Deriving selectional restrictions of clause-embedding predicates*

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Abstract

It is a long-standing puzzle why verbs like *believe* embed declarative but not interrogative complements (e.g., *Bill believes that/*whether Mary left*), while verbs like *wonder* embed interrogative but not declarative complements (e.g., *Bill wonders whether/*that Mary left*). This paper discusses how such selectional restrictions can be derived from independently observable properties of the relevant verbs.

1 Introduction

Certain clause-embedding verbs 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* verbs, verbs like *wonder* as *rogative* verbs, and verbs like *believe* as *anti-rogative* verbs. Any account that aims at explaining the distribution of clausal complements will have to capture both the selectional *restrictions* of rogative and anti-rogative verbs and the selectional *flexibility* of responsive verbs. 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 verbs can then be captured by postulating that rogative verbs take arguments of type $\langle\langle s, t\rangle, t\rangle$, while anti-rogative verbs take arguments of type $\langle s, t\rangle$. On the other hand, to capture the selectional flexibility of responsive verbs, 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 verbs 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

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interrogatives (as in Uegaki, 2015b), the account of the selectional restrictions of rogative verbs 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 verb classes needs to be derived from factors other than the postulated type-distinction between declaratives and interrogatives.

A second drawback is that, in the absence of independent motivation for the type-distinction between declarative and interrogative complements and for the assumptions that are made as to which clause-embedding verbs require which type of argument, the approach remains stipulative to a certain degree.[1] An account which derives the selectional restrictions of (anti-)rogatives from independently observable properties of these verbs would be preferable.

The present paper assumes a *uniform* account of clausal complements, which has been motivated on independent grounds in Theiler *et al.* 2016. The account is uniform in the sense that it assigns the same semantic type to declarative and interrogative complements, namely $\langle\langle s,t\rangle,t\rangle$, and it assumes that all clause-embedding verbs take arguments of this type. On such an account, the selectional flexibility of responsive verbs 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 verbs. Such an explanation has recently been given for *wonder* and some closely related rogative verbs (Ciardelli and Roelofsen, 2015; Uegaki, 2015b).[2] The present paper does so for another class of rogative verbs, namely verbs of dependency like *depend on* and *be determined by*, as well as two classes of anti-rogative verbs, namely (i) neg-raising verbs like *believe* and *think* and (ii) truth-evaluating predicates like *be true* and *be false*.

The paper is structured as follows. Section 2 briefly lays out our uniform account of clausal complements, and exemplifies our treatment of responsive verbs. Section 3 is concerned with the selectional restrictions of anti-rogative verbs, Section 4 with those of rogative verbs, and Section 5 concludes. Appendix A discusses related work in some detail, Appendix B spells out some technical details of the proposed account, and Appendix C presents an extension of the core account to presuppositional complements.

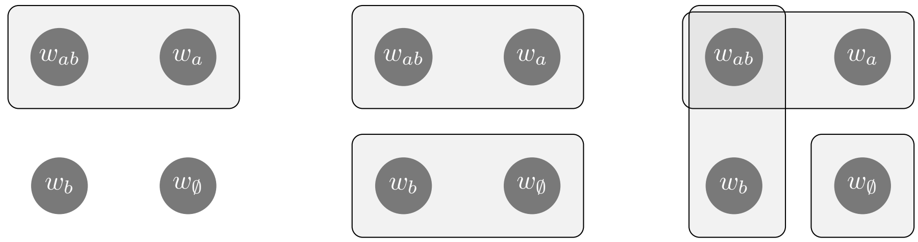
2 A uniform treatment of clausal complements

Our treatment of clausal complements is couched in inquisitive semantics (Ciardelli *et al.*, 2013, 2015). 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 additionally 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 raise an issue whose resolution requires establishing one of the propositions in $[\![\varphi]\!]$, while simultaneously providing the information that the actual world is contained in the union of these propositions, $\bigcup[\![\varphi]\!]$. $\bigcup[\![\varphi]\!]$ is the informative content of φ, written as $\mathsf{info}(\varphi)$.

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

[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 A.2.



(a) that Ann left (b) whether Ann left (c) who left

Figure 1: Examples of complement clause meanings in inquisitive semantics.

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., $w \in \mathsf{info}(\varphi)$.

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 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.

2.3 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.[3] That is, its meaning $[\![\varphi]\!]$ always contains a single alternative, which coincides with its informative content, $\mathsf{info}(\varphi)$. For example:

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

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.[4] For example, if the domain of discourse consists of Ann and Bob, we assume

[3]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.

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

the following sets of alternatives for the interrogative complements *whether Ann left* and *who left*.[5]

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

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

The alternative sets in (4)–(6) are also depicted in Figure 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.

2.4 Responsive verbs: a brief illustration

Before dealing with the selectional restrictions of anti-rogative verbs, let us first briefly specify a lexical entry for the responsive verb *be certain*, showing that its selectional flexibility is immediately captured.[6,7] 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.[8]

(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 whether John left.
$\rightsquigarrow$ True in w iff $\exists p \in \left\{ \begin{array}{l} \{w \mid \text{ John left in } w\}, \\ \{w \mid \text{ John didn't leave in } w\} \end{array} \right\}$ s.t. $\text{DOX}_m^w \subseteq p$

The present approach thus yields a more economical treatment of responsive verbs than approaches that assume a type distinction between declarative and interrogative complements. It is not necessary here to assume a type-shifting operation (or multiple lexical entries for each responsive verb). Moreover, as discussed in detail in Theiler *et al.* 2016, the approach avoids certain thorny problems, brought to light by George (2011) and Elliott *et al.* (2017), for mainstream theories which assume a type-shifting operation from $D_{\langle\langle s,t\rangle,t\rangle}$ to $D_{\langle s,t\rangle}$. 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.

[5]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.*, 2016). This refinement doesn't affect any of the results presented here.

[6]We consider *be certain* here rather than *know* because the latter involves a factivity presupposition, which makes its lexical entry somewhat more complex. See Theiler *et al.* (2016) for discussion of *know* as well as several other responsive verbs.

[7]Mayr (2017) claims that *be certain* only licenses interrogative complements in negative environments; not in plain episodic, positive sentences. Recent experimental results, however, show that while there is indeed a slight contrast in acceptability between interrogative complements under *be certain* and under *know* in plain episodic sentences, in both cases the acceptability rate is relatively high, much higher than for similar sentences with *believe* (van Gessel *et al.*, 2017).

[8]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 B.

3 Anti-rogative verbs

We will now turn our attention to anti-rogative verbs, which include attitude verbs like *think* and *believe*,[9] likelihood predicates such as *seem* and *be likely*, speech-act verbs like *claim* and *assert*, truth-evaluating predicates like *be true* and *be false*, and non-veridical preferential predicates like *hope* and *fear*. We will focus here on two classes, namely *neg-raising* verbs such as *believe*, *think*, *seem*, and *be likely* (Section 3.1), and the *truth-evaluating* predicates *be true* and *be false* (Section 3.2). In the concluding remarks in Section 5 we will briefly return to anti-rogative speech act verbs and non-veridical preferential predicates.

3.1 Neg-raising verbs

3.1.1 Zuber's observation: all neg-raising verbs are anti-rogative

It has been observed that—diverse as the class of anti-rogative verbs 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:[10]

(10) Mary does **not** believe that Ann left.
$\therefore$ Mary believes that Ann did **not** leave.

Zuber (1982) claims that *all* neg-raising verbs 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 verbs.

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*[11]
b. Non-veridical preferential verbs: e.g., *desire*, *fear*
c. Speech act verbs: e.g., *claim*, *assert*

[9] 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 (i-a-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!

Note that, as illustrated in (i-c), other anti-rogative verbs do not seem to exceptionally license interrogative complements in these configurations, and as illustrated in (i-d), while *believe* exceptionally licenses *wh*-interrogatives in these cases, polar interrogative complements are still unacceptable. Finally, note that *believe* seems to become factive when it felicitously embeds an interrogative complement. Further investigation of this peculiar phenomenon must be left for another occasion.

[10] See, e.g., Horn (1989); 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.

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 3.2, and will briefly return to the anti-rogativity of the remaining verbs in (12) in Section 5.

3.1.2 Deriving neg-raising from an excluded-middle presupposition

We start with a preliminary entry for *believe*, which is identical to that of *be certain* from Section 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).[12] On this account, neg-raising behavior results from a so-called *excluded-middle (EM) presupposition*, carried by all neg-raising verbs. 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 the opinionatedness assumption is suspended, as in (16), *believe* receives a non-neg-raising reading. This behavior sets neg-raising verbs 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...

[11] *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 verbs like *think* and *believe*; see also footnote 10 above.

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

As we will see in a moment, we will assume that neg-raising verbs 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) would amount to assuming a tautological presupposition for these verbs (since it is true for any proposition p that p is true or that $\neg p$ is true).

[12] 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 verbs are anti-rogative can also be derived on these other accounts.

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 verb 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.[13]

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

Since the semantic object P that *believe* takes as its argument on our account is not a single proposition but a set of propositions, we do not compute its negation simply by taking its set-theoretical complement, but rather using the negation operation from inquisitive semantics, written as $\neg$. When applied to a sentence meaning P this operation returns the set of those propositions that are inconsistent with every member of P:[14]

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

Using inquisitive negation, we arrive at the lexical entry in (19). 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) $[\![\text{believe}]\!]^w = \lambda P_T . \lambda x : \underline{\textsc{dox}_x^w \in P \vee \textsc{dox}_x^w \in \neg P} \, . \, \textsc{dox}_x^w \in P$

What will be crucial for our account of the selectional restrictions of neg-raising verbs 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, 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 $\textsc{dox}_x^w \subseteq p$ (x believes that p), while the second disjunct amounts to $\textsc{dox}_x^w \cap p = \emptyset$ (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.

[13] 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.

[14] 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).

Interrogative complements. On the other hand, we assume that interrogative complements are never informative, and typically inquisitive. This means that the alternatives in the meaning of an interrogative complement, taken together, always cover the entire logical space.[15] As a consequence, the inquisitive negation of an interrogative complement meaning P is always $\neg P = \{\emptyset\}$ since there can be no non-empty proposition that is inconsistent with every alternative in P. This means that 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. Moreover, even if we want to allow for inconsistent doxastic states, the second disjunct of the presupposition can only be satisfied if the first disjunct is satisfied as well, since $\emptyset$ is contained in any complement meaning P. Thus, with or without the assumption that doxastic states are consistent, the second disjunct in the presupposition turns out redundant. That is, 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. In the following sections we will show that this triviality is a systematic triviality in the sense of Gajewski (2002) and that it can thus be taken to explain the anti-rogative nature of *believe* and other neg-raisers.

3.1.4 L-analyticity

What we mean here by *systematic* triviality is that the meaning of a sentence in which a neg-raising verb 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 verb is used—the triviality only depends on the fact that the verb 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

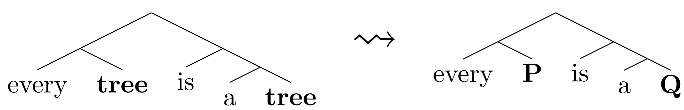
[15] Recall that we leave presuppositional complement clauses out of consideration here; see Appendix C for an extension of the core account developed here that deals with such complements.

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 also come out as logical under any suitable definition of logicality.

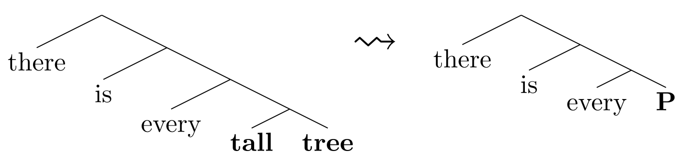
Logical skeleton. To determine whether a given sentence is L-analytical, we first compute its *logical skeleton* (LS) using the algorithm from Gajewski (2002). Let α be the logical form (LF) of the sentence. Then we obtain the LS from α by (i) identifying the maximal constituents of α that don't contain 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) $[\![\text{there is every } \mathbf{P}]\!]^{\langle D,I\rangle} = [\![\text{every}]\!](I(\mathbf{P}))([\![\text{there}]\!]^{\langle D,I\rangle})$
$\qquad\qquad\qquad\qquad\quad = [\![\text{every}]\!]^{\langle D,I\rangle}(I(\mathbf{P}))(D_e)$

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.

3.1.5 Capturing the anti-rogativity of neg-raising verbs in terms of L-analyticity

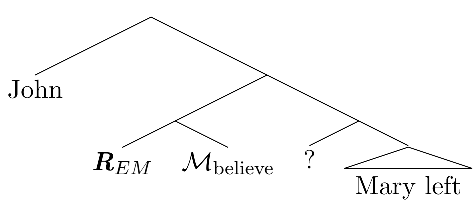
Let us now return to the selectional restrictions of neg-raising verbs and see how the account sketched in Section 3.1.3 can be made fully explicit by phrasing it in terms of L-analyticity. In order to do so, two assumptions about the structure of interrogative clauses and neg-raising predicates are 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.[16]

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 to the predicate V.[17] 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 verb 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. $[\![\mathcal{M}_{\text{believe}}(x)]\!]^w = \text{DOX}_x^w$
 b. $[\![\mathcal{M}_{\text{want}}(x)]\!]^w = \text{BOUL}_x^w$

[16]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).

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

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

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

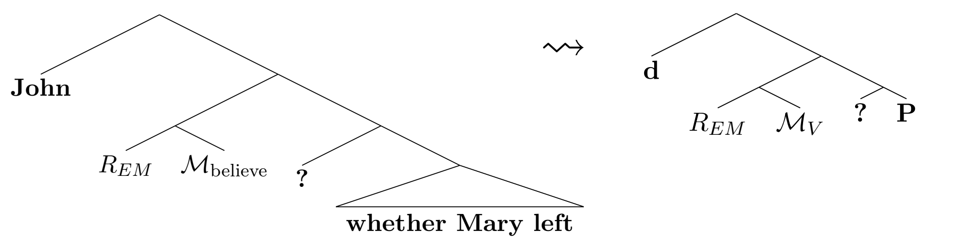
R_{EM} takes the function $\mathcal{M}_V$, the complement meaning P and the subject x as arguments; it contributes the EM presupposition (the modal base $\mathcal{M}_V(x)$ has to be a resolution either of P or of the negation of P); and it asserts that $\mathcal{M}_V(x)$ is a resolution of P. Intuitively, 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 3.1.3 are L-analytical. There, we had found that whenever a neg-raising attitude verb 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 $\mathcal{M}_{\text{believe}}$ each get substituted by a fresh constant, while both R_{EM} and the interrogative marker remain untouched.

(32)



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

(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 if this holds, then the first disjunct is also satisfied, since $[\![\mathbf{?P}]\!]^{\langle D,I \rangle}$ always contains $\emptyset$. This means that 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 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.
$\not\leadsto$ Bill believes that Brutus didn't kill Caesar

One might expect that in such contexts, since the neg-raising inference of the verb 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 by our account. Recall that Gajewski's (2009) general theory of L-analyticity holds that 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.

3.2 Truth-evaluating verbs: *be true* and *be false*

We have seen above how the selectional restrictions of a substantial class of anti-rogative verbs, 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 verbs *be true* and *be false*.

We treat truth-evaluating verbs in the obvious way: *be true* and *be false* take a clausal complement and assert that this complement is true or false, respectively. Recall that in inquisitive semantics, a clause φ is true in a world w just in case $w \in \mathsf{info}(\varphi)$, where $\mathsf{info}(\varphi) = \bigcup[\![\varphi]\!]$. Thus we assume the following lexical entries:

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

When combined with a declarative complement, these entries give the expected results. What happens if they take an interrogative complement, though? We have seen in Section 2, that if P is an interrogative complement, its informative content covers the entire logical space, i.e., $\mathsf{info}(P) = W$. In this case, the truth conditions for *be true* amount to $w \in W$, a tautology, while the truth conditions for *be false* amount to $w \notin W$, a contradiction. Hence, when taking interrogative complements, *be true* and *be false* systematically yield trivial sentence meanings. Assuming that *be true* and *be false* constitute logical vocabulary, these are again cases of L-analyticity.

The reader might wonder why we went all the way to deriving the anti-rogativity of verbs like *believe* in terms of neg-raising—seeing that we could have simply treated *all* anti-rogative verbs as being sensitive only to the informative content (and not the inquisitive content) of their complement. For instance, for *believe* we could have started out with the following entry:

(37) $[\![\text{believe}]\!]^w = \lambda P_T . \lambda x : \textsc{dox}_x^w \subseteq \mathsf{info}(P)$

This would also have allowed us to derive that combining *believe* with an interrogative complement systematically leads to triviality. Recall, however, that while *believe* does not take interrogative complements, closely related verbs like *know* and *be certain* do. Thus, we would have to assume that while *believe* is only sensitive to the informative content of its complement, *know* and *be certain* aren't. We see no independent motivation for such an assumption. Thus, such an account would be more stipulative than one that derives the anti-rogativity of *believe* from the fact that it is neg-raising, a property that sets it apart from *know* and *be certain* on independent grounds.

4 Rogative verbs

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

4.1 Inquisitive verbs

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 verbs such as *be curious* and *investigate*. For discussion of the subtle differences between the accounts of Ciardelli and Roelofsen (2015) and Uegaki (2015b), respectively, we refer to Appendix 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, $\textsc{inq}_x^w$, is a downward-closed set of consistent propositions which together cover her doxastic state, i.e., $\bigcup \textsc{inq}_x^w = \textsc{dox}_x^w$. The propositions in $\textsc{inq}_x^w$ 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.

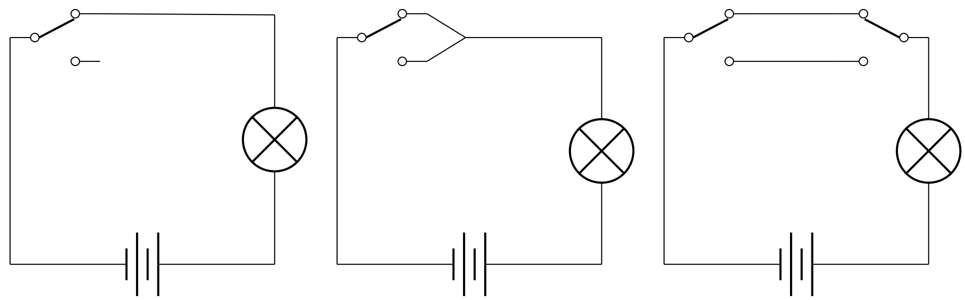
Informally, x wonders about a question, e.g., about *who called*, just in case (i) x isn't certain yet who called, and (ii) she wants to find out who did. This is the case exactly if (i) x's current doxastic state does not resolve the question; and (ii) every doxastic state in x's inquisitive state is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

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

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

(39) *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 (38) holds: $\textsc{dox}_x^w \notin P$. Then it must be that $\textsc{dox}_x^w \not\subseteq \alpha$. But then, since $\bigcup \textsc{inq}_x^w = \textsc{dox}_x^w$, it must also be that $\bigcup \textsc{inq}_x^w \not\subseteq \alpha$. It follows that there is at least one $s \in \textsc{inq}_x^w$ such that $s \not\subseteq \alpha$. But if $s \not\subseteq \alpha$, 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.



(a) Full dependency (b) Trivial dependency (c) Partial dependency

Figure 2: Full, trivial, and partial dependency between (left) switch and light.

4.2 Verbs of dependency

We now turn to rogative verbs 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 verbs 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 be either explicitly given, as in (40), or inferred from the context, as in (41), where, roughly, it is construed as *given the laws of nature and the electrical circuit under discussion.*

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

(41) 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 (41), and consider the electrical circuit in Figure 2a. 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 2a. That is, $\sigma_{w_1} = \{w_1, w_2\}$. Let P_{light} be the meaning of the the first argument of the verb in (41), *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 $\alpha \in \mathsf{alt}(P')$ to an alternative $f(\alpha) \in \mathsf{alt}(P)$ such that for all $p \subseteq \sigma$, if $p \subseteq \alpha$ for some $\alpha \in \mathsf{alt}(P')$ 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 $\mathsf{alt}(P')$ that is compatible with σ to the *same* alternative in $\mathsf{alt}(P)$. 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 2b. 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 $\mathsf{alt}(P_{\text{switch}})$

to some alternative $f(\alpha)$ in $\mathsf{alt}(P_{\text{light}})$ such that for all $p \subseteq \sigma_{w_3}$, if $p \subseteq \alpha$ for some $\alpha \in \mathsf{alt}(P')$ then $p \subseteq f(\alpha)$ as well. Just let f map both alternatives in $\mathsf{alt}(P_{\text{switch}})$ to the same alternative in $\mathsf{alt}(P_{\text{light}})$, namely the alternative 'that the light is on'. But we would not say that sentence (41) 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 $\mathsf{alt}(P_{\text{switch}})$ that are compatible with σ_{w_3} to the same alternative in $\mathsf{alt}(P_{\text{light}})$. This leads us to the following entry for *depend on*:[18]

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

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

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

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

(43) *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, (43) comes out as a contradiction, and this will always be the case if the first argument of the verb is a declarative clause.

Now consider a case in which the second argument is a declarative clause.

(44) *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 verb. So (44) also comes out as a contradiction, and the same result obtains if the verb takes other declarative clauses as its second argument. This systematic contradictoriness explains why *depend on* cannot take declarative complements.[19]

5 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 verbs 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 verbs, such an account remains stipulative.

[18]This entry may be further refined in order to allow for *partial* dependencies. For instance, in the circuit in Figure 2c, 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*.

[19]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*.

On the second approach, the selectional restrictions of clause-embedding verbs have to be explained entirely based on independently observable properties of the relevant verbs. 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 verbs, namely neg-raising verbs, truth-evaluating verbs, inquisitive verbs, and verbs of dependency.

Cases that we have not treated here include rogative speech act verbs such as *ask* and *inquire*, anti-rogative speech act verbs such as *assert* and *claim*, as well as non-veridical preferential predicates like *fear* and *desire*. The selectional restrictions of this last class of verbs have been addressed elegantly in recent work by Uegaki and Sudo (2017).

For rogative speech act verbs 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 (something that seems to be an inherent aspect of the speech act of asking, and similarly for inquiring). This is impossible if φ is a declarative, because then it is bound to be non-inquisitive.

For anti-rogative speech act verbs like *assert* and *claim*, however, we believe that an explanation is harder to find. This is because there are closely related speech act verbs such as *tell* which are responsive. If we tried to appeal to a similar reasoning as with rogative speech-act verbs, we would have to motivate why this reasoning applies to verbs like *assert*, but not to verbs like *tell*. Instead, following White and Rawlins (2016), we conjecture that the relevant factor determining whether a speech act verb is responsive might lie in the verb's event structure. Further exploring this hypothesis, however, must be left for another occasion.

Finally, while all verbs we discussed here could easily be classified as either responsive or (anti-)rogative, not all embedding verbs fall so neatly into one of these categories. One complication stems from the fact that the selectional restrictions of some verbs appear to be polarity sensitive. For instance, as illustrated in (45), it seems that *say* allows for interrogative complements only when it appears in NPI-licensing environments.

(45) a. Mary didn't say what/whether Bill had eaten.
b. Mary said ?what/*whether Bill had eaten.

Mayr (2017) proposes an account of embedded polar questions that predicts such polarity sensitivity.

Another complication, illustrated in (46), is that certain verbs, namely emotive factives like *surprise* and *amaze*, only accept *wh*-interrogatives as complements, but not polar interrogatives.

(46) 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, 2015). 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).

A Related work

This appendix discusses some work that is, like the present paper, also concerned with the selectional restrictions of rogative and/or anti-rogative verbs. 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 (Section 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 (Section A.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 observed connection.[20] While these accounts are largely in the same spirit as ours, they are, in their current shape, more limited in scope and less explicit in some important regards. In particular, neither of them explicitly shows that embedding an interrogative clause under a neg-raising verb gives rise to L-analyticity.

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 relies on a particular mechanism of presupposition projection which would have to be specified in more detail in order to see whether the proposal is tenable.

The proposal of Cohen (2017a) wrongly predicts that under negation, neg-raising verbs do take interrogative complements. Moreover, it assumes that the EM presupposition of neg-raising verbs 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 verbs like *believe* trigger an EM presupposition while closely related verbs like *be certain* don't.

A different proposal is sketched in Cohen (2017b). On this proposal, EM presuppositions are semantic in nature and neg-raising verbs 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, 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 will leave until June*), a core empirical fact about neg-raising predicates (for discussion, see Gajewski, 2007 and Križ, 2015).

A.2 Uegaki (2015b)

We have shown that the selectional restrictions of some important classes of rogative and anti-rogative verbs can be derived from the lexical semantics of these verbs, 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.

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

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 $\{p\}$.[21]

(47) $[\![\mathsf{Id}]\!]^w = \lambda p.\{p\}$

Thus, type shifting is not needed when a responsive verb like *know* takes an interrogative complement, as on the standard reductive approach (e.g., Heim, 1994), but rather when such a verb takes a declarative complement. For instance, *John knows that Mary left* is rendered as follows:

(48) John knows [Id [that Mary left]]

In this setup, the selectional restrictions of anti-rogative verbs like *believe* can be seen as resulting from a type mismatch, under the assumption that such verbs require a single proposition as their input. On the other hand, the selectional restrictions of rogative verbs like *wonder* have to be given a different kind of explanation, because in terms of semantic type they do not differ from responsive verbs like *know*.

Uegaki provides such an explanation, as well as independent motivation for the assumed type distinction between anti-rogative verbs on the one hand and responsive and rogative verbs on the other. We will consider these aspects of Uegaki's proposal in Section A.2.1 and A.2.2, respectively, in each case drawing comparisons with our own approach.

A.2.1 Rogative verbs

Summary of Uegaki's account. The fact that *wonder* does not license declarative complements is accounted for by Uegaki (2015b, Section 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 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.

(49) $[\![want]\!]^w(p)(w)$ is defined only if:

(i) $\sigma_x^w \subseteq \{w' \mid p(w') = 1 \text{ or } p(w') = 0\}$ ‘x believes presupposition of p’

(ii) $\sigma_x^w \not\subseteq \{w' \mid p(w') = 1\}$ ‘x does not believe that p is true’

Now consider a case where *wonder* takes a declarative complement.

(50) *John wonders that Mary left.

If *wonder* is analyzed as *want to know*, then the truth value of (50) 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 (50) can never be satisfied. This explains the fact that *wonder*

[21] 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 $\lambda w.[\![\alpha]\!]^w$.

does not license declarative complements, and Uegaki suggests that the account can be extended to other rogative verbs as well, assuming that all these verbs 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 verbs. Let us first consider the predictions of the account for a case where *wonder* takes an interrogative complement:

(51) 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 survive under negation, it is therefore also predicted that (52) presupposes that John doesn't know whether Mary left.

(52) John does not wonder whether Mary left.

This is a problematic prediction, because (52) can very well be true in a situation in which John already knows whether Mary left. 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 (52) implies that John is ignorant as to whether Mary left.

Now let us turn to the possibility of extending Uegaki's account of *wonder* to other rogative verbs. 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 verbs of *dependency* or even for rogative speech act verbs like *ask*.

There are certainly many contexts in which asking a question pragmatically implicates not knowing the answer to that question. But the assumption that asking a question generally, i.e., independently of the context of utterance, presupposes not knowing the answer to that question is too strong. For instance, (53) below does not imply that the math teacher doesn't know the square root of 169.

(53) Our math teacher asked us today what the square root of 169 is.

As for verbs of dependency, it is clear that a sentence like (54) does not make reference to any agent's knowledge or desires, and can therefore not be paraphrased in terms of *want to know*.

(54) 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 verbs.

A.2.2 Anti-rogative verbs

Summary of Uegaki's account. As mentioned above, Uegaki assumes that anti-rogative verbs like *believe* require a single proposition as their input, while responsive and rogative verbs 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 verbs 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 verbs can take both declarative and interrogative complements.

Uegaki motivates the assumption that anti-rogative verbs like *believe* and responsive verbs like *know* require different types of input, based on a contrast that arises when these two types of verbs 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 (55).

(55) a. John believes the rumor that Mary left.
∴ John believes that Mary left.
b. John knows the rumor that Mary left.
$\not\therefore$ 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 verbs behave just like *believe* in this respect, while all responsive verbs behave just like *know.* He then provides an account of the contrast in (55) 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 verbs as well, it indeed provides independent motivation for the type distinction that Uegaki assumes to account for the selectional restrictions of anti-rogative verbs.

Problem and comparison. The problem for this approach is that there are counterexamples to the claim that all anti-rogative verbs behave like *believe* when combined with content DPs, and that all responsive verbs behave like *know* in this respect. First, there are anti-rogative verbs which, unlike *believe*, cannot be combined with content DPs at all.

(56) *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 verbs.

A more drastic problem is that there are also responsive verbs that do not behave like *know* when combined with content DPs. Such verbs include *hear* and *prove*, as illustrated in (57)-(58).[22]

(57) John heard the rumor that Mary left.
∴ John heard that Mary left.

(58) John proved the hypothesis that every positive integer has a unique prime factorization.
∴ John proved that every positive integer has a unique prime factorization.

On Uegaki's account these verbs 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 verbs 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 verbs can be derived from independently observable properties of these verbs, without the need to assume a mismatch in semantic type.

[22] Uegaki (2015b, p.49,61) remarks that certain responsive verbs 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 verbs do license inferences like those in (57)-(58). However, to the extent that such readings exist for *hear* and *prove*, they don't seem to be necessary for the inferences in (57)-(58) to go through.

B Support-conditional lexical entries

In the main text, we have given truth-conditional lexical entries for a number of verbs. For instance, according to our entry for *be certain*, repeated in (59) below, the verb 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.

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

Another, equivalent formulation of the entry is given in (60) below. This formulation makes clear that, when given a complement meaning P and an individual x as its input, the verb yields a function from possible worlds to truth-values. Such a 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.

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

In inquisitive semantics, however, as discussed in Section 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, verbs 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 verbs should therefore be of the following form:

(61) $[\![\cdot]\!] = \lambda P_T.\lambda x.\lambda p_{\langle s,t\rangle} \ldots$

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 (61) are called support-conditional, rather than truth-conditional entries.

Now, what are the support-conditional entries of the verbs 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 verb 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:

(62) $[\![\text{be certain}]\!] = \lambda P_T.\lambda x.\lambda p.\, \forall w \in p.\, \textsc{dox}_x^w \in P$

(63) $[\![\text{believe}]\!] = \lambda P_T.\lambda x.\lambda p.\, \underline{\forall w \in p.\, (\textsc{dox}_x^w \in P \vee \textsc{dox}_x^w \in \neg P)}.\, \forall w \in p.\, \textsc{dox}_x^w \in P$

(64) $[\![\text{be true}]\!] = \lambda P_T.\lambda p.\, \forall w \in p.\, w \in \mathsf{info}(P)$
$= \lambda P_T.\lambda p.\, p \subseteq \mathsf{info}(P)$

(65) $[\![\text{be false}]\!] = \lambda P_T.\lambda p.\forall w \in p.\, w \notin \mathsf{info}(P)$
$= \lambda P_T.\lambda p.\, p \cap \mathsf{info}(P) = \emptyset$

(66) $[\![\text{wonder}]\!] = \lambda P_T.\lambda x.\lambda p.\, \forall w \in p.\, (\textsc{dox}_x^w \notin P \;\wedge\; \textsc{inq}_x^w \subseteq P)$

(67) $[\![\text{depend on}]\!] = \lambda P'_T.\lambda P_T.\lambda p.\, \forall w \in p.\, \exists f \in \mathsf{alt}(P)^{\mathsf{alt}(P')}$ such that:
   (i) $\forall q \subseteq \sigma_w.\forall \alpha \in \mathsf{alt}(P').(q \subseteq \alpha \rightarrow q \subseteq f(\alpha))$ and
   (ii) $\exists \alpha, \alpha' \in \mathsf{alt}(P').\alpha \cap \sigma_w \neq \emptyset \wedge \alpha' \cap \sigma_w \neq \emptyset \wedge f(\alpha) \neq f(\alpha'))$

To briefly illustrate what these entries deliver, consider the following sentence:

(68) John wonders whether Mary called.

According to the entry in (66), a proposition p belongs to $[\![(68)]\!]$ 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 $[\![(68)]\!]$ 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 (68) is not inquisitive, and that the sentence is true in w, i.e., $w \in \mathsf{info}([\![(68)]\!])$, exactly when it is true according to our truth-conditional entry for *wonder* in (38).

More generally, our support-conditional entries predict for any verb 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., $w \in \mathsf{info}(\varphi)$ 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 verbs 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.* (2016).

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.

C.1 Presuppositional questions

Let us consider the example of a polar question containing the presupposition trigger *stop*:

(69) 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 $w \in p$:

(70) $[\![$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 1 (Presupposition)**.**
The presupposition $\pi(P)$ of a sentence meaning P is $\pi(P) = \{p \mid P(p) \text{ is defined}\}$.

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.

(71) $$\neg = \lambda P.\lambda p. \begin{cases} \forall q \in P : p \cap q = \emptyset & \text{if } P(p) \text{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

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 verbs. Next, we turn to the embedding verb, *believe*. As observed by Karttunen (1973, 1974), a sentence like (72) presupposes not that John used to smoke, but that Mary *believes* that he used to smoke. That is, *believe* and other non-factive attitude verbs project the presupposition of their complement clause by attributing it to the attitude holder as a belief.

(72) 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 (73) (see Appendix 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 ($\forall w \in p : \textsc{dox}_x^w \in P$ or $\forall w \in p : \textsc{dox}_x^w \in \neg P$) as the *EM condition*.

(73) $[\![\text{believe}]\!]$
$$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \textsc{dox}_x^w \in P & \text{if } \forall w \in p : \textsc{dox}_x^w \in P \text{ or } \forall w \in p : \textsc{dox}_x^w \in \neg P \\ \text{undefined} & \text{otherwise} \end{cases}$$

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 $[\![\text{believe}]\!](P)(x)(p)$ to be defined is that, in every world $w \in p$, the subject's doxastic state, $\textsc{dox}_x^w$, satisfies the presuppositions of the complement meaning P. That is, for every $w \in p$, $P(\textsc{dox}_x^w)$ should be defined. A lexical entry for *believe*, including this additional condition is given in (74).

(74) $[\![\text{believe}]\!]$
$$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \textsc{dox}_x^w \in P & \text{if } (\forall w \in p : \textsc{dox}_x^w \in P \text{ or } \forall w \in p : \textsc{dox}_x^w \in \neg P) \\ & \textbf{and } \boldsymbol{\forall w \in p : \textsc{dox}_x^w \in P} \textbf{ is defined} \\ \text{undefined} & \text{otherwise} \end{cases}$$

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 $\textsc{dox}_x^w \in P$. This means that we may also just omit the additional definedness condition and stick with the entry in (73).

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 $\mathsf{info}(\varphi) = W$. 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 $\pi([\![\varphi]\!])$ is non-informative w.r.t. its presupposition iff $\mathsf{info}(\varphi) = \bigcup \pi([\![\varphi]\!])$. This is the case iff the alternatives in $[\![\varphi]\!]$ together cover $\bigcup \pi([\![\varphi]\!])$. Intuitively, we can think of this along the following lines. Suppose that $\mathsf{info}(\varphi) = \bigcup \pi([\![\varphi]\!])$ 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 $\pi([\![\varphi]\!])$, it will also already contain all the information encoded by $\mathsf{info}(\varphi)$, 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 (71) 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 (75).

(75) $[\![\text{believe}]\!]$

$$= \lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \text{DOX}_x^w \in P & \text{if } \forall w \in p : \text{DOX}_x^w \in P \\ \text{undefined} & \text{otherwise} \end{cases}$$

Note that the definedness condition in (75) 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.

C.4 L-analyticity

It is straightforward to translate the notion of L-analyticity into our support-conditional framework:

Assumption 3 (L-analycity, 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 (76) still comes out as L-analytical on the presuppositional account.

(76) *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.

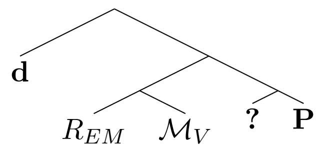
(77) $[\![\mathcal{M}_{\text{believe}}(w)(x)]\!] = \text{DOX}_x^w$

(78) $[\![R_{\text{EM}}]\!]$

$$= \lambda \mathcal{M}_{\langle s,\langle \text{e},\text{st}\rangle\rangle}.\lambda P.\lambda x.\lambda p. \begin{cases} \forall w \in p : \mathcal{M}(w)(x) \in P & \text{if } (\forall w \in p : \mathcal{M}(w)(x) \in P \text{ or} \\ & \quad \forall w \in p : \mathcal{M}(w)(x) \in \neg P) \\ \text{undefined} & \text{otherwise} \end{cases}$$

The LS for (76) is given in (79).

(79)



Now, let p be a proposition. We want to determine whether $p \in [\![(79)]\!]$. Whether this is the case, though, is only defined if p supports the presupposition $\pi([\![(79)]\!])$. 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 $\pi([\![(79)]\!])$. 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 $p \in [\![(79)]\!]$, it is indeed the case that $p \in [\![(79)]\!]$. Hence, (79) comes out as L-analytical.

References

Abels, K. (2004). Why surprise-predicates do not embed polar interrogatives. *Linguistische Arbeitsberichte*, **81**, 203–222.

Abrusán, M. (2014). *Weak island semantics*. Oxford University Press.

Abusch, D. (2002). Lexical alternatives as a source of pragmatic presuppositions. In *Proceedings of SALT*, volume 12, pages 1–19.

Abusch, D. (2010). Presupposition triggering from alternatives. *Journal of Semantics*, **27**, 37–80.

AnderBois, S. (2012). Focus and uninformativity in Yukatek Maya questions. *Natural Language Semantics*, **20**, 349–390.

AnderBois, S. (2014). The semantics of sluicing: Beyond truth conditions. *Language*, **90**(4), 887–926.

Bartsch, R. (1973). "Negative transportation" gibt es nicht. *Linguistische Berichte*, **27**(7).

Barwise, J. and Cooper, R. (1981). Generalized quantifiers and natural language. *Linguistics and Philosophy*, **4**(2), 159–219.

Bošković, Ž. and Gajewski, J. (2011). Semantic correlates of the NP/DP parameter. In *Proceedings of NELS*, volume 39, pages 121–134.

Ciardelli, I. (2016). *Questions in logic*. Ph.D. thesis, Institute for Logic, Language and Computation, University of Amsterdam.

Ciardelli, I. and Roelofsen, F. (2015). Inquisitive dynamic epistemic logic. *Synthese*, **192**(6), 1643–1687.

Ciardelli, I., Groenendijk, J., and Roelofsen, F. (2012). Inquisitive semantics. NASSLLI lecture notes, available via www.illc.uva.nl/inquisitivesemantics.

Ciardelli, I., Groenendijk, J., and Roelofsen, F. (2013). Inquisitive semantics: A new notion of meaning. *Language and Linguistics Compass*, **7**(9), 459–476.

Ciardelli, I., Groenendijk, J., and Roelofsen, F. (2015). Inquisitive semantics. European Summer School in Logic, Language and Information lecture notes, available via www.illc.uva.nl/inquisitivesemantics.

Ciardelli, I., Roelofsen, F., and Theiler, N. (2016). Composing alternatives. *Linguistics and Philosophy*.

Cohen, M. (2017a). Neg-raising and question embedding. Presented at the UCSC-Stanford Workshop on Sentence Types.

Cohen, M. (2017b). A note on belief, question embedding and neg-raising. In *International Workshop on Logic, Rationality and Interaction*, pages 648–652. Springer.

d'Avis, F.-J. (2002). On the interpretation of *wh*-clauses in exclamative environments. *Theoretical linguistics*, **28**(1), 5–31.

Dayal, V. (1996). *Locality in wh-quantification: questions and relative clauses in Hindi*. Kluwer Academic Publishers.

Egré, P. (2008). Question-embedding and factivity. *Grazer Philosophische Studien*, **77**, 85–125. Special issue on Knowledge and Questions edited by F. Lihoreau.

Elliott, P. D., Klinedinst, N., Sudo, Y., and Uegaki, W. (2017). Predicates of relevance and theories of question embedding. *Journal of Semantics*.

Gajewski, J. (2002). L-analyticity and natural language. Manuscript, MIT.

Gajewski, J. (2009). L-triviality and grammar. Handout of a talk given in the Logic Colloquium at UConn.

Gajewski, J. R. (2005). *Neg-raising: Polarity and presupposition*. Ph.D. thesis, Massachusetts Institute of Technology.

Gajewski, J. R. (2007). Neg-raising and polarity. *Linguistics and Philosophy*, **30**(3), 289–328.

George, B. R. (2011). *Question embedding and the semantics of answers*. Ph.D. thesis, University of California, Los Angeles.

Ginzburg, J. (1995). Resolving questions, i & ii. *Linguistics and Philosophy*, **18**(5/6), 459–527, 567–609.

Guerzoni, E. (2007). Weak exhaustivity and *whether*: a pragmatic approach. In T. Friedman and M. Gibson, editors, *Proceedings of Semantics and Linguistic Theory (SALT 17)*, pages 112–129.

Heim, I. (1994). Interrogative semantics and Karttunen's semantics for *know*. In R. Buchalla and A. Mittwoch, editors, *The Proceedings of the Ninth Annual Conference and the Worshop on Discourse of the Israel Association for Theoretical Linguistics*. Academon, Jerusalem.

Horn, L. (1978). Remarks on neg-raising. *Syntax and semantics*, **9**, 129–220.

Horn, L. R. (1989). *A Natural History of Negation*. University of Chicago Press.

Karttunen, L. (1973). The last word. *University of Texas, Austin*.

Karttunen, L. (1974). Presupposition and linguistic context. *Theoretical linguistics*, **1**(1-3), 181–194.

Karttunen, L. (1977). Syntax and semantics of questions. *Linguistics and Philosophy*, **1**, 3–44.

King, J. C. (2002). Designating propositions. *The Philosophical Review*, **111**(3), 341–371.

Križ, M. (2015). *Aspects of Homogeneity in the Semantics of Natural Language*. Ph.D. thesis, University of Vienna.

Lahiri, U. (2002). *Questions and answers in embedded contexts*. Oxford University Press.

Mayr, C. (2017). Predicting polar question embedding. In *Proceedings of Sinn und Bedeutung 21*, pages 1–18.

Moltmann, F. (2013). *Abstract objects and the semantics of natural language*. Oxford University Press.

Nicolae, A. C. (2013). *Any questions? Polarity as a window into the structure of questions*. Ph.D. thesis, Harvard.

Roelofsen, F. (2013a). Algebraic foundations for the semantic treatment of inquisitive content. *Synthese*, **190**(1), 79–102.

Roelofsen, F. (2013b). An inquisitive perspective on meaning: the case of disjunction. Stanford Linguistics Colloquium, February 2013.

Roelofsen, F. (2017). *Suprise for Lauri Karttunen*. To appear in *Lauri Karttunen Festschrift*, edited by Cleo Condoravdi.

Roelofsen, F., Herbstritt, M., and Aloni, M. (2016). The **whether* puzzle. To appear in *Questions in Discourse*, edited by Klaus von Heusinger, Edgar Onea, and Malte Zimmermann.

Romero, M. (2015). Surprise-predicates, strong exhaustivity and alternative questions. In *Semantics and Linguistic Theory*, volume 25, pages 225–245.

Romoli, J. (2013). A scalar implicature-based approach to neg-raising. *Linguistics and philosophy*, **36**(4), 291–353.

Sæbø, K. J. (2007). A whether forecast. In B. ten Cate and H. Zeevat, editors, *Logic, Language, and Computation*, pages 189–199. Springer.

Spector, B. and Egré, P. (2015). A uniform semantics for embedded interrogatives: An answer, not necessarily the answer. *Synthese*, **192**(6), 1729–1784.

Theiler, N., Roelofsen, F., and Aloni, M. (2016). A uniform semantics for declarative and interrogative complements. Manuscript, ILLC, University of Amsterdam.

Uegaki, W. (2015a). Content nouns and the semantics of question-embedding. *Journal of Semantics*, **33**(4), 623–660.

Uegaki, W. (2015b). *Interpreting questions under attitudes*. Ph.D. thesis, Massachusetts Institute of Technology.

Uegaki, W. and Sudo, Y. (2017). The anti-rogativity of non-veridical preferential predicates. Selection Fest, ZAS Berlin.

van Gessel, . T., Cremers, A., and Roelofsen, F. (2017). Acceptability of interrogatives under *be certain*. Manuscript, University of Amsterdam.

Vendler, Z. (1972). *Res cogitans: An essay in rational psychology*. Cornell University Press.

White, A. S. and Rawlins, K. (2016). Question agnosticism and change of state. In *Sinn und Bedeutung*, volume 21.

Zuber, R. (1982). Semantic restrictions on certain complementizers. In *Proceedings of the 12th International Congress of Linguists, Tokyo*, pages 434–436.