On the gradient acceptability of quantifiers scoping over questions[1]

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Abstract. Questions with quantifiers such as *Which book did every student read?* can allow for pair-list answers. However, whether or to what extent such pair-list answers are acceptable varies for different types of quantifiers. Recently, van Gessel and Cremers (2021) experimentally tested the acceptability of pair-list answers for questions with different types of quantifiers, and discovered a full gradient in their acceptability judgments. In this paper, we start with the intuitive idea that pair-list answers are expected if we let quantifiers take scope above questions, and show that we can extend inquisitive semantics in a principled way using independently motivated ingredients to derive such wide-scope readings that expect pair-list answers for various quantifiers. We also identify factors that contribute to their gradient acceptability.

Keywords: quantifiers, questions, pair-list readings, scope, inquisitive semantics, alternative semantics, numerals

1. Introduction

Questions with quantifiers such as *every student* are known to allow for *pair-list answers* (e.g., May, 1985). For instance, (1) can be answered by (2), which specifies for each student x what x read.[2]

(1) Which book did every student read?
(Intended interpretation ≈ for every student x, which book did x read?)

(2) Alice read *Martin Chuzzlewit*, Bob read *Nicholas Nickleby*, and Carol read *Oliver Twist*.

An important question for any theory of question meanings is how to represent and compositionally derive the meaning of a question such as (1) so that pair-list answers such as (2) are expected. Intuitively, such an interpretation of (1) can be roughly paraphrased by letting the quantifier *every student* take scope over the entire question. That is, (1) is asking what x read, for every student x. For this reason, we will call this the *quantifier-over-question* ($Q >?$) reading of (1).[3]

It has been observed (see, e.g., Szabolcsi, 1997) that the $Q >?$ reading is not as acceptable for questions with quantifiers other than *every* and *each*. For instance, it is clearly unavailable for

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[2]Of course, (1) also has an interpretation that asks about a single book that was read by all students. Since this interpretation can be straightforwardly derived by all existing accounts of questions, we will not discuss it here.
[3]This reading is often called the pair-list reading of a question, but in this paper we will stick with $Q >?$ readings for questions and reserve the term *pair-list* for answers. This highlights our formal analysis of such question meanings and avoids potential confusion when it comes to quantifiers other than *every* and *each*.

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questions with negative quantifiers such as *no student*, as illustrated in (3). Indeed, the intended interpretation sounds incoherent or self-defeating.

(3) #Which book did no student read?
Intended: for no student x, which book did x read?

However, the judgments are less clear for other quantifiers, including those where the head noun is modified by bare numerals such as *two*, modified numerals such as *fewer than three*, or the superlative *most* (4). On the one hand, the $Q >?$ reading for numerals (bare or modified) and *most* generally does not feel as natural as that for *every*. On the other hand, (4) does not feel as incoherent as (3). This suggests that the $Q >?$ reading might be somewhat available but degraded for numerals and *most*, hence the question marks in (4).

(4) ?/??Which book did {two/most/fewer than three} students read?
Intended: for {two/most/fewer than three} students, which book did they (each) read?
A pair-list answer: Alice read *Martin Chuzzlewit* and Bob read *Nicholas Nickleby*

The judgments reported so far are based on introspection, and there are disagreements in the literature on the judgments for numerals and *most*. Recently, van Gessel and Cremers (2021) conducted an online experiment to systematically test for the acceptability of $Q >?$ readings for different quantifiers. Concretely, for questions containing the various types of quantifiers in (1), (3), and (4), they asked participants to judge whether pair-list answers were appropriate. Such judgments would indicate whether the $Q >?$ readings of the questions were acceptable.

Their experimental results are shown in Fig. 1. In this paper we focus on matrix questions (the bottom panel). The acceptability judgments for different types of quantifiers show a gradient. Pair-list answers were most appropriate for *every*, and they were more and more degraded for bare numerals, *most*, and downward-entailing modified numerals such as *fewer than three*. Note that van Gessel and Cremers (2021) did not test the acceptability of pair-list answers to matrix questions with *no* because, as discussed before, the intended $Q >?$ reading of such questions is incoherent/self-defeating. However, from the results of cases with embedded questions we can reasonably conclude that such $Q >?$ readings for questions with *no* were indeed unacceptable.

While van Gessel and Cremers's (2021) experimental results confirm many empirical observations about the acceptability of pair-list answers for various types of quantifiers reported in the literature based on introspection (in particular those of Szabolcsi, 1997), they also present several important challenges. (i) The $Q >?$ readings for numerals and *most* are at least somewhat acceptable (particularly for bare numerals such as *two*). This suggests that they should be semantically derivable, but many existing theories either predict that they are not derivable or provide no account of whether or how they can be semantically derived. (ii) The $Q >?$ readings for numerals and *most*, while acceptable to a certain degree, are also degraded and less acceptable than for *every*. Therefore, in addition to a semantic analysis that can compositionally derive such readings, we also need to account for why they are degraded. (iii) In particular, the $Q >?$ readings for downward-entailing modified numerals such as *fewer than three* are the most degraded, so we also need to account for why they are more degraded than *two* and *most*.[4]

We will propose an analysis of $Q >?$ readings for various types of quantifiers that addresses

[4] In this paper, we will leave open the question of why the $Q >?$ readings for *most* appear to be more degraded than *two* (in matrix questions or when embedded under *wonder*).

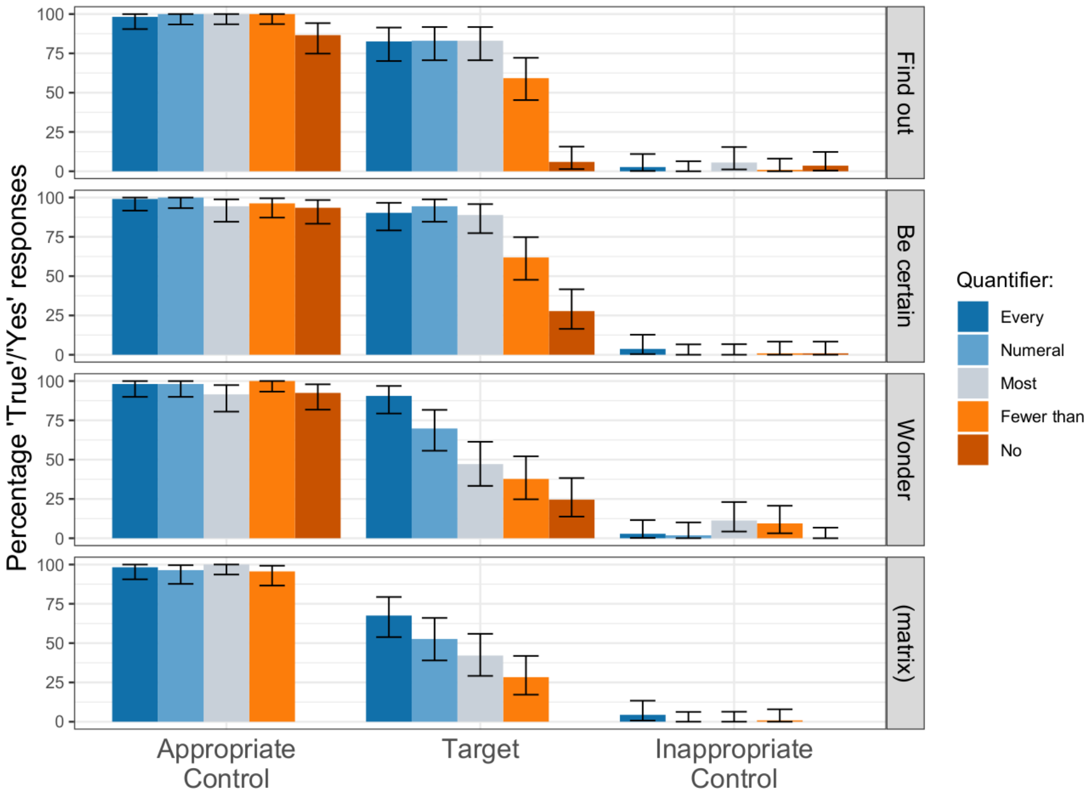

Figure 1: Results from van Gessel and Cremers's (2021) online experiment. A 'True/Yes' response indicates that the participant considered the $Q >?$ reading acceptable.

these challenges, which makes two original contributions. Concretely, we propose a novel account that provides a uniform treatment of quantifier scope-taking in declarative and interrogative clauses, and we identify two factors that contribute to the degraded acceptability of $Q >?$ readings for numerals and *most*.

The rest of the paper is organized as follows. In Section 2, we review a basic analysis of questions in inquisitive semantics and show that it already provides an account of the $Q >?$ readings for *every* and *no*. In Section 3, we address challenge (i) by extending this basic analysis in a principled way to derive the $Q >?$ readings for numerals and *most*. The ingredients we need for the extension include an adjectival analysis of modified numerals and *most* (Buccola and Spector, 2016), an alternative-semantic analysis of indefinites Charlow (2014, 2019, 2020), and a distributivity operator defined in parallel with *every* generalizing from the classical one (Link, 1987), which are all independently motivated. In Section 4, we address challenge (ii) by showing that there is a tension between the $Q >?$ readings for numerals and *most* and an independently motivated general constraint on question meanings (Hoeks and Roelofsen, 2019), and we address challenge (iii) by showing that there is a tension between the $Q >?$ reading for *fewer than three* and a pragmatic constraint independently motivated based on examples involving declarative sentences (Buccola and Spector, 2016). Section 5 concludes with remaining issues and future directions.

2. A basic analysis of questions with *every* and *no* in inquisitive semantics

Inquisitive semantics provides a unified treatment of declaratives and interrogatives. Below we present a basic system that roughly follows Ciardelli et al. (2017) and Ciardelli et al. (2018). The goal is to introduce and highlight the conceptual backbone of inquisitive semantics, and to show that this basic system already provides an analysis of questions with *every* and *no*.

In inquisitive semantics, a clause (whether declarative or interrogative) denotes a non-empty, downward-closed set of classical propositions.[5] We will call such a set a *Proposition* and will abbreviate its semantic type, $\langle\langle s,t\rangle,t\rangle$, as T.

Whereas classical propositions can be understood as representing the truth conditions of declarative clauses, a Proposition in inquisitive semantics can be seen as representing the *resolution conditions* of declarative and interrogative clauses. A resolution of a declarative clause is a classical proposition that verifies it.[6] For instance, consider the sentence *Alice is ready*. A classical proposition verifies this sentence iff it entails its classical denotation $\mathbf{ready}(\mathbf{a})$. Therefore, in inquisitive semantics *Alice is ready* denotes a Proposition containing the classical proposition $\mathbf{ready}(\mathbf{a})$ and all stronger classical propositions. Assuming for simplicity that the domain of individuals only consists of Alice and Bob, this Proposition is schematically shown in (5).[7]

(5) $[\![\text{Alice is ready}]\!] = \{\mathbf{ready}(\mathbf{a})\}^{\downarrow}$ $\quad \boxed{\begin{array}{cc} \boxed{ab} & \boxed{a\bar{b}} \end{array}} \atop {\begin{array}{cc} \bar{a}b & \bar{a}\bar{b} \end{array}}$

A few remarks are in order. First, it should be clear by now why Propositions denoted by declarative clauses are downward-closed: if a classical proposition p verifies a declarative clause S, i.e., p entails S, then any classical proposition q that entails p would also verify S. Second, a maximal element in a Proposition P (i.e., a classical proposition $p \in A$ such that for any $q \in P$, if $q \supseteq p$ then it must be $q = p$) is called an *alternative*. A declarative sentence such as *Alice is ready* only has a single alternative, i.e., its classical denotation $\mathbf{ready}(\mathbf{a})$. Third, we define the *informative content* of a Proposition to be its union, i.e., $\mathtt{info}(P) = \bigcup P$.[8] We can verify that the informative content of a declarative clause is simply its classical denotation (6).

(6) $\mathtt{info}([\![\text{Alice is ready}]\!]) = \bigcup(\{\mathbf{ready}(\mathbf{a})\}^{\downarrow}) = \mathbf{ready}(\mathbf{a})$

Finally, we define the negation of a Proposition P to be the Proposition containing the set-theoretic complement of the informative content of P, and all subsets thereof, and we can

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[5] A set of classical proposition A is downward-closed iff the following condition holds: for any classical propositions p and q, if $q \subseteq p$ and $p \in A$ then $q \in A$. The motivation for requiring downward closure will become clear after we explain how the classical propositions in the set are understood.

[6] A classical proposition p verifies a declarative sentence S iff p ensures the truth of S. Resolution conditions can be equivalently defined in terms of information states and the notion of support (e.g., Ciardelli et al., 2017, 2018). Such an alternative formulation has some conceptual advantages and can be naturally integrated into models of discourse dynamics, but discussing them would take us too far afield.

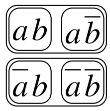
[7] Let A be a set of classical propositions. We define $A^{\downarrow}$, i.e., its *downward closure*, to be the set $\{q \mid \exists p \in A. q \subseteq p\}$. Note that even though it is not depicted in (5), the empty set $\emptyset$ is also an element in the Proposition. In fact, due to downward closure, $\emptyset$ is an element of any Proposition.

[8] By extension, we also refer to the informative content of the Proposition denoted by a clause (whether it is declarative or interrogative) as the informative content of the clause.

verify that this indeed provides the correct denotation for *Alice is not ready* (7).[9]

(7) $\mathbf{not}(P) = \{\neg\texttt{info}(P)\}^{\downarrow}$; $[\![\text{Alice is not ready}]\!]) = \{\neg\mathbf{ready}(\mathbf{a})\}^{\downarrow}$

Now we turn to interrogative clauses. A resolution of an interrogative clause is a classical proposition that fully settles the issue it expresses. For instance, the polar question *Is Alice ready?* is fully settled by the classical propositions $\mathbf{ready}(\mathbf{a})$ and $\neg\mathbf{ready}(\mathbf{a})$, as well as those that entail either one of these (8). We see that the Proposition denoted by an interrogative clause is also downward-closed, because for any classical proposition p that settles the question, so does any classical proposition q that entails p.

(8) $[\![\text{Is Alice ready?}]\!] = \{\mathbf{ready}(\mathbf{a}), \neg\mathbf{ready}(\mathbf{a})\}^{\downarrow}$ 

To compositionally derive such resolution conditions for interrogative complements, we assume that the interrogative complementizer denotes an operator $\langle ? \rangle$ that ensures inquisitiveness (i.e., multiple alternatives) in its argument (9).

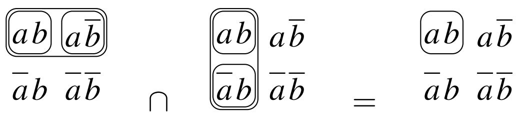
(9) If P contains a single alternative, $\langle ? \rangle(P) = P \cup (\mathbf{not}(P))$, otherwise $\langle ? \rangle(P) = P$

We can verify that this correctly derives the denotations of polar questions (10).

(10) $[\![\text{Is Alice ready?}]\!] = \langle ? \rangle([\![\text{Alice is ready}]\!]) = \langle ? \rangle(\{\mathbf{ready}(\mathbf{a})\}^{\downarrow})$
$= \{\mathbf{ready}(\mathbf{a})\}^{\downarrow} \cup \{\neg\mathbf{ready}(\mathbf{a})\}^{\downarrow} = \{\mathbf{ready}(\mathbf{a}), \neg\mathbf{ready}(\mathbf{a})\}^{\downarrow}$

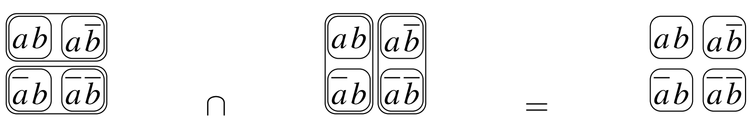
Before we turn to constituent questions, we note that one attractive feature of inquisitive semantics is that it provides a uniform treatment of conjunction and disjunction across clause types. Below we illustrate this point with conjunction, which is analyzed as set intersection, i,e., $[\![\text{and}]\!] = \lambda P_T \lambda Q_T . P \cap Q$, and we will provide further discussion on disjunction in Section 4. First, we can verify that the conjunction of two declarative clauses denotes a Proposition whose single alternative is the (classical) conjunction of their classical denotations (11).

(11) $[\![\text{Alice is ready and Bob is ready}]\!]$
$= \{\mathbf{ready}(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{ready}(\mathbf{b})\}^{\downarrow} = \{\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b})\}^{\downarrow}$



Second, we can verify that the conjunction of two polar questions denotes a Proposition whose elements settle both questions (12).

(12) $[\![\text{Is Alice ready? And is Bob ready?}]\!]$
$= \{\mathbf{ready}(\mathbf{a}), \neg\mathbf{ready}(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{ready}(\mathbf{b}), \neg\mathbf{ready}(\mathbf{b})\}^{\downarrow} = \{\{ab\}, \{a\bar{b}\}, \{\bar{a}b\}, \{\bar{a}\bar{b}\}\}^{\downarrow}$



[9]This definition ensures that the negation of a Proposition always has a single alternative corresponding to the intuitively correct informative content. It also has an algebraic motivation (Roelofsen, 2013). We use $\neg$ to refer to set complementation, which corresponds to the meaning of negation in classical semantics.

The examples above show that conjunction can be treated uniformly as set intersection. Universal quantifiers such as *every student* have a parallel treatment in inquisitive semantics.[10]

(13) $[\![\text{every student}]\!] = \lambda F_{eT}.\bigcap_{x:\mathbf{student}(x)} F(x)$

For instance, assuming that Alice and Bob are the only students, we can see that (14) indeed has the same denotation as (11).

(14) $[\![\text{every student is ready}]\!] = [\![\text{every student}]\!](\lambda x_e.\{\mathbf{ready}(x)\}^{\downarrow}) = \bigcap_{x:\mathbf{student}(x)}\{\mathbf{ready}(x)\}^{\downarrow}$
$= \{\mathbf{ready}(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{ready}(\mathbf{b})\}^{\downarrow} = \{\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b})\}^{\downarrow}$

In the polar question *Is every student ready?*, *every student* can take narrow scope. In this case, (14) becomes the argument of $\langle ? \rangle$, and the two alternatives in the denotation (15) correspond to the yes/no answers to the polar question.

(15) $[\![\text{Is every student ready?}]\!] = \langle ? \rangle([\![(14)]\!]) = [\![(14)]\!] \cup \mathbf{not}([\![(14)]\!])$
$= \{\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b})\}^{\downarrow} \cup \{\neg(\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b}))\}^{\downarrow}$
$= \{\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b}), \neg(\mathbf{ready}(\mathbf{a}) \wedge \mathbf{ready}(\mathbf{b}))\}^{\downarrow}$

However, in principle *every student* can also take scope above $\langle ? \rangle$. In this case the denotation (16) is the same as that of the conjunction of two polar questions (12), which has four alternatives. Under this $Q >?$ reading, the question can be answered by *both are ready*, *Alice is ready but Bob is not*, *Alice is not ready but Bob is*, and *neither is ready*, or anything that entails some of these answers. Crucially, however, the question will not be settled by an answer weaker than the ones above. For instance, *Alice is not ready (and Bob may or may not be)* would not settle the question under this $Q >?$ reading, even though it would under the $? > Q$ reading in (15).[11]

(16) $[\![\text{Is every student ready?}]\!] = [\![\text{every student}]\!](\lambda x_e.\langle ? \rangle(\{\mathbf{ready}(x)\}^{\downarrow}))$
$= [\![\text{every student}]\!](\lambda x_e.\{\mathbf{ready}(x), \neg\mathbf{ready}(x)\}^{\downarrow})$
$= \{\mathbf{ready}(\mathbf{a}), \neg\mathbf{ready}(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{ready}(\mathbf{b}), \neg\mathbf{ready}(\mathbf{b})\}^{\downarrow}$
$= \{\{ab\}, \{a\overline{b}\}, \{\overline{a}b\}, \{\overline{a}\overline{b}\}\}^{\downarrow}$

This provides a first example showing how universal quantifiers can be treated in parallel to conjunction in inquisitive semantics, and that the $Q >?$ reading can indeed be derived by letting the universal quantifier take scope above $\langle ? \rangle$.

Now we turn to constituent questions. To avoid the additional complications due to the uniqueness presupposition of singular *which*-questions, we start with the simpler wh-word *what*, whose denotation we assume here to be similar to that of a universal quantifier, except that set intersection in (13) is replaced by set union: $[\![\text{what}]\!] = \lambda F_{eT}.\bigcup_{x \in D} F(x)$. As an example, the derivation of the radical of *What did Alice read* (i.e., before $\langle ? \rangle$ is applied) is shown in

[10] For simplicity, we abstract away here from the internal composition of *every student*. Interested readers may consult Ciardelli et al.'s (2017) implementation, but there are other possibilities as well. We also assume for simplicity that there is no uncertainty about who the students are, so that **student** can be seen as extensional.

[11] Multiple reviewers asked whether such a reading is actually attested. We believe that it is, contra Chierchia (1993). For instance, a waiter asking a group of guests *Does everybody want a beer?* would not consider the question settled after hearing *I don't* from one guest without also getting answers from the others. The same point can be made with embedded questions: *John would like to know whether everybody wants a beer before he makes the order, but so far only Mary has told him that she does not, so he is still waiting for other people's responses.*

(17).[12] The resulting Proposition contains two alternatives corresponding to *Alice read Martin Chuzzlewit* and *Alice read Nicholas Nickleby*.

(17) $[\![\text{what did Alice read}]\!] = [\![\text{what}]\!](\lambda x_e.\{\mathbf{read}(x)(\mathbf{a})\}^{\downarrow}) = \bigcup_{x:\mathbf{book}(x)}\{\mathbf{read}(x)(\mathbf{a})\}^{\downarrow}$
$= \{\mathbf{read}(\mathbf{m})(\mathbf{a})\}^{\downarrow} \cup \{\mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow} = \{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow}$

Note that the question *What did Alice read?* typically implies that Alice read something. This is commonly characterized as the *existential presupposition* of a constituent question. For concreteness, we assume that immediately after the application of $\langle ? \rangle$, the informative content of the result is added as a presupposition (following, e.g., Roelofsen, 2015; Dotlačil and Roelofsen, 2020), and we use $\bullet$ to separate the at-issue content (left) and the presupposition (right). Combining this assumption and the definition of $\langle ? \rangle$ in (9), we summarize the overall effect of applying $\langle ? \rangle$ in (18).

(18) The overall effect of applying $\langle ? \rangle$:
(i) if P has a single alternative, then $\langle ? \rangle(P) = P \cup \mathbf{not}(P) = \{\mathtt{info}(P), \neg\mathtt{info}(P)\}^{\downarrow}$.[13]
(ii) if P has multiple alternatives, then $\langle ? \rangle(P) = P \bullet \mathtt{info}(P)$.

This allows us to complete the derivation of *What did Alice read?* in (19).

(19) $[\![\text{what did Alice read?}]\!] = \langle ? \rangle([\![(17)]\!])$
$= \{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow} \bullet (\mathbf{read}(\mathbf{m})(\mathbf{a}) \vee \mathbf{read}(\mathbf{n})(\mathbf{a}))$
$= \{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow} \bullet \exists x.(\mathbf{book}(x) \wedge \mathbf{read}(x)(\mathbf{a}))$

Similarly, when *every student* takes wide scope above $\langle ? \rangle$ in *What did every student read?*, the type-eT argument it is expecting is in (20).[14]

(20) $[\![\text{what did \_\_ read?}]\!] = \lambda x.(\{\mathbf{read}(\mathbf{m})(x), \mathbf{read}(\mathbf{n})(x)\}^{\downarrow} \bullet \exists y.(\mathbf{book}(y) \wedge \mathbf{read}(y)(x)))$

Combining (13) and (20), we derive the $Q >?$ reading in (21).

(21) $[\![\text{what did every student read?}]\!] = [\![\text{every student}]\!]([\![\text{what did \_\_ read?}]\!])$

At-issue content: $\bigcap_{x:\mathbf{student}(x)}(\{\mathbf{read}(\mathbf{m})(x), \mathbf{read}(\mathbf{n})(x)\}^{\downarrow}$

$= \{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{read}(\mathbf{m})(\mathbf{b}), \mathbf{read}(\mathbf{n})(\mathbf{b})\}^{\downarrow}$
$= \{$ $\mathbf{read}(\mathbf{m})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{m})(\mathbf{b})$, (i.e., *A and B both read M*)
$\mathbf{read}(\mathbf{m})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{n})(\mathbf{b})$, (i.e., *A read M and B read N*)
$\mathbf{read}(\mathbf{n})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{m})(\mathbf{b})$, (i.e., *A read N and B read M*)
$\mathbf{read}(\mathbf{n})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{n})(\mathbf{b})$ (i.e., *A and B both read N*) $\}^{\downarrow}$

Presupposition (assuming universal projection):
$\forall x(\mathbf{student}(x) \rightarrow \exists y.(\mathbf{book}(y) \wedge \mathbf{read}(y)(x)))$

Let us break down the derivation in (21) step by step. We first focus on the derivation of the at-issue content. The at-issue content of the $Q >?$ reading is essentially the conjunction of the

[12]Here we assume that the domain D is further restricted to the set of contextually relevant things. And in this case we assume for simplicity that the set only contains two books **m** and **n**.
[13]The presupposition to be added in this case, $\mathtt{info}(P) \cup \neg\mathtt{info}(P)$, is trivial and therefore omitted.
[14]Strictly speaking, eT is the type of the at-issue content of (20). We abstract away from the formal details of the presupposition because the only assumption relevant for the later discussion is that it projects universally.

two constituent questions *What did Alice/Bob read?*, which is expected given the parallel treatment between universal quantifiers and conjunction. Each alternative in the denotation settles both questions. In other words, each alternative corresponds to a pair-list answer, which is exactly what we want. Now we consider the overall presupposition. Note that for each individual x (Alice or Bob in this case), the corresponding constituent question has an existential presupposition of the form *x read a book*. If we assume that this presupposition projects universally under *every student*, then the overall presupposition is that *every student read a (possibly different) book*. Intuitively, this seems a reasonable result, but one might worry whether the prediction is too strong. This worry can be alleviated by the fact that the existential presupposition of a constituent question is not particularly strong in the first place. As a result, we do not need to assume that the universal projection is strong, either. Furthermore, as we will see in the next section, the assumption of universal projection is only needed to account for why the $Q >?$ reading is degraded for numerals and *most*.

We have shown that basic inquisitive semantics can derive the $Q >?$ reading for *every student*. Now we consider *no student* and account for its lack of the $Q >?$ reading. First, recall that the overall effect of applying $\langle ? \rangle$ to a Proposition P is such that the result is non-informative. This is because either $\texttt{info}(\langle ? \rangle(P))$ is already the universe U (the set of all possible worlds), or it is added as a presupposition. In any case, negating it would lead to a contradiction. Note that the possibility of accommodating the presupposition would not make a difference here. Consider (19) for instance. If its existential presupposition is accommodated (or simply does not arise in the first place), then (19) would also have the negation of this existential presupposition as an alternative, because *Alice did not read anything* would be an answer that settles it and therefore should be part of its resolution conditions. That is, the denotation of (19) would be $\{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a}), \neg\exists x.(\mathbf{book}(x) \wedge \mathbf{read}(x)(\mathbf{a}))\}^{\downarrow}$. But the informative content of this denotation is still U, and hence negating it still leads to a contradiction. Therefore, negation taking scope above $\langle ? \rangle$ always leads to a contradiction, regardless of whether we assume presupposition accommodation.

Given this, together with the equivalence between $[\![\text{no student}]\!](P')$ and $[\![\text{every student}]\!](\mathbf{not}(P'))$, we can see that there would be a contradiction if P' has the form $\langle ? \rangle(P)$. Therefore, the $Q >?$ reading for *no student* is always contradictory.

3. A modular extension of basic inquisitive semantics for numerals and *most*

3.1. An adjectival analysis of numerals and *most*

In classical generalized quantifier theory, numerals and *most* are treated as determiners (Barwise and Cooper, 1981).

(22) $[\![\text{two}]\!] = \lambda P \lambda Q. |P \cap Q| \geq 2$
$[\![\text{fewer than three}]\!] = \lambda P \lambda Q. |P \cap Q| < 3$
$[\![\text{most}]\!] = \lambda P \lambda Q. |P \cap Q| > |P|/2$

However, over the past two decades, adjectival analyses of numerals and *most* have gained more prominence and are now widely adopted. The concrete analysis we present below mostly follows Buccola and Spector (2016), but with simplifications and modifications.

We start with the assumption that numerals and *most* are adjectival modifiers. Consequently, composing them with the head noun results in new individual predicates (23).[15]

(23) $[\![\text{two students}]\!] = \lambda x.(\textbf{students}(x) \wedge \#x = 2)$
$[\![\text{fewer than three students}]\!] = \lambda x.(\textbf{students}(x) \wedge \#x < 3)$
$[\![\text{most students}]\!] = \lambda x.\,(\textbf{students}(x) \wedge \#x > \#\textbf{students}/2)$

The new predicates are then composed with a silent indefinite determiner $\emptyset_{\text{SOME}}$ and finally with the VP. Just for now, we use Buccola and Spector's (2016) definition of $\emptyset_{\text{SOME}}$ to illustrate how the adjectival analysis derives the denotation of *two students read Martin Chuzzlewit* in the classical truth-conditional setup. According to (24), this sentence is predicted to be true iff there exists a plurality of students with cardinality 2 who read *Martin Chuzzlewit*. This correctly derives the one-sided, lower-bounded reading of the sentence. However, intuitively the sentence also has a two-sided, "exactly two" reading. We will return to this issue later and discuss its relation to the degradedness of $Q >?$ readings, especially for *fewer than three*.

(24) $[\![\emptyset_{\text{SOME}}]\!] = \lambda P \lambda Q.\exists x.(P(x) \wedge Q(x))$ (to be replaced)
$[\![\emptyset_{\text{SOME}} \text{ two students}]\!] = \lambda Q.\exists x.(\textbf{students}(x) \wedge \#x = 2 \wedge Q(x))$
$[\![\emptyset_{\text{SOME}} \text{ two students read } \textit{Martin Chuzzlewit}]\!] = \exists x.(\textbf{students}(x) \wedge \#x = 2 \wedge \textbf{read}(\textbf{m})(x))$

3.2. An alternative-semantic treatment of indefinites

According to the definition of $\emptyset_{\text{SOME}}$ in (24), the result of composing it with the NP is a classical generalized quantifier (type $et \to t$). While such a treatment can derive the correct truth conditions (modulo some complications concerning maximality to be discussed later), it does not provide an explanation of the exceptional scope-taking behavior of indefinites (25).

(25) a. If two relatives of mine die, I will be rich. (*two* > *if* possible)
b. If every relative of mine dies, I will be rich. (*every* > *if* impossible)

In light of this, we adopt Charlow's (2014, 2019, 2020) alternative-semantic treatment of indefinites, which elegantly accounts for their exceptional scope-taking property, and update the definition of $\emptyset_{\text{SOME}}$ in (26).

(26) $[\![\emptyset_{\text{SOME}}]\!] = \lambda P.\{x \mid P(x)\}$; $[\![\emptyset_{\text{SOME}} \text{ two students}]\!] = \{x \mid \textbf{students}(x) \wedge \#x = 2\}$

To facilitate semantic composition, in (27) we define an operator $\leftleftharpoons$ that allows us to compose expressions of types $\{\alpha\}$ and $\alpha \to \beta$ and obtain an expression of type $\{\beta\}$.[16]

[15] We follow Buccola and Spector (2016) in adopting Link's (1983) classic account of pluralities. We use $\#x$ to represent the cardinality of an individual x (which can be atomic or plural) and reserve $|\cdot|$ for the cardinality of a set. Slightly abusing the # notation, we use **#student** to represent the number of students. Technically, this is just a shorthand for $|\{x \mid \textbf{students}(x) \wedge \textbf{atom}(x)\}|$. Finally, we abstract away from the compositional details of the modification to avoid having to introduce the full apparatus of degree semantics.

[16] We use $\{\alpha\}$ to represent the type corresponding to sets of objects of type α. Crucially, note that here we do not assume the equivalence between sets and their characteristic functions, i.e., $\{\alpha\}$ is not the same as $\alpha \to t$. The symbol $\leftleftharpoons$ is chosen to suggest the intuition that $A \leftleftharpoons f$ amounts to applying the type $\alpha \to t$ function f "point-wise" to each element (which is of type α) in A.

(27) For A of type $\{\alpha\}$, f of type $\alpha \to \beta$, $A \leftleftarrows f = \{f(a) \mid a \in A\}$, which is of type $\{\beta\}$.

Following Charlow, we can think of $\leftleftarrows$ as a type-shifter, which transforms the type of an indefinite from $\{e\}$ to $e\beta \to \{\beta\}$ so that it can take scope over type $e\beta$ expressions. Concretely, in the truth-conditional setup, the VP is of type *et*, and the result of $\emptyset_{SOME}$ *two students* taking scope over it is shown in (28), which is a set of classical propositions.

(28) $[\![\emptyset_{\text{SOME}}$ two students read *Martin Chuzzlewit*$]\!]$
$= [\![\emptyset_{\text{SOME}}$ two students$]\!] \leftleftarrows [\![$read *Martin Chuzzlewit*$]\!]$
$= \{x \mid \textbf{students}(x) \wedge \#x = 2\} \leftleftarrows \textbf{read}(\textbf{m})$
$= \{\textbf{read}(\textbf{m})(x) \mid \textbf{students}(x) \wedge \#x = 2\}$

Finally, to retrieve a classical proposition from (28) , we apply Existential Closure (EC), which is defined as set union (29). Note that we obtain the same classical proposition in (29) as in (24), and therefore we indeed recover the correct truth conditions.

(29) $[\![\exists(\emptyset_{\text{SOME}}$ two students read *Martin Chuzzlewit*$)]\!]$
$= \bigcup\{\textbf{read}(\textbf{m})(x) \mid \textbf{students}(x) \wedge \#x = 2\}$
$= \exists x(\textbf{read}(\textbf{m})(x) \wedge \textbf{students}(x) \wedge \#x = 2)$

3.3. Deriving $Q >?$ readings for numerals and *most*

A nice feature of Charlow's alternative semantic account is that it is *modular*, in that it provides a general and principled way to extend any base system, so that it incorporates a notion of alternatives for indefinites and accounts for their scope-taking behavior.

For instance, in (28), $\emptyset_{SOME}$ *two students*, which is of type $\{e\}$, is composed with a VP denotation in classical truth-conditional semantics, which is of type *et*. However, note that the type-shifter $\leftleftarrows$, which facilitates the composition in (28), is defined in a general way in (27). Due to this generality, $\emptyset_{SOME}$ *two students* can also be type-shifted to $eT \to \{T\}$, which would allow it to be composed with a type eT expression in inquisitive semantics. As a concrete example, *What did __ read?* is of type eT. Its denotation, updated from (20) to reflect the incorporation of plural semantics, is shown in (30).[17] The type-shifted $\emptyset_{SOME}$ *two students* can take scope above it and this results in an expression of type $\{T\}$ (31).[18]

(30) $[\![$what did __ read?$]\!] = \lambda x.(\{\textbf{read}(y)(x) \mid \textbf{books}(y)\}^{\downarrow} \bullet \exists y.(\textbf{books}(y) \wedge \textbf{read}(y)(x)))$

(31) $[\![$what did $\emptyset_{\text{SOME}}$ two students read?$]\!]$
$= [\![\emptyset_{\text{SOME}}$ two students$]\!] \leftleftarrows [\![$what did __ read?$]\!]$
$= \{x \mid \textbf{students}(x) \wedge \#x = 2\} \leftleftarrows \lambda x.\{\textbf{read}(y)(x) \mid \textbf{books}(y)\}^{\downarrow}$
$= \{\{\textbf{read}(y)(x) \mid \textbf{books}(y)\}^{\downarrow} \mid \textbf{students}(x) \wedge \#x = 2\}$ (type $\{T\}$)

Similar to the case with declaratives in (29), we apply EC to retrieve a type T denotation (32).

(32) Applying EC to (31): $\bigcup\{\{\textbf{read}(y)(x) \mid \textbf{books}(y)\}^{\downarrow} \mid \textbf{students}(x) \wedge \#x = 2\}$
$= \{\textbf{read}(y)(x) \mid \textbf{books}(y) \wedge \textbf{students}(x) \wedge \#x = 2\}^{\downarrow}$

[17] Again, we assume that the domain of *what* is restricted to books.
[18] We focus on the at-issue content for now and will discuss how the existential presupposition projects.

The alternatives in (32) have the form $\mathbf{read}(y)(x)$, where y is a plurality of books and x is a plurality of students with cardinality 2. Such alternatives correspond to answers such as *Alice and Bob read Martin Chuzzlewit* and *Alice and Bob read Martin Chuzzlewit and Nicholas Nickleby*. This means that if we let $\emptyset_{SOME}$ *two students* directly take scope above $\langle ? \rangle$, while we do get a sensible $Q >?$ reading, it is not the intended one that expects pair-list answers. Rather, (32) corresponds to the cumulative reading of the question.

Upon further inspection of (31), we see that the problem is that when the denotations of $\emptyset_{\text{SOME}}$ *two students* and *What did __ read?* are composed via $\leftleftarrows$, effectively the latter is composed with each element in the former. This yields a Proposition corresponding to the question *What did x read?* for every x that is a plurality of students with cardinality 2. However, in order to ensure that only pair-list answers are expected, we need to further distribute the denotation of *What did __ read?* to every atomic part of x. That is, we would like to generate questions of the form *What did each atomic individual in x read?* for every x that is a plurality of students with cardinality 2. Fortunately, the form of the question already suggests the last missing ingredient that we need: a distributivity operator D ensuring that a type eT meaning is distributed over the atomic parts of its type e argument (33), which is a straightfoward extension of the classical one that distributes type et meanings (e.g., Link, 1987). Note that this definition of D is completely parallel to that of *every* in (13).

(33) $[\![D]\!] = \lambda F_{eT} \lambda x. \bigcap_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} F(x')$

Now we illustrate how we can derive the $Q >?$ reading that expects pair-list answers with the help of D. In order to tease this reading apart from the cumulative one, we now return to the wh-questions van Gessel and Cremers (2021) used in (4). Crucially, since those questions use *which book* instead of *what*, an answer to the cumulative reading can involve only one book. Therefore the answer in (4) is indeed a pair-list answer.

The semantics of *which book* is similar to that of *what*, except that its domain is explicitly specified by the NP and it also has a uniqueness presupposition (34).[19]

(34) $[\![\text{which book}]\!] = \lambda F_{eT}. \bigcup_{x:\mathbf{book}(x)} F(x) \bullet \exists! x.\mathtt{info}(F(x))$

The derivation of *Which book did Alice read* is shown in (35). Its alternatives have the form *Alice read x*, where x is a book, and it presupposes that there is a unique book that Alice read. Since this denotation already has multiple alternatives, further composition with $\langle ? \rangle$ will result in the same denotation.

(35) $[\![\text{which book did Alice read}]\!]$

a. At-issue content: $(\lambda F_{eT}. \bigcup_{x:\mathbf{book}(x)} F(x))(\lambda x. \{\mathbf{read}(x)(\mathbf{a})\}^{\downarrow})$
$= \bigcup_{x:\mathbf{book}(x)} \{\mathbf{read}(x)(\mathbf{a})\}^{\downarrow}$
$= \{\mathbf{read}(x)(\mathbf{a}) \mid \mathbf{book}(x)\}^{\downarrow}$

b. Presupposition: $\exists! x.\mathbf{read}(x)(\mathbf{a})$

[19]For compactness, we use $\exists!$ in the presupposition of *which book*, which means that besides the uniqueness presupposition, the existential presupposition is also encoded in the meaning of *which book*. This assumption is not crucial for our purposes in this paper, because for the $Q >?$ readings we are interested in, the existential presupposition will also be added by $\langle ? \rangle$. That said, to the extent that the existential presupposition of a *which*-question is stronger than that of a *what*-question, this assumption might be independently justified. Finally, we will not discuss the possibility that the uniqueness presupposition of *which book* takes scope at a site different from its at-issue content, because as far as we can tell, it does not affect the analysis of the examples in this paper.

Given (35), we can quickly verify the denotation in (36).

(36) $[\![\text{which book did \_\_ read?}]\!] = \lambda x.(\{\mathbf{read}(y)(x) \mid \mathbf{book}(y)\}^{\downarrow} \bullet \exists! y.\mathbf{read}(y)(x))$

Now we have all the ingredients we need to derive the intended $Q>?$ reading of *Which book did two students read?* that expects pair-list answers. As discussed earlier, (36) is first composed with the distributivity operator D to ensure that a *which*-question is formed for every atomic part of its individual argument. We first focus on the at-issue content, which is shown in (37).

(37) $[\![D(\text{which book did \_\_ read?})]\!] = (\lambda F_{eT} \lambda x. \bigcap_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} F(x'))([\![(36)]\!])$
At-issue content: $\lambda x. \bigcap_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} \{\mathbf{read}(y)(x') \mid \mathbf{book}(y)\}^{\downarrow}$

It helps to start with a simple example to get a sense of what the at-issue content amounts to. Suppose the individual argument supplied to (37) is $\mathbf{a} \sqcup \mathbf{b}$, which has two atomic parts $\mathbf{a}$ and $\mathbf{b}$. Then after taking this argument, we end up having the intersection between two Propositions $\{\mathbf{read}(y)(\mathbf{a}) \mid \mathbf{book}(y)\}^{\downarrow}$ and $\{\mathbf{read}(y)(\mathbf{b}) \mid \mathbf{book}(y)\}^{\downarrow}$. The two Propositions correspond to the questions *Which book did Alice read?* and *Which book did Bob read?*, respectively. And we know from Section 2 that their intersection amounts to conjoining the two questions. If we further assume that the domain of (atomic) books only consists of $\mathbf{m}$ and $\mathbf{n}$, the result of the intersection can be shown more explicitly in (38).[20]

(38)
$$\begin{aligned}
&\{\mathbf{read}(y)(\mathbf{a}) \mid \mathbf{book}(y)\}^{\downarrow} \cap \{\mathbf{read}(y)(\mathbf{b}) \mid \mathbf{book}(y)\}^{\downarrow} \\
&= \{\mathbf{read}(\mathbf{m})(\mathbf{a}), \mathbf{read}(\mathbf{n})(\mathbf{a})\}^{\downarrow} \cap \{\mathbf{read}(\mathbf{m})(\mathbf{b}), \mathbf{read}(\mathbf{n})(\mathbf{b})\}^{\downarrow} \\
&= \{ \begin{array}{ll}
\mathbf{read}(\mathbf{m})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{m})(\mathbf{b}), & \text{(i.e., } \textit{A and B both read M}) \\
\mathbf{read}(\mathbf{m})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{n})(\mathbf{b}), & \text{(i.e., } \textit{A read M and B read N}) \\
\mathbf{read}(\mathbf{n})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{m})(\mathbf{b}), & \text{(i.e., } \textit{A read N and B read M}) \\
\mathbf{read}(\mathbf{n})(\mathbf{a}) \wedge \mathbf{read}(\mathbf{n})(\mathbf{b}) & \text{(i.e., } \textit{A and B both read N})
\end{array} \}^{\downarrow}
\end{aligned}$$

Each alternative in (38) specifies which book Alice read and which book Bob read, and therefore it indeed corresponds to a pair-list answer. Also, the alternatives in (38) exhaust all the possible combinations. We can use functions representing dependencies from individuals to atomic books to simplify (37) and highlight the fact that each alternative corresponds to a pair-list answer ranging over the atomic parts of the individual argument (39).

(39) $[\![D(\text{which book did \_\_ read?})]\!]$
At-issue content: $\lambda x. \{\bigwedge_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} \mathbf{read}(f(x'))(x') \mid f \in DF(\mathbf{book})\}^{\downarrow}$,
where $DF(\mathbf{book})$ is the set of functions that map individuals to (atomic) books.

Now, we let $\emptyset_{SOME}$ *two students* take scope above (39) to derive the intended $Q>?$ reading that expects pair-list answers (40).

(40)
$$\begin{aligned}
&[\![\text{which book did } \emptyset_{\text{SOME}} \text{ two students read?}]\!] \\
&= [\![\emptyset_{\text{SOME}} \text{ two students}]\!] \leftleftharpoons [\![D(\text{which book did __ read?})]\!] \\
&= \{x \mid \mathbf{students}(x) \wedge \#x = 2\} \leftleftharpoons \lambda x. \{\bigwedge_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} \mathbf{read}(f(x'))(x') \mid f \in DF(\mathbf{book})\}^{\downarrow} \\
&= \{\{\bigwedge_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} \mathbf{read}(f(x'))(x') \mid f \in DF(\mathbf{book})\}^{\downarrow} \mid \mathbf{students}(x) \wedge \#x = 2\}
\end{aligned}$$

Essentially, in (40) we apply the type eT denotation in (39) to each plurality in the set denoted by $\emptyset_{SOME}$ *two students* (which is always a plurality of students with cardinality 2). For each plurality, this leads to a Proposition whose alternatives correspond to a pair-list answer ranging

[20] Note that (38) is essentially the same as (21), reinforcing the parallel between D and *every*.

over its atomic parts. Therefore, overall we end up having a set of Propositions as the at-issue content in (40). Assuming that the uniqueness and existential presuppositions project universally across the domain of students, the question presupposes that every student read a unique (but possibly different) book. It is not too difficult to come up with a context where this presupposition is natural. For instance, the question could be about a lecture on Charles Dickens's work, where every student is required to read one of his books. Such contexts might even be considered quite typical or salient by the participants in van Gessel and Cremers's (2021) experiment. However, there may well be other contexts where weaker presuppositions are more appropriate. In the next section, we will discuss how the presupposition can affect the acceptability of the $Q >?$ reading.

Finally, in order to retrieve a type T denotation from (40) so that we can obtain and verify the resolution conditions predicted, we apply Existential Closure, which yields (41).

(41) Applying EC to (the at-issue content of) (40):
$\bigcup\{\{\bigwedge_{x':(x'\sqsubseteq x\wedge\mathbf{atom}(x'))}\mathbf{read}(f(x'))(x') \mid f\in DF(\mathbf{book})\}^{\downarrow} \mid \mathbf{students}(x)\wedge \#x=2\}$
$=\{\bigwedge_{x':(x'\sqsubseteq x\wedge\mathbf{atom}(x'))}\mathbf{read}(f(x'))(x') \mid f\in DF(\mathbf{book})\wedge\mathbf{students}(x)\wedge \#x=2\}^{\downarrow}$

Each alternative in (41) corresponds to a pair-list answer ranging over a plurality of students with cardinality 2. For instance, an answer that would settle the question can be *Alice read Martin Chuzzlewit and Bob did, too*, or *Bob read Nicholas Nickleby and Carol read Martin Chuzzlewit*. Therefore, we have successfully derived the intended $Q >?$ reading that expects pair-list answers for *two students*. The $Q >?$ readings for *fewer than three students* and *most students* can be derived in a parallel way given their semantics in (23).

Summing up, in this section we provided a compositional derivation of the $Q >?$ readings for numerals and *most*. There are three main ingredients in our proposal: (i) an adjectival treatment of numerals and *most* along the lines of Buccola and Spector (2016), (ii) Charlow's (2014, 2019, 2020) modular alternative-semantic account of indefinites, and (iii) a distributivity operator D defined in parallel with *every* generalizing from the classical one (Link, 1987). These ingredients have motivations independent of the phenomenon of pair-list answers to questions with quantifiers. In fact, their motivations are based on data that only concern declarative sentences and their original implementations are in formal systems that do not involve question meanings. However, since inquisitive semantics provides a uniform treatment of declarative and interrogative sentences, and Charlow's alternative-semantic account of indefinites is modular, these ingredients can be incorporated into a theory of questions relatively straightforwardly.

4. Explaining the degraded acceptability of $Q >?$ readings for numerals and *most*

In the previous section, we provided a way to compositionally derive the $Q >?$ readings for numerals and *most*. This accounts for why they are at least somewhat acceptable. In this section, we address two remaining questions: Why are they generally degraded? Moreover, why are $Q >?$ readings more degraded for *fewer than three* than *two students* or *most students*?

To address the first question, we appeal to a general constraint on question meanings. Hoeks and Roelofsen (2019) observe that (42) is infelicitous.

(42) #Does Ann speak French, does she speak German, or does she not speak German?

Their formal account, which takes inspiration from Fox (2018), is based on a theory of exhaustification and has wider empirical coverage than just accounting for the infelicity of (42). However, for our current purposes, we do not need to go into the details of their proposal. In fact, it is not even necessary for us to be committed to their account. All we need is the following generalization, or constraint, on question meanings (43).

(43) It is infelicitous to ask a question whose meaning has the following property: after taking the presuppositions into account, i.e., by using them to restrict the context set, there exists an alternative covered by a set of other disjoint alternatives.

Clearly, (42) satisfies the property in (43): the alternative *Ann speaks French* is covered by the set containing *Ann speaks German* and *Ann does not speak German*.

Now we consider the $Q >?$ reading for *two students* (41) and show that it also satisfies this property, under the assumption that the existential presupposition projects universally. Recall that each alternative in (41) corresponds to a pair-list answer ranging over a plurality of students with cardinality 2. Therefore, (41) would at least contain the alternatives listed in (44).

(44) a. Alice read *Martin Chuzzlewit* and Bob read *Nicholas Nickleby*.
b. Bob read *Nicholas Nickleby* and Carol read *Martin Chuzzlewit*.
c. Bob read *Nicholas Nickleby* and Carol read *Nicholas Nickleby*, too.

Let us focus on (44a). Assume without loss of generality that *Martin Chuzzlewit* and *Nicholas Nickleby* are the only books. We show that (44a) is covered by the set containing (44b) and (44c) under the assumption that the existential presupposition projects universally, i.e., every student read a book.[21] This is because under this assumption, in each world in (44a) there would be a book that Carol read, and hence the world must be in either (44b) or (44c). Therefore, (44a) is indeed covered by the set containing (44b) and (44c). Moreover, (44b) and (44c) are disjoint because of the uniqueness presupposition of *which book*, i.e., there can be at most one book that Carol read. Therefore, under the assumption that the existential presupposition projects universally, (41) satisfies the property in (43) and therefore is infelicitous.

However, without the assumption that the existential presupposition projects universally, (41) need not satisfy the property in (43). Again, consider (44a). In this case, the alternative would also contain a world w where nobody else read a book. Such a world w cannot be in any alternative other than (44a), because (i) w cannot be in an alternative that involves Alice and Bob because such an alternative is disjoint from (44a) due to the uniqueness presupposition of *which book*, and (ii) w cannot be in an alternative that involves someone other than Alice and Bob because such an alternative specifies a book this person read, contrary to the condition that nobody else read a book in w. This means that (44a) is not covered by a set of other alternatives, and by symmetry the same argument holds for any alternative in (41). Therefore (43) does not apply when we do not assume universal projection of the existential presupposition.

[21] If there are more books, we just include more alternatives of the form *Bob read Nicholas Nickleby and Carol read y*, where *y* ranges over all the books. Then these alternatives will still cover (44a) under the assumption that the existential presupposition projects universally.

The discussion above shows that if the existential presupposition holds across the domain of students, i.e., it projects universally, the $Q >?$ reading for *two students* would be infelicitous due to (43). However, as discussed before, there are typical or salient scenarios where the existential presupposition holds across the domain of students. If the participants in van Gessel and Cremers's (2021) experiment were indeed imagining such scenarios, the tension with (43) would lead to degraded acceptability judgments. Crucially, note that the $Q >?$ reading for *every* does not suffer from this problem because its alternatives are all disjoint. Therefore, the $Q >?$ reading is correctly predicted to be less acceptable for *two* than for *every*. The same discussion applies to *fewer than three* and *most*, and hence (43) provides an account of why $Q >?$ readings for numerals and *most* are generally degraded (in particular, less acceptable than for *every*).

Now we turn to why $Q >?$ readings are less acceptable for *fewer than three* than *two* and *most*. We start by taking a closer look at the adjectival analysis of *fewer than three* in (23) and spell out its prediction for *fewer than three students read Martin Chuzzlewit* in (45).

(45) $[\![\exists(\emptyset_{\text{SOME}}$ fewer than three students read *Martin Chuzzlewit*$)]\!]$
$= \bigcup\{\textbf{read}(\textbf{m})(x) \mid \textbf{students}(x) \wedge \#x < 3\} = \exists x(\textbf{read}(\textbf{m})(x) \wedge \textbf{students}(x) \wedge \#x < 3)$

According to (45), *fewer than three students read Martin Chuzzlewit* is true iff there is a plurality of students x with cardinality less than three and x read *Martin Chuzzlewit*. This entails that there is an atomic student x_0 who read *Martin Chuzzlewit*, because *read* is distributive wrt its subject: if x read *Martin Chuzzlewit*, then we can take x_0 to be any atomic part of x and we know that x_0 read *Martin Chuzzlewit*. The other direction of the entailment also trivially holds: if there is an atomic student x_0 who read *Martin Chuzzlewit*, then x_0 itself would be a plurality of students with cardinality less than 3. This means that *fewer than three students read Martin Chuzzlewit* is equivalent to *a student read Martin Chuzzlewit*, but this does not seem right. Intuitively, the former should be stronger than the latter in also having 3 as an upper bound. That is, the former should entail that it is not the case that {three/four/…} students read *Martin Chuzzlewit*. Given this problem for the adjectival analysis of *fewer than three*, first pointed out by van Benthem (1986), one might think that such an analysis should be abandoned. However, Buccola and Spector (2016) observe that this problem only arises when the VP is distributive. For instance, *fewer than ten students surrounded Martin* is not equivalent to *#a student surrounded Martin* (which does not even make sense). Neither does it entail that it is not the case that 10 students surrounded Martin, because the sentence can be true by virtue of there being a group of 7 students surrounding Martin, which does not exclude the possibility of there being a different group of 10 students also surrounding Martin. In such cases, the adjectival analysis in fact predicts the correct truth conditions (46).

(46) $[\![\exists(\emptyset_{\text{SOME}}$ fewer than ten students surrounded Martin$)]\!]$
$= \exists x(\textbf{surrounded}(\textbf{m})(x) \wedge \textbf{students}(x) \wedge \#x < 10)$

Therefore, the unavailability of the reading in (45) needs a different explanation. Buccola and Spector (2016) suggest that it is due to pragmatic blocking. Recall that according to (45), *fewer than three students read Martin Chuzzlewit* is equivalent to *a student read Martin Chuzzlewit*. In fact, this will still be true if we replace *three* by any number n greater than one. Therefore, in this case *three* is virtually irrelevant to the meaning of the sentence, and the reading in (45) will be ruled out by the pragmatic blocking mechanism on the basis of this irrelevance. The only reading available is one where a maximality operator is applied, effectively conjoining (45) with the negations of numbers higher than three (47).[22]

(47) $\text{Max}([\![\exists(\emptyset_{\text{SOME}}$ fewer than three students read *Martin Chuzzlewit*$)]\!])$
$= [\![\exists(\emptyset_{\text{SOME}}$ fewer than three students read *Martin Chuzzlewit*$)]\!]$
$\wedge\neg[\![\exists(\emptyset_{\text{SOME}}$ three students read *Martin Chuzzlewit*$)]\!]$
$\wedge\neg[\![\exists(\emptyset_{\text{SOME}}$ four students read *Martin Chuzzlewit*$)]\!] \wedge \ldots$
$= \exists x(\mathbf{read}(\mathbf{m})(x) \wedge \mathbf{students}(x) \wedge \#x < 3) \wedge \neg\exists x(\mathbf{read}(\mathbf{m})(x) \wedge \mathbf{students}(x) \wedge \#x = 3)$
$\wedge\neg\exists x(\mathbf{read}(\mathbf{m})(x) \wedge \mathbf{students}(x) \wedge \#x = 4) \wedge \ldots$

Now we turn to the $Q >?$ reading for *fewer than three* (48).

(48) $[\![\exists($which book did $\emptyset_{\text{SOME}}$ fewer than three students read?$)]\!]$
$= \{\bigwedge_{x':(x' \sqsubseteq x \wedge \mathbf{atom}(x'))} \mathbf{read}(f(x'))(x') \mid f \in DF(\mathbf{book}) \wedge \mathbf{students}(x) \wedge \#x < 3\}^{\downarrow}$

Before applying downward closure, each element in the set corresponds to a pair-list answer ranging over the atomic parts of a plurality of students with cardinality less than 3. However, because of downward closure, pair-list answers ranging over the atomic parts of a plurality of students with cardinality 3 or higher will also be included in the set because they are more informative answers. Therefore, similar to cases with declaratives, *Which book did $\emptyset_{SOME}$ fewer than three students read?* is predicted to be equivalent to *Which book did some student read?*, and this is still the case if we replace *three* by any number *n* greater than one. Therefore, the $Q >?$ reading is pragmatic blocked. However, unlike cases with declaratives, applying the maximality operator is not an option here. This is because it would result in negating denotations of questions of the form *Which book did n students read?*, where $n \geq 3$, but we already know that negating the denotation of a question leads to a contradiction.

Based on the discussion above, it might seem that the $Q >?$ reading for *fewer than three* is predicted to be simply unacceptable: it will be ruled out by Buccola and Spector's (2016) pragmatic blocking mechanism because its resolution conditions remain the same when we replace *three* with other numerals greater than one, and it cannot be strengthened by a maximality operator because that would lead to a contradiction. However, even though they are indeed the most degraded, they still appear to be somewhat acceptable and more acceptable than *no*. We suggest the crucial difference between *fewer than three* and *no* is that the $Q >?$ reading of the former is merely highly dispreferred due to its tension with the pragmatic blocking mechanism, whereas the latter is a semantic contradiction. That is, we suggest that the $Q >?$ reading for *fewer than three* is not completely blocked, for two reasons. First, even though Buccola and Spector (2016) seem to take the pragmatic blocking mechanism to be obligatory, they also acknowledge experimental evidence suggesting that the intuitively unattested reading of *fewer than three* (45) might still affect participants' judgments to some extent (Marty et al., 2015). This suggests that their pragmatic blocking mechanism is not entirely obligatory and can leave room for what Marty et al. (2015) call "phantom readings." Second, note that the equivalence

[22] Since we have not incorporated degree semantics into our formal system, we will not be able to provide a precise definition of the maximality operator. In fact, it is still an open issue how to best define such an operator. Buccola and Spector (2016) discussed various options but did not reach a definitive conclusion. However, for our purposes, note that (47) specifies the intended outcome of applying the Max operator regardless of its specific implementation. Therefore, to the extent that this outcome involves negating certain propositions, it will lead to a contradiction in inquistive semantics when we consider the $Q >?$ readings.

between the $Q >?$ readings of *Which book did fewer than three students read?* and *Which book did some student read?* holds only in so far as their resolution conditions are considered. However, the two readings could be different wrt other more fine-grained aspects of meaning. One such aspect is the range of answers that are considered over-informative. For instance, intuitively, whereas *Alice read Martin Chuzzlewit and Bob read Nicholas Nickleby* feels an over-informative answer to *Which book did some student read?* in the sense that the answerer provides more than what the question requires, this is not the case when it is an answer to *Which book did fewer than three students read?* because such an answer is indeed expected by the question. Such a distinction is not captured when only resolution conditions are considered. However, under a more finer-grained semantic analysis of questions, one that goes beyond resolution conditions, there would not be an equivalence between *Which book did fewer than three students read?* and *Which book did some student read?*, and hence Buccola and Spector's (2016) pragmatic blocking mechanism would not apply. This way, we can account for why the $Q >?$ reading is still somewhat acceptable for *fewer than three*, while keeping our analysis of why such a reading is the most degraded: pragmatic blocking can be avoided for *fewer than three* only for some highly fine-grained meaning representations, whereas it would not apply to *two* and *most* even if we only consider resolution conditions as the meaning representations.

5. Conclusion

In this paper, we provided a compositional analysis of $Q >?$ readings of questions with various quantifiers that expect pair-list answers and identified factors that affect the acceptability of such readings. We started with a basic analysis of questions in inquisitive semantics, which already accounts for the $Q >?$ reading for *every* and the lack thereof for *no*. We then presented a modular extension of the basic system to compositionally derive the $Q >?$ readings for numerals and *most*, using independently motivated ingredients. Specifically, we adopted Buccola and Spector's (2016) adjectival analysis of numerals, Charlow's (2014, 2019, 2020) alternative-semantic treatment of indefinites, and defined a distributivity operator D in parallel with *every*, generalizing the classical treatment of distributivity (Link, 1987). Furthermore, we identified two factors that contribute to the degraded acceptability of $Q >?$ readings for numerals and *most*. First, we showed that there is a tension between such readings and an independently motivated constraint on question meanings against there being one alternative that is covered by a set of other alternatives. This accounts for why $Q >?$ readings for numerals and *most* are generally degraded and less acceptable than for *every*. We then showed that the $Q >?$ reading for *fewer than three* is in tension with Buccola and Spector's (2016) pragmatic blocking mechanism and cannot be strengthened by a maximality operator.This accounts for why the $Q >?$ reading for *fewer than three*, while not entirely unacceptable, is the most degraded.

In general, our proposal demonstrates how insights from various research areas can be incorporated into a basic analysis of questions in inquisitive semantics, maintaining attractive features such as a uniform treatment of declarative and interrogative clauses, and a simple and general treatment of conjunction and universal quantification in terms of set intersection. But evidently, many issues in this domain require further work, including in particular those concerning $Q >?$ readings of *embedded* questions, whose availability does not only depend on the quantifier involved but also on the verb that takes the question as its argument (see Fig. 1). We also emphasize that the factors we identified in this paper as possibly affecting the acceptability of $Q >?$ readings may not be the only such factors. There could well be many other morpho-syntactic/semantic/pragmatic/processing factors at play. For instance, $Q >?$ readings being inverse-scope readings could be another element reducing their acceptability, which potentially accounts for the fact that their acceptability ratings were not at the ceiling even for *every* in van Gessel and Cremers's (2021) experiment. Finally, while we have provided a possible account of the gradient acceptability of $Q >?$ readings with different quantifiers, we have not made any attempt at arguing that this account is better than others. In the same vein, while we have found that inquisitive semantics provides a suitable basis for an analysis of the interaction between quantification and questions, we have not attempted to contrast it to other frameworks in this regard. A systematic comparison between our proposal and various other approaches (e.g., Groenendijk and Stokhof, 1984; Chierchia, 1993; Szabolcsi, 1997; Krifka, 2001; Sharvit, 2002; Dayal, 2016; Igel and Sachs, 2021; Xiang, 2022) must be left for future work.

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