Journal of Semantics, 33, 2016: 623–660
doi:10.1093/jos/ffv009
Advance Access publication July 17, 2015

Content Nouns and the Semantics of Question-Embedding

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Abstract

This article proposes that RESPONSIVE PREDICATES—predicates that embed both interrogatives and declaratives, such as *know*—select for questions (modeled as sets of propositions) rather than propositions. Declarative complements denote singleton proposition-sets, meaning that declarative-embedding is a special ('trivialized') case of question-embedding. This analysis is in contrast to the more standard analysis of responsive predicates that treats them as proposition-taking items and reduces embedded questions to propositions (Groenendijk & Stokhof 1984; Lahiri 2002).

The argument is based on the semantic contrast between responsive predicates and predicates that only embed declaratives (e.g., *believe*), when they take DP complements headed by content nouns (Vendler 1972), as in *John* ***knows*** *the rumor that Mary left* vs. *John* ***believes*** *the rumor that Mary left*. Under the common assumption that responsive predicates are proposition-taking, any plausible predictive account of the entailment from *John* ***believes*** *the rumor that Mary left* to *John* ***believes*** *that Mary left* would run into an incorrect prediction that *John* ***knows*** *the rumor that Mary left* would also entail *John* ***knows*** *that Mary left*. On the other hand, if responsive predicates are question-taking, the contrast can be captured given an inventory of type-shifters that map entities to propositions and questions. It is also argued that the proposed analysis enables a natural semantic account of the selectional restrictions of attitude predicates: *believe*-type predicates select for propositions, *know*-type predicates select for questions, and *ask/wonder*-type predicates select for *non-singleton* questions.

1 INTRODUCTION

Attitude verbs vary in the types of complements they select for. As exemplified in (1), the verb *know* can embed either a declarative or an interrogative complement while *believe* and *ask / wonder* take only one of the two complement types: *believe* only takes a declarative complement, and *ask / wonder* only takes an interrogative complement.

(1) a. John **knows** {that Sue came / who came} to the party.
b. John **believes** {that Sue came / *who came} to the party.
c. John **asked** me/**wonders** {*that Sue came / who came} to the party.

In this article, we focus on the semantics of the first class of attitude verbs, such as *know*, *forget* and *tell*, which can embed either a declarative or an interrogative complement. Hereafter, we refer to this class of attitude verbs as RESPONSIVE PREDICATES, following Lahiri (2002). One of the basic issues in the semantics of question-embedding concerns the selectional property of these predicates. Namely, how we can semantically account for their compatibility with both declarative and interrogative complements. This question does not have a straightforward answer if we assume that responsive predicates are unambiguous, and that declarative complements and interrogative complements denote different kinds of objects, i.e., propositions and questions.

The standard answer to this question states that the basic denotation of responsive predicates selects for a proposition, which is the meaning of declarative clauses, and assumes some form of reduction from the meaning of embedded interrogatives to propositions (Karttunen 1977; Groenendijk & Stokhof 1984). However, such an account wrongly predicts that a *believe*-type predicate would be able to embed an interrogative complement if it were not for further stipulations.[1] For example, in Groenendijk & Stokhof's (1984) theory, the intension of an interrogative clause is a propositional concept (i.e., a function from worlds to propositions). Thus, the extension of an interrogative clause is a proposition (corresponding to the true exhaustive answer to the question) which can be combined with the proposition-taking denotation of a responsive predicate. However, if the semantic type of *believe* is the same as *know* in that it selects for a proposition, we expect that *believe* would embed an interrogative complement in a derivation in which its denotation is combined with the extension of the complement, just as in the case of *know*, unless further stipulations are made.

In this article, I propose an alternative approach to the issue that avoids this problem, arguing that the basic denotation of responsive predicates select for a *question*, rather than a *proposition*. According to this view, responsive predicates select for a *set of propositions*, which corresponds type-wise to an interrogative complement, even when *know* takes a declarative complement. On the other hand, I will argue that the *believe*-type predicates are simply proposition-taking predicates just as in the standard analysis. In other words, I will argue that there is a difference between *know* and *believe* in their semantic types, contrary to the standard view that they are both proposition-taking.

[1] An exception is Ginzburg (1995), who has a reduction in terms of coercion, but avoids this problem by positing an ontological distinction between the objects *believe* and *know* select for. See Section 4.1 for a review of Ginzburg's position in the context of the current article.

The argument will be based on a contrast in entailment patterns between responsive predicates and the *believe*-type predicates when they embed a DP with a clausal complement, such as *the rumor that S*. I will argue that the proper analysis of this phenomenon crucially requires that *know* and other responsive predicates operate on a set of propositions, in contrast to the *believe*-type predicates which simply take a proposition. Below are the crucial claims I will make in the argument:

- There is a contrast in entailment patterns between *John believes the rumor that p* and *John knows the rumor that p*, which generalizes to other exclusively proposition-embedding predicates and responsive predicates (Section 2).
- If we follow the standard view in assuming that both *believe* and *know* are proposition-taking, we face a problem in accounting for the above contrast. More specifically, we either over-generate the entailment-pattern in the case of *know*-type predicates (Section 2.1) or are forced to stipulate lexical entries that do not provide an explanation of the observation (Section 2.2).
- To account for the observation, I propose that *know*-type predicates only take a question while *believe*-type predicates take a proposition (Section 3.1). Given this, the contrast in the entailment between the two kinds of predicates is accounted for in terms of the difference in available type-shifters resolving the type-mismatch between the attitude predicate and the object DP. More specifically, what I will call the content-retrieval type-shift can be applied to *believe*-type predicates, but not to *know*-type predicates (Section 3.2).

Also, in Section 4, I compare the current proposal with two existing analyses of responsive predicates, i.e., Ginzburg's (1995) analysis and the analysis in which question-embedding is reduced to proposition-embedding (Karttunen 1977; Groenendijk & Stokhof 1984; Lahiri 2002), and offer arguments that prefer the current proposal over these alternatives.

2 THE PUZZLE OF 'CONTENT' DPs

The central puzzle dealt with in the present paper is the contrast between *believe* and *know* as exemplified in (2): the two verbs have different entailment patterns when they are combined with a DP with a propositional complement, such as *the rumor that Mary left* (Vendler 1972; Ginzburg 1995; King 2002; Moltmann 2013).

(2) a. John **believes** the rumor that Mary left. ⊨ John **believes** that Mary left.
b. John **knows** the rumor that Mary left. ⊭ John **knows** that Mary left.

In (2), it is shown that *believe* can, but *know* cannot, license the entailment from *x Vs the rumor that p* to *x Vs that p*. As I will argue in detail below, in the standard assumption that *know* has a proposition-taking denotation, an additional stipulation will be needed to block whatever the mechanism that licenses the entailment of *believe* in the case of *know*.[2]

Generally, the contrast is between attitude verbs that only embed a declarative *that*-clause, and those that can embed either a declarative or an interrogative clause, as shown in (3). I refer to the former class of predicates as EXCLUSIVELY PROPOSITION-TAKING PREDICATES (henceforth ProPs) and to the latter class of predicates as RESPONSIVE PREDICATES (from Lahiri 2002; henceforth ResPs). Note that factivity crosscuts this distinction as verbs like *report*, *predict* and *tell* are nonfactive ResPs while verbs like *resent* and *regret* are factive ProPs.[3]

(3) a. John {**believes** / **accepted** / **trusted** / **denied** / **(dis)proved** / **validated**} the rumor that Mary left.
⊨ John {**believes** / **accepted** / **trusted** / **denied** / **(dis)proved** / **validated**} that Mary left.
b. John {**knows** / **discovered** / **reported** / **predicted**} the rumor that Mary left.
⊭ John {**knows** / **discovered** / **reported** / **predicted**} that Mary left.

The contrast can be intuitively described in the following way: ProPs like *believe* can establish the relevant attitude relation between the attitude holder and the 'content' of the DP in the object position, but there is no parallel reading of ResPs that establishes the entailment. The puzzle is why there is such a contrast between the two types

[2] I will discuss the fact that sentences equivalent to (2b) using *wissen* is unacceptable in German (and the corresponding facts in other languages that lexically distinguish the acquaintance 'know' and the knowledge 'know') in Section 3.2.2.

[3] A possible counterexample to the generalization is *tell*. Although *tell* is a ResP, it seems that there is a reading of (i) that entails that John told me that Mary left.

(i) John told me the rumor that Mary left.

In this article, I tentatively assume that *tell* is ambiguous between the ResP version, which can embed an interrogative, and the ProP version, which cannot embed an interrogative but licenses the entailment in question. I would like to leave further investigation of the behavior of *tell* for future research.

of predicates. More roughly, the question is why *know* cannot do what *believe* can do.[4]

To see the problem more clearly, let us consider concrete compositional semantics for the sentences in (3). Below, I describe two kinds of plausible compositional semantics, one deriving the entailment with ProPs (e.g., *believe*) straightforwardly in the compositional system, and the other deriving the contrast in entailment by virtue of the lexical denotation of attitude predicates. I will argue that the contrast above cannot be given an explanatory account with either account, as long as we assume that ResPs like *know* take propositions.

2.1 *Compositionally deriving the entailment*

First, let us assume the following propositional denotation for *rumor* in (4a), with which we can derive the correct entailment with *believe* based on its standard denotation in (4b).

(4) a. $[\![\text{rumor}]\!]^w = \lambda q \in D_{\langle s,t\rangle}\lambda p \in D_{\langle s,t\rangle}.\mathbf{rumor}(p,w) \wedge p = q$
b. $[\![\text{believe}]\!]^w = \lambda p \in D_{\langle s,t\rangle}\lambda x.\text{DOX}^w_x \subseteq p$

(5) $[\![\text{John believes the rumor that Mary left}]\!]^w = 1$
iff $\text{DOX}^w_{\mathbf{j}} \subseteq \iota p[\mathbf{rumor}(p, w) \wedge p = \{w' | \mathbf{left(m)}(w')\}]$

Here, *believe* has its standard denotation that takes a propositional argument. The denotation of *rumor* takes a complement proposition and returns a predicate of propositions that is true of a proposition satisfying the description **rumor** and is identical to the complement proposition. As a result of the standard functional application, *John believes the rumor that Mary left* is true iff John believes the unique proposition that is a rumor and identical to the proposition that Mary left. This is true only when John believes that Mary left. Thus, giving the standard denotations to ProPs and a propositional denotation to content DPs, as in (4), captures the correct entailment pattern for ProPs.

However, the problem arises when we replace the denotation of *believe* in (5) with the proposition-taking denotation of *know*. We would incorrectly predict exactly the same entailment as in the case

[4] One might wonder whether the 'anti-factive' meaning/implication associated with *rumor* has to do with the non-entailment in the case of *know*. Specifically, one might suggest that the factivity of *know* is incompatible with the 'anti-factivity' of *rumor*, and thus *x knows the rumor* can only be interpreted as an acquaintance, which is why the entailment does not hold. However, this hypothesis does not account for the fact that the entailment does not hold for non-factive verbs such as *report* and *predict* either. Also, this hypothesis incorrectly predicts that if the noun is neutral in factivity, as *story* or *hypothesis*, the entailment would go through. However, this is not the case:

(i) John knows the story/hypothesis that Mary left. ⊭ John knows that Mary left.

See Section 4.1 for cases where the noun is factive, as *fact* or *truth*, and an account of them.

of *believe*. Below, it is shown that given the simplified proposition-taking meaning for *know* in (6) (i.e., *believe* + factivity),[5,6] we would predict the truth conditions of *John knows the rumor that Mary left* in (7), which is true only when John believes that Mary left, and that it is true that Mary left (due to the factivity presupposition, underlined in (7)). This entails that John knows that Mary left, contrary to the fact.

(6) $[\![\text{know}]\!]^w = \lambda p \in D_{\langle s,t\rangle}\!:\![p(w) = 1]\lambda x.\, \text{DOX}_x^w \subseteq p$

(7) $[\![\text{John knows the rumor that Mary left}]\!]^w = 1$ iff
$\text{DOX}_{\mathbf{j}}^w \subseteq \iota p[\mathbf{rumor}(p, w) \wedge p = \{w' | \mathbf{left(m)}(w')\}] \wedge \underline{\mathbf{left(m)}(w)}$

In fact, the argument here does not hinge on the exact implementation of the meaning of content nouns assumed here. As long as there is a general compositional mechanism deriving the relevant entailment for any proposition-taking predicates, we would predict the same mechanism to hold for both ProPs and ResPs given the standard assumption that both kinds of verbs have proposition-taking denotations.[7]

2.2 *Lexically specifying the entailment patterns*

The way the problem is stated above assumes a simplistic denotation for *the rumor* so that the entailment of *believe* goes through with its standard denotation while the lack of entailment of *know* is problematic. Another plausible way to analyze the contrast is to capture it by the lexical denotations of the relevant attitude predicates. The accounts by King (2002) and Moltmann (2013) are both along these lines although there are technical differences. In this line of approach, it is easier to start the discussion with the non-entailment fact with ResPs. The non-entailment fact straightforwardly comes out if we assume that a content

[5] In this article, I model presuppositions including factivity in terms of partial functions. A clause after a colon in a lambda term indicates a restriction on the domain of the function that the lambda term expresses.

[6] Of course, this denotation of *know* is oversimplified. After Gettier (1963), there is vast philosophical discussion on the proper conditions for knowledge that goes beyond the traditional picture that knowledge consists of justified true belief. However, this problem is orthogonal to the issue discussed in this article, which arises in a more sophisticated analysis of *know* as long as the analysis assumes that it takes a propositional complement.

[7] I categorize the treatment of content nouns by Kratzer (2006) and Moulton (2008) as a variant of the approach considered here, as their compositional system is constructed in such a way that the entailment fact with *believe* is predicted straightforwardly. In their system, a content DP like *the rumor* denotes an abstract object called a 'content' from which its propositional information can be retrieved. Their denotation for *believe* is such that it takes a content argument and the subject believes whatever the propositional information of this content. It is clear that this system correctly predicts the entailment fact with *believe*, but it over-generates the entailment if we simply extend their denotation for *believe* to *know*. Hence their treatment faces the same problem as the approach considered here. It should be emphasized, however, that the analysis of ResPs is outside the scope of Kratzer and Moulton, and so this is not a problem with their analysis of content nouns *per se*.

DP denotes a non-propositional object and that *know* is ambiguous between the proposition-taking variant for 'knowledge' and the non-proposition taking variant for 'acquaintance', the distinction (roughly) corresponding to that between *wissen* and *kennen* in German. The denotation for the former variant of *know* is given in (6) and the latter in (8), where α is a variable over a specific kind of non-propositional (type *a*) objects, whose instance a content DP denotes.

(8) $[\![\text{know}_A]\!]^w = \lambda\alpha \in D_a \lambda x \in D.\mathbf{acquainted}(x)(\alpha)(w)$

Under this system, since a content DP like *the rumor* is compatible only with the 'acquaintance' *know* in (8), and 'being acquainted' with a certain object does not entail propositional knowledge of its content, the non-entailment fact comes out naturally. Here, I stay away from detailed model-theoretic characterization of objects of type *a* and the relation **acquainted** to make the argument general. The only assumption needed to derive the non-entailment is that *x*'s being acquainted with α with propositional content *p* does not entail *x*'s knowing that *p*. This is a fairly uncontroversial assumption: one can be acquainted with a rumor, story etc. without believing its propositional content. For example, one can be acquainted with a rumor about oneself, by just being told by someone that such a rumor is going around, while disbelieving the content of the rumor.[8]

Now, the problem is how to account for the entailment fact with *believe*. A possible way out is to stipulate the lexical semantics of *believe* in a way so that it can access the propositional content of the abstract object it combines with, as shown in (9). In (9), *believe* establishes the believing relation between the subject and the propositional content retrieved from its first argument by the function $\mathscr{F}_{cont}$.

(9) $[\![\text{believe}_{cont}]\!]^w = \lambda\alpha \in D_a \lambda x \in D.[\![\text{believe}]\!]^w(\mathscr{F}_{cont}(w)(\alpha))(x)$
where $\mathscr{F}_{cont} \in D_{\langle s,\langle a,st\rangle\rangle}$ and $\mathscr{F}_{cont}(w)(x) :=$ the propositional content of x in w

Indeed, this might be a descriptively adequate analysis of the contrast in (3). However, simply stipulating lexical entries like these does not *explain* why the (im)possibility of embedding an interrogative complement correlates with the contrast, i.e., why ProPs license the relevant entailment while ResPs do not. One of the problems with this account is that

[8] Another possibly distinct reading of *know* + DP is a Concealed Question (henceforth CQ) reading, but it is clear that it does not have the relevant entailment, either. This is because knowing an answer to the CQ 'What is α?' does not entail the knowledge of α's content however we formalize CQ readings.

it does not answer why *believe* is not like *know* in being ambiguous between the standard proposition-taking version and the other version as in (10) below (i.e., the 'acquaintance' version of *believe*), which does not involve $\mathscr{F}_{cont}$.

(10) $[\![*\text{believe}_A]\!]^w = \lambda\alpha \in D_a \lambda x \in D.\mathbf{R}(x)(\alpha)(w)$
where $\mathbf{R}$ is a relation such that $\mathbf{R}(x)(\alpha)(w) \not\models \text{DOX}_x^w \subseteq \mathscr{F}_{cont}(\alpha)$

Having (10) as the denotation of *believe* that combines with a content DP incorrectly predicts that *believe* would lack the entailment.

One way to solve this problem is to state a general lexical rule that turns a proposition-embedding verb like *believe* into its content-retrieving version, as in (9). This lexical rule can be stated as follows:

(11) For any predicate R such that $[\![R]\!]^w \in D_{\langle st,et\rangle}$, there is a predicate R_{cont} with the same phonological form such that $[\![R_{cont}]\!]^w = \lambda\alpha \in D_a.[\![R]\!]^w(\mathscr{F}_{cont}(w)(\alpha))$

This general lexical rule gives us the correct prediction that all ProPs license the relevant entailment. However, the problem is that it over-generates the same entailment with all ResPs, as long as we assume that ResPs take propositions just like ProPs. That is, the rule in (11) predicts that the following denotation for *know* is available, which incorrectly predicts the entailment for *know*.

(12) $[\![*\text{know}_{cont}]\!]^w = \lambda\alpha \in D_a \lambda x \in D.[\![\text{know}]\!]^w(\mathscr{F}_{cont}(\alpha))(x)$

Thus, the approach that just uses lexical specifications lacks a principled explanation of the correlation between the ability to embed interrogatives and the relevant entailment pattern. If the approach is supplemented with a general lexical rule to capture one direction of the correlation, i.e., that ProPs always license the entailment, we over-generate the entailment with ResPs as well, under the standard theory that ResPs are proposition-taking. Indeed, one could imagine that the lexical rule in (11) is sensitive not just to the *types*, but to the *specific semantic features* of the predicates they can apply to. However, the question is what such general semantic features would be that distinguish ProPs and ResPs. (Recall that factivity crosscuts the distinction.)

In sum, the contrast in (3) is problematic whether we assume a compositional semantics that predicts the entailment fact of *believe* straightforwardly, or we lexically specify the entailment patterns in the denotation of the relevant predicates. Generally speaking, the problem with the former approach is that the combination of assumptions (i) and (ii) below over-generates the relevant entailment for ResPs.

(i) ResPs select for the same kind of object that ProPs select for (such as a proposition).
(ii) A general mechanism (e.g., propositional denotation of content DPs, the lexical rule in (11)) derives the entailment fact of ProPs with its standard denotation.

On the other hand, the problem with the latter approach is that, either we end up lexically stipulating the entailment pattern for each predicate, or we would be forced to assume (ii) above in the form of a lexical rule. In the former case, we lack an explanation for the generalization, and in the latter case, we again over-generate the entailment for ResPs, given assumption (i).

The proposal I will put forth in this article agrees with assumption (ii), but it further gives a general constraint on the lexical semantics of attitude predicates that explains the crucial contrast between ResPs and ProPs in terms of their ability to embed an interrogative complement. The basic proposal is fairly simple: it denies assumption (i).

3 PROPOSAL

The central proposal of the current article is that ResPs do not take a proposition, but only take a proposition-set as their complement. In this section, after presenting the basic compositional semantics of the proposed analysis, I illustrate how this proposal leads to the solution to the puzzle of content DPs described in the previous section. In the last subsection, I will discuss the general constraint on the lexical semantics of attitude verbs arising from the proposal, especially in relation to exclusively interrogative-embedding verbs, such as *ask* and *wonder*.

3.1 *ResPs only take a question complement*

As stated briefly above, I propose that ResPs only select for a question, but not for a proposition. For instance, below is the *only* denotation for *know*, which will be used both for its declarative-embedding and for its interrogative-embedding use.

(13) $[\![\text{know}]\!]^w = \lambda Q \in D_{\langle st,t\rangle} : [\exists p \in Q[p(w) = 1]]\lambda x.\exists p \in Q[p(w) = 1 \wedge \text{DOX}_x^w \subseteq p]$

Following Hamblin (1973), I assume that the denotation of an interrogative complement is the set of possible answers to the question (including false ones), as exemplified below.

(14) $[\![\text{who left}]\!]^w = \{p|\exists x[p = \lambda w'.\mathbf{left}(x)(w')]\}$

I follow George (2011) and Spector & Égré (2015) in the treatment of exhaustivity in the interpretation of embedded questions. The denotation in (13) takes a set of propositions, e.g., a question-denotation, and returns true iff the subject believes *some* true proposition in the set.[9] Thus, when (13) is combined with a *wh*-complement, a mention-some reading is predicted by default. The strongly exhaustive reading is optionally derived by converting a Hamblin denotation into the corresponding partition of worlds using the following covert operator.

(15) $[\![\textsc{Part}]\!]^w = \lambda Q \in D_{\langle st,t\rangle}.\{p|\exists w[p = \lambda w' \forall p' \in Q[p'(w) = p'(w')]]\}$
(Partition-formation)

When we combine the denotation of *know* in (13) to the partition resulting from applying (15) to (14), we derive the strongly exhaustive reading. An example of how the PART-operator converts a Hamblin denotation into a partition is given in (16), and combining it with the denotation of *know* yields (17). It is easy to see that the reading resulting from (17) is the strongly exhaustive reading: the subject believes the true partition of worlds that agree on who left.[10]

(16) $[\![\textsc{Part}\ \text{who left}]\!]^w = \{p|\exists w[p = \lambda w'.\forall x[\mathbf{left}(x)(w) \leftrightarrow \mathbf{left}(x)(w')]]\}$

(17) $[\![\text{know PART who left}]\!]^w$
$= \lambda x.\exists p[\exists w[p = \lambda w'.\forall x[\mathbf{left}(x)(w) \leftrightarrow \mathbf{left}(x)(w')]] \wedge [p(w) = 1 \wedge \mathrm{DOX}_x^w \subseteq p]]$

On the other hand, when *know* takes a declarative complement, I assume that the type-shifter in (18) turns the proposition denoted by the embedded clause into the singleton set containing it. Combining this singleton set with (13), we derive the correct truth conditions of a sentence in which *know* embeds a declarative clause, as shown in (19). The underlined conjunct is projected from the factivity presupposition of *know*.

(18) $[\![\textsc{Id}]\!]^w = \lambda p[\lambda q.q = p]$[11]

[9] There is an additional factivity presupposition which states that at least one of the propositions in the proposition set is true.

[10] It is under active discussion in the literature whether the strongly exhaustive reading is empirically optional or obligatory (Groenendijk & Stokhof 1984; Heim 1994; Beck & Rullmann 1999). Here, in light of recent arguments by Klinedinst & Rothschild (2011) and George (2011) who claim that the strongly exhaustive reading is in fact optional, I make my system flexible enough to deal with both mention-some and strongly exhaustive readings. However, nothing in the current argument hinges on this particular theoretical choice.

[11] The name ID is inspired by Partee (1986), where the type-shifter IDENT is defined as a type-shifter that turns an individual into (the characteristic function of) its singleton set, as follows:

(i) $[\![\textsc{Ident}]\!]^w(x) = \lambda y \in D_e.[y = x]$

(19) $[\![$John knows [ID [that Mary left]]$]\!]^w = 1$
iff $\exists p \in \{\lambda w'.\mathbf{left}(\mathbf{m})(w')\}[p(w) = 1 \wedge \mathrm{DOX}_{\mathbf{j}}^w \subseteq p] \wedge \underline{\exists p \in \{\lambda w'.\ \mathbf{left}(\mathbf{m})(w')\}[p(w) = 1]}$
iff $\mathrm{DOX}_{\mathbf{j}}^w \subseteq \{w' | \mathbf{left}(\mathbf{m})(w')\} \wedge \underline{\mathbf{left}(\mathbf{m})(w)}$

As for ProPs, they have the standard proposition-taking denotations, as the following one for *believe*, repeated from the previous section.

(4b) $[\![\text{believe}]\!]^w = \lambda p \in D_{\langle s,t\rangle} \lambda x.\mathrm{DOX}_x^w \subseteq p$

This denotation takes a proposition as its first argument. Thus, it is compatible with a declarative complement with a propositional denotation without the ID type-shift. An interrogative complement is incompatible with this kind of predicate due to type mismatch: an interrogative complement denotes a set of propositions, but (4b) selects for a proposition.

3.2 *Solution to the puzzle*

In this section, I illustrate how the proposal above can provide a solution to the puzzle of content DPs. The analysis assumes a non-propositional denotation for content DPs, and basically follows the lexical specification approach considered in the previous section, but avoids the problem of stipulation and over-generation pointed out there. The proposal that ResPs only take a question complement offers an explanation for the difference in the entailment patterns between ResPs and ProPs.

The gist of the proposal is the following. When a ProP or ResP is combined with an entity-denoting content DP, a type-mismatch arises. However, a ProP can be related to the propositional content of the DP via a type-shifting operation. As a result of this, the entailment under discussion holds of ProPs. On the other hand, the same mechanism involving entity-to-proposition conversion is not applicable to ResPs. Since ResPs select for questions, the resulting proposition of such a conversion is not a suitable argument for ResPs. Instead, a ResP combines with a DP through one of two ways. One is through converting the DP into its corresponding CQ, as in *John discovered the answer* under the interpretation 'John discovered what the answer is'. The other is through the predicate's entity-relating acquaintance-like denotation, as in *John discovered the rumor on the Internet*. Note here that some predicates allows only one of the two interpretations for independent reasons. For example, *John knows the rumor that p* resists a CQ reading for pragmatic reasons which I will discuss below. I will argue that neither of these two readings licenses the relevant entailment if the reading is possible at all. This captures the fact

that ResPs do not exhibit the same entailment pattern as ProPs. In other words, the difference in entailment between ResPs and ProPs comes out as the result of the type-shift forced by the selectional property of each type of verbs. Below, I will discuss how the meanings of ProP + DP and ResP + DP are derived in the proposed system, after which I show how the analysis solves the puzzle of content DPs.

3.2.1 *ProP + content DP* First of all, I claim that content DPs such as *the rumor that Mary left* denotes an individual of type *e* as shown in (20).

(20) $[\![\text{the rumor that Mary left}]\!]^w = \iota x[\mathbf{rumor}(x)(w) \wedge \mathscr{F}_{cont}(w)(x) = \{w' | \mathbf{left}(\mathbf{m})(w')\}]$

Since a ProP like *believe* wants a proposition as its complement, as in (4b), (20) cannot be combined with it directly. However, the type-shifting operation in (21) is available, which denotes the following function:

(21) $[\![\textsc{Cont}]\!]^w(x) = \lambda w'.\begin{cases} w' \in \mathscr{F}_{cont}(w)(x) & \text{if } \mathscr{F}_{cont}(w)(x) = \mathscr{F}_{cont}(w')(x) \\ \text{undefined} & \text{otherwise} \end{cases}$

In words, when applied to x, this function returns a proposition that states that x's actual content is true, with the presupposition that x's actual content *is* the content of x. For example, when applied to (20), it returns the following partial proposition:

(22) $[\![\textsc{Cont}\ [\text{the rumor that Mary left}]]\!]^w$
$= \lambda w'.\begin{cases} \mathbf{left}(\mathbf{m})(w') & \text{if } \mathscr{F}_{cont}(w')(\text{the rumor that Mary left}^w) = \{w'' | \mathbf{left}(\mathbf{m})(w'')\} \\ \text{undefined} & \text{otherwise} \end{cases}$

The (partial) proposition derived this way can be combined with *believe*. Regardless of how the presupposition of (22) is projected, the resulting proposition entails (23).

(23) $\text{DOX}_{\mathbf{j}}^w \subseteq \{w' | \mathbf{left}(\mathbf{m})(w')\}$

Hence, the entailment fact of ProPs + DP can be correctly captured.

One might wonder why the denotation of the Cont type-shifter in (21) has to be so complex. That is, why the following simpler denotation does not suffice.

(24) $[\![\textsc{Cont}]\!]^w(x) = \mathscr{F}_{cont}(w)(x)$

Indeed, this version of Cont would capture the entailment fact, but it would make an incorrect prediction about the precise interpretation of *believe* + DP sentences. The interpretation of *believe* + DP cannot be

described simply in terms of belief of the content of the object denoted by the DP. Let me illustrate this using the following example:

(25) John believes the rumor Bill has been circulating.

Suppose the content of the rumor Bill has been circulating is that Mary left the town. Suppose further that John believes that Mary left the town, but he is not sure what the content of the rumor Bill has been circulating is. He has seen Bill whispering something to people, but does not know what he was whispering, nor has he heard the rumor from Bill. In this situation, the sentence in (25) is not intuitively true.

This intuitive judgment is not captured by the definition of CONT in (24), as it would make the sentence true as long as John believes that Mary left the town. On the other hand, the definition of CONT in (21) predicts that (25) is a presupposition failure. Here is why. Let us first write the denotation of the object DP *the rumor Bill has been circulating* as **r**, as in (26a), for simplicity. The actual content of this object is the proposition that Mary left, as shown in (26b).

(26) a. $[\![\text{the rumor Bill has been circulating}]\!]^w = \mathbf{r}$
b. $\mathscr{F}_{cont}(w)(\mathbf{r}) = \lambda w'.\mathbf{left}(\mathbf{m})(w')$

Then, the result of applying CONT to this DP would be the following, according to the definition in (21).

(27) $[\![\text{CONT [the rumor Bill has been circulating]}]\!]^w$

$$= \lambda w'.\begin{cases} w' \in \mathscr{F}_{cont}(w)(\mathbf{r}) & \text{if } \mathscr{F}_{cont}(w)(\mathbf{r}) = \mathscr{F}_{cont}(w')(\mathbf{r}) \\ \text{undefined} & \text{otherwise} \end{cases}$$

$$= \lambda w'.\begin{cases} \mathbf{left}(\mathbf{m})(w') & \text{if } \lambda w''.\mathbf{left}(\mathbf{m})(w'') = \mathscr{F}_{cont}(w')(\mathbf{r}) \\ \text{undefined} & \text{otherwise} \end{cases}$$

Following the standard assumption that the presupposition of the complement of *believe* universally projects to the belief state of the subject (Karttunen 1974), (25) would have the presupposition that John believes the presupposition of (27).

(28) $[\![\text{John believes CONT [the rumor Bill has been circulating]}]\!]^w$ is defined
iff $DOX_{\mathbf{j}}^{w} \subseteq \{w' | \lambda w''.\mathbf{left}(\mathbf{m}, w'') = \mathscr{F}_{cont}(w')(\mathbf{r})\}$

This presupposition is not satisfied in the scenario given above since John does not know that the content of **r**, i.e, the rumor that Mary has been circulating, is the proposition that Mary left. I submit that this is an empirically adequate treatment of the 'un-trueness' of (25)

in the given situation. Here, note that the condition in the presupposition of CONT cannot be encoded in the assertion since the negation of (25), i.e., (29) is also intuitively untrue in the situation introduced above.

(29) John does not believe the rumor Bill has been circulating.

The presuppositional treatment in (21) predicts that (29) is a presupposition failure just like (25) is. This is in line with the intuitive judgment of (29). Hence, I will use (21) rather than the simpler (24) as the definition of CONT.

As King (2002) discusses, something like the type-shifter CONT is needed outside the domain of attitude verbs. Data like (30a) suggest that adjectives such as *true* and *false* denote predicates of propositions of type $\langle st, t\rangle$. Given this, we need CONT to account for (30b), in which *true/false* is predicated of the propositional content of the rumor. That is, *true / false* is predicated of the denotation of CONT [*the rumor*].

(30) a. That Mary left is true/false.
b. The rumor is true/false.

Similar arguments can be made using examples like the following involving the predicates *compatible* and *contradict*.

(31) a. The rumor {is compatible with / contradicts} what she said.
b. That John saw Mary {is compatible with / contradicts} what she said.

Before closing the section, let me address an issue regarding a data point brought to my attention by an anonymous reviewer. Some ProP + DP constructions have readings different from the ones discussed above, as shown in the following examples. The paraphrases are given below each example.

(32) a. John accepted/denied the roundness of the earth.
'John accepted/denied that the earth is round.'
b. John denied the existence of witnesses.
'John denied that witnesses existed'

The existence of other readings of ProP + DP as paraphrased above does not itself pose a problem for the analysis as long as it can be argued that the content-retrieval type-shift is *possible* for the examples with the relevant entailment. If a ProP + DP has the reading involving CONT possibly among other readings, the entailment fact is accounted for.

This said, one can ask what makes the examples in (32) and (33) below different, where (33) does not have the reading parallel to the ones in (32).

(33) John accepted/denied the rumor that Mary left.
*'John accepted/denied that it was rumored that Mary left.'

Regarding this issue, I suggest that the difference between (32) and (33) comes from the nature of the nominals involved in the construction. The nominals in (32) involve nominalization, which is arguably not the case with the content nouns such as *rumor*, *story*, *fact* etc.[12] The generalization seems to be that the paraphrase in (32) is possible only with nominalized DPs, but not with content nouns. To analyze this pattern, I take the nominalized DPs in (32) to be proposition-denoting from the outset. Thus, there is no type-shifting involved in (32). On the other hand, the content nouns are not derived from the verbal/adjectival counterpart, and are not proposition-denoting as their basic meaning. Hence, the kind of paraphrase available for (32), which requires the DP itself to denote a proposition, is unavailable in (33).

3.2.2 *ResP + content DP* In the previous section, I discussed how ProP + DP licenses the relevant entailment by virtue of the content-retrieval type-shifter applied to the DP. In this section, we turn to ResP + DP. I will argue that ResP + DP is interpreted with the CQ reading of the DP. Also, depending on the predicate, it can combine with a DP under a distinct entity-relating reading, such as the acquaintance reading of *know*. In the following, I will argue that none of them guarantees the relevant entailment. It should be stressed at this point that it suffices for the purpose of this article—to explain the contrast in entailment between ResPs and ProPs—to show that the compositional semantics does not guarantee that ResP + DP licenses the relevant entailment. Thus, although there are some cases where CQ or an acquaintance/entity-relating reading is not possible for a particular ResP + DP combination, investigating the constraints that govern the distributions of these readings is beyond the scope of this article. As long as the possible readings of ResP + DP are shown *not* to license the relevant entailment, we can account for the contrast between ResPs and ProPs.

Concealed questions Let us consider a case where a ResP combines with a content DP. Similarly to the case of ProP + DP, the proposed

[12] The verb *rumor* in (33) is presumably derived from the noun *rumor* and not the other way around.

denotation of a ResP, which is question-taking, cannot be combined with (20), repeated below.

(20) $[\![\text{the rumor that Mary left}]\!]^w = \iota x[\mathbf{rumor}(x)(w) \wedge \mathscr{F}_{cont}(x) = \{w' | \mathbf{left}(\mathbf{m})(w')\}]$

Therefore, again, some extra operation is needed to make the composition go through,[13] but this time the operation has to involve a conversion from an individual into a question, rather than into a proposition. I argue that this operation can be carried out by CQ, a type-shifter which turns an individual into its corresponding CQ.

Due to this operation, for example, the truth conditions of *John knows* CQ *[the president of the US]* will be, roughly, that John knows which person the president of the US is. Concretely, I adopt Aloni's (2008) analysis of CQs,[14] slightly modifying it to fit the compositional setup of this paper. In Aloni's (2008) analysis, *John knows the winning card* in its CQ reading roughly means 'John knows that x is the winning card', where x is an individual concept in a contextually salient CONCEPTUAL COVER (Aloni 2001), a set of individual concepts with the constraint that each individual in the set is mapped from each world by exactly one cover.[15] Examples of a cover are the sets A and B in the following, the former identifies a card by position while the latter by suit.

(34) a. A = {the card on the left, the card on the right}
b. B = {the Ace of Spades, the Ace of Hearts}

The CQ reading of *John knows the winning card* differs depending on which cover is contextually given. If the position cover, A, is salient, the sentence means that John can identify the winning card based on its position. On the other hand, if the suit cover, B, is salient, the sentence means that John can identify the winning card based on its suit.

A CQ reading of the DP *the winning card* is then analyzed in terms of the type-shifter CQ as follows, using the notion of conceptual covers.

(35) $[\![\text{CQ}]\!]^C = \lambda x \in D.\{p | \exists w[p = \lambda w'.\forall c' \in \mathscr{R}_C[c'(w') = x \leftrightarrow c'(w) = x]\}$
where $\mathscr{R}_C$ is a conceptual cover given by context C

In prose, the CQ corresponding to the individual denoted by *the winning card*, for example, is the partition of worlds in which each cell consists of

[13] I discuss below the possibility of applying CONT and then ID.

[14] In Aloni & Roelofsen (2011), a number of problems with Aloni (2008) are addressed, and a modification is proposed. However, since the simpler analysis of Aloni (2008) suffices for my purpose, I adopt Aloni's version here.

[15] Formally, a conceptual cover CC is a set of functions $W \mapsto D$ such that $\forall w \in W[\forall d \in D[\exists! c \in CC[c(w) = d]]]$

worlds that agree on which concept identifies the winning card. The conceptual cover, i.e., the domain of individual concepts quantified in (35), is contextually determined. Therefore, the interpretation of (35) differs according to which of the two covers in (34) is salient in the context.

For example, applying CQ to the DP *the winning card*, the predicted truth conditions of the sentence *John knows* CQ *[the winning card]* will be (36). (Here, we let the extension of *the winning card* be **wc**.)

(36) $[\![$John knows CQ [the winning card]$]\!]^{w,C} = 1$
iff $\exists p \in \{p | \exists w[p = \lambda w'.\forall c \in R_C[c(w') = \mathbf{wc} \leftrightarrow c(w) = \mathbf{wc}]\}[p(w) = 1 \wedge \mathrm{DOX}_{\mathbf{j}}^{w} \subseteq p]$
iff $\mathrm{DOX}_{\mathbf{j}}^{w} \subseteq \{w' | \forall c \in R_C[c(w') = \mathbf{wc} \leftrightarrow c(w) = \mathbf{wc}]\}$

For illustration, suppose that the contextually salient cover is the one in (34a), and further suppose that the winning card is the card on the left. Then, the truth conditions of *John knows* CQ *[the winning card]* predicted by (36) is that John correctly believes that the card on the left is the winning card. When we replace *the winning card* in (36) with a content DP like *the rumor that p*, the resulting truth conditions would not entail that John knows that Mary left. This is so because we can easily construct John's belief state so that a particular concept (e.g., the rumor that Sue told, the rumor that he read on the Internet) identifies the rumor that *p*, but he does not believe that *p*.

Digression: pragmatic constraint on CQ Above, I discussed the general treatment of CQs and what the predicted CQ reading of ResP + DP would look like. One might wonder at this point whether examples like *John knows the rumor that p* actually have CQ readings. In fact, many speakers find it difficult to accept these sentences under CQ readings. The fact is clearer if we move to languages that have a lexical distinction between the 'knowledge' *know* and the 'acquaintance' *know*. German *wissen* and French *savoir* are unacceptable when they are combined with a content DP such as 'the rumor', as shown in (37).

(37) Ich kenne/#weiß das Gerücht, dass Maria weggegangen ist.
I know$_{Acq}$/know$_{K}$ the rumor that Maria left is.

If the CQ type-shifter CQ is available in general, why are these verbs unacceptable with 'the rumor' whereas it can be used with other CQ-denoting DPs? I argue that this is due to an independent problem concerning pragmatic conditions on whether a DP can denote a CQ. Specifically, I argue that this is due to the constraint on CQs that the identifying concept has to be more salient than the description of the

DP whose identity is in question (Aloni & Roelofsen 2011). To see this, observe the following contrast.

(38) a. John knows Obama. (#CQ)
b. John knows the president of the United States. (✓CQ)

Here, out of the blue, (38a) is odd as a CQ where it means, for example, that John can identify Obama by his political role. On the other hand, (38b) can be naturally understood as a CQ, where it means that John can name the president of the US. This contrast can be explained by the relative salience of names and political roles: since names are more salient concept than political roles, it is more natural to identify the latter using the former.

What is going on in the CQ reading of *John knows the rumor that p* (and its German counterpart in (37)) can be understood in terms of the same pragmatic constraint. In the following pair, (39a) is odd as a CQ, but (39b) can be a felicitous CQ which, for example, means that John can identify the content of the rumor that Mary told.[16]

(39) a. John knows the rumor that Mary left. (#CQ)
b. John knows the rumor which Mary told. (✓CQ)

I argue that these data are due to the fact that the content of a rumor is a more salient identifying concept than its source. Thus, identifying a rumor's source using its content, as in (39b) is natural, but the other way around, as in (39a) is not. In other words, sentences like (39a) is infelicitous as a CQ, just like (38a) is, since it is difficult to find an identifying concept for a rumor more salient than its propositional content.

Acquaintance Next, we turn to the acquaintance reading and, more generally, entity-relating meanings of ResPs. As in the analysis entertained in Section 2.2, I simply treat English *know* as ambiguous between the knowledge version and the acquaintance version, where the latter has the following denotation as a simple transitive verb with type-*e* arguments.

(40) $[\![\text{know}_A]\!]^w = \lambda y \in D_e \lambda x \in D_e.\textbf{acquainted}(x)(y)(w)$

Languages like German and French lexicalize this distinction. Thus, *kennen* and *connaître* have the same denotation as (40) while *wissen* and *savoir* have the denotation of the 'knowledge' *know*, repeated below.

[16] I thank an anonymous reviewer for pointing out this contrast.

(13) $[\![\text{know}_K]\!]^w = \lambda Q \in D_{\langle st,t\rangle}.[\exists p \in Q[p(w) = 1]]\lambda x.\exists p \in Q[p(w) = 1 \wedge \text{DOX}_x^w \subseteq p]$

As we discussed in Section 2.2, we assume that the relation **acquainted** is defined so that **acquainted**$(x)(y)(w)$ does not entail that y knows, or believes, the content of x (if x has a content at all). This is an uncontroversial assumption given the natural understanding of the notion of acquaintance. With this, we can account for the fact that *John knows$_A$ the rumor that Mary left* does not entail *John knows$_K$ that Mary left*: simply being acquainted with the rumor that p does not entail knowing/believing that p.

ResPs other than *know* also have entity-relating denotations. For example, *discover* and *report* have non-CQ readings as in the paraphrases given below.

(41) John discovered the rumor (on the Internet) that Mary left.
'John came across a text (on the Internet) saying that Mary left'

(42) John reported the rumor that Mary left.
'John reported that it is being rumored that Mary left.'

I will not attempt to analyze these entity-relating meanings in terms of the verbs' meanings as a ResP,[17] and simply capture them using lexical entries separate from their entries as ResPs, as given in the following:

(43) a. $[\![\text{discover}_{entity}]\!] = \lambda x\lambda y.$**discoverEntity**$(y)(x)(w)$
b. $[\![\text{report}_{entity}]\!] = \lambda x\lambda y.$**reportEntity**$(y)(x)(w)$

The lack of the relevant entailment is again accounted for by the natural assumptions about the relations involved in these readings: discovering an object whose content is p does not entail discovering that p; reporting a communicative event whose content is p does not entail communicating that p.[18]

It should be noted that I do not have a proof that entity-relating denotations of ResPs *never* license the relevant entailment since I do not provide a general theory of entity-relating denotations of ResPs.[19] Still, it is important to stress that the current account avoids the incorrect prediction that the entailment should be *generally* possible across ResPs,

[17] I will discuss a specific semantic relation between the knowledge *know* and the acquaintance *know* in Section 4.1, in relation to the behavior of *know* when they take factive DPs like *the fact*.

[18] I am assuming here that events are a subtype of entities in the ontology, and that the DP *the rumor* can denote a linguistic object whose content is a rumor or a communicative activity that involves rumoring.

[19] In fact, what is happening with *tell the rumor* discussed in footnote 3 might be a case in which the entity-relating denotation of *tell* happens to be one that licenses the entailment.

unlike the account considered in Section 2.1. Also, the current account is more advantageous than the theory considered in Section 2.2 in successfully predicting that ProPs generally license the entailment. In Section 3.2.4, I discuss the advantage of the current approach over an account based on lexical stipulations in more detail.

3.2.3 *Problem with nesting* ID *and* CONT Summarizing the solution discussed above, the contrast in the entailment patterns between ResPs and ProPs can be explained based on their basic selectional properties, once we adopt the current proposal, i.e., ProPs only select for propositions while ResPs only select for questions. When attitude verbs are combined with a content DP, there has to be a type-shifting operation by which the individual denoted by the DP is coerced into the type of object that the attitude verbs select for. When the verb is a ProP, the type-shifter CONT can convert an individual into its propositional content. This treatment gives us the correct entailment pattern of *x ProP the N that p*. On the other hand, when the verb is a ResP, the same type-shifter is not applicable since the propositional content retrieved from an individual cannot be combined with a ResP, which selects for a question rather than a proposition. There are two ways in which a ResP can select for an individual, i.e., through CQ or through a separate entity-relating denotation. CQ readings do not allow the entailment from *x ResP the N that p* to *x ResP that p*. An entity-relating readings does not automatically guarantee the relevant entailment for ResPs, either. This accounts for the empirical pattern we observed in Section 2.

Nevertheless, there is one issue in the current account which I have not discussed yet. The issue concerns the nested applications of the type-shifters CONT and ID, as in the following:

(44) John knows [ID [CONT [the rumor that Mary left]]].

The nested type-shifting in (44) predicts that the sentence is true iff (Mary actually left and) John's epistemic state entails the content of the rumor that Mary left, which entails that John knows Mary left. This is a reading that we wanted to rule out.

Below, I will offer two ways to avoid this problem, one of which is stated in terms of a principle governing type-shifting,[20] and the other (suggested to me by Floris Roelofsen) is formulated by modifying the basic semantics of declarative clauses. In this article, I will not commit to a specific choice between these two solutions. Rather, I will simply show that the current main proposal—that ProPs are

[20] I thank an anonymous reviewer for discussion on this point.

proposition-taking while ResPs are question-taking—can be amended in multiple ways to rule out the problematic prediction made by (44).

Economy Principle on type-shift The application of CONT and ID in (44) can be ruled out if sequential application of multiple type-shifters is blocked when the resulting type can be achieved by an application of a single type-shifter. Application of ID + CONT in (44) maps entities to proposition-sets, but the same result can be obtained by simply applying the CQ-type shifter, CQ. I argue that a principle on type-shift blocks the former (more complex) kind of type-shift if the latter (simpler) kind of type-shift is possible. The principle can be stated in the following way.

(45) **Economy Principle on type-shifting operations**
A structure involving successive applications of multiple type-shifters α and β to the form φ i.e., $[\beta\ [\alpha\ \varphi]]$, is ruled out if there is a basic type-shifter γ such that the semantic type of $[\gamma\ \varphi]$ is the same as that of $[\beta\ [\alpha\ \varphi]]$.

This principle is conceptually similar to Chierchia's (1998) 'Type-shifting as a Last Resort'[21] in that it blocks a structure involving type-shifting operations in the presence of another structure involving less type-shifting operations. However, the Economy Principle in (45) is different from 'Type-shifting as a Last Resort' in that it is blind to the actual meaning of the resulting type-shift, and applies just based on the comparison of *types* between the two structures. This is necessary for our purpose because $[\![\text{ID}\ [\text{CONT}\ X]]\!]$ is distinct from $[\![\text{CQ}\ X]\!]$, but we still want the latter to block the former. This feature of the Economy Principle can be understood as a consequence of the fact that type-shift is a *repair strategy of type-mismatches*. Given a type-mismatch, the semantic computation compares all combination of type-shifters that can resolve the mismatch regardless of the resultant meaning, and chooses a simpler candidate. In this conception of type-shift, ID + CONT and CQ are compared by the semantic computation as possible candidates to resolve the type-mismatch between *know* and a DP, and the latter is chosen because it involves less type-shifting operators. Of course, this analysis still leaves open why there is no type-shifter that does what ID + CONT does in one step, i.e., the hypothetical type-shifter in (46) below:

(46) $[\![\text{ID-CONT}]\!]^w = \lambda x \in D_e.\{\mathscr{F}_{cont}(x)\}$

[21] 'Type-shifting as a Last Resort' (Chierchia 1998) is formulated as follows: for any type-shifting operator τ and any expression X: $*\tau(X)$ if there is an expression E such that for any X in its domain, $E(X) = \tau(X)$.

This question will be discussed in Section 3.2.4 in connection to the comparison of the current analysis with an account based on lexical stipulations.

Declaratives as sets of propositions Another solution to the problem suggested to me by Floris Roelofsen (personal communication) is to assume a semantics of declarative clauses in which they denote singleton proposition-sets from the outset.[22] In this formulation, we can get rid of ID because ResPs can simply combine with declarative clauses. Instead, we need a type-shifter that maps singleton proposition-sets to its sole member in order to treat the declarative embedding of ProPs.[23] This formulation still preserves the account of the contrast between ProPs and ResPs in terms of their basic type-distinction. At the same time, it avoids the problem with ID + CONT by doing away with the ID type-shifter.

3.2.4 *How is this better than lexical stipulations?* Finally, let me address a question concerning the stipulation I have in my account, and how the proposal can be argued to be superior to an alternative account in which the existence and absence of the relevant entailment is simply lexically encoded in each attitude predicate.

In the account laid out above, I propose an inventory of type-shifters that relate entities, propositions and proposition-sets. Namely, there are following three type-shifters.[24]

(47) a. $[\![\text{ID}]\!]^w = \lambda p \in D_{\langle s,t\rangle}.\lambda q \in D_{\langle s,t\rangle}.[p = q]$ (proposition-to-singleton)
b. $[\![\text{CONT}]\!]^w = \mathscr{F}_{cont}$ (entity-to-content)
c. $[\![\text{CQ}]\!]^w = \lambda x \in D_e.\{p | \exists w[p = \lambda w'.\forall c' \in R_C[c'(w') = x \leftrightarrow c'(w) = x]\}$ (entity-to-CQ)
where $\mathscr{R}_C$ is a conceptual cover given by context C

One thing that is crucial in the account is that the following type-shifter is not available:

(48) $[\![\text{ID-CONT}]\!] = \lambda x \in D_e.\{\mathscr{F}_{cont}(x)\}$

[22] This can be implemented in Alternative Semantics (Kratzer & Shimoyama 2002) or Inquisitive Semantics (Ciardelli *et al.*, 2013) with a declarative operator that 'collapses' the alternatives in a declarative complement into a singleton set. Kratzer & Shimoyama's (2002) ∃-operator can be thought of as such an operator:

(i) $[\![\exists\alpha]\!]^{w,g} = \{\lambda w'.\exists p[p \in [\![\alpha]\!]^{w,g} \wedge p(w') = 1]\}$

[23] This is in fact Partee's (1986) ι (iota) type-shifter.

[24] ι instead of ID if we choose the second solution to the problem discussed in the previous section.

If this type-shifter were available, using it to resolve the type-mismatch between a ResP and a DP would make an incorrect prediction that *John knows the rumor that p* entails that *John knows that p*, just as in a case where the two type-shifters ID and CONT are nested.

It would be more desirable if I could offer an independent argument for the unavailability of (48), but I will not venture such an explanation in this article. Rather, I submit the inventory in (47) as part of my theoretical claim about how entities, propositions, and proposition-sets are mapped into each other in the grammar.[25] Indeed, this involves stipulation, but the stipulation, together with the proposal regarding the semantics of ProPs and ResPs, enables us to make *predictions* about possible interpretations of ProP/ResP + DP constructions. Specifically, it captures the fact that all ProP + DP combinations license the relevant entailment while ResP + DP combinations do not license the entailment modulo entity-relating readings.

This predictive power is what makes the current proposal more desirable than an account in which the denotation of each attitude predicate is lexically specified as to whether it gives rise to the relevant entailment, as discussed in Section 2.2. Simply stipulating the entailment pattern for each predicate is descriptively adequate, but it does not *predict* that any ProP will license the entailment. Also, it is superior to the sophisticated version of the lexical specification account that uses a general lexical rule, as in (11) repeated from Section 2.2, to capture this fact.

(11) $R_{\langle st,et\rangle} \mapsto \lambda x \in D_e.R(\mathscr{F}_{cont}(x))$

This is so because the sophisticated lexical specification account incorrectly predicts that ResPs generally license the relevant entailment whereas the current account crucially avoids this prediction. One way to save the lexical rule account, of course, is to adopt the semantic-type distinction between ProPs and ResPs in my proposal. In this account, the lexical rule is defined to apply only to proposition-taking predicates, and since ResPs are question-taking, the lexical rule

[25] A similar kind of stipulation is made in other works on type-shifting as well (Partee 1986; Chierchia 1998). For example, Partee (1986) defines the type-shifter IDENT as in (i), which maps entities to predicates, but she does not include another possible type-shifter IDENT*, given in (ii), in the inventory of type-shifters that maps entities to generalized quantifiers.

(i) $\text{IDENT}(x) = \lambda y \in D_e.[y = x]$
(ii) $\text{IDENT}^*(x) = \lambda P \in D_{\langle e,t\rangle}.\lambda x_e.[y = x]$

Note that IDENT* is similar to (48) in that it returns a singleton set of what would result from another type-shifter.

simply does not apply to them. However, now this is an account that is equivalent to the my proposal with just a technical difference: what is being done by CONT in my account is now carried out by (11).

3.3 *On exclusively interrogative-embedding verbs*

The proposed typology of ProPs and ResPs is the following: if a predicate can embed either a declarative or an interrogative clause, it is semantically (only) question-taking. On the other hand, if a predicate only embeds a declarative clause, it is semantically proposition-taking. Thus, schematically, a finite-clause-embedding attitude verb R can have one of the two denotations in the following.

(49) a. $\mathrm{R}_P = \lambda p \in D_{\langle s,t\rangle} \lambda x.\mathrm{R}*_x^w \subseteq p$
b. $\mathrm{R}_Q = \lambda Q \in D_{\langle st,t\rangle} \lambda x.\exists p \in Q[C_\mathrm{R}(p) \wedge \mathrm{R}*_x^w \subseteq p]$
where $\mathrm{R}*_x^w$ is a set of worlds that are compatible with the relevant attitude of the attitude holder x in w and C_R is a lexically-determined restriction on the propositions.

A predicate having the denotation in (49b) can embed a declarative complement as well as an interrogative complement with the help of ID in (18). Also, I follow Lahiri (2002) in treating the restriction C_R in (49b) as lexically determined. In the case where R is a factive/veridical predicate, C_R restricts the quantification to be over true propositions. This does not mean that C_R in the case of non-veridical predicates are trivial. For example, *report* can be analyzed as having the following denotation.

(50) $[\![\text{report}]\!]^w = \lambda Q \in D_{\langle st,t\rangle} \lambda x.\exists p \in Q[\mathrm{DOX}_x^w \subseteq p \wedge \mathrm{REPORT}_x^w \subseteq p]$

An immediate question that one would raise against the current proposal is what to do with exclusively interrogative-embedding verbs like *ask* and *wonder* (i.e., INQUISITIVE VERBS in Karttunen's 1977 classification). If these verbs have the schematic denotation in (49b), we wrongly predict that they can embed a declarative complement just like *know* does, with the help of ID, unless an independent explanation is given for their selectional restriction.

I argue that this problem can be avoided since exclusively interrogative-embedding verbs are characterized by what I will refer to as the NON-TRIVIALITY PRESUPPOSITION, which requires the proposition set in the complement to be a non-singleton. The presupposition is stated below.

(51) **Non-triviality presupposition of inquisitive verbs**
$[\![\text{wonder/ask/inquire}]\!]^w(Q)(x)$ is defined only if the following proposition is compatible with x's beliefs: $\lambda w.\exists p \in Q[p(w)] \wedge \exists p \in Q[\neg p(w)]$

Intuitively, inquisitive verbs presuppose that it is compatible for the agent that the question is non-trivial, in the sense that there are true answers as well as false answers to the question.

The presupposition in (51) cannot be satisfied if Q is a singleton given that a single proposition cannot be both true and false in a particular world. The net result is that the singleton set of a proposition—which results from applying ID to a declarative complement—cannot be combined with an inquisitive verb like *ask* or *wonder*, as it will necessarily result in a presupposition failure.[26]

Not only is it intuitively the case that inquisitive verbs have the non-triviality presupposition, but the presupposition can be derived from the semantic analysis of these predicates once we assume that these predicates share the meaning core that can be paraphrased as 'want to know', as suggested by Karttunen (1977) and Guerzoni & Sharvit (2007). Below, I show how the non-triviality presupposition is derived in the meaning of *want to know*, once we make the following two assumptions about the semantics of *want*: (i) *x wants p* presupposes that *x wants p* presupposes that *x* does not believe *p*, and (ii) presuppositions triggered by the complement of *want* is projected into the belief state of the agent of *want*, e.g., *John wants Mary to stop smoking* presupposes that John believes that Mary used to smoke. These presuppositions are relatively uncontroversial aspects of the meaning of *want* maintained in analyses

[26] Guerzoni (2004) argues that questions containing minimizers are singletons, due to the fact that the presupposition of the positive proposition is false.

(i) John asked Mary whether Paul had lifted a finger to help her.
(ii) {#EVEN(Paul lifted a finger to help Mary), EVEN(not(Paul lifted a finger to help Mary))}

This creates a potential conflict with my analysis that *ask/wonder*-type predicates presuppose the embedded question to be non-singletons.

The conflict can be resolved if the presupposition of the *ask/wonder*-type predicates is evaluated without reference to whether the presupposition of each proposition in the question is satisfied. Assuming that the denotation of an embedded question that enters into the semantic composition contains its possible answers irrespective of whether their presupposition is satisfied, the following kind of implementation of the presupposition of *wonder* takes care of the fact.

(iii) $[\![\text{wonder}]\!]^w = \lambda Q{:}[|Q| > 1]\lambda x.\mathbf{wonder}(x,Q,w)$

On the other hand, we can assume that the bias of a question is evaluated with reference to the presuppositions of the possible answers, deriving the fact that questions containing minimizers have a negative bias.

such as Heim (1992), von Fintel (1999) and those in the subsequent literature. They can be formally stated as follows:

(52) $[\![\text{want}]\!]^w(p)(x)$ is defined only if
(i) $\text{DOX}_x^w \not\subseteq p$, and ($x$ does not believe p)
(ii) $\text{DOX}_x^w \subseteq \{w' \mid p(w') \in \{0, 1\}\}$ (x believes the presupposition of p)

In the case of *x wants to know that p*, these two presuppositions together turn out to be contradictory. This is so because the first presupposition requires that x does not believe that x knows p, but the second presupposition, i.e., the projection of the presupposition of the complement, requires that x believes p due to the factivity of *x knows that p*.[27]

What this shows is that the sentence *x wants to know that p* always faces a presupposition failure. Thus, in order for *x wants to know Q* to be defined, Q has to be a non-singleton. We have now seen that the non-triviality presupposition falls out from the semantics of *want to know*. Hence, assuming that *wonder* and *ask* share the same meaning core as *want to know*, we can derive the non-triviality presupposition from their semantics.

To sum up, exclusively interrogative-embedding verbs, such as *wonder* and *ask*, do not constitute counterexamples to the current proposal.[28] This is because they have a characteristic presupposition

[27] Formally, this can be proved as follows. By assumption, we have the following two presuppositions:

(i) $\text{DOX}_x^w \not\subseteq \{w' \mid p(w') \wedge \text{DOX}_x^{w'} \subseteq p\}$ (x does not believe that x knows p)
(ii) $\text{DOX}_x^w \subseteq p$ (x believes p)

From (ii) and positive introspection, we derive the following:

(iii) $\text{DOX}_x^w \subseteq \{w' \mid \text{DOX}_x^{w'} \subseteq p\}$ (x believes that x believes p)

Conjoining (ii) and (iii), we derive the following:

(iv) $\text{DOX}_x^w \subseteq \{w' \mid p(w') \wedge \text{DOX}_x^{w'} \subseteq p\}$ (x believes that [p and x belives p])

This contradicts (i). This proof assumes that *know* is analyzed as *believe* + factivity, but an analogous proof can be constructed as long as we assume the principle of POSITIVE CERTAINTY, i.e., 'x believes p' entails 'x believes that x knows p' (see e.g., van der Hoek 1993) in the place of positive introspection.

[28] Another problem concerning *wonder* is that they do not embed CQs. If the CQ type-shifter turns an entity into a question, and if *wonder* selects for a question, why can not it combine with a DP under a CQ reading? This is a problem for any theory that treats the semantics of CQs on a par with *wh*-complements (see Nathan 2006 for discussion). Capturing the distribution of CQs is a long-standing issue (see e.g., Nathan 2006; Frana 2010; Aloni & Roelofsen 2011), and is certainly beyond the scope of this article. Here, I follow Pesetsky's (1991) syntactic treatment and assume that *wonder* cannot embed a CQ due to its Case requirement, specifically, that it requires its object to be Caseless. Since Case Filter rules out DPs without a Case, this assumption captures the fact that *wonder* cannot embed a DP complement. In contrast, *ask* does not have the same Case requirement. Thus, it does take a CQ complement, as in *John asked the time*.

requiring the question-denotation of the complement to be 'non-trivial', which explains their impossibility to combine with a singleton proposition-set.

4 COMPARISON WITH ALTERNATIVE APPROACHES

4.1 *Ginzburg (1995)*

Ginzburg (1995) accounts for the contrast in the entailment patterns between ResPs and ProP by arguing that ProPs select for a proposition but factive ResPs select for a 'fact', a different object from a proposition in his ontology (originally due to Russell 1918/1919). According to him, a declarative complement of *know* denotes a fact while the question-denotation of an interrogative complement can be turned into a fact that *resolves* the question by the mechanism of semantic coercion. Factive predicates like *know* are combined with the fact resulting from this coercion.

Specifically, assuming that a content DP like *the rumor* denotes a proposition, Ginzburg argues that a sentence of the form *x knows the rumor* only has a CQ (or an acquaintance) reading. On the other hand, a declarative complement of *know* can denote a fact, which combines with *know*. Hence the entailment does not go through. In contrast, ProPs such as *believe* select for a proposition. Since *the rumor* denotes a proposition which is identical to the denotation of its complement, the entailment from *x believes the rumor that p* to *x believes that p* is straightforward.

He supports his claim about ResPs by the observation that the entailment of the form in (3) does hold when the nominal is factive, such as *fact* or *truth*, as shown below.

(53) John knows the {fact/truth} that Mary left. ⊨ John knows that Mary left.

Factive DPs such as *the fact* or *the truth* denote facts. Therefore, it is predicted that a fact-selecting verb such as *know* can license the

However, as Nathan (2006) points out, this cannot be the whole story since *wonder* does take a limited number of DP complements, as shown below.

(i) a. Kim wondered **something**.
b. Kim wondered who left, and Sandy wondered {**that** as well/**the same thing**}.

I have to leave this problem open in this article, and simply point out the connection of these data to another open question, namely the selectional restriction of *think*. Although the verb *think* is a ProP, it does not embed content DPs, except the kind of DPs exemplified in (i) above (see Moltmann 2013 for a semantic proposal for discussion concerning *something* in these examples):

(ii) John thought {*the rumor/**something**/**that**/**the same thing**}.

entailment when they take a factive DP object, just as in the case where a proposition-selecting verb such as *believe* takes a proposition-denoting DP object.

However, Ginzburg's analysis thus sketched has several problems. First of all, his account of the lack of the entailment applies only to *factive* responsive ResPs, but not to *non-factive* ResPs, such as *report* or *predict*. Ginzburg argues that non-factive ResPs select for a proposition, and thus predicts that the problematic entailment goes through when they take a content DP like *the rumor*. However, as Lahiri (2002: 290–1) notes, this prediction is not borne out, as shown below.[29]

(54) John {**reported/predicted**} the rumor/hypothesis that Mary left.
⊭ John {**reported/predicted**} that Mary left.

Also, there is a problem of over-generation due to the coercion mechanisms he posits. In accounting for the declarative-embedding of factive ResPs, Ginzburg actually assumes a mechanism of coercion that converts a proposition denoted by a declarative clause into a fact that *proves* the proposition, in addition to the coercion from questions to facts. But, once we had this coercion mechanism, it is not clear how it does not apply to content DPs like *the rumor*, and licenses the problematic entailment. That is, if *know* is combined with the result of applying the proposition-to-fact coercion to *the rumor*, *John knows the rumor that p* would mean 'John knows a fact proving the rumor that *p*', which in turn means that John knows that *p*. This is exactly the entailment that we want to prevent from arising, but it is not clear how it is blocked in Ginzburg's system.[30] Ginzburg mentions this problem (597–8). However, he only suggests that an alternative CQ reading is available in these sentences, and does not discuss why the problematic reading that I sketched above is blocked.[31]

Furthermore, other things being equal, a general process of coercion from questions to facts predicts that a verb must be able to embed a

[29] The non-factive ResP *tell* does not behave exactly in the same way as *report* or *predict*. See footnote 3. This behavior of *tell* is not a problem for Ginzburg unlike *report*. However, the current account might need to assume that *tell* is ambiguous between a proposition-taking and a question-taking version to account for it.

[30] A similar problem arises in example (i).

(i) John **knows** the question of who left. ⊭ John **knows** who left.

Given that the DP *the question*... denotes a question just as an interrogative complement does, as Ginzburg assumes, the coercion from a question to a fact resolving the question should license the entailment, contrary to the data. It follows from 'John knows a fact that resolves the question of who left' that 'John knows who left'.

[31] On the other hand, in the proposed system, there are multiple answers to why the nesting of ID and CONT is ruled out, as discussed in Section 3.2.3.

question if a verb can embed a fact (i.e., it is factive). However, there are counterexamples to this prediction: verbs such as *regret* and *resent* are factive, but they do not embed an interrogative, as the following example shows.

(55) John regrets {that he cannot accept the invitation/*who can accept the invitation}.

Ginzburg needs independent stipulations to account for the behavior of these verbs.

Lastly, the fact that the entailment goes through for ResPs when the nominal is factive, as shown in (53), does not favor Ginzburg's analysis over my analysis. This is because the data can be captured in the current analysis as a result of the acquaintance reading, assuming a specific analysis of the acquaintance relation. That the relevant construction involves an acquaintance reading rather than a CQ reading is evidenced by the fact that the acquaintance predicates like *kennen* or *wissen um* 'know about', but not *wissen*, can be combined with the German equivalent of *the fact*:[32]

(56) a. Hans kennt die Tatsache, dass *p*.
John know$_A$ the fact that *p*
(entails 'John knows that *p*')
b. #Hans weiß die Tatsache, dass *p*.
John know$_K$ the fact that *p*

Roughly, my derivation of the entailment relies on two assumptions: (i) being acquainted with *x* entails (among other things) knowing that *x* exists; (ii) the content-bearing object denoted by the DP *the fact that p* exists only if *p* is a fact. Combining (i) and (ii) together, we derive the fact that *John know*$_A$ *the fact that p* entails 'John knows that *p* is true'. Below, I explain this derivation in more detail.

The first (arguably reasonable) assumption is that one is acquainted with an object only if the object exists and she believes that the object exists. This can be stated as follows:

(57) **acquainted**$(y)(x)(w)$ only if **exist**$(y)(w) \wedge \mathrm{DOX}_x^w \subseteq \{w' \mid \textbf{exist}(y)(w')\}$

That is, *x* can be acquainted with *y* only if *y* actually exists and *x* knows that *y* exists. The second assumption is that the DP *the fact that p* is *necessarily* extensionless if *p* is not a fact. This is not a trivial assumption, and needs some elaboration. What underlies here is an ontological assumption about the properties of content-bearing objects. I assume that the properties of a content-bearing object are *essential*, i.e., are

[32] I thank an anonymous reviewer for bringing up this fact.

world-independent across worlds in which the object exists.[33] That is, it cannot be the case that a content-bearing object is a rumor in one world, but not in another world. In other words, an object predicated of as a rumor in one world cannot be identified with another object predicated of as a non-rumor in another world even if their contents are the same. In worlds where the content is not rumored, the object simply does not exist. This is also true of objects that are predicated of as facts. In worlds where *p* is false, the object denoted by *the fact that p* does not exist (see Moltmann (2013: 132–4) for a similar assumption about the characteristics of ATTITUDINAL OBJECTS, an ontological category for the objects of attitudes in her semantics).[34]

Given these two assumptions, we can derive the entailment in (53), i.e., the entailment from *John knows the fact that p* to *John knows that p*. First, the first conjunct of (57) tells us that *p* is true (since, otherwise, the object DP would be extensionless)—(a). Furthermore, given the second assumption, *p* is true in all worlds in which the object denoted by the DP exists. This is because, in those worlds, the object is a fact and its content is *p*, due to the essentialness of the properties of content-bearing objects. Finally, the second conjunct of (57) tells us that John believes

[33] This assumption can be formally stated as follows:

$$\forall x \in D[x \in dom(\mathscr{F}_{cont}) \rightarrow \forall P \in D_{\langle e,st\rangle}[\exists w[P(x)(w)] \rightarrow \forall w'[P(x)(w') \vee \neg \mathbf{exist}(x)(w')]]]$$

[34] The ontological assumption is motivated by the truth conditions of acquaintance sentences in general, independently of the considerations of factive content nouns. The starting point is that acquaintance readings are extensional, i.e., the DP in the object position of the acquaintance *know* cannot be interpreted *de dicto*. This is evidenced by the oddness of the example in (i). On the other hand, a *de re* reading of the object DP of the acquaintance *know* is exemplified by (ii).

(i) #John knows the president, but it is not Obama.
Paraphrase (Intended): John is acquainted with someone who he mistakenly believes to be the president.

(ii) John knows the president, but he does not know that he is the president.
Paraphrase: John is acquainted with Obama, but he does not know that Obama is the president.

On the other hand, what is interesting about the content nouns and contentful objects is that the example in (iii), which is parallel to (ii), sounds odd.

(iii) #John knows the rumor that Mary left, but he does not know that it is rumored that Mary left.

The oddness of (iii) is accounted for given the assumption about the properties of content-bearing objects described above. If an object is a rumor in some world, it is a rumor in every world in which it exists. In (iii), since the object with which John is acquainted has the property of being a rumor in the actual world, it is a rumor also in the worlds compatible with John's beliefs (The object exists in all worlds compatible with John's beliefs because he is acquainted with it). Thus, if one is acquainted with a content-bearing object which is a rumor, he knows of the object as a rumor. This is why the sentence in (iii) sounds odd: it is a contradiction that John knows the rumor, and does not know that the rumor is not a rumor.

the existence of the object denoted by the DP, which means that he believes that *p* is true—(b). By (a) and (b), we conclude that John knows that *p* in *w*.[35] Hence, the data in (53) can be accounted for in the current proposal with assumptions about the semantics of factive nominals and the ontology of contentful objects. Also, this proof can be extended to other combinations of factive ResPs and factive nominals such as *discover the truth that p*.

Thus, I argue that the current proposal has advantages over Ginzburg's (1995) account. Furthermore, it is worthwhile to note that the current proposal succeeds in capturing the data in an ontology that is more conservative than Ginzburg's, who assumes quite a rich ontology including 'facts' and 'questions' as primitives distinct from 'propositions'.

4.2 *Question-to-proposition reduction theories*

In this section, I compare the current analysis with a more standard approach to ResPs where their question-taking meanings are reduced to their proposition-taking meanings. (Karttunen 1977; Groenendijk & Stokhof 1984; Lahiri 2002, among others) An interesting property of the current proposition-to-question reduction analysis is that it involves the opposite reduction from the standard approach. In the standard approach, the proposition-embedding meaning of a ResP is basic, from which question-embedding is derived in some way or other. On the other hand, in the current analysis, the question-embedding meaning of a ResP is basic, from which the embedding of declaratives is derived. In this section, I make two further kinds of arguments for favoring the current analysis.

4.2.1 *The selectional restrictions of attitude predicates* The two analyses differ in the variety of embedding possibilities they allow for a single predicate. Specifically, as stated in Section 3.3, the current theory predicts that there would in principle be no verb that exclusively embeds an interrogative, unless independent explanations are made. On the other hand, the standard question-to-proposition reduction theory predicts that there would be no exclusively proposition-taking predicates unless further explanations are made. This is because, for any

[35] The proof here assumes a simplified view that a true belief constitutes knowledge, which is known to be too simplistic (Gettier 1963). However, the explanation described here can be carried over to a more sophisticated analysis of *know* which involves conditions for capturing the so-called Gettier cases, in addition to the traditional 'truth', 'belief' and 'justification' conditions. What is needed is that the truth of the content holds across the worlds compatible with the beliefs^{+} of the attitude holder, where beliefs^{+} are constrained by the additional conditions that are needed to account for the Gettier cases.

proposition-taking denotation, there must in principle be a corresponding question-taking denotation if the reduction from question-embedding to proposition-embedding is general. Take, for example, Groenendijk and Stokhof (1984) theory. In their analysis, the extension of an interrogative clause is a proposition, and thus it can be combined with a responsive predicate such as *know*, which selects for a proposition. However, unless there is an additional stipulation, it is predicted that *believe* can embed an interrogative clause in the same way.[36]

At first glance, both of these predictions seem to be problematic, as can be seen in the actual embedding patterns of attitude predicates summarized below.

(58) **The typology of the selection restrictions of attitude predicates**

	embed declaratives	not embed declaratives
embed interrogatives	*know, be certain, tell* etc.	*ask, wonder* etc.
not embed interrogatives	*believe, think* etc.	—

The exclusively interrogative-embedding verbs such as *ask* and *wonder* are *prima facie* problematic for the current analysis, and so are the exclusively declarative-embedding verbs such as *believe* and *think* for the standard question-to-proposition reduction analysis. However, as argued in Section 3.3, there is an independent semantic explanation for why verbs such as *ask* or *wonder* cannot embed a declarative: they presuppose that the proposition-set they combine with is a non-singleton.

On the other hand, it is difficult to account for the existence of exclusively declarative-embedding verbs on independent semantic grounds. That is, the set of verbs that exclusively embed declaratives does not seem to be characterized by any independent lexical semantic property. One argument comes from the lexical semantic similarity between *believe* and *be certain*. Assuming that there is no independently testable lexical semantic difference between *believe* and *be certain*, it is hard to explain from their meanings why *believe* does not embed an interrogative complement while *be certain* does. Note, however, that the existence of exclusively declarative-embedding predicates (and the fact that they cannot be independently characterized) is not

[36] One piece of evidence for the reduction of question-embedding to proposition-embedding in terms of extensionalization that Groenendijk & Stokhof (1984) discuss is the alleged fact that the responsive predicate *tell* becomes veridical when it embeds an interrogative complement although it is not factive when it embeds a declarative complement. However, this claim is questioned by Spector & Égré (2015), who argue that *tell* in question-embedding can in fact be non-veridical, based on the following example.

(i) Every day, the meteorologists tell the population where it will rain the following day, but they are often wrong.

problematic for the proposed analysis. This is because the proposed constraint on the lexical denotation allows an attitude verb to have a proposition-taking denotation, and there is no general operation by which a question-taking denotation is created out of this proposition-taking denotation.

Hence, there is an asymmetry between the current proposal and the standard analysis. In both accounts, semantic types do not explain the selectional restriction of one of the three classes of predicates in the table in (58). In the current proposal, types do not explain the selectional restriction of exclusively question-taking predicates while, in the standard analysis, types do not explain exclusively proposition-taking predicates. What I argued in this section is that it is easy to semantically account for the former case, but not the latter. Exclusively question-taking verbs form a semantically natural class in having the non-triviality presupposition, so that their behavior can be explained away within the proposed theory. On the other hand, exclusively proposition-taking verbs are difficult to characterize semantically.

4.2.2 *George (2011)* Another argument against the question-to-proposition reduction was recently made by George (2011). George points out an example of *know-wh* and *forget-wh* sentences that are problematic for the question-to-proposition reduction theories. In the problematic scenario he describes, two individuals have exactly the same set of propositional knowledge/forgetting, but have different question-knowledge/forgetting. The concrete example goes as follows. In the scenario described in (59), sentence (60a) is intuitively true, but (60b) is not. Crucially, (60b) feels false even under the intuitively weakest interpretation of *know*, i.e., the mention-some reading, under which (60a) is true.

(59) **Scenario:**
- Store A sells an Italian newspaper, but store B doesn't.
- John knows that Mary can buy an Italian newspaper at store A.
- John is unopinionated about whether she can buy an Italian newspaper at store B.
- Bill knows that Mary can buy an Italian newspaper at store A.
- Bill wrongly believes that Mary can buy an Italian newspaper at store B.
- John and Bill have exactly the same beliefs except for whether Mary can buy an Italian newspaper at store B.

(60) a. John knows where Mary can buy an Italian newspaper.
b. #Bill knows where Mary can buy an Italian newspaper.

This is problematic for the reduction of *know-wh* to *know-that*. Note that John and Bill have exactly the same set of relevant propositional knowledge, i.e., the set including (61a), but not (61b).

(61) a. Mary can buy an Italian newspaper at store A.
b. Mary can buy an Italian newspaper at store B.

Thus, if question-knowledge can be reduced to propositional knowledge, John and Bill should have the same question-knowledge. The fact that (60a) and (60b) differ in the truth values speaks against this prediction. George also describes a similar non-reductive scenario for *forget*.

What George's argument shows is that if one wants to keep the semantics of *know* unambiguous and derive its selection behavior from there, the basic meaning of *know* has to be question-taking rather than proposition-taking.[37] This point is exactly what is defended in the current paper. Below, I illustrate how the above phenomenon can be incorporated in the current approach without committing to a specific denotation of *know* except that it is question-taking.

First of all, following George (2011) himself, I assume that the mention-some reading is derived by combining the denotation of *know* and the Hamblin denotation without the PART-operator (i.e., George's X-operator).[38] Then, we can further revise the entry as follows to account for George's observation discussed above.

(62)
$[\![\text{know}_{rev}]\!]^w = \lambda Q \lambda x.\text{know}^w(Q)(x) \wedge \underline{\forall p' \in Q[\text{DOX}_x^w \subseteq p' \rightarrow p'(w) = 1]}$

Note the latter (underlined) conjunct in (62). The conjunct requires that all the propositions in the question denotation that the subject believes are true. This provides us with the desired consequence that sentence (60b) is false in (59). The truth conditions of (60b) is given in (63), and the underlined conjunct states that for any proposition of the form 'Mary can buy an Italian newspaper at x', if Bill believes the proposition,

[37] I thank an anonymous review for making this point explicit. George (2011) himself does not approach the issue by positing an unambiguous lexical entry of *know*. In his approach, the lexicon associates two meaning components for each responsive predicate, from which its question-embedding denotation and its proposition-embedding denotation are composed by procedures general to all responsive predicates.

[38] A detailed discussion of the proper treatment of mention-some readings would be a topic for another article (See e.g., Beck & Rullmann 1999; George 2011 for discussion).

it is true. This condition is violated in George's scenario since Bill believes incorrectly that Mary can buy an Italian newspaper at Store B.

(63) $[\![\text{Bill knows}_{rev} \text{ where Mary can buy an Italian newspaper}]\!]^w = 1$
iff $[\![\text{know}]\!]^w(\{p' | \exists x[p' = \lambda w'.\mathbf{buyItaNP}(\mathbf{m},x,w')]\})(\mathbf{b})$
$\wedge \underline{\forall p'[\exists x[p' = \lambda w'.\mathbf{buyItaNP}(\mathbf{m}, x, w')] \rightarrow [\text{DOX}^w_{\mathbf{b}} \subseteq p' \rightarrow p'(w) = 1]]}$

This captures the intuition that example (60b) is false in George's scenario. Also, note that the denotation for the mention-some *know* in (62) does not make any incorrect prediction in the case of declarative-embedding in the current proposal. This is shown in the predicted truth conditions of the sentence *x knows*$_{rev}$ ID *that p* below.

(64) $[\![x \text{ knows}_{rev} \text{ ID that } p]\!]^w = 1$
iff $\text{know}(\{p\})(x) \wedge \underline{\forall p''[p'' = p \rightarrow [\text{DOX}^w_x \subseteq p'' \rightarrow p''(w) = 1]]}$
iff $p(w) = 1 \wedge \text{DOX}^w_x \subseteq p$

The underlined conjunct in the above truth conditions, which is added to capture George's observation, is entailed by the first conjunct. Hence, we end up with the truth conditions equivalent to the conservative '(justified) belief + truth' picture assumed in the earlier sections.

The upshot of the current discussion is that George's (2011) observation about the non-reducibility of *know* is problematic for the standard reduction of *know-wh* to *know-that* while it is not for the current picture where *know-that* is reduced to *know-wh*. In the proposition-to-question reduction analysis, we can analyze *know-wh* as having a more involved truth conditions than is standardly assumed, by which we can capture the case George (2011) discusses while preserving the standard truth conditions of *know-that*.

5 CONCLUSIONS

In this article, I have argued for the semantics of question-embedding in which the denotation of a question-embedding Responsive Predicate (ResP), such as *know*, always selects for a question. This contrasts with the standard treatments (Karttunen 1977; Groenendijk & Stokhof 1984; Lahiri 2002), where ResPs select for a proposition. According to the proposal, the basic denotation of these predicates takes a set of propositions, which corresponds to the Hamblin-semantic denotation of an interrogative complement. Thus, they straightforwardly combine with the Hamblin-semantic donation of an interrogative complement, deriving appropriate truth conditions of question-embedding sentences. When the predicates embed a declarative complement, a type-shifter

converts the embedded proposition into the singleton set containing that proposition. The 'trivialized' question derived this way is combined with a ResP, yielding the correct truth conditions of declarative-embedding sentences. Thus, the current proposal reduces proposition-embedding to question-embedding, as opposed to the standard treatment in which question-embedding is reduced to proposition-embedding.

Equipped with independently motivated type-shifting operations, the proposal provides a novel account of the contrast in entailment between ResPs and ProPs when they take a content DP. The account has empirical and conceptual advantage over Ginzburg's (1995) existing analysis. Also, the proposed reduction from declarative-embedding to interrogative-embedding enables a straightforward semantic account of the selectional restrictions of attitude predicates, which is difficult in the more standard question-to-proposition reduction theories. Although exclusively interrogative-embedding predicates, such as *ask* and *wonder*, pose a *prima facie* problem for the current analysis, their behavior can be explained in terms of their characteristic presupposition that requires their complements to be non-trivial questions.

Acknowledgements

I would like to thank Kai von Fintel, Danny Fox, Benjamin George and Irene Heim for helpful comments and discussion. Constructive criticisms by two anonymous *JoS* reviewers helped me improve the content of this article considerably. I also appreciate questions and comments by the audience at SuB 16 (Utrecht, 2011), CSSP 2011 (Paris), Semantics Research Group meeting (Tokyo, 2011) and 6th DFG meeting on Questions in Discourse (Göttingen, 2014). An older version of this article appeared in *Proceedings of Sinn und Bedeutung 16* (2012). All errors are my own.

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First version received: 03.09.2013
Second version received: 17.04.2015
Accepted: 18.06.2015