An inquisitive perspective on modals and quantifiers

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Abstract

Drawing on recent work in inquisitive semantics, this paper presents a new perspective on modals and quantifiers, which has the potential to address a number of challenges that have been raised for standard approaches to such operators. To illustrate the new perspective, we present an inquisitive take on the semantics of attitude verbs, and on quantifiers taking scope out of questions.

Contents

1. INTRODUCTION

1.1. Statements and questions

The meaning of a sentence is traditionally taken to lie in its *truth-conditions*: one knows the meaning of a sentence if one knows under which circumstances it is true. This notion of meaning has been very fruitful, but also has a fundamental limitation: while suitable for statements, it does not apply to sentence types that are not naturally thought of as being true or false in a given state of affairs. Prominent among such sentence types are *questions*.

Just like statements, questions play a central role in communication. They allow speakers to specify requests for information, which other participants are then expected to address. Thus, questions give structure to the process of information exchange, allowing speakers to steer it towards certain goals. Furthermore, statements and questions are so intimately connected that it is impossible to fully understand either one of them in isolation from the other. One simple reason for this is that questions can occur *embedded* in statements and vice versa:

(1) a. Bill wonders *who called him today*.
  b. Who thinks *that the director should resign*?

Second, the interpretation of a statement often depends on the question that it addresses:

(2) a. A: What did you do this morning?
  B: I only read the newspaper. $\rightsquigarrow$ I didn't do the laundry
  b. A: What did you read this morning?
  B: I only read the newspaper. $\not\rightsquigarrow$ I didn't do the laundry

And third, questions and statements are to a large extent built up from the *same parts*. For instance, the disjunctive connective *or* is used to form both questions and statements:

(3) a. Is he in London or in Paris?
  b. He is in London or in Paris.

This means that one cannot fully identify the meaning contribution of disjunction (and other operators) by considering only its role in statements, i.e., its effect on truth conditions. Its role in questions needs to be factored in as well.

These observations show that statements and questions do not constitute two separate domains that can be studied in isolation; rather, they should be analyzed in an integrated way. This requires a notion of sentence meaning that does not just comprise informative content, i.e., truth-conditions, but also inquisitive content, i.e., the potential to raise issues (for further elaboration of the arguments presented here, see Ciardelli et al. 2015).

1.2. Inquisitive semantics: from truth to support

Recent work addressing this need has led to the development of a new semantic framework called *inquisitive semantics*. Rather than identifying the meaning of a sentence with the conditions under which it is true in a given state of affairs, inquisitive semantics identifies the meaning of a sentence with the conditions under which it is *supported by a given information state*, which requires that the information available in the state does not only entail the information conveyed by the sentence but also resolves the issue that it raises. E.g., the statement *Bill sang* is supported by an information state s in case it follows from the information available in s that Bill sang. On the other hand, the question *Did Bill sing?* is supported in s in case it either follows from the information available in s that Bill sang, or it follows from the information available in s that Bill didn't sing. Thus, it becomes possible to analyze both statements and questions using a single notion of meaning.

Since this simple switch in perspective takes place at such a basic level, it opens up new horizons for all disciplines that traditionally rely on the truth-conditional notion of meaning. But this potential is to a large extent yet to be deployed—inquisitive aspects of meaning are not nearly as well understood yet as truth-conditional aspects. Which linguistic constructions give rise to inquisitiveness? How do various operators propagate the inquisitive content of their argument? Which operators exploit the inquisitive content of their argument to produce a truth-conditional effect? Inquisitive semantics paves the way for systematic empirical and theoretical investigations to address these questions.

1.3. Beyond connectives to modality and quantification

The meaning of a sentence is determined not only by its *content* words but also, to an important extent, by its *function* words, which form complex meanings out of simpler ones. These function words include connectives (e.g., *and*, *or*, *not*), quantifiers (e.g., *everyone*, *someone*), and modal operators (e.g., *may*, *must*). In logic, these three types of operators correspond to the three main classes of logical systems that have been considered: propositional logics (focusing just on connectives), predicate logics (adding quantifiers), and modal logics (adding modal operators). Similarly, connectives, quantifiers, and modal operators also constitute three major areas of research in linguistics.

Initial work on inquisitive semantics has focused on the repercussions of the new semantic perspective in the most basic domain, that of connectives. This has led to a better understanding of the role of disjunction, conjunction, and negation in questions and in statements (see, e.g., AnderBois 2012, 2014; Roelofsen and Farkas 2015; Ciardelli et al. 2016; Ciardelli 2016a; Champollion et al. 2016; Ciardelli and Roelofsen 2017) and, on the logical side, to in-depth investigations of propositional inquisitive logics (e.g., Ciardelli 2009, 2016b; Ciardelli and Roelofsen 2011; Roelofsen 2013a; Punčochář 2015, 2016; Frittella et al.

2016; Yang and Väänänen 2016).

While these results are promising, in order to fully appreciate the repercussions of the approach modal operators and quantifiers have to be brought under the inquisitive lens as well. We expect that this will not only shed new light on a number of long-standing puzzles, but also bring out new issues which were invisible through the more coarse-grained lens of truth-conditional semantics.

The goal of the present paper is twofold. First, we want to describe in general terms what the inquisitive perspective on modals and quantifiers amounts to. And second, we want to give concrete illustrations of the benefits that this perspective may have, drawing on recently initiated (and to a large extent still ongoing) work in this direction. Thus, while the paper does provide a survey of some recent developments, as expected of a review article, it is mostly to be seen as a 'programmatic' piece, carving out directions for future work rather than providing a systematic and comprehensive summary of established results.

The structure of the paper is straightforward: after providing some technical background in Section 2, we discuss modals in Section 3 and quantifiers in Section 4. Section 5 concludes.

2. PROPOSITIONS AND PROPERTIES IN INQUISITIVE SEMANTICS

Following a tradition going back to Hintikka (1962), inquisitive semantics models information states as sets of possible worlds, the idea being that a body of information is determined by the set of states of affairs compatible with it. Let $\mathcal{S}$ denote the set of all information states. If $s, t \in \mathcal{S}$ and $t \subseteq s$, then t contains all the information that s contains, and possibly more; we say that t is an *enhancement* of s. As we mentioned above, the fundamental semantic notion in inquisitive semantics is the relation of *support*, relating sentences to information states. Support is construed as a persistent notion, meaning that if a sentence φ is supported at an information state s, it remains supported at every enhancement $t \subseteq s$.

The semantic value $[\![\varphi]\!]$ of a sentence φ in inquisitive semantics can be identified with a set of information states, namely, those states that support φ. Since each information state is a set of possible worlds, $[\![\varphi]\!]$ is a set of sets of possible worlds—rather than a set of possible worlds, as usually assumed. Moreover, the persistency condition on support implies that if $s \in [\![\varphi]\!]$ and $t \subseteq s$, then also $t \in [\![\varphi]\!]$. Thus, $[\![\varphi]\!]$ is a *downward closed* set of information states; we refer to such a set as an *i-proposition*. The maximal elements of the i-proposition $[\![\varphi]\!]$ are called the *alternatives* for φ; that is, the alternatives for φ are those information states that contain just as much information as needed to support φ.

An i-proposition $[\![\varphi]\!]$ is said to be *flat* if there is a single classical proposition p—a set of worlds—such that $[\![\varphi]\!] = \{s \in \mathcal{S} \mid s \subseteq p\}$. This means that in order to support φ it is necessary and sufficient to establish that p holds. Clearly, a flat proposition always contains a unique alternative. If a proposition is not flat, we say that it is *inquisitive*. It is easy to see that, if $\mathcal{S}$ is finite, an inquisitive i-proposition always has two or more alternatives. For an illustration, consider the following three sentences.

(4) a. Bob is home.
    b. Is Bob home?
    c. Where is Bob?

Let $s \in \mathcal{S}$. The statement 4a is supported in s if the information available in s implies that Bob is home—that is, if all worlds in s are worlds where Bob is home. The question 4b is supported in s if the available information determines whether Bob is home—that is, if all worlds in s agree on whether Bob is home. Finally, the question 4c is supported in s if the available information determines where Bob is—that is, if Bob is in the same location in all worlds in s. Thus, the sentences in 4 express the following i-propositions:

(5) a. $P_1 = \{s \mid s \subseteq \{w \mid \text{Bob is home at } w\}\}$
b. $P_2 = \{s \mid s \subseteq \{w \mid \text{Bob is home at } w\} \text{ or } s \subseteq \{w \mid \text{Bob is not home at } w\}\}$
c. $P_3 = \{s \mid s \subseteq \{w \mid \text{Bob is in } y \text{ at } w\} \text{ for some place } y\}$

Note that the statement 4a expresses a flat i-proposition with $\{w \mid \text{Bob is home at } w\}$ as its only alternative. By contrast, the questions in 4b and 4c express inquisitive i-propositions. The polar question 4b has two alternatives, namely, $\{w \mid \text{Bob is home at } w\}$ and $\{w \mid \text{Bob is not home at } w\}$. The *wh*-question 4c has multiple alternatives, namely all the states $\{w \mid \text{Bob is in } y \text{ at } w\}$ where y is a place.

In terms of meaning composition, inquisitive semantics is implemented within the standard intensional semantics framework, i.e., the typed λ-calculus with basic types $\mathtt{e}, \mathtt{s}$, and $\mathtt{t}$ for entities, possible worlds, and truth-values (for details, see Ciardelli et al. 2016). Since its semantic value is a set of sets of worlds, a complete sentence is taken to have the type $\langle\langle \mathtt{s}, \mathtt{t}\rangle, \mathtt{t}\rangle$, which is abbreviated as $\mathtt{T}$. The types of sub-sentential constituents are inferred from this together with the assumption that the basic mode of composition is function application. In particular, in inquisitive semantics a verb phrase has semantic type $\langle \mathtt{e}, \mathtt{T}\rangle$. This means that the semantic value of a VP is a function from individuals to i-propositions. We refer to such objects as *i-properties.* We say that an i-property is *flat* if it maps any individual to a flat i-proposition, and *inquisitive* otherwise. For an illustration, consider:

(6) a. $[\![\text{sang}]\!] = \lambda x.\{s \mid s \subseteq \{w \mid x \text{ sang at } w\}\}$
b. $[\![\text{sang or danced}]\!] = \lambda x.\{s \mid s \subseteq \{w \mid x \text{ sang at } w\} \text{ or } s \subseteq \{w \mid x \text{ danced at } w\}\}$

The VP *sang* denotes a flat i-property, mapping an individual x to a flat i-proposition having a unique alternative, $\{w \mid x \text{ sang at } w\}$. By contrast, the VP *sang or danced* denotes an inquisitive i-property, mapping an individual x to an i-proposition having two alternatives, namely, the states $\{w \mid x \text{ sang at } w\}$ and $\{w \mid x \text{ danced at } w\}$.

3. MODALS

3.1. Some challenges for the standard view

On the standard view, modal auxiliary verbs like *may* and *must* and propositional attitude verbs like *know* and *believe* are analyzed as relating two classical propositions: the proposition expressed by their argument, and a relevant set of worlds associated to the actual world, the *modal base*. Conditionals are handled similarly, by taking the antecedent to restrict the modal base in which the consequent is evaluated (see, e.g., Kratzer 2012).

In recent years, a number of challenges have been raised for this approach. For instance, it has been argued that in order to account for deontic modals in the context of decision problems, it is crucial to take into account the decision problem at hand as a parameter of the evaluation (Lassiter 2011; Cariani et al. 2013; Charlow 2013). In the domain of conditionals, it has been observed that disjunctive antecedents appear to contribute two distinct propositions as assumptions, each corresponding to one of the two disjuncts, which are inevitably conflated on a truth-conditional approach (Alonso-Ovalle 2009; Fine 2012; Champollion et al. 2016). Finally, in the domain of attitude verbs, certain problems have been identified for the standard approaches to responsive verbs (verbs that take both declarative and interrogative complements), arguing that they cannot always be seen as applying to a single proposition contributed by the verb's complement (George 2011; Elliott et al. 2016). In the same spirit, philosophers have emphasized that question-directed attitudes such as *wonder* and *investigate* fall beyond the scope of current theories of propositional attitudes, and call for a generalization (Friedman 2013).

3.2. The inquisitive perspective

Inquisitive semantics suggests a new view on modal operators which has the potential to address all these issues:

> **MAIN IDEA**
>
> Do not construe modal operators as expressing a relation between two classical propositions, but as expressing a relation between two i-propositions, comprising both information and issues.

What are the repercussions of this shift in perspective for the challenges above? First, when evaluating a deontic modal in the context of a decision problem, the relevant modal base will represent both the contextual information and the contextual *issue*—the decision problem at hand. Second, in evaluating a conditional, it is not only the truth-conditional content of the antecedent that matters, but also its inquisitive content; disjunctive antecedents are typically inquisitive, i.e., they introduce multiple alternatives, which the conditional can manipulate individually. Finally, generalizing the notion of modal base to include both information and issues paves the way for a uniform analysis of propositional attitude verbs like *believe*, *know*, and *wonder*. Thus, the inquisitive view on modal operators allows us to address a number of limitations of the standard truth-conditional view. To exemplify concretely what this amounts to, we zoom in below on the case of propositional attitude verbs. For work on conditionals along the lines sketched above we refer to Ciardelli (2016a) and Champollion et al. (2016), as well as the closely related work of Alonso-Ovalle (2009), Fine (2012), and Santorio (2016).

3.3. An illustration: attitude verbs

3.3.1. The traditional view and its limits. Attitude verbs like *believe, know, want,* and *remember* are usually analyzed as expressing *propositional attitudes*, that is, attitudes towards propositions. The traditional analysis of propositional attitudes, which goes back to Hintikka (1969), can be described succinctly as follows. For each attitude A, we consider a map σ_A which assigns to each individual x and possible world w a set $\sigma_A(x, w)$ of possible worlds—those which are in accordance with the relevant attitude of x at w. Thus, when analyzing *know*, $\sigma_{\text{know}}(x, w)$ will consist of those worlds that are compatible with what x knows at w; when analyzing *want*, $\sigma_{\text{want}}(x, w)$ will consist of those worlds that are compatible with what x wants at w; and so on. The set of worlds $\sigma_A(x, w)$ is referred to as the *modal base* for the attitude A. The attitude itself is then analyzed as a relation $A(x, w, p)$ which holds between an individual x, a possible world w, and a proposition p if and only if p is true at every world in $\sigma_A(x, w)$. When the proposition p itself is analyzed as a set of possible worlds—those worlds in which it is true—this means that we have $A(x, w, p)$ if and only if $\sigma_A(x, w) \subseteq p$. Thus, for instance, we have:

(7) a. $\text{know}(x, w, p) \iff \sigma_{\text{know}}(x, w) \subseteq p$
b. $\text{want}(x, w, p) \iff \sigma_{\text{want}}(x, w) \subseteq p$

Finally, a sentence like "*Alice Vs that* α", involving an attitude verb V, is analyzed as being true if, in the actual world, Alice bears the relevant attitude to the proposition expressed by the declarative clause *that* α, i.e., to the set of worlds where α is true. This analysis of propositional attitudes has been very fruitful, and has been extended and refined in a number of ways (see, among others, Stalnaker 1984; Heim 1992). Yet, the analysis is limited in several important respects. Let us review some of them.

First, some attitude verbs, like *know* and *remember*, can combine not only with declarative clauses, but also with interrogative ones.

(8) a. Alice knows/remembers whether Bob is home.
b. Alice knows/remembers where Bob is.

In order to account for the semantics of sentences like those in examples 8a-b, maintaining the view that *know* and *remember* operate on a proposition even when they take an interrogative complement, two types of approaches have been pursued in the literature. Groenendijk and Stokhof (1984) proposed a uniform approach: in their theory, declarative and interrogative embedded clauses have the same type of denotation—a proposition, modeled as a set of possible worlds; in the case of a declarative clause *that* α, the denotation is the set of worlds where α is true; in the case of an interrogative clause μ, the denotation is the true complete answer to μ at the world of evaluation. In either case, the attitude verb can thus apply directly to the denotation of the embedded clause. Other authors, notably Karttunen (1977) and Spector and Egré (2015) have taken a reductive approach: on this approach, declarative clauses and interrogative clauses denote different types of objects, namely, propositions and sets of propositions, respectively. The entry for the verb is designed to apply to a proposition, and can thus be applied directly to the denotation of a declarative clause. In order for the verb to combine with an interrogative clause, some type-shifting needs to take place. In the approach of Karttunen (1977) it is the question denotation Q' which gets type-shifted to fit the embedding verb, resulting in the proposition $\bigcap Q'$—the complete answer to Q' at the world of evaluation as given by Karttunen's theory. In the approach of Spector and Egré (2015), by contrast, it is the verb denotation V' which gets type-shifted to fit the type of the interrogative complement, resulting in the entry $\lambda Q_{\langle\langle \mathtt{s},\mathtt{t}\rangle,\mathtt{t}\rangle}.\lambda x_{\mathtt{e}}.\exists p \in Q.V'(x, p)$.

Essentially, in the approaches of Groenendijk and Stokhof (1984) and Karttunen (1977), sentences like 8a-b claim that Alice stands in the relevant relation to the complete true answer to the embedded question, while in the approach of Spector and Egré (2015) these sentences claim that she stands in the relevant relation to *some* complete answer.

The first class of approaches rests on the assumption that sentences like 8a-b always express relations between an individual and a specific proposition—the complete answer to the embedded question. But not all questions have a single complete answer at a world. Consider example 9:

(9) Where can one buy an Italian newspaper in Amsterdam?

This question can be completely resolved by providing only one of multiple places where

Italian newspapers are sold. Now, a question like 9 may very well appear embedded under an attitude verb:

(10) Alice knows where one can buy an Italian newspaper in Amsterdam.

There is no single proposition that Alice needs to know for this statement to be true; rather, the statement may be true by virtue of Alice knowing one among various propositions, e.g., that one can buy an Italian newspaper at Central Station, that one can buy an Italian newspaper at the airport, etc. Thus, the approaches of Groenendijk and Stokhof (1984) and Karttunen (1977)—which would interpret sentence 10 as a claim that Alice knows a certain particular proposition—cannot assign the right truth-conditions in this case.[1,2]

The account of Spector and Egré (2015) does not deal with cases like 10 either, but it could in principle be adapted to do so. However, while such an account may be successful in the case of *know*, the situation seems different for verbs like *care*, as pointed out by Elliott et al. (2016). Suppose Alice is preparing for a long walk home and does not know whether it is raining outside. Then, sentence 11 is likely to be true.

(11) Alice cares whether it is raining.

On the account of Spector and Egré, this is equivalent with the following statement:

(12) Alice cares that it is raining, or she cares that it is not raining.

But this statement, unlike the one in 11, is not true in the given scenario: for Alice to care that it is raining, she would have to know that it is, and similarly for her to care that it isn't raining; since she lacks this knowledge, neither disjunct is true.[3] Thus, it seems that a reductive account of *care* is bound to fail. In fact, this problem with analyzing the verb *care* stems from a deeper problem with analyzing the attitude of caring. It seems that the object of Alice's caring in the above scenario is the question as such, not some answer to it. If this is right, then the attitude of caring cannot in general be analyzed as a relation between an individual and a proposition. Rather, in some cases it must be understood as a relation between an individual and a question.

This point becomes even more evident when we consider attitude verbs like *wonder* and *investigate*, which can only take an interrogative complement. Consider example 13:

(13) Alice wonders where Bob is.

It is clear that Alice cannot be thought of as bearing the wondering relation to any answer

[1] To deal with these cases, Groenendijk and Stokhof (1984) propose to treat (9) as having a higher semantic type (namely, $\langle\langle\langle \mathtt{s}, \mathtt{t}\rangle, \mathtt{t}\rangle, \mathtt{t}\rangle$ instead of $\langle \mathtt{s}, \mathtt{t}\rangle$), and to type-shift the entry for the embedding verb so that it can apply to objects of this type. We will not discuss this option in detail here. A problem with this lifting strategy is pointed out in Footnote 20 of Ciardelli (2017).

[2] Another challenge for the approaches of Karttunen (1977) and Groenendijk and Stokhof (1984) is raised by George (2011). He argues that the truth of sentences like 10 does not just require that Alice knows of at least one true answer to the embedded question that it is true, but also that she does not wrongly believe of any false answer that it is true. We will not discuss this issue here. For an account in inquisitive semantics, see Theiler et al. (2016a). For other accounts, see Uegaki (2015); Xiang (2015), among others.

[3] Incidentally, notice that a similar problem arises for the accounts of Groenendijk and Stokhof (1984) and Karttunen (1977), which would interpret (11) as claiming that Alice cares that it rains, if it in fact rains, and cares that it does not rain, if in fact it does not rain.

to the question—or any proposition for that matter (see Friedman 2013). Rather, it is natural to regard the object of Alice's wondering to be the question expressed by the embedded interrogative, as a whole. Thus, the attitude of wondering falls squarely outside the traditional framework, which assumes the object of an attitude to be a set of possible worlds. For this reason, a verb like *wonder* has mostly been treated in the literature as an un-analyzed relation between individuals and questions. However, without some analysis of this relation, we lack an account of the entailments licensed by sentences involving *wonder*. We cannot predict, for instance, that the conclusion in 14c follows from the premises in 14a and 14b, but not from either premise alone.

(14) a. Alice wonders who the culprit is.
b. Alice knows that the culprit is Bob or Charlie.
c. So, Alice wonders whether the culprit is Bob or Charlie.

3.3.2. The inquisitive view and its prospects. We saw above that, in inquisitive semantics, statements and questions are assigned the same kind of semantic value, namely, an i-proposition—a downward closed set of information states. We assume that the same treatement applies to embedded declarative and interrogative clauses. E.g., the sentences in 15 will have the same semantic values as the corresponding main clauses, given in 5.

(15) a. that Bob is home
b. whether Bob is home
c. where Bob is

This uniform treatment of declarative and interrogative complements allows for an analysis of verbs like *know* (as well as *remember*, *discover*, ...) which is uniform with respect to the kind of complement that the verb is applied to.[4] The crucial move is that, now, we can construe *knowing* as a relation that involves an individual, a possible world (typically the actual world), and an i-proposition, rather than a classical proposition. In the case of *know*, a natural treatment is as follows (Ciardelli and Roelofsen 2015):

(16) $\text{know}(x, w, P) \iff \sigma_{\text{know}}(x, w) \in P$

That is, a claim like *Alice knows* φ is true if φ is supported by Alice's knowledge state $\sigma_{\text{know}}(x, w)$, consisting of those worlds that are compatible with her knowledge. If we apply this to the semantic values of our indirect clauses in 15, given in 5, we obtain:

(17) a. $\text{know}(x, w, P_1) \iff \sigma_{\text{know}}(x, w) \subseteq \{w \mid \text{Bob is home at } w\}$
b. $\text{know}(x, w, P_2) \iff \sigma_{\text{know}}(x, w) \subseteq \{w \mid \text{Bob is home at } w\}$ or $\sigma_{\text{know}}(x, w) \subseteq \{w \mid \text{Bob is not home at } w\}$
c. $\text{know}(x, w, P_3) \iff \sigma_{\text{know}}(x, w) \subseteq \{w \mid \text{Bob is in } y \text{ at } w\}$ for some place y

In words, x knows that Bob is home iff it follows from what x knows that Bob is home; x knows whether Bob is home if it follows from what x knows that Bob is home, or it follows from what x knows that Bob is not home; and x knows where Bob is if, for some place y, it

[4]The uniform inquisitive approach to the semantics of attitude verbs presented here was first proposed in Ciardelli and Roelofsen (2015) and has been further developed in Theiler (2014); Theiler et al. (2016b). A closely related approach, with similar advantages, has been pursued by Uegaki (2015). For a detailed comparison, see the appendix of Theiler et al. (2016b).

follows from what x knows that Bob is in y. Finally, the attitude verb *know* can be assigned the following entry:

(18) $\lambda P_{\langle\langle \mathtt{s},\mathtt{t}\rangle,\mathtt{t}\rangle}.\lambda x_{\mathtt{e}}.\{s \mid s \subseteq \{w \mid \text{know}(x,w,P)\}\}$

This makes sure that the sentence *Alice knows* φ is supported in a state s if it follows from the information available in s that Alice bears the *know* attitude to the semantic value of φ.

Notice that this treatment of *know*, unlike the ones of Groenendijk and Stokhof (1984) and Karttunen (1977), has no problems dealing with questions that have more than one true answer at a given world. To see this, consider again the mention-some question in example 9. This question expresses the following i-proposition:[5]

(19) $P_4 = \{s \mid \exists x \text{ such that } s \subseteq \{w \mid x \text{ sells Italian newspapers at } w\}\}$

Our analysis then predicts that sentence 10 is true under the following conditions:

(20) $\text{know}(a,w,P_4) \iff \exists x \text{ s.t. } \sigma_{\text{know}}(a,w) \subseteq \{w \mid x \text{ sells Italian newspapers at } w\}$

That is, sentence 10 is predicted to be true iff there is some place of which Alice knows that it sells Italian newspapers. This is the expected result; as usual, the inquisitive meaning of the sentence then consists of those information states in which it is established to be true. Thus, the inquisitive perspective yields an elegant and transparent analysis of *know* which requires no special type-shifting to interpret embedded interrogatives, and which is not restricted to questions with a unique complete answer at each world.[6] An analogous treatment can be given for similar verbs such as *remember* and *discover*.

Now consider the verb *care*. In the inquisitive setting, we can model caring as a relation that holds directly between an individual and an i-proposition—say, the semantic value of an interrogative clause like *whether it rains*—one that does not have to be reducible to a more basic relation holding between an individual and a classical proposition. This avoids the problem pointed out above for a reductive analysis of *care*.

Finally, consider the problem of accounting for inquisitive attitudes like *wonder* and *investigate*. In our analysis of *know* above, we have followed Hintikka in supposing that the modal base $\sigma_A(x,w)$ used to relate the subject x to the object P of an attitude A is a set of possible worlds—a classical proposition. However, under the inquisitive perspective it is also natural to consider attitudes for which the modal base is not a classical proposition, but an i-proposition $\Sigma_A(x,w)$. Of course, the actual reading of $\Sigma_A(x,w)$ will depend on the specific attitude A under consideration. In the case of *wonder*, for instance, we can take the set $\Sigma_{\text{won}}(x,w)$ to consist of those information states where every issue that x wonders about at w is resolved. Notice that this is completely parallel to the characterization of $\sigma_{\text{know}}(x,w)$ as consisting of those worlds where everything that x knows at w is true. A simple analysis of *wondering* as an attitude can then be given as follows:

(21) $\text{wonder}(x,w,P) \iff \Sigma_{\text{won}}(x,w) \subseteq P$ (to be refined)

That is, a claim like *Alice wonders* μ is true if in every information state where the issues that

[5]For the sake of succinctness, in describing the relevant meaning we rephrase "one can buy an Italian newspaper at y" as "y sells Italian newspapers". Of course, this rephrasing is not necessary.

[6]For an investigation of the epistemic logic that arises from this analysis of *know*, see Ciardelli (2014, 2016b).

Alice wonders about are resolved, μ is resolved as well—that is, if resolving μ is necessary in order for Alice's issues to be resolved. However, this minimal analysis needs to be refined slightly to take into account what the agent already believes. For instance, suppose Alice already believes that Bob is home, but she wonders whether he is cooking in the kitchen, or reading a book on the couch. In this case, all the information states where her issues are resolved are states where the question *whether Bob is home* is indeed resolved—since all such states imply that he *is* home. Yet, in this situation we would not say that Alice wonders whether Bob is home: from her point of view, that question is resolved. To capture this, we will add to our analysis a condition specifying that, in order for x to wonder about a question, the question must not already be supported by her belief state. This leads us to the following analysis of the attitude of wondering (see Ciardelli and Roelofsen 2015):

(22) $\text{wonder}(x, w, P) \iff \sigma_{\text{bel}}(x, w) \notin P \text{ and } \Sigma_{\text{won}}(x, w) \subseteq P$

As an illustration of this analysis, consider again example 13, repeated in 23 below. If we apply our proposal to the semantic value of the embedded question, given in 5, we obtain 24.

(23) Alice wonders where Bob is.

(24) $$\begin{aligned}\text{wonder}(a, w, P_3) \iff\ & \forall y : \sigma_{\text{bel}}(x, w) \not\subseteq \{w \mid \text{Bob is in } y \text{ at } w\} \text{ but} \\ & \forall s \in \Sigma_{\text{won}}(a, x)\, \exists y : s \subseteq \{w \mid \text{Bob is in } y \text{ at } w\}\end{aligned}$$

Thus, sentence 23 is true if (i) Alice's current beliefs do not entail of any place y that Bob is in y; but (ii) if the issues that Alice wonders about were resolved, the resulting state would entail of some place y that Bob is in y. This seems a natural analysis of example 23. The account also allows us to make predictions concerning the (in)validity of certain inference patterns. In particular, it is not hard to see that it would predict our earlier observation that sentence 14c is jointly entailed by 14a and 14b, but not by either premise alone.[7]

A question that naturally arises, given the view of attitude verbs that we are advocating, is the following: if attitude verbs all apply to i-propositions, and if declarative and interrogative complements both express i-propositions, why can't all attitude verbs embed both kinds of complements? We will not give a general answer to this question here, but we will show that an explanation of the ungrammaticality of *wonder-that* arises naturally from our account of *wonder*, and extends to other inquisitive attitude verbs like *investigate*.[8]

The explanation is based on two ingredients. The first is the fact that declarative complements express a very specific kind of i-propositions, namely, *flat* i-propositions, which have a unique alternative.[9] E.g., we saw above that the clause *that Bob is home* is supported exactly by the information state $\{w \mid \text{Bob is home at } w\}$ and its subsets.

The second ingredient is the observation is that one can only meaningfully wonder about a certain question if one believes that the question *can* be resolved. For instance, one cannot wonder about the question in 25 unless one believes that Bob actually has a wife.

(25) What is Bob's wife's name?

[7] For a further refinement of the analysis of *wonder* given here, see Roelofsen and Uegaki (2016).

[8] For a possible explanation of the selectional restrictions of other attitude verbs, see Theiler et al. (2016b).

[9] This is due to the fact that, in inquisitive semantics, the declarative complementizer is associated with a flattening operator, also referred to as *non-inquisitive closure* (see, e.g., Ciardelli et al. 2015).

This means that a tight connection must hold between the belief state $\sigma_{\text{bel}}(x,w)$ of an agent and her wondering state $\Sigma_{\text{won}}(x,w)$, namely, we must have $\sigma_{\text{bel}}(x,w) \subseteq \bigcup \Sigma_{\text{won}}(x,w)$. This requirement is connected to the well-known observation, going back to Belnap (1966), that a question is always associated with a presupposition that some true answer exists; the requirement $\sigma_{\text{bel}}(x,w) \subseteq \bigcup \Sigma_{\text{won}}(x,w)$ amounts precisely to the fact that, in order to wonder about a question, one needs to believe the associated presupposition.

Now consider example 26, where the complement of *wonder* is a declarative. The truth-conditions that our analysis predicts for this sentence are given in 27, where $P_1 = \{s \mid s \subseteq \{w \mid \text{Bob is home at } w\}\}$ is the i-proposition expressed by the complement.

(26) #Alice wonders that Bob is home.

(27)
$$\begin{aligned} \text{wonder}(a,w,P_1) &\iff \sigma_{\text{bel}}(a,w) \notin P_1 \text{ and } \Sigma_{\text{wonder}}(a,w) \subseteq P_1 \\ &\iff \sigma_{\text{bel}}(a,w) \not\subseteq \{w \mid \text{Bob is home at } w\} \text{ and} \\ &\qquad \forall s \in \Sigma_{\text{won}}(a,w), s \subseteq \{w \mid \text{Bob is home at } w\} \end{aligned}$$

Given the connection which must hold between Alice's belief state and wondering state, these conditions can never be satisfied. For the second line implies that $\bigcup \Sigma_{\text{bel}}(a,w) \subseteq \{w \mid \text{Bob is home at } w\}$. The requirement that $\sigma_{\text{bel}}(a,w) \subseteq \bigcup \Sigma_{\text{won}}(a,w)$ then implies $\sigma_{\text{bel}}(a,w) \subseteq \{w \mid \text{Bob is home at } w\}$, which conflicts with the first condition.

In deriving this result we have not used anything specific about the embedded clause, other than the fact that it expresses a flat i-proposition—a fact which is common to all declarative complements. This means that combining *wonder* with a declarative complement systematically results in a contradictory meaning. This can be taken to explain the ungrammaticality of this sort of construction (for the connections between systematic contradictions and ungrammaticality, see Gajewski 2002; Chierchia 2013). An analogous explanation can be given for the verb *investigate*.

Summing up, inquisitive semantics suggests a new perspective on attitude verbs as expressing relations between individuals and i-propositions. Firstly, this perspective allows for a simple, uniform account of verbs like *know, remember*, and *discover*, which can embed both declarative and interrogative clauses. Secondly, it avoids some problems that arise when we try to reduce an attitude directed towards a question to the same attitude directed towards an answer to the question, as we discussed above in the case of *care*. Finally, it broadens the scope of the traditional theory of attitude verbs, bringing within reach an elegant analysis of inquisitive attitude verbs like *wonder*, and providing us with an explanation of their infelicity in combination with declarative clauses.

4. QUANTIFIERS

4.1. Some challenges for the standard view

On the standard view, quantifiers like *every man* and *many students* are treated as operators that map a property (denoted by the predicate that they combine with) to a truth value (denoted by the full clause that the quantifier and the predicate form together). While this approach allows for an insightful characterization of the truth-conditional contribution of quantifiers, it also has some important limitations. First, interrogative quantifiers like *which men* and *how many students* are squarely beyond its scope, because these are used to form interrogative sentences, which do not denote truth values.

Second, even plain quantifiers like *every man* are problematic when they occur in questions. For instance, to derive the so-called *pair-list* reading of the question in example 28a, paraphrased in 28b, it seems that the quantifier needs to scope out of the question, something that is impossible if its argument is required to be a standard property.

(28) a. What did every man eat?
b. Pair-list reading: 'For every man x, what did x eat?'

Finally, puzzling differences have been observed between truth-conditionally equivalent quantifiers. For instance, sentence 29a conveys ignorance on the part of the speaker about the exact number of students who cheated, while the truth-conditionally equivalent sentence 29b does not seem to convey such ignorance, or at least not so robustly (see, e.g., Geurts and Nouwen 2007; Westera and Brasoveanu 2014; Ciardelli et al. 2016). How can this difference in meaning be captured, alongside the truth-conditional equivalence?

(29) a. At least three students cheated.
b. More than two students cheated.

4.2. The inquisitive perspective

Again, inquisitive semantics suggests a new perspective, allowing us to address these issues:

MAIN IDEA

Don't construe quantifiers as operators mapping standard properties to truth-values, but rather as operators mapping i-properties to i-propositions.

This move allows us to pursue an account of quantifiers that captures (i) their ability to *propagate* inquisitive content, which is necessary to deal with quantifiers scoping out of questions, and (ii) their potential to *generate* inquisitive content, which is necessary to deal with interrogative quantifiers like *which men*, and which also provides a handle on the ignorance implications of quantifiers like *at least three students* (note that inquisitive constructions like questions and disjunctions typically convey ignorance as well). We zoom in below on the case of quantifiers scoping out of questions. For work on quantifiers like *at least three students* in inquisitive semantics, see Coppock and Brochhagen (2013), Blok (2015), Ciardelli et al. (2016); for interrogative quantifiers, see Champollion et al. (2015).

4.3. An illustration: quantifiers scoping out of questions

4.3.1. A closer look at the problem. Let us consider in some more detail the challenge that questions like 28a pose under standard assumptions. First, let us briefly make these standard assumptions a bit more explicit. Consider example 30.

(30) Exactly one woman kissed every man.

For concreteness, let us assume that quantifiers take scope by means of quantifier raising (the points we will make do not hinge on this assumption in any way). The inverse-scope reading of sentence 30 is then derived from the logical form in Figure 1a. The clause *exactly one woman kissed* x denotes an object of type $\mathtt{t}$, i.e., a truth value. Abstraction over x yields a property of type $\langle \mathtt{e}, \mathtt{t} \rangle$. The quantifier *every man* takes this property as its input

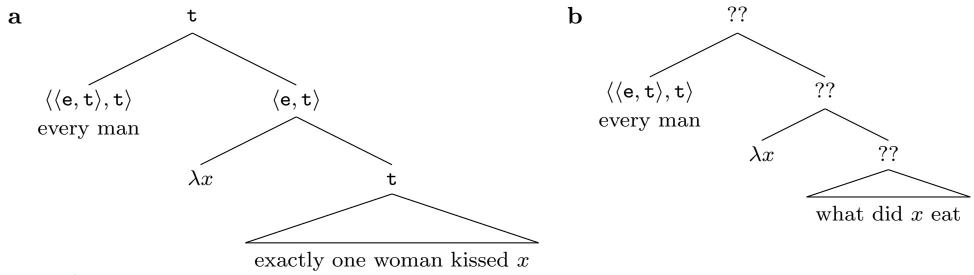

Figure 1

Logical forms where quantifiers raise (a) out of a declarative and (b) out of an interrogative clause.

and yields a truth value as its output.

Now consider example 28a again. One would expect that the pair-list reading of this question can be derived by letting the quantifier take wide scope, as in Figure 1b. But this is problematic. Suppose that the interrogative clause *what did x eat* denotes a set of propositions, i.e., is of type $\langle\langle \mathtt{s}, \mathtt{t}\rangle, \mathtt{t}\rangle$, as assumed in Hamblin (1973), Karttunen (1977), and much subsequent work. Then abstraction over x then yields an object of type $\langle \mathtt{e}, \langle\langle \mathtt{s}, \mathtt{t}\rangle, \mathtt{t}\rangle\rangle$, which is something that the quantifier *every man* cannot take as its input.

Different assumptions have been made about the semantic value of interrogative clauses. For instance, on the partition theory of Groenendijk and Stokhof (1984) questions denote propositions, i.e., they are of type $\langle \mathtt{s}, \mathtt{t}\rangle$. And on categorial approaches (e.g., Hull 1975; Tichy 1978; Hausser and Zaefferer 1978) they denote n-place relations, where n is the number of *wh*-phrases they contain. However, under any of these assumptions, the object that is obtained in 30 after abstracting over x is not a property of type $\langle \mathtt{e}, \mathtt{t}\rangle$, i.e., not of the right type to serve as input for *every man*.

4.3.2. Some proposed solutions. Various approaches have been taken to address this issue. We won't be able to review all of them in detail, but will outline some of the main ideas (for recent overviews, see Dayal 2016; Xiang 2016).

First, it may seem promising to assume that *every* does not need an expression of type $\langle \mathtt{e}, \mathtt{t}\rangle$ as its second argument, but can in principle take an expression of any type $\langle \mathtt{e}, \tau\rangle$ where τ is a conjoinable type (roughly, a type whose objects are sets of some kind), and essentially expresses set intersection. Under such an account, we would have that:

(31) $[\![$ [every man [λx [what did x eat] $]\!]^{w,g} = \bigcap_{d\in[\![\text{man}]\!]^{w,g}} [\![\text{what did } x \text{ eat}]\!]^{w,g[x\mapsto d]}$

Whether this yields reasonable predictions, however, depends on one's background theory of questions. In the framework of Karttunen (1977), $[\![\text{what did } x \text{ eat}]\!]^{w,g[x\mapsto d]}$ is the set of true propositions of the form '*d ate y*', for some object y. But this means that, as soon as there are at least two men in w, $[\![$ [every man [λx [what did x eat] $]\!]^{w,g}$ will be the *empty* set of propositions, certainly not a desirable result (as noted by Karttunen 1977, p.31). On the other hand, in the framework of Groenendijk and Stokhof (1984), $[\![\text{what did } x \text{ eat}]\!]^{w,g[x\mapsto d]}$ is a single proposition, embodying the true exhaustive answer to '*what did d eat*' in w. Thus, $[\![$ [every man [λx [what did x eat] $]\!]^{w,g}$ is a proposition which, for every $d \in [\![\text{man}]\!]^{w,g}$, exhaustively specifies what d ate in w. This seems the right result.

Groenendijk and Stokhof (1984), however, are not satisfied with this account and ultimately opt for a rather different approach. One reason for this is that, while the analysis of *every* as expressing intersection works out well in their framework, the corresponding analysis of *some* as expressing union does not. Consider, for instance, the question in 32a:

(32) a. What book did some boy read?
b. Choice reading: 'For some boy, what book did he read?'

The so-called *choice reading* of this question is paraphrased in 32b. One would expect that this reading could be derived by letting the existential scope out of the question. However, a treatment of existentials as expressing union, analogous to that of universals as expressing intersection, gives undesirable results in Groenendijk and Stokhof's framework. In fact, it does not yield a proper question meaning at all in their setting for questions like 32a.[10]

The alternative approach that Groenendijk and Stokhof pursue assumes that quantifiers can combine with questions using a special 'quantifying-in rule' (see also, e.g., Karttunen and Peters 1980; Higginbotham and May 1981; Belnap 1982). One evident weak point of this approach is that it does not treat quantifiers uniformly; a theory in which quantifiers are always combined with other material in the sentence using the same rule of meaning composition would be more parsimonious (see, e.g., Chierchia 1993).

Another prominent approach is to derive the pair-list reading as a 'functional reading' (Engdahl 1980). Informally speaking, example 28a is analysed under this approach as in 33:

(33) Which function $f_{\langle \mathsf{e},\mathsf{e} \rangle}$ is such that every man x ate $f(x)$?

A 'pair-list answer' like 34a can be seen as one way to specify the requested function, along with other answers like 34b which do not explicitly spell out the extension of the function but rather give a more 'intensional' description of it.

(34) a. Bill ate the chocolate cake, Tom the rice pudding, and Fred the raspberry pie.
b. Every man ate what his wife recommended.

Under this approach, pair-list readings are obtained without letting quantifiers scope out of questions, thus avoiding our initial problem altogether.[11]

However, Pafel (1999) makes a general argument against all approaches that derive pair-list readings without letting the quantifier scope out of the question—which include both the 'quantifying-in' approach and the functional approach. Namely, these approaches fail to

[10]It should be noted that this is just one among several reasons why Groenendijk and Stokhof develop an alternative account of the interaction between quantifiers and questions, and that in a footnote they actually express some skepticism about the ability of existential quantifiers to trigger choice readings (p.556). They *are* convinced, however, that choice readings can be generated by *disjunction*, and pursue a theory that treats disjunction and existential quantification uniformly. Szabolcsi (1997) has argued that choice readings do not exist at all, neither with existentials nor with disjunction. We agree that existentials have not been convincingly shown to trigger choice readings. In our view, the most prominent reading of a question like 32a is a mention-some reading: it can be resolved simply by specifying a book that some boy read, without necessarily specifying which boy read it. We do think, however, that disjunction can trigger choice-like readings (see Ciardelli et al. 2015). No matter whether existentials can or cannot trigger choice readings, Groenendijk and Stokhof's partition theory needs to be extended in order to deal with mention-some readings as well as the choice-like readings generated by disjunction.

[11]Groenendijk and Stokhof (1984) and Chierchia (1993) point out a number of shortcomings of Engdahl's functional approach that we cannot review in detail here, involving downward monotonic quantifiers, choice readings, and quantificational variability. Chierchia (1993) addresses these challenges by combining ideas from the 'quantifying-in' approach with Engdahl's functional account.

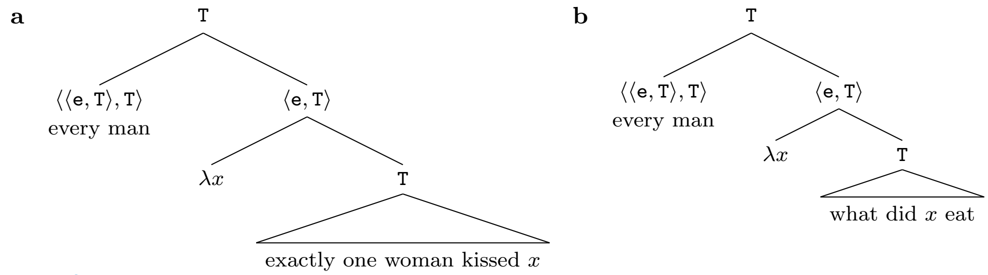

Figure 2

Logical forms where quantifiers raise (a) out of a declarative clause and (b) out of an interrogative clause, with semantic types as given in inquisitive semantics.

capture the fact that pair-list readings and ordinary inverse-scope readings are constrained in similar ways. E.g., since universal quantifiers cannot scope out of declarative finite clauses, the statement in 35a has no inverse-scope reading. Similarly, the question in 35b lacks a pair-list reading.[12]

(35) a. Exactly one woman believes that every man loves her. [no inverse-scope]
b. Which woman does Susan believe that every man loves? [no pair-list]

This similarity is expected if pair-list readings require the universal quantifier to scope out of the question, but unexpected on the 'quantifying in' approach and the functional approach.

This brings us back to our initial problem: the fact that quantifiers, under standard assumptions, cannot scope out of questions. Neither of the two strategies to overcome this problem—devising a special rule for quantifying into questions, and deriving pair-list readings without invoking scope at all—seems to be fully satisfactory. We will not attempt to 'fix' any of the two approaches, or propose yet another way to overcome the problem. Rather, we will try to identify the *source* of the problem, and show that this source is no longer present in inquisitive semantics. As a consequence, the problem no longer arises.

4.3.3. An inquisitive perspective. Which standard assumption is responsible for the fact that quantifier scope cannot be treated uniformly across declaratives and interrogatives? In our view, it is the assumption that declarative and interrogative sentences are of a different semantic type. As we have seen, in inquisitive semantics both kinds of sentences are taken to be of the same semantic type—both express i-propositions, i.e., downward closed sets of information states. This, we will see, allows for a uniform account of quantifier scope-taking across the two kinds of sentences.

First, consider the logical form in Figure 2a, which is similar to the one in Figure 1a but now with 'inquisitive types' assigned to each constituent. Recall that $\mathtt{T}$ abbreviates $\langle\langle \mathtt{s}, \mathtt{t}\rangle, \mathtt{t}\rangle$, the type of full declarative and interrogative clauses in inquisitive semantics. The clause *exactly one woman kissed* x expresses an i-proposition, i.e., an object of type $\mathtt{T}$. Abstraction over x yields an i-property, i.e., an object of type $\langle \mathtt{e}, \mathtt{T}\rangle$. Finally, the quantifier *every man* takes this i-property as its input and yields again an i-proposition as its output.

[12]The finite-clause constraint is in fact not discussed by Pafel. Rather, he discusses several constraints on quantifier scope in German, which seem to lack a direct counterpart in English. Kuno (1991) also emphasises parallels between quantifier scope-taking in statements and questions.

Now, consider the logical form in Figure 2b, similar to the one in Figure 1b but with 'inquisitive types'. No type-clash arises in this case, because the interrogative clause that the quantifier scopes over in Figure 2b has exactly the same semantic type as the declarative clause in Figure 2a. What remains to be seen, however, is whether a single semantic entry for *every* can be given which yields the desired result in both cases. This can indeed be achieved, just by lifting the standard entry of the determiner to the inquisitive setting in a natural way (Ciardelli et al. 2016). The first step is to formulate the standard interpretation of *every* at an 'intensional' level (where it takes two properties of type $\langle \mathtt{e}, \langle \mathtt{s}, \mathtt{t} \rangle \rangle$ and delivers a proposition) rather than the extensional level (where it takes two properties of type $\langle \mathtt{e}, \mathtt{t} \rangle$ and delivers a truth-value). This gives the following entry:

(36) $[\![every]\!] = \lambda P_{\langle \mathtt{e}, \langle \mathtt{s}, \mathtt{t} \rangle \rangle} \lambda Q_{\langle \mathtt{e}, \langle \mathtt{s}, \mathtt{t} \rangle \rangle} . \bigcap_{x \in D} (Px \rightarrow Qx)$

where for any two classical propositions p and q: $p \rightarrow q \ := \ \{w \mid \text{if } w \in p \text{ then } w \in q\}$.

Now, lifting this entry to inquisitive semantics yields the following:[13]

(37) $[\![every]\!] = \lambda P_{\langle \mathtt{e}, \mathtt{T} \rangle} \lambda Q_{\langle \mathtt{e}, \mathtt{T} \rangle} . \bigcap_{x \in D} (Px \twoheadrightarrow Qx)$

where for two i-propositions $\mathcal{P}$ and $\mathcal{Q}$: $\mathcal{P} \twoheadrightarrow \mathcal{Q} \ := \ \{s \mid \forall s' \subseteq s : \text{if } s' \in \mathcal{P} \text{ then } s' \in \ \mathcal{Q}\}$.

What does this entry deliver for the two logical form in Figure 2? First consider the declarative in Figure 2a. The noun *man* denotes an i-property which maps every individual x to the set of information states in which it is established that x is a man:

(38) $[\![man]\!] = \lambda x. \lambda s. \forall w \in s : x \text{ is a man in } w$

Similarly, the sister node of *every man* in Figure 2a denotes an i-property mapping every x to the set of states in which it is established that x was kissed by exactly one woman:

(39) $\lambda x. \lambda s. \forall w \in s : x \text{ was kissed by exactly one woman in } w$

Applying the function expressed by *every* to these two i-properties, we derive that the logical form in Figure 2a expresses the following i-proposition:

(40) $$\left\{ s \;\middle|\; \begin{array}{l} \forall x \in D. \forall s' \subseteq s. \\ \text{if } \forall w \in s' : x \text{ is a man in } w \\ \text{then } \forall w \in s' : x \text{ was kissed by exactly one woman in } w \end{array} \right\}$$

which can be simplified to:

(41) $$\left\{ s \;\middle|\; \begin{array}{l} \forall w \in s. \forall x \in D. \\ \text{if } x \text{ is a man in } w \\ \text{then } x \text{ was kissed by exactly one woman in } w \end{array} \right\}$$

As desired, this is a downward closed set of information states with a unique maximal element, the set of all worlds in which every man was kissed by exactly one woman.

Now let us turn to the logical form in Figure 2b. In this case the sister node of *every*

[13] In algebraic terms, $\mathcal{P} \twoheadrightarrow \mathcal{Q}$ is the *pseudo-complement* of $\mathcal{P}$ relative to $\mathcal{Q}$, i.e., the weakest i-proposition $\mathcal{P}'$ such that $\mathcal{P} \cap \mathcal{P}'$ entails $\mathcal{Q}$ (Roelofsen 2013a). Similarly, $p \rightarrow q$ is the pseudo-complement of p relative to q, i.e., the weakest classical proposition p' such that $p \cap p'$ entails q. So from an algebraic perspective the treatment of *every* given here is really exactly the same as the standard treatment (see Ciardelli et al. 2016, for more detailed discussion).

man expresses an i-property which maps every individual x to the set of information states in which it is known what x ate:

(42) $\lambda x.\lambda s.\forall w, w' \in s$: what x ate in w is the same as what x ate in w'

Applying *every* we derive that the logical form in Figure 2b expresses the following i-proposition:

(43) $$\left\{ s \;\middle|\; \begin{array}{l} \forall x \in D.\forall s' \subseteq s. \\ \text{if } \forall w \in s' : x \text{ is a man in } w \\ \text{then } \forall w, w' \in s' : \text{what } x \text{ ate in } w \text{ is the same as what } x \text{ ate in } w' \end{array} \right\}$$

What does this mean? First, suppose that s is an information state in which it is known exactly which individuals are men. Such a state supports the sentence just in case for each man x, it is known what x ate. This is as expected. But note that according to our semantics it is also possible for s to support the sentence if it is *not* known in s which individuals are men. For instance, it may be known in s that all men, whoever they are, ate raspberry pie (and nothing else). In that case s supports the sentence as well.

Under which circumstances, then, is the sentence not supported by s? This is the case when there is an individual x such that the information available in s together with the information that x is a man is not sufficient to establish what x ate. For instance, if we don't know what Robin ate, and when given the information that he is a man we would still not know what he ate, then our information state fails to support the sentence. Of course, this also means that if we do already know that Robin is a man and we don't know what he ate, our information state fails to support the sentence. These predictions seem correct.

4.3.4. Some further empirical issues. What we have sketched above is of course just intended as a proof of concept, not a full theory of the interaction between quantifiers and questions. In further developing the approach, it will be particularly important to ensure that it does not overgenerate. For instance, if we switch from *wh*-questions to polar questions, wide scope readings are no longer available (Chierchia 1993).

(44) a. Did every man eat an apple?
b. #For every man x: did x eat an apple?

Similarly, if we switch from universals (and perhaps existentials) to other kinds of quantifiers, as in example 45a, the reading paraphrased in 45b is not available.

(45) a. Which woman did {most/no/exactly three} men kiss?
b. #For {most/no/exactly three} men: which woman did they kiss?

Many quantifiers do, however, permit wide scope readings if the question that they are part of is embedded under a responsive verb like *know* or *find out* (Szabolcsi 1997).

(46) a. Bill found out which woman {most/two/exactly three} men kissed.
b. 'For {most/two/exactly three} men, Bill found out which woman they kissed.'

How could these empirical observations be captured? Below, we outline an account of the absence of pair-list readings in matrix polar questions. An investigation of non-universal quantifiers must be left for future work.[14]

To explain the contrast between polar and *wh*-questions suppose, as suggested in Roelofsen (2013b), that questions involve an operator Q of type $\langle \mathtt{T}, \mathtt{T} \rangle$, which does two things:[15]

- First, Q *ensures inquisitiveness*. More precisely, if the input i-proposition is not yet inquisitive, i.e., if it contains a single alternative, then the complement of this alternative is added. If the input i-proposition is already inquisitive, it is left untouched.
- Second, Q *ensures non-informativeness*. This is done by adding a presupposition, to the effect that the actual world is contained in some element of the given i-proposition.

Assume that Q always takes highest scope in its clause. Then the logical form of a polar and a *wh*-question with a quantifier taking widest possible scope below Q is as follows:

(47) a. [Q [every man [λx [did x kiss Mary]]]]
b. [Q [every man [λx [which woman did x kiss]]]]

Assume that [did x kiss Mary] expresses a proposition containing a single alternative,[16] namely the set of all worlds where x kissed Mary, and that [which woman did x kiss] expresses a proposition containing multiple alternatives, one for each woman y, consisting of all worlds where y was the unique woman that x kissed. This gives the desired results. No pair-list reading arises in the case of the polar question, since the clause that the quantifier scopes over does not generate multiple alternatives yet (this is done later, by Q, to ensure inquisitiveness). By contrast, a pair-list reading does arise in the case of the *wh*-question, since now the clause that the quantifier scopes over already generates multiple alternatives (and Q only adds the presupposition that every man kissed exactly one woman).

5. CONCLUSION

Our aim in this paper has been to lay out a new perspective on modality and quantification, arising from recent work in inquisitive semantics. We have illustrated the benefits of this new perspective in two concrete domains, and have also briefly indicated some potential advantages of the approach in other empirical domains. As mentioned at the outset, the paper was not intended as a comprehensive literature review, but rather as a 'programmatic' piece, pointing the way for more systematic future investigations, which we hope will eventually lead to a deeper understanding of modality, quantification, and inquisitiveness.

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[14] There are at least two possible strategies to explore. First, the entry for certain non-universal quantifiers may be such that the resulting wide-scope reading is always contradictory or tautological. This would be the case, for instance, for quantifiers like *no man* under its most natural treatment in inquisitive semantics (see Ciardelli et al. 2016). Second, certain quantifiers may involve a definedness condition, requiring their input to be a *flat* i-property. Under such a treatment of, say, *most men*, a logical form like (ia) would be uninterpretable, while a logical form like (ib) would be fine because the embedding verb neutralises the inquisitiveness of its complement before the quantifier is applied.

(i) a. [most men [λx [which woman did x kiss]]] $\rightsquigarrow$ uninterpretable
b. [most men [λx [Bill found out [which woman did x kiss]]]] $\rightsquigarrow$ interpretable

[15] Alternative questions are left out of consideration here for reasons of space, but the sketched account can be extended to them under natural assumptions.

[16] This assumption can be motivated by considering cases in which polar questions are disjoined with other polar or *wh*-questions (see, e.g., Roelofsen 2013b).

DISCLOSURE STATEMENT

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To be added.

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