$.

    c. Alice [sang]$_F$. #She also [sang beautifully]$_F$.

These are all cases where the prejacent of the additive particle entails the antecedent. Observe that with entailment in the opposite direction, however, the discourse is degraded too:

(19) a. Sam is [ecstatic]$_F$. #He's also [happy]$_F$.
      b. I called [Alice and Mary]$_F$. #I also called [Mary]$_F$.
      c. Sam has a [brother and a sister]$_F$. #He also has [siblings]$_F$.

One might think that these data can be explained as cases of redundancy. But the degradedness seems to persist even if we take care to construct non-redundant discourses, e.g., discourses that guide through a reasoning process step by step or explain the meaning of a word:

(20) a. Sam is [ecstatic]$_F$. That means that he is (?#also) [happy]$_F$.
      b. I called [Alice and Mary]$_F$. This means in particular that I (#also) called [Mary]$_F$.
      c. Sam has [a brother and a sister]$_F$. That means that Sam (#also) has [siblings]$_F$.

Leaving out the additive particle does seem to improve acceptability, which suggests that the problem is indeed caused by the particle. I conclude that the non-identity condition needs to be strengthened into both directions: prejacent of the additive particle and antecedent need to be logically independent.

    Implementing both Beaver and Clark's CQ-based version of the EXISTENCE condition and a strengthened version of their NON-IDENTITY condition, we arrive at the following formulation of the additive presupposition.

(21) **Additive presupposition (after Beaver and Clark):**
      If an additive particle occurs in a declarative S, this presupposes that:
     (i) a positive partial answer p of the CQ has saliently been established, and   EXISTENCE
     (ii) p is logically independent of $[\![S]\!]$.   NON-IDENTITY

This presupposition can capture the contribution of additive particles in assertions. In the following section, we will generalize it to also be applicable to additives in polar questions and wh-questions.[6]

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[6]For related work that is concerned with lifting the account of another kind of focus-sensitive expression, namely exclusive particles, to an inquisitive semantics setting, see Möller Kalpak 2018. A comparison of this approach with the one proposed here must be left for future work.

4.4.   Generalizing the additive presupposition

4.4.1. Preview of the account

We will use a generalized version of the additive presupposition to derive
the distribution of *also*. The intuitive idea behind this account is as follows.
The additive presupposition requires that there already is a partial answer p
to the CQ, and that the additional partial answer q asserted by or invited by
the *also*-marked utterance is logically independent of the pre-existing answer.
Assertions and polar questions are alike in that they "mention" just one concrete
partial answer q—which makes it easy to ensure that p and q are independent.
By contrast, with wh-questions, ensuring the independence of p and q is more
difficult, and as we will see, sometimes even impossible. This is because wh-
questions don't mention just a single partial answer, but rather make a whole
range of propositions available as admissible answers. In order to ensure that p
and q are logically independent, all of these propositions must be logically
independent of p. With canonical, unrestricted wh-questions, this will turn
out to be impossible, whereas with summoning questions and showmaster
questions we will see that it can be achieved through restricting the set of
admissible answers such that it only contains propositions that are logically
independent of p.

4.4.2. Resolutions and positive partial resolutions

In order to make the intuitive solution outlined above more explicit, we will
borrow some notions from inquisitive semantics (Ciardelli *et al.* 2018).[7]

4.4.2.1 Resolutions

In inquisitive semantics, the meaning of both declaratives and interrogatives
is construed as the same kind of semantic object, namely a set of propositions.
By uttering a sentence with meaning P, a speaker is taken to raise an issue
whose resolution requires establishing one of the propositions in P, while at
the same time providing the information that the actual world is contained in
the union of these propositions, $\bigcup P$. We call the elements of P *resolutions* of

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[7]This choice is motivated by conceptual reasons. Inquisitive semantics is a framework
specifically designed to deliver a uniform notion of meaning for declarative and interrogative
sentences. Adopting this notion here will provide a stronger conceptual underpinning for
the proposed account. It is not a technical necessity, however: the same predictions could in
principle be achieved without using concepts from inquisitive semantics.

(a) Amy left. (b) Did Amy leave? (c) Who left?
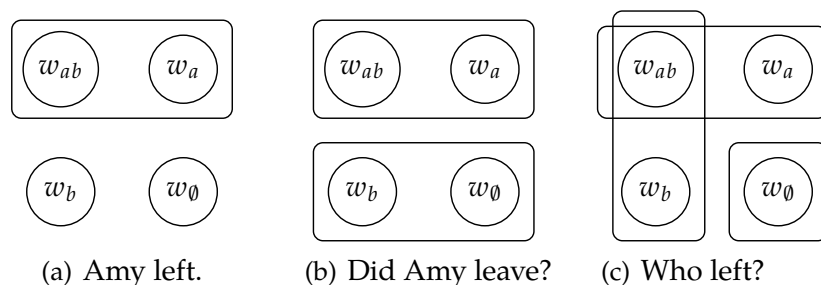
FIGURE 4.2. Examples of sentence meanings in inquisitive semantics.

the sentence. The difference between declaratives and interrogatives is that, by uttering a declarative, a speaker raises a trivial issue, i.e., she provides enough information in order to resolve the issue she raises. Uttering an interrogative sentence, by contrast, typically raises a non-trivial issue.

Sentence meanings in inquisitive semantics are *downward closed*: for any proposition p and sentence meaning P, if $p \in P$ and $q \subset p$, then also $q \in P$. This captures the intuition that, if a proposition p resolves a given issue, then any stronger proposition $q \subset p$ will also resolve that issue. Given a set of propositions P, we call $P^{\downarrow} = \{p \mid \exists q \in P : p \subseteq q\}$ the *downward closure* of P.

To illustrate these notions, consider the following three sentences:

(22) a. Amy left.
      b. Did Amy leave?
      c. Who left?

Assuming a domain with exactly two individuals, Amy and Bill, these sentences may be assigned the meanings depicted in Figure 4.2, where w_{ab} and w_a are worlds where Amy left, w_b and $w_{\emptyset}$ are worlds where Amy didn't leave, w_{ab} and w_b are worlds where Bill left, and w_a and $w_{\emptyset}$ are worlds where Bill didn't leave. The rectangles are the least informative propositions contained in the given meanings. They are also refered to as *alternatives*. By downward closure, all propositions contained in an alternative are also included in the respective sentence meaning.

4.4.2.2 *Positive partial resolutions*

For our account of additive particles, we won't use resolutions simpliciter, but a closely related notion that we will refer to as *positive partial resolutions*.

Partial resolutions.   A *partial resolution* is to a resolution what a partial answer is to an answer: to be a partial resolution of a sentence S, a proposition p doesn't have to resolve the issue raised by S completely, but it is sufficient if p rules out some resolution in the meaning of S. For instance, while (23a) resolves the issue raised by the question in (23) completely, both (23b) and (23c) only resolve it partially: the former by virtue of ruling out the resolution that C will come, and the latter by ruling out the resolution that nobody will come.

(23)   Who (of A, B, and C) will come?

    a. A will come.   resolution
    b. A or B will come.   partial resolution
    c. Someone will come.   partial resolution

Note that every proposition that resolves an issue completely also resolves it partially. This means that every resolution also is a partial resolution. The reverse doesn't hold.

    To see why partial resolutions are the relevant notion when it comes to modeling additive presuppositions, consider (24). In both examples, the use of the additive particle is licensed by a merely partial resolution.

(24)   a. Alice invited John or Mary, I don't remember which. She also invited Bob.
    b. Someone from your soccer team called. Your grandmother also called.

Positive partial resolutions.   Intuitively, a *positive partial resolution* is a resolution that partially resolves a given issue positively. In the case of an assertion or a polar question, it is a non-empty resolution entailing a *yes*-reply. For instance, (25a) is a positive partial resolution of issues raised by the assertion and corresponding polar question in (25), while (25b) is not a positive partial resolution of these issues.

(25)   B will come. / Will B come?

    a. B will come.   positive
    b. B won't come.   not positive

A positive partial resolution of a wh-question is a non-empty partial resolution entailing a *somebody/something*-reply. For instance, (26a) and (26b) are positive partial resolutions of the issue raised by the question in (26), while (26c) and (26d) are not positive partial resolutions of this issue.

(26)   Who will come?

    a. A will come.   positive

b.	One of A, B and C will come.	positive
c.	A won't come.	not positive
d.	Nobody will come.	not positive

To see why positive partial resolutions are needed for licensing additive particles, consider (27). In the first sentences of both examples, the CQ gets (partially) resolved, but not positively. As a consequence, the use of an additive particle is not acceptable.

(27) CQ: Who called?

    a. John didn't call. #Alice also called.

    b. Nobody called. #Alice also called.

4.4.2.3 *Formal definitions*

To give a formal definition of positive partial resolutions, we need one additional concept, namely that of *highlighting* (see, e.g., Roelofsen and Farkas 2015). This notion is used to capture which semantic objects a sentence makes salient.[8] For example, both the polar interrogative in (28a) and the declarative in (28b) are taken to highlight the proposition that Ann watched Psycho, i.e., $\lambda w.W(p)(a)(w)$. The single-wh-question in (28c) is taken to highlight the unary property of having been watched by Ann, i.e., $\lambda x.\lambda w.W(x)(a)(w)$, and the multiple-wh-question in (28d) is taken to highlight the binary relation $\lambda y.\lambda x.\lambda w.W(x)(y)(w)$.

(28)
a.	Ann watched Psycho.	$\rightsquigarrow \lambda w.W(p)(a)(w)$	0-place property
b.	Did Ann watch Psycho?	$\rightsquigarrow \lambda w.W(p)(a)(w)$	0-place property
c.	What did Ann watch?	$\rightsquigarrow \lambda x.\lambda w.W(x)(a)(w)$	1-place property
d.	Who watched what?	$\rightsquigarrow \lambda y.\lambda x.\lambda w.W(x)(y)(w)$	2-place property

We can generalize over these different cases by viewing propositions as 0-place properties. All of the above sentence types then highlight an n-place property, where $n \geq 0$ is the number of wh-elements in the sentence.

    With the notion of highlighting in place, we can now formally define the set of positive partial resolutions of a sentence S. We do this in two steps, first defining positive resolutions, then defining positive partial resolutions in terms of positive resolutions.

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[8]The idea that uttering a question makes certain semantic objects salient, which become available for anaphoric reference, has been used in several theories of questions (Groenendijk and Stokhof 1984, von Stechow 1991, Krifka 2001, Aloni *et al.* 2007). Here, we use Roelofsen and Farkas (2015)'s implementation of this idea, which applies to both questions and assertions, and was motivated by the licensing patterns of polar particle responses.

(29) Let S be a sentence. Let $[\![S]\!]$ be the set of resolutions of S and let $h : D_e^n \to D_{\langle s,t \rangle}$ be the property highlighted by S.

    a. The set of positive resolutions $[\![S]\!]^+$ of S is:[9]

$$[\![S]\!]^+ := \left\{ p \in [\![S]\!] \ \middle| \ p \cap \bigcap_{\vec{d} \in D_e^n} \overline{h(\vec{d})} = \emptyset \right\}$$

    b. The set of positive partial resolutions $[\![S]\!]^{\cup +}$ of S is:

$$[\![S]\!]^{\cup +} := \left\{ \bigcup R \ \middle| \ R \subseteq [\![S]\!]^+ \right\}$$

A positive resolution is any resolution entailing a *yes/somebody/something* reply, that is, any resolution incompatible with a *no/nobody/nothing* reply. In the definition of positive resolutions in (29a), the proposition $\bigcap_{\vec{d} \in D_e^n} \overline{h(\vec{d})}$ corresponds to the *no/nobody/nothing* reply. To see this, let's consider two examples. First, assume that S is a multiple-wh interrogative with two wh-phrases, which means that h is a 2-place property, and let $D_e^n = \{(a,b), (b,a)\}$. The proposition $n = \bigcap_{\vec{d} \in D_e^n} \overline{h(\vec{d})}$ amounts to $n = \overline{h(a,b)} \cap \overline{h(b,a)}$, that is, the proposition conveying that a doesn't stand in an h-relation to b and b doesn't stand in an h-relation to a. Any proposition incompatible with n is a positive resolution of S.

For another example, assume that S is a polar interrogative or a declarative. Then h is a 0-place property, that is, a proposition. There is only one instantiation of a 0-place property, namely the property itself. So, the proposition $n = \bigcap_{\vec{d} \in D_e^n} \overline{h(\vec{d})}$ simply amounts to $n = \overline{h}$, that is, the proposition conveying that h doesn't hold true. Any proposition incompatible with n is a positive resolution of S.

Finally, we obtain the set of positive *partial* resolutions by closing the set of positive resolutions under union.

4.4.3. *A generalized additive presupposition*

We are now ready to formulate a generalized version of the additive presupposition. Compared to the previous version in (21), the main difference lies in the NON-IDENTITY condition. Rather than requiring that the propositional content

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[9]The overline notation indicates set complementation, i.e., for any $X \subseteq D_{\langle \sigma, \tau \rangle}$, $\overline{X} = D_\sigma \backslash X$.

of S is logically independent of p, we now require that every positive partial resolution of S is logically independent of p.

(30) **Generalized additive presupposition:**

If an additive particle occurs in a sentence S, this presupposes that:

   (i) a positive partial resolution p of the CQ has saliently been established, and   EXISTENCE

   (ii) all $q \in [\![S]\!]^{\cup+}$ (i.e., all positive partial resolutions of S) are logically independent of p.   NON-IDENTITY

Sentence S can be a declarative, a polar interrogative or a wh-interrogative. In the remainder of this section, we will check which predictions the presupposition makes for these different cases.

DECLARATIVES. Let's consider the example in (31). As we have seen in Section 4.3.3, this sentence addresses the CQ *What did John read?*. So, the EXISTENCE condition requires there to be a saliently established positive partial resolution p of *What did John read?*.

(31) John also read [Middlemarch]$_F$.

To find out what the NON-IDENTITY condition amounts to, we first have to determine the set of positive partial resolutions of (31). This set contains the proposition m that John read Middlemarch and all non-empty subsets of m. The NON-IDENTITY condition requires that all of these positive partial resolutions are logically independent of p. This is equivalent to requiring that p and m are logically independent.[10] So, we predict (31) to presuppose that there is a positive partial resolution p of the question what John read and that p is logically independent of the proposition that John read Middlemarch. Hence, for declaratives, the generalized version of the additive presupposition boils down to a classical additive presupposition (albeit in terms of logical independence).

POLAR INTERROGATIVES. Let's consider example (32), the polar interrogative analogue of (31). We will see that, in all relevant respects, it behaves like (31).

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[10]In fact, due to the downward-closedness of the set of positive partial resolutions, there is an easier, equivalent, but less transparent formulation of the NON-IDENTITY condition: there must be no positive partial resolution q of S such that $q \subseteq p$. Let's check whether this formulation yields the same result for our example in (31). The new formulation tells us that no positive partial resolution of S entails p, i.e., for all $m' \subseteq m$, $m' \not\subseteq p$ and in particular $m \not\subseteq p$. Since p is a *positive* partial resolution, we also know that $p \neq \emptyset$. Hence, for all $m' \subseteq m$, $m' \neq p$. That is, $p \not\subseteq m$. So, we have $m \not\subseteq p \not\subseteq m$, i.e., p is logically independent of m. So, the alternative formulation gives us the same result.

(32) Did John also read [Middlemarch]$_F$?

The classical QUD framework doesn't tell us how polar questions relate to their CQ. It seems to be a natural assumption, however, that (32) is part of a strategy for finding an answer to the wh-question *What did John read?*. As illustrated below, this latter question can be split up into a series of polar questions of the form *Did John read X?* such that if we know the answer to all the polar questions, we will also know the answer to *What did John read?*. For this reason, I will assume that *What did John read?* is the CQ of (32).[11]

<div align="center">

CQ: What did John read?

Did John read Did John read . . .
[Emma]$_F$?   [Middlemarch]$_F$?

</div>
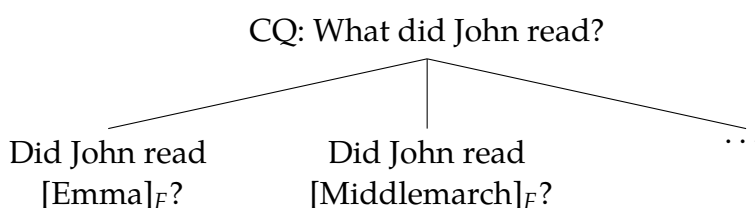
Note that a principle similar to question-answer congruence is in place here: the focus-marked constituent in the polar questions corresponds to the wh-phrase in the CQ. This means that an assertion and its corresponding polar question have the same CQ. Furthermore, because an assertion and its corresponding polar question highlight the same proposition, they also have the same set of positive partial resolutions. So, for polar questions the generalized additive presupposition amounts to exactly the same as for assertions. For example, just like the assertion in (31), the polar question in (32) presupposes that there's a saliently established positive partial resolution p of *What did John read?* such that p is logically independent of the proposition that John read Middlemarch.

WH-INTERROGATIVES. Just as with polar questions, we first have to think about how wh-questions relate to the CQ. We have seen earlier that the CQ can remain implicit. However, it can of course also be asked explicitly—and I think it makes sense to assume that this is what wh-questions without an overt domain restriction usually do.[12] For instance, I will assume that the unrestricted wh-question in (33) is part of a strategy to answer the CQ *What did John read?*, i.e., the wh-question itself specifies the CQ.

(33) [CQ: What did John read?]
  What did John read?

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[11]More work is needed to investigate when exactly polar questions should be taken to be part of a strategy to answer a wh-CQ, and when they should be taken to simply constitute "their own CQ".

[12]We will discuss wh-question with domain restrictions in Section 4.5.

I further assume that adding an expression like *also*, which doesn't contribute to the at-issue question meaning, doesn't have an effect on the associated CQ. That is, I take (34) to have the same CQ as (33).

(34) [CQ: What did John read?]
      #What did John also read?

The fact that CQ and overtly asked question S are identical is crucial for our account of why *also* is marked in (34). The EXISTENCE condition requires that there is a saliently established positive partial resolution p of the CQ, i.e., of the question what John read. The NON-IDENTITY condition requires that p is logically independent of all positive partial resolutions q of S, i.e., of all positive partial resolutions q of the question what John read. It is impossible to find a p that satisfies these two conditions: since S and the CQ are identical, whenever a proposition p is a positive partial resolution of the CQ, it is trivial to find a positive partial resolution q of S such that p and q are not logically independent, namely $q = p$. I take this impossibility to satisfy the additive presupposition to explain why *also* is marked in (34).

On an intuitive level, we might think of the problem as follows. When an additive particle appears in a wh-question and associates with the wh-phrase, then the NON-IDENTITY condition is much more demanding than when the particle appears in an assertion or polar question. This is because assertions and polar questions highlight a concrete proposition, and NON-IDENTITY only requires this proposition to be independent of the antecedent proposition p. By contrast, a wh-question doesn't "mention" a concrete proposition, but rather highlights an n-place property with $n \geq 1$. This means that for a wh-question there are usually several different positive partial resolutions, all of which are required by NON-IDENTITY to be independent of p.

To take stock, so far we have accounted for the markedness of *also* in canonical unrestricted wh-questions. What remains to be done is to explain why *also* is acceptable in summoning and showmaster questions, and why *else* is acceptable in canonical wh-questions.

4.5. *Ways of rescuing* NON-IDENTITY

As we have seen, canonical unrestricted wh-questions are taken to coincide with their CQs. As a consequence, it becomes impossible to satisfy the NON-IDENTITY condition for these questions. In this section, we will discuss how *else*-marked wh-questions and different kinds of non-canonical wh-questions circumvent this problem. The crucial difference will be that with these question

types the overtly asked question and the CQ are not identical, but the CQ is a proper superquestion of the overtly asked question.

4.5.1. 'Else'-questions and witness removal

For simplicity, we will treat *else* as an additive particle here (following Schwarz, 2017). This is motivated by the fact that, just like a bona fide additive particle, *else* in wh-questions gives rise to an additive inference, as illustrated in (35b).[13]

(35)   Who danced?
       a.   John danced. Who else danced?
       b.   John didn't dance. #Who else danced?

So, we assume that *also* and *else* contribute the same additive presupposition. What then is the relevant difference between the particles? I suggest it is that *else* but not *also* modifies the wh-domain of its containing question by removing the witness of the additive presupposition from that domain (Romero 1998, Harris 2014, Schwarz 2017). For instance, in (36), Mary is removed from the wh-domain. The resulting question is what Eckardt (2006) calls a *remnant question*.

(36)   A: Mary called.
       B: Who else called? = Who other than Mary called?

Further evidence for this difference between *also* and *else* comes from the contrast in (37). In this discourse, Paul McCartney is the witness. In (37a), *else* tries to remove Paul McCartney from the wh-domain. With the *of the Beatles* restriction, this is unproblematic because the witness is one of the Beatles. By contrast, with the *of you* restriction, it is problematic because the witness is not in the domain in the first place, which means the witness removal fails. I take this to explain why *else* is marked with the *of you* restriction.[14] Turning to (37b), the *of you* restriction is acceptable with *also* because *also* doesn't remove the

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[13]Note that if *else* associates with an indefinite rather than with a wh-phrases, this doesn't seem to give rise to the same inference, as shown in (i). This suggests that *else* doesn't conventionally trigger an addivitity presupposition. In this paper, I treat *else* as an additive particle for reasons of exposition: assuming *else* is maximally similar to *also* makes it easier to discuss which difference between the two is relevant for the difference in their behavior in wh-questions. As far as I can see, nothing in the proposed account of *also* will hinge on the assumptions about *else*.

(i)   John didn't dance, but someone else did.

[14]An analogous explanation can be given to the following example from Eckardt (2006, p.86). If *noch* is like *else* in that it removes the witness from the wh-domain, then the markedness of (ib) is predicted: the witness(es), namely the coffee drinker(s) from table 1, are not in the wh-domain, and hence can't be removed.

witness from the wh-domain. Finally, the *of the Beatles* restriction is marked with *also* for the reason discussed in Section 4.4.3 above: the NON-IDENTITY condition can't be satisfied.

(37)   I know that Paul McCartney played the guitar. But...

a.   Who else of $\left\{ \begin{array}{c} \text{the Beatles} \\ \text{\#you} \end{array} \right\}$ played the guitar?

b.   Who   of $\left\{ \begin{array}{c} \text{\#the Beatles} \\ \text{you} \end{array} \right\}$ also played the guitar?

Let's now have a look at why *else*, unlike *also*, can appear in canonical unrestricted wh-questions. In a nutshell, it will be the witness removal that saves *else* in these questions, by guaranteeing that the NON-IDENTITY condition can be met.

In order to see what the generalized additive presupposition amounts to for *else*-questions, we first have to see how such questions relate to the CQ. An *else*-question Q is a subquestion of the corresponding question without *else*, Q' (if one knows a complete answer to Q', one also knows a complete answer to Q). For this reason, Q is part of a strategy to answer Q' (cf., Eckardt 2006). I therefore take an *else*-question to have the corresponding question without *else* as its CQ:

CQ: What did John read?

John read   What else   ...
[Middlemarch]$_F$.   did John read?
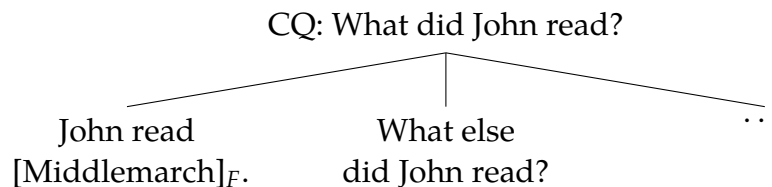
Crucially, this means that for *else*-marked wh-questions—unlike for unrestricted wh-questions—the CQ is different from the question itself. In particular, the antecedent proposition p is not a positive partial resolution of the *else*-question. This fact makes it possible to satisfy NON-IDENTITY. To see why, consider the question *What else did John read?*, and assume that the domain consists of Middlemarch, Emma and Frankenstein. According to the generalized additive presupposition, *else* signals that there is a proposition p such that:

– p is a saliently established partial resolution of *What did John read?* (=*Which of Middlemarch, Emma and Frankenstein did John read?*), and   EXISTENCE

(i)   Waitress first takes orders for coffee at table 1. Turning then to table 2, she asks:

a.   Wer an diesem Tisch will AUCH Kaffee? (*Who at this table wants coffee, too?*)
b.   #Wer an diesem Tisch will NOCH Kaffee? (*Who at this table wants* NOCH *coffee?*)

– all positive partial resolution q of *What **else** did John read?* (=*Which of Emma and Frankenstein did John read?*) are logically independent of p.

<div align="right">NON-IDENTITY</div>

Because Middlemarch is not in the domain of *What else did John read*, it is easy to find a proposition p satisfying the above conditions. We can simply choose p to be the proposition that John read Middlemarch. More generally, it is the presence of the witness in the wh-domain of unrestricted wh-questions that prevents NON-IDENTITY from being satisfiable. So, since *else* removes precisely the witness from the domain, with *else*-questions it will always be possible to satisfy NON-IDENTITY.

4.5.2. *Summoning questions and domain restriction*

If witness removal can save NON-IDENTITY, we would expect domain restriction more generally to be able to do the same: *also* should be acceptable in wh-questions whose domain has been restricted so as to not contain the witness. Consider the example (38), where John is the witness. If we assume that John is not in the hearer's dorm, then the domain restriction *from your dorm* ensures that the wh-domain doesn't contain the witness. Indeed, adding this overt domain restriction in (38), seems to improve the acceptability of *also*. Similarly, adding *other* to the wh-restrictor in (39) excludes the witness from the wh-domain, and indeed seems to improve the acceptability of *also*.

(38)   John danced all night at Mary's birthday party. Who #(from YOUR dorm) also danced?

(39)   A: Where can I get an Italian newspaper?
        B: At Newstopia.
        A: I'd rather not get it there—I really dislike the owner. Which of the #(other) shops in town also sell Italian newspapers?

Now, I suggest that in summoning questions a suitable restriction doesn't have to be spelled out overtly—because it is already supplied by the setup of the context. If a speaker addresses a group using a summoning question, she restricts the wh-domain to that group. In (40), for example, the *of you guys* restriction doesn't change the meaning of the question since the wh-domain would be understood to consist of the hearers even without the overt restriction.

(40)   I'm getting an ice cream. Who (of you guys) also wants one?

Crucially, since the speaker is the witness in (40), the wh-domain doesn't contain

the witness. This means that NON-IDENTITY can be satisfied. For this reason, *also* is acceptable in summoning questions.

Finally, it seems that the acceptability of *also* improves more through certain domain restrictions than others. For instance, the contextual restriction in summoning questions seems to "work better" than the overt one in (39). One possible generalization might be that those restrictions that improve the acceptability of *also* the most have one thing in common: they guarantee that the witness is not contained in the wh-domain without relying on world knowledge. This can happen, as in *else*-questions, through grammaticalized strategies for removing the witness, or, as in summoning questions, through splitting up a situation into speaker and hearers, two groups that are guaranteed to be disjoint. By contrast, whether the witness is contained in the wh-domain in (39) depends on whether John is in the hearer's dorm, i.e., it depends on contingent facts about the world.

4.5.3. *Showmaster questions and speaker meaning*

As we have seen, the mechanisms that allow NON-IDENTITY to be satisfied in the case of *else*-questions and summoning questions are closely related: they both result in a wh-domain that doesn't contain the witness. In this subsection, I will outline a possible account of showmaster questions that also relies on domain restriction. The difference will be that this domain restriction isn't implemented on the level of semantic meaning, but rather on the level of Grice (1975)'s *speaker's meaning*.

4.5.3.1 *Extreme domain restriction*

It is the characteristic property of showmaster questions that the speaker already has a particular answer or a particular set of answers in mind. One way of modeling this property formally is to treat showmaster questions as cases of extreme domain restriction, with the speaker restricting the wh-domain to just that entity or those entities she will allow as an answer. George (2011) goes this route for trivia questions like (41a), providing the following motivation:

(41)   a.   What was considered a sin in the 16th and 17th century?
       b.   Eating chocolate.

       "[T]here are certainly many other things that were considered sins in the centuries in question. . . . [W]e understand [(41a)] as a question about which activity or activities in some suitably restricted domain was or were considered sinful, but, in the context of a trivia card, we

have no way of knowing what this domain might be – the question
becomes a game not of testing our trivia knowledge, but of asking
us to guess which sin the author of the question was thinking of."

(George 2011, p.208f)

If we adopt George's account, the acceptability of *also* falls out straightfor-
wardly. For example, recall the zoo scenario from Section 4.2.1 and assume
that the particular answer Auntie has in mind is that a giraffe stole Lisa's hat.
Then the meaning of Auntie's question contains just a single alternative, namely
the proposition that a giraffe stole Lisa's hat:

(42)   ⟦ What also happened at the zoo? ⟧ = { **giraffe-stole-lisa's-hat** }$^{\downarrow}$

Hence, the NON-IDENTITY condition for (42) boils down to the requirement that
the pre-existing answer is logically independent of a giraffe having stolen Lisa's
hat. This condition is unproblematic to satisfy, which means that *also* is pre-
dicted to be acceptable.

4.5.3.2   *Against mixing intentions and wh-domains*

Although the extreme domain restriction account seems to work straight out
of the box, there are still some details we need to clarify. Most importantly,
what exactly is the status of the postulated domain restrictions? In this section,
I give two arguments against taking showmaster domain restrictions to affect
the semantic meaning of the question, and in the following section, I will
propose an alternative solution, which instead makes them part of the speaker's
meaning of the question.

SHOWMASTER QUESTIONS WITH OVERT DOMAIN RESTRICTIONS.   For the sake of ar-
gument, let's assume that the extreme domain restriction of a showmaster
question affects the semantic meaning of the question. Then, also the wh-
domain of a multiple-choice question like (43) would be taken to consist of just
the true answer.[15] This is neither in line with our intuitions about (43) nor with
the empirical picture. Intuitively, (43) makes its wh-domain fully explicit. It
consists of all of the options (A)–(D) listed as possible answers, not just the true
answer intended by the speaker. Empirically, this is reflected in how a speaker
can react to a reply to (43). If the question receives one of (A)–(D) as a reply,
the speaker can either accept this reply by uttering (44a) or reject it by utter-
ing (44b). Crucially, it is not permissible to reject the reply by uttering (44c).

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[15]Thanks to Matthijs Westera (p.c.) for this observation and lovely example.

If (43) had a smaller wh-domain than (A)–(D), we would expect (44c) to be acceptable here.

(43)   Which of the following things was considered a sin in the 16th and 17th century?

    (A) eating chocolate   (B) hiding chocolate eggs

    (C) making chocolate without the   (D) feeding chocolate to a dog.
        Queen's permission

(44)   a. Yes/True/That's right/. . .
      b. No/False/That's wrong/. . .
      c. #Okay, that's technically true, but that's not what I had in mind.

The existence of multiple choice questions shows that, also with showmaster questions, we need a representation of the wh-domain that does not reflect the speaker's intentions or her knowledge. Arguably the easiest way of implementing this representation is to stick to the traditional solution and let overt domain restrictions determine the wh-domain of the question's semantic meaning. For the implicit domain restrictions associated with showmaster questions, we will need to find another place. But before we move on to doing this, let's consider one more argument in favor of this solution.

LITERAL DISCOURSE EFFECTS.   If we implement showmaster domain restrictions as part of the semantic meaning, then the semantic meaning of those showmaster questions where the speaker has exactly one specific answer in mind will contain just a single alternative. This makes their semantic meaning indistinguishable from that of assertions. This is problematic for work on discourse dynamics that derives the discourse effects of an utterance (at least in the absence of special marking) from its semantic meaning (see especially Farkas and Roelofsen 2017 for an account treating declaratives and interrogatives uniformly, but also Condoravdi and Lauer 2012, Lauer 2013 for a closely related non-uniform account). Work like this might assume, for instance, that by uttering a sentence S, a speaker proposes that the hearer commits to one of the alternatives in $[\![S]\!]$. So, if $[\![S]\!]$ contains just a single alternative, as is the case for declarative S, then the hearer is asked to commit to this alternative. By contrast, if $[\![S]\!]$ contains several alternatives, as is typically the case for interrogative S, the hearer is asked to commit to one of them (cf., Condoravdi and Lauer 2012; Lauer 2013), or in other words, to answer S.

    If the meaning of, e.g., Auntie's question contains just a single alternative, then under this perspective, it will be predicted to have the same discourse

effects as an assertion. But this is not what we find empirically, since Auntie's question—at least on the literal level—proposes that Lisa commits to *some* answer to the question, not that she commits to the specific answer Auntie has in mind. If Lisa gives an unintended answer, which Auntie rejects, as in (45), then Lisa can call Auntie out on her original question:

(45) Auntie: What also happened at the zoo?
Lisa: An elephant sneezed!
Auntie: No, that's not what I had in mind.
Lisa: Well, you asked me what happened at the zoo, and I told you.

In order to correctly derive the literal discourse effects of a showmaster question, we need to derive them from the question's unrestricted meaning. Arguably the easiest way of achieving this is to assume that literal discourse effects get determined by semantic meaning and, as already suggested above, to implement implicit showmaster domain restrictions on a different level.

4.5.3.3 *Extreme domain restriction on the level of speaker's meaning*

In spite of their literal discourse effects, which, as we just saw, are those of an ordinary unrestricted question, showmaster questions allow the speaker to reject replies as true but not conforming to what she had in mind:

(46) Auntie: What also happened at the zoo?
Lisa: An elephant sneezed!
Auntie: Well, true, but that's not what I had in mind.

So, showmaster questions seem to have two distinct discourse effects. On the one hand, they have a literal discourse effect, on which the speaker can get called out. This effect gets determined by the semantic meaning of the question. On the other hand, showmaster questions communicate that the speaker wants the hearer to commit to a specific answer (or to one out of a specific set of answers). If the hearer fails to do that, then the speaker can reject this answer because it isn't what she had in mind, even if it satisfyingly answers the question on its literal reading.

This contrast brings to mind Grice (1975)'s distinction between a sentence's semantic meaning and its *speaker's meaning*. The semantic meaning is literal in that it is compositionally computed from the sentence, and it determines those discourse effects that the speaker can get called out on. For example, the semantic meaning of (47) is that of a polar question. On our account, it would contain an alternative corresponding to a *yes*-reply and one corresponding to a

no-reply. If the hearer replies to (47) with *yes* and doesn't do anything further, she might not be cooperative, but she is on the safe side. After all, the speaker asked a question, and she answered it.

(47)   Can you pass me the salt?

By contrast, the speaker's meaning of an utterance is determined by the semantic meaning as well as the speaker's intentions and contextual factors. In (47), these factors conspire to produce as the speaker's meaning a request to pass the salt. We may say that those discourse effects *intended by the speaker* are derived from the speaker's meaning.

I suggest that extreme domain restriction, as introduced in Section 4.5.3.1, should be part of the speaker's meaning. More concretely, given an interrogative S that is used as a showmaster question and that has the semantic meaning $[\![S]\!]$, we take its speaker's meaning $[\![S]\!]_{sp}$ to be $[\![S]\!]$ restricted to just those resolutions to which the speaker intends the hearer to commit.[16] This restriction of a question meaning is the only kind of difference between semantic meaning and speaker's meaning that we will consider in this paper.[17] So, for our purposes, semantic meaning and speaker's meaning coincide for interrogatives that are used as genuine questions as well as for declaratives. To generalize, we may hence say that for any sentence S, we can obtain $[\![S]\!]_{sp}$ by restricting $[\![S]\!]$ to those resolutions that are not unintended by the speaker. For showmaster questions, this amounts to those resolutions that are intended, while for genuine questions and assertions, it amounts to all resolutions.

There is one final modification we need in order to account for *also* in showmaster questions. Namely, the generalized additive presupposition needs to be made sensitive to the speaker's meaning rather than the semantic meaning of a sentence:[18]

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[16]This might again give rise to a concern about discourse effects: since we take the speaker's meaning to determine the speaker's intended discourse effects, we predict that, if the speaker's meaning contains only a single alternative, the speaker intends her utterance to have the same discourse effect as an assertion. It might seem that this prediction is wrong—after all, the speaker intends the hearer to answer the question and not merely to agree by saying, e.g., *yes*. I believe that this prediction is exactly right, though: the speaker does intend the discourse effect to be the same as that of an assertion, namely asking the hearer to commit to the single alternative p. However, the hearer can't do this just by saying *yes* or nodding, because the speaker hasn't actually uttered p, as she would have if she had asserted it. This means, p hasn't become available for anaphoric reference via *yes*, and in order to commit to it, the hearer herself has to utter p rather than to merely say *yes*. So, in short, I think showmaster questions have the same intended discourse effects as assertions, and the empirical differences arise from differences in anaphoric potential.

[17]But see footnote 18.

[18]It might be desirable to treat *also* as sensitive to speaker's meaning in a more general sense

(48) **Generalized additive presupposition (speaker's meaning version):**

If an additive particle occurs in a sentence S, this presupposes that:

    (i) a positive partial resolution p of the CQ has saliently been established, and   **EXISTENCE**

    (ii) all $q \in [\![S]\!]_{\mathrm{sp}}^{\cup+}$ (i.e., all positive partial resolutions of the speaker's meaning of S) are logically independent of p.   **NON-IDENTITY**

With (48), *also* straightforwardly comes out as acceptable in showmaster questions, just as on the extreme domain restriction account in Section 4.5.3.1. The only difference is that now the action takes place on the level of speaker's meaning: the question is restricted on that level, and the additive presupposition is sensitive to that level. For genuine questions as well as for assertions, nothing changes, since their semantic meaning coincides with their speaker's meaning.

4.5.3.4 *Open problem: implicit admissibility criteria as a more general phenomenon*

To conclude, let's critically examine the generality of the solution proposed here. As we saw in the previous section, the speaker of a showmaster question can reject a reply as technically correct but not meeting the implicit criterion of being the answer she has in mind. Showmaster questions are not alone in giving the speaker this option. In fact, virtually all questions without an overt domain restriction allow the speaker to reject a reply as true yet unsuitable. This is usually done by appealing to some additional criterion that was only implicit in the original question. A speaker may, for instance, reject a reply to a mention-some question because she doesn't find this reply useful enough, as in (49), where the reply points to a place the speaker considers too far away. Similarly, the reply in (50) can be rejected because it doesn't fall within the intended range of useful resolutions.

(49) A: Where can I get an Italian newspaper?
      B: At Newstopia.
      A: Alright, but that's so far from here. Anywhere else?

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than we are using this concept here. In particular, additive particles seem to be sensitive to speaker's reference in the sense of Kripke (1977). Assume that in (i), the man described as drinking champagne is actually drinking sparkling water, while, unbeknownst to A and B, Bob is standing right next to that man and drinking champagne. B's use of *also* seems acceptable here, although it would violate NON-IDENTITY if *also* was sensitive to the semantic meaning of B's utterance.

(i)   [A and B are at a party, hosted by Mary and John.]
      A: Which of the guests did Mary invite?
      B: Well, she invited Bob, and she also invited the man over there drinking champagne.

(50)   A: I can't find the milk. Where is it?
       B: At the supermarket.
       A: Duh.

Also note that it's not permissible in any of these cases for the speaker to reject a true but unintended resolution by uttering something along the lines of (51). This indicates that the speaker's implicit admissibility criterion should not be treated as the question's at-issue content.

(51)   A: #No/False/That's wrong.

On the basis of these data, it seems that some representation of what counts as an *admissible resolution* to a question is needed not only to account for additives in showmaster questions, but also in order to make sense of a much more general phenomenon. In principle, Grice's concept of speaker's meaning seems to fit cases like (49) and (50) as well. We took the speaker's meaning to model the discourse effects intended by the speaker—and certainly, getting a reply that conforms to her admissibility criteria is something she intends.

However, if we assume that the speaker's meaning of questions like (49) and (50) is restricted in accordance with the speaker's admissibility criteria, then this would overgenerate the distribution of *also*. For instance, the particle would wrongly be predicted to be acceptable in (52). This is because the witness, Newstopia, doesn't satisfy the speaker's admissibility criterion of being close enough and the resolutions corresponding to Newstopia are therefore excluded from the speaker's meaning. Hence, NON-IDENTITY is satisfied and *also* is predicted to be licensed.

(52)   A: Where can I get an Italian newspaper?
       B: At Newstopia.
       A: Alright, but that's so far from here. #Where can I also get one?

In fact, the basic pattern of this example seems to be remarkably similar to that of showmaster examples: the speaker rejects a reply because it doesn't have a certain property and asks for one that does have this property. So, what is the relevant difference between (52) and showmaster questions? It doesn't only seem to be that with a showmaster question, the speaker has a particular resolution in mind, but rather she must also be able to specify this resolution herself. To see this, consider the contrast between (53) and (54). In both examples A has a particular resolution in mind, which in both examples is different from the resolution offered by B. Yet, only in (53), A would be able to resolve her own question. So, it seems to play a role for licensing *also* that

the speaker can *list* the admissible resolutions, rather than merely describing them. I will leave an explanation of this for future work.

(53) A: I bet you can't guess which actress I saw on the subway yesterday! I'll
      give you a hint: what's a typical old-fashioned name?
      B: Eleanor.
      A: No, that's not the one. What's also an old-fashioned name?

(54) A: I recently saw a movie with a great actress, but I can't remember her
      name. . . What's a typical old-fashioned name?
      B: Eleanor.
      A: No, that's not the one. #What's also an old-fashioned name?

On a related note, it seems fair to say that of all the cases we considered in this section, showmaster questions pose the biggest puzzle. Since it appears that speakers can implicitly restrict the set of admissible resolutions in these questions, this implicit restriction mechanism must in principle be available. So, wouldn't it make sense to, in *all* questions, restrict the set of admissible resolutions such that already provided resolutions are excluded? If this was indeed a possibility, then on the present account, *also* would wrongly be predicted to be licensed in all wh-questions. So, the account relies on the assumption that such witness-excluding implicit restrictions are not freely available—or indeed, that they are available, but insufficient for licensing *also* after all, just like the restrictions in (52) and (54).

To conclude this section, we have seen different ways in which the NON-IDENTITY condition can be rescued when an additive particle appears in a wh-question: through "splitting up" the wh-domain into speaker and hearers with summoning questions, through removing the witness with *else*-questions, and finally through implicitly restricting the wh-domain on the level of speaker's meaning with showmaster questions. What is underlying all of these cases is a wh-domain that doesn't contain the witness and therefore guarantees the feasibility of the incremental discourse strategy marked by the additive particle.

4.6.   Conclusion

The current paper makes contributions on three fronts. First, it makes the empirical generalization about the distribution of *also*-like additive particles more differentiated by considering novel data. Contrary to what Umbach (2012) claims, it is not necessary for licensing German *auch* in a wh-question

that the question receives a showmaster interpretation, and the same goes for English *also*. Rather, *auch/also* can also appear in summoning questions, whose speaker typically doesn't know the answer. This gives rise to the puzzle what it is about showmaster and summoning questions, two at first blush very different kinds of question, that licenses *also*-like particles. It is suggested that the mechanism responsible for licensing these particles is the same for both kinds of questions: the wh-domain is restricted such that it does not contain the witness of the additive presupposition. This has the effect of ensuring that the NON-IDENTITY condition of this presupposition can be satisfied.

Second, the paper proposes an account of additive particles that is unified in that it captures the contribution of these particles in declaratives as well as in different kinds of interrogatives. This is achieved by assuming that declaratives and interrogatives make the same kind of semantic objects available for additive particles to operate on. The conceptual backdrop that makes this move possible is borrowed from inquisitive semantics (Ciardelli *et al.* 2018).

Third, the proposed account contributes to our understanding of the role that questions can play in organizing discourse. It connects the fine-grained semantic content of questions to a higher-level representation of discourse structure, in a way analogous to how this was done by Beaver and Clark (2008) for assertions. Essentially, Beaver and Clark analyzed *also* as marking that the propositional content of its containing sentence contributes a partial answer to an incremental discourse strategy for answering the CQ. The current paper generalizes this idea: the ways in which a sentence can contribute to an incremental discourse strategy are more diverse than just by asserting a partial answer. Polar questions contribute by mentioning a particular partial answer and inquiring whether it holds; and wh-questions contribute by inquiring about a certain subset of partial answers to the CQ.

I believe it is important to realize that Beaver and Clark's account, as well as any work utilizing Roberts (1996)'s seminal QUD-model, in principle aspires to capture two distinct conceptions of questions at the same time. On the one hand, it clearly treats questions as analytic tools for describing discourse structure. But on the other hand, it also grants that these tools, these questions, can be asked aloud, which makes them linguistic objects. In practice, this latter conception of questions as linguistic objects doesn't play a role in the standard QUD-model, however: nothing is said about how different kinds of questions are associated with a CQ. So, prima facie, focus-sensitive expressions appearing in questions are outside the reach of the standard QUD-model.

I believe it is a worthwhile enterprise to expand this model, and in particular Beaver and Clark's project, in a way that takes the linguistic properties of questions seriously. Why? Questions do host interesting expressions like

focus particles and other expressions that are sensitive to both the discourse structure and the semantic content of the question. And questions exhibit certain idiosyncratic properties, such as the differences between polar questions and wh-questions, that we would miss if we just treated questions as idealized tools for organizing discourse. What I hope this paper has shown in particular is that this enterprise is feasible. In future work, I plan to revisit many of the assumptions made here about the CQs that are associated with different kinds of questions. They will have to be made more principled and be further motivated.

Another important question that will need to be addressed in future work is what exactly constitutes the relevant notion of "having an answer in mind" that allows speakers to use *also* in showmaster questions. We saw data suggesting that this notion has something to do with literal knowledge of an answer. The account proposed here, which derives the markedness of *also* from a violation of the NON-IDENTITY condition can't explain why literal knowledge would be a requirement, since it's possible to know that two propositions are logically independent even without knowing which exact propositions they are.

Perhaps this puzzle will eventually lead us back to the notion of contrastive topics. As already pointed out by Umbach (2012), if *also* associates with a preceding constituent, such as the wh-phrase of a single wh-question, then the associated constituent is interpreted as a contrastive topic (Krifka 1998). Umbach takes the referentiality requirement of contrastive topics to enforce a showmaster interpretation of the question. But the account proposed here suggests a different way of construing this requirement. Couldn't it be the wh-domain of a question that serves as the topic of this question (*Here is a question about you guys: who of you wants an ice cream?*)? In order to make the wh-domain a contrastive topic, of course, the question needs to be part of a specific kind of larger discourse strategy. Interestingly, though, those strategies that are suitable for contrastive topics seem to be exactly those strategies that satisfy NON-IDENTITY and therefore license *also*. On the one hand, this is unsurprising, since the independence condition on contrastive topics (Büring 2003) plays a similar role as our NON-IDENTITY condition. On the other hand, though, this prompts interesting questions: by starting from the notion of contrastive topic, we might arrive at an account very similar to the one we arrived at by starting from the additive presupposition. I don't think this on its own means that we should give up the proposed account in favor of a contrastive topic account— after all, a generalized additive presupposition is independently needed to account for the contribution of additive particles in interrogatives. Rather, I believe we can adopt a more optimistic stance on the potential equivalence between the present account and a contrastive-topic-based one: we might be

on track towards a deeper understanding of the connection between additive particles and contrastive topics.

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Samenvatting

Dit proefschrift ontwikkelt semantische verklaringen van verschillende soorten expressies: attitude werkwoorden (zoals *weten*), modale partikelen (zoals Duits *denn*) en additieve partikelen (zoals *ook*). Wat deze expressies gemeen hebben is dat (i) ze semantische operaties uitdrukken die toegepast worden op de betekenis van de zin waarmee ze verschijnen, (ii) ze met zowel declaratieve als vragende zinnen voorkomen en (iii) hun gedrag op een interessante manier afhankelijk is van het type zin waarmee ze verschijnen.

De oplossingen die hier naar voren worden gebracht verschillen van bestaand werk omdat ze uniforme verklaringen verschaffen die van toepassing zijn op zowel het declaratieve als het vragende geval. Dit voorspelt direct de distributionele en selectionele flexibiliteit van de onderzochte expressies en vat hun betekenisbijdrage zonder dat hulpmechanismes als type-shifting nodig zijn.

Hoewel uniforme theorieën declaratieve en vragende zinnen gelijk behandelen, kunnen ze tegelijkertijd ook uitleggen waarom deze twee zinstypes verschillen in distributie en interpretatie. Dit is mogelijk omdat deze verschillen kunnen worden afgeleid van de interactie tussen de lexicale semantiek van attitudinale predikaten en partikelen enerzijds en de semantische eigenschappen van vragende en declaratieve zinnen anderzijds.

Om semantische theorieën die het declaratieve en vragende geval verenigen formeel mogelijk te maken, gebruikt dit proefschrift uniforme noties van semantische inhoud. Aangenomen wordt dat declaratieve en vragende zinnen dezelfde soort semantische objecten beschikbaar maken, en dat expressies als attitude werkwoorden, modale partikelen en additieve partikelen op deze objecten opereren. Er wordt specifiek gekeken naar het gebruik van twee uniforme noties van semantische inhoud. De notie van resolutie uit inquisitieve semantiek (Ciardelli *et al.* 2018) wordt aangewend in de analyse van attitude werkwoorden, terwijl de notie van highlighting in de zin van Roelofsen and Farkas (2015) wordt gebruikt om de semantiek van discourse particles en additive particles vast te leggen.

Abstract

This dissertation develops semantic accounts of a range of expressions: attitude verbs, discourse particles, and additive particles. What all of these expressions have in common is that (i) they can be viewed as operating on the semantic content of the clause they appear with, (ii) they can appear with both declarative and interrogative clauses, and (iii) their behavior differs in interesting ways depending on the clause type they appear with.

The solutions advanced here depart from existing work in that they provide unified accounts that are applicable to both the declarative and interrogative case. This immediately predicts the distributional and selectional flexibility of the expressions under investigation and captures their meaning contribution without the need of invoking auxiliary mechanisms like type-shifting. At the same time, although unified accounts treat declarative and interrogative clauses alike, they can still predict the distributional and selectional restrictions and interpretive differences that an expression may exhibit between these two clause types. This is possible because these differences can be derived from the way in which the lexical semantics of the expression interacts with independent semantic properties of interrogative and declarative clauses.

In order to formally enable semantic accounts that unify the declarative and interrogative case, this dissertation uses unified notions of semantic content. It is assumed that declarative and interrogative clauses make the same kind of semantic objects available, and expressions like attitude verbs, discourse particles and additive particles operate on these objects. More specifically, the use of two unified notions of semantic content is explored. The notion of resolution from inquisitive semantics (Ciardelli *et al.* 2018) is employed in the analysis of attitude predicates, while the notion of highlighting in the sense of Roelofsen and Farkas (2015) is used to capture the semantics of discourse particles and additive particles.

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