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Theiler, N.; Roelofsen, F.; Aloni, M.

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What's wrong with *believing whether*?*

Nadine Theiler
University of Amsterdam

Floris Roelofsen
University of Amsterdam

Maria Aloni
University of Amsterdam

Abstract It is a long-standing puzzle why verbs like *believe* and *think* take declarative but not interrogative complements (e.g., **Bill believes whether Mary left*), while closely related verbs like *know* and *be certain* take both kinds of complements. We show that this contrast can be derived from the fact that *believe* and *think*, unlike *know* and *be certain*, are neg-raising verbs.

Keywords: clause-embedding verbs, selectional restrictions, neg-raising.

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 & Egré 2015; Uegaki 2015b). Usually,

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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 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.[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 & Roelofsen 2015; Uegaki 2015b).[2] The present paper does so for two classes

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 Theiler, Roelofsen & Aloni (2016) for detailed discussion.

2 The proposals of Ciardelli & Roelofsen (2015) and Uegaki (2015b) are very much in the same spirit. For discussion of the subtle differences between them, see Theiler et al. (2016).

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 derives the selectional restrictions of neg-raising verbs, and Section 4 those of truth-evaluating verbs. Section 5 discusses some closely related work, and Section 6 concludes.

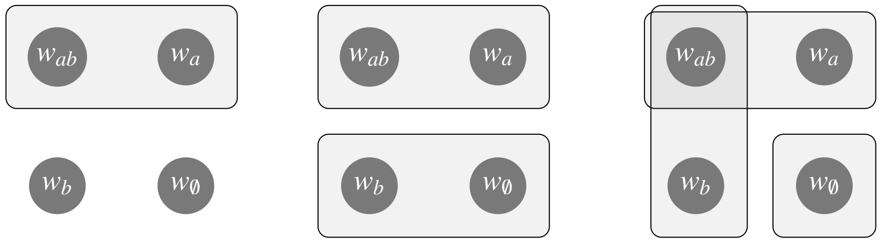
2 A uniform treatment of clausal complements

Our treatment of clausal complements is couched in inquisitive semantics (Ciardelli, Groenendijk & Roelofsen 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 $[\![\varphi]\!]$ (the so-called *resolutions*), 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 $\mathsf{info}(\varphi)$.

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



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

Figure 1 Examples of complement clause meanings in inquisitive semantics.

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

3 There is also work in inquisitive semantics that does not make this assumption (e.g., AnderBois 2012), but this requires a view under which uttering an inquisitive sentence does not necessarily involve issuing a request for information. See Ciardelli, Groenendijk & Roelofsen (2012) for discussion.

4 For simplicity we leave the presuppositions of complement clauses out of consideration here; the

of discourse consists of Ann and Bob, we assume 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} and w_a are worlds where Ann left, w_b and $w_\emptyset$ are worlds where Ann didn't leave, w_{ab} and w_b are worlds where Bill left, and w_a and $w_\emptyset$ are worlds where Bill didn't leave.

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 how 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 $\textsc{dox}_x^w$ is the doxastic state of the subject x in world w.[8]

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

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 $\textsc{dox}_m^w \subseteq \{w \mid \text{John left in } w\}$

proposed account can be extended in a straightforward way to deal with such presuppositions.

5 The alternatives assumed here for *wh*-interrogatives only allow us to derive non-exhaustive (mention-some) readings. The account can be refined to derive strongly and intermediate exhaustive readings too (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, Cremers & Roelofsen 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 Ciardelli, Roelofsen & Theiler 2016).

(9) Mary is certain whether John left.

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

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, Klinedinst, Sudo & Uegaki (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.

3 Neg-raising verbs

We will now turn our attention to anti-rogative verbs, which is a rather heterogeneous group of verbs. Among these are attitude verbs like *think* and *believe*,[9] likelihood predicates such as *seem* and *be likely*, speech-act verbs like *claim* and *assert*, and truth-evaluating verbs like *be true* and *be false*.

3.1 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]

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 too far afield here.

(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 verbs that are not neg-raising:

(12) *desire*, *claim*, *assert*, *suggest*, *be true*, *be false*[11]

This means that an analysis which derives anti-rogativity from neg-raising will not cover all anti-rogative verbs. In Section 4, we will consider the truth-evaluating verbs *be true* and *be false*. Explaining the anti-rogativity of the remaining verbs in (12) is left for future work.

3.2 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) $[\![\text{believe}]\!]^w = \lambda P_{\langle\langle s,t\rangle,t\rangle}.\lambda x.\,\textsc{dox}_x^w \in P$ (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,

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 make wrong predictions about the licensing of strict NPIs.

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

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 are logically independent. Taken together, they imply that Mary believes 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.
$\therefore$ Mary believes that Ann didn't leave.

Bartsch (1973) notes that neg-raising inferences are defeasible. That is, she observes that in cases like (16), where the opinionatedness assumption is explicitly suspended, the neg-raising inference does not arise:

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

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

We assume, following Gajewski (2007), that the excluded middle presupposition is locally accommodated in such cases, in order to obtain an interpretation that is consistent with the contextually given information.[13]

3.3 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.

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.

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.

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

Since the clausal argument P that *believe* takes on our account is not a single proposition but a set of propositions, we cannot compute its negation by taking its set-theoretical complement. Rather, we will use the standard 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) $[\![\text{believe}]\!]^w = \lambda P_T.\lambda x : \underline{\text{DOX}_x^w \in P \vee \text{DOX}_x^w \in \neg P}\,.\,\text{DOX}_x^w \in P$

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

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 $\text{DOX}_x^w \subseteq p$ (x believes that p), while the second disjunct amounts to $\text{DOX}_x^w \cap p = \emptyset$ (x believes that $\neg p$). Hence, for declarative complements, our generalized rendering of the EM presupposition boils down to the ordinary version of this presupposition.

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. As a consequence, the inquisitive negation of an interrogative complement meaning P always is $\neg P = \{\emptyset\}$ 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 in $\text{DOX}_x^w = \emptyset$. 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

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).

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.

3.4 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 by (22). Below we will see how he recasts a prominent analysis of this restriction, originally due to Barwise & Cooper (1981), in terms of L-analyticity.

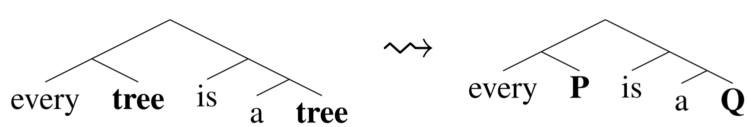
(22) *There is every tall tree.

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

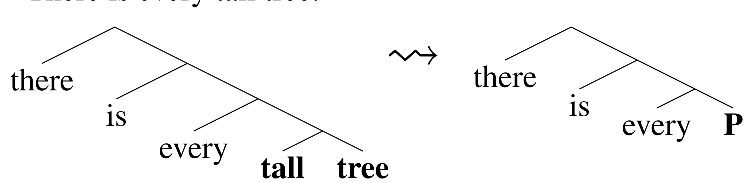
Logical skeleton. To determine if a given sentence is L-analytical, we first compute its *logical skeleton* (LS) using the algorithm from Gajewski 2002. Let α be the logical form (LF) of the sentence. Then we obtain the LS from α by (i) identifying the maximal constituents of α that don't contain any 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 sentential constituent 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 perceived as 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 & Cooper (1981), we assume that *there* simply denotes the domain of individuals D_e.

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

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.

3.5 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 3.3 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.

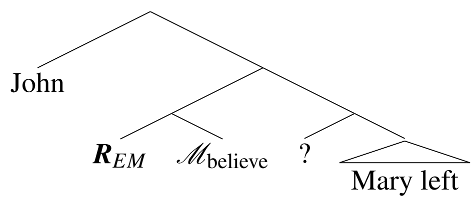
Interrogative clauses are headed by a question operator. Firstly, we asssume that interrogative clauses are headed by a question operator, written as '?'. Semantically, this operator takes the semantic value of its prejacent P as its input, and yields $P \cup \neg P$ as its output:

(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.[15]

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 $\mathscr{M}_V$, 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, $\mathscr{M}_V$ is specific to the predicate V.[16] An LF in which *believe* is decomposed into these two components is given in (28).

(28)



The non-logical component, $\mathscr{M}_V$, 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. $[\![\mathscr{M}_{\text{believe}}(x)]\!]^w = \text{DOX}_x^w$
b. $[\![\mathscr{M}_{\text{want}}(x)]\!]^w = \text{BOUL}_x^w$

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

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

R_{EM} takes the function $\mathscr{M}_V$, the complement meaning P and the subject x as arguments; it contributes the soft EM presupposition (the modal base $\mathscr{M}_V(x)$ has to be a resolution either of P or of the negation of P); and it asserts that $\mathscr{M}_V(x)$ 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 $\mathscr{M}_V$, does not vary between models.

15 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).

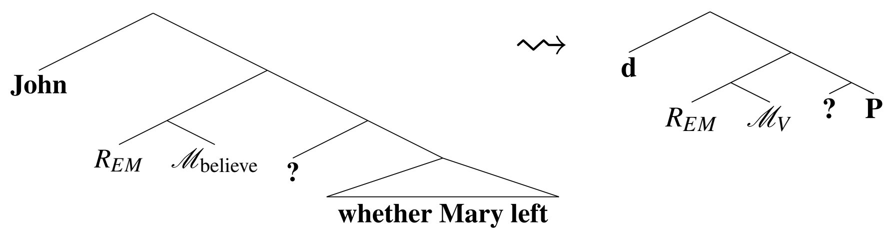
16 Bošković & Gajewski (2011) propose a very similar decomposition of neg-raising predicates, motivated on independent grounds.

L-analyticity. We now have all the ingredients needed to show that the trivial sentence meanings we identified in Section 3.3 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 $\mathscr{M}_{\text{believe}}$ 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 soft presupposition in (33-b).

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

Let's first 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 $[\![\mathscr{M}_V(\mathbf{d})]\!]^{\langle D,I\rangle} = \emptyset$. But if this holds, then the first disjunct is also satisfied, since $[\![\mathbf{?P}]\!]^{\langle D,I\rangle}$ always contains $\emptyset$. This means that the second disjunct in the presupposition is vacuous.

Turning to the non-vacuous first disjunct in the presupposition, we find that it is identical with the asserted content. But this 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.
$\not\rightsquigarrow$ 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 in (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 explain the perceived ungrammaticality.

4 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. The reason is that while this assumption is natural for *be true* and *be false*, it would be highly stipulative for verbs like *believe*. To see this, recall 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, an account that would derive the anti-rogativity of *believe* from insensitivity to inquisitive content would be more stipulative than one that derives it from the fact that *believe* is neg-raising, a property that sets the verb apart from *know* and *be certain* on independent grounds.

5 Some remarks on closely related work

Evidently, the present paper greatly draws from Zuber (1982)'s observation about 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, Cohen (2017) and Mayr (2017) have also recently proposed ways to explain the observed connection.[17] 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 left for future work), and it implicitly relies on a particular mechanism of presupposition projection—to see whether this is tenable it would have to be specified in more detail.

On the other hand, the account of Cohen (2017) in its current form 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.

17 A first version of the present account started circulating in the Spring of 2016.

6 Conclusion

There are two kinds of approaches to the semantics of clausal complements, one that assumes different types for declarative and interrogative complements and one that assumes uniform typing. On the first approach, the selectional restrictions of clause-embedding 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.

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. In recent work (Ciardelli & Roelofsen 2015; Uegaki 2015b), such an explanation has been given for the selectional restrictions of rogative verbs like *wonder*. The present paper has done so for two classes of anti-rogative verbs.

Within the class of rogative verbs, cases that remain to be explained are verbs of dependency such as *depend on* and *be determined by*, and rogative speech act verbs such as *ask* and *inquire* (see Theiler et al. 2016 for a rough first attempt). Within the class of anti-rogative verbs, cases that need further attention include speech act verbs like *assert*, *claim*, and *suggest*, as well as the verb *desire* which, surprisingly, is not neg-raising, unlike its close relative *want*.

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Floris Roelofsen
Science Park 107
1098 XG Amsterdam
floris.roelofsen@gmail.com

Nadine Theiler
Science Park 107
1098 XG Amsterdam
nadine.theiler.87@gmail.com

Maria Aloni
Science Park 107
1098 XG Amsterdam
m.d.aloni@uva.nl