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An Experimental Investigation of the Scope of Object Comparative Quantifier Phrases

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Abstract

Recent investigations of the constraints on the scope of Comparative Quantifier Phrases (CQPs) (Takahashi 2006; Mayr & Spector 2012; Fleisher 2015) have revealed a puzzle: while CQPs give the appearance of behaving like typical generalized quantifier phrases in some environments, they seem to have a more restricted scopal range than other quantificational phrases, apparently resisting inverse scope over indefinite subjects, except in certain discourse contexts. In this paper, we present a set of three experiments probing the scope of object CQPs relative to a singular indefinite in subject position. Based on the results, make two major contributions. First, we demonstrate that CQPs in object position can uncontroversially take wide scope over an indefinite subject, thereby revealing that they have a wider scopal range than has been assumed based on introspection, and than the current decompositional accounts on the market allow. Second, we identify two factors related to processing scopally ambiguous sentences and three specific factors that affect the accessibility availability of the inverse scope reading: the form of the subject indefinite, the form of the object CQP, and the felicity conditions supporting the use of a CQP. Our results thus underscore the features of the optimal contexts for examining the full scopal range of quantificational phrases more generally. We propose that the varied scopal behavior of object CQPs in particular are related to their post-suppositional cardinality requirements (Brasoveanu 2013), which interact with independently motivated processing preferences.

1 INTRODUCTION AND BACKGROUND

In many instances, two quantificational elements appearing in the same sentence (in particular, as subject and object) are able to scopally interact with each other freely, as shown in (1). Here, the indefinite (*some student*) in subject position interacts with either

the universal (*every book*) or the indefinite (*two (of the) books*) in object position, giving rise to two distinct interpretations, based on the scope of the two quantifiers relative to each other.

(1) **Some** student read [**every/two(of the)**] book(s).
some > *every/two (of the)*, *every/(two of the)* > *some*.

In contrast, the sentences in (2) and (3) appear to have only one reading, with the Comparative Quantificational Phrases (CQPs)[1] ostensibly unable to take 'wide scope' over the indefinite in subject position.

(2) **Some** student read **more than five books**.
some > CQP, #CQP > some.
Takahashi (2006: 58 (2)), from Beghelli (1995: 48).

(3) **One** student read **more than three books**.
one > CQP, #CQP > one.
Takahashi (2006: 64 (16a))

A common assumption based on examples such as these is that a CQP in object position simply cannot take wide scope over an indefinite in subject position (cf. Beghelli 1995; Beghelli & Stowell 1997; Szabolcsi 1997; Takahashi 2006; Fleisher 2015).[2] Indeed, Takahashi (2006) observed that this restriction on the scope of object CQPs is in fact broader, applying not only to interaction with existentials in subject position but also to other upward monotone quantifiers such as *every*, downward monotone quantifiers such as *no*, and non-monotone quantifiers such as *exactly two*, leading Takahashi to offer the descriptive generalization in (4).[3]

(4) *The Comparative QP Scope Generalization*
Comparative QPs in object position must take narrow scope relative to QPs in subject position.
Takahashi (2006: 61 (9))

This restriction is surprising if one assumes that CQPs are generalized quantifiers, which are generally not barred from taking scope over a subject when they are in object position.[4]

It is not that object CQPs are obligatorily interpreted *in situ*. In fact, they are able to host Antecedent-Contained Deletion (ACD), as shown in (5).

(5) John speaks **more than three of the languages** that Mary does ⟨*speak*⟩.
Takahashi (2006: 61 (10))

1 In Beghelli & Stowell (1997), a CQP is a *Counting* Quantifier Phrase.

2 We use '#' throughout to indicate questionable or difficult to access, without commitment to whether or not the reading is actually barred by the grammar or not. Previous authors have marked such sentences as *, #, or %.

3 In the experiments reported in this paper, we concentrate on the interaction of CQPs with indefinites, though future research should probe a wider range of cases to see how general the pattern is.

4 For Beghelli & Stowell (1997), the restriction is a matter of the relative landing sites that are targeted in the Case-driven movement of the object CQP and reconstruction of the indefinite subject.

ACD is a grammatical construction whose interpretation relies upon the ability of the object QP to scope out of the VP in which it is contained (often formalized via the covert operation of Quantifier Raising, QR) so that the subsequent VP ellipsis can be properly licensed / resolved (Sag 1976; May 1985; Larson & May 1990; Jacobson 1992; Kennedy 1997; Fox 2002). In addition, CQPs in an indirect object position are able to take wide scope over a direct object in a dative construction, as in (6).

(6) John submitted **some paper** to **more than five journals** this month.
some > CQP, CQP > some.
Takahashi (2006: 73 (42))

These patterns render the restricted pattern observed in (2) and (3) rather surprising: why should extra-wide scope of an object CQP over an indefinite subject be unavailable, if a CQP can interact scopally with other quantificational elements in other environments?

One promising start to explaining the inability of CQPs to take inverse scope over indefinite subjects starts appeals to the fact that CQPs are inherently comparative, and therefore, following Hackl (2000) and Heim (2000, 2001), can be decomposed into two constituent subparts: *many N* and the comparative operator *–er (than n)*, as illustrated in (7).[5]

(7) *more than three books* = [$_{DP}$ [$_{DegP}$ er than three] many books]

This is the approach adopted by Takahashi (2006).[6] In this representation, the comparative operator *–er*, which heads the Degree Phrase (*–er than three*), and the DP *many N* are scope-bearing elements, and therefore take scope separately (see also Wold (1995) and Ferreira (2007)). In a sentence such as (2) or (3), the indefinite subject raises from a VP-internal position to TP. The object undergoes obligatory QR for interpretation, and then decomposes into the two subparts. The comparative operator raises for reasons of type mismatch, and binds its trace in the DP with which it was composed, as shown in (8).

(8) [$_{TP}$ one student$_1$ [$_{vP}$ [**$_{DegP}$ er than three**]$_2$ [$_{vP}$ [**$_{DP}$ t$_2$ many books**]$_3$ [$_{vP}$ [$_{DP}$ t$_1$ read t$_3$]]]]

These assumptions are crucial for Takahashi's particular version of a decompositional approach, because in order for the CQP to scope over the indefinite subject, *both* subparts of the CQP must take wide scope over the indefinite. However, because the interaction of the indefinite subject with *–er than n* is semantically vacuous, movement of the comparative phrase to a position higher than the indefinite is barred.

While this approach very nicely explains readings in (2) and (3), a problem arises, however, when one considers that there *are* examples in which a CQP in object position *can* take wide scope over an indefinite in subject position: examples such as (9) and (10),

5 The situation is slightly different for downward monotone CQPs such as *fewer than N*, which are not the subject of our investigation, although they do appear as filler items in Experiment 3.

6 Takahashi further assumes that covert Scope Shifting Operations (SSOs) such as Quantifier Raising (QR) and Quantifier Lowering (QL) are constrained by Shortest Move and cannot be semantically vacuous: that is, they must target the closest node (landing site) dominating the QP and have a semantic effect. (See Fox (1995, 2000).) Fleisher (2015) later follows Takahashi's approach, but includes a modification to Scope Economy to cover cases where a CQP interacts with negation.

discussed in the literature, where the surface scope is not just false, but implausible given real world knowledge.

(9) **A soldier** is standing on **more than ten government buildings**.
Mayr & Spector (2012, (25)); cf. Hirschbühler (1982)

(10) **A** body guard has been assigned to **more than fifteen** officials.
a > *CQP, CQP* > *a*.
Farkas (1997: 210 (8))

The fact that the wide scope reading is even accessible, as shown here, is entirely unexpected within the version of the decompositional approach laid out above.

Takahashi also concedes (cf. footnote 23, pg. 89) that he cannot account for cases in which an object CQP can take scope over negation (e.g., (i) *John does not speak more than three (of the) languages*.), and suggests that cases where a CQP interacts with a non-DP quantificational element may be similar to instances in which a QDP can cross a tensed clause boundary in ACD constructions, in that it eludes some constraints. However, Cecchetto (2004), Syrett (2015a, b), and Wilder (1997) present convincing evidence with constructions in which ACD is embedded in a finite clause that QR is not in fact subject to an arbitrary clause-boundedness constraint. As a result, the connection between the two unexpected scopal behaviors does not hold under closer scrutiny, providing us with further evidence that CQPs are able to take wide scope in an environment not predicted by current decompositional approaches, without granting another exception. Thus, while we do not wish to take issue *a priori* with the decomposition of comparative expressions in general, the accessibility of the inverse scope reading with such object CQP sentences seems to call for a revision of this particular instantiation of a decompositional account with respect to the specific assumptions about how and why movement of the individual components of the CQP take place.

An alternative to decomposition is to keep the CQP intact as a generalized quantifier. This is the approach adopted by Mayr & Spector (2012) (M&S). Doing so, of course, allows for an object CQP to take inverse scope not only in surface scope implausible cases as in (9) and (10), but in cases such as (2) and (3) as well.[7,8] M&S rely on CQPs involving pluralities

7 Szabolcsi (1997) also makes a case for the object CQP being able to take wide scope over the subject CQP in (i), indicating that although this inverse scope reading is "very difficult," it can be forced by the context. The accounts we discuss here do not actually mention such CQP-CQP sentences and their possible interpretations.

(i)**More than three** men read **more than six** books.
CQP(3) > CQP(6), CQP(6) > CQP(3) Szabolcsi (1997: 115 (17))

While sentences such as this are featured in our Experiment 1, we focus on cases in which an object CQP interacts with a singular indefinite in subject position, because this linguistic environment stands at the center of the ongoing debate. Certainly, if these sentences are judged to be acceptable as well, then the theoretical accounts should be extended to sentences such as (i).

8 M&S also assume restrictions on movement of the CQP, modifying Fox (2000)'s Scope Economy Condition slightly to propose their *Generalized Scope Economy Condition*, which bars not only semantically vacuous SSOs, but also only licenses those in which the output is semantically weaker than the input.

with a part-whole structure *à la* Link (1983) and the presence of a distributivity operator *DIST* in the structure, as illustrated in (11) (M&S's (2012)'s (27) and (26) respectively).[9]

(11) a. surface scope
[**a soldier**] [λy. (**more than ten govt. buildings**) [*DIST* [λX. (y stands on X)]]]
b. inverse scope
[**More than ten govt. buildings**] [*DIST* [λX. (**a soldier** stands on X)]]

They do not mention the possibility of generating the inverse scope reading with examples where the surface scope is plausible, but it should follow naturally that extending their distributivity approach to those cases would predict that the inverse scope reading should be easily accessible (and as (2) and (3) demonstrate, devoid of any supporting context, it is not). Though Fleisher's (2015) proposal to meld together characteristics of these previous proposals in order to account the data with negation, it, too, does not solve this problem.

We are left with the following observation, left unaccounted for by previous theoretical approaches: CQPs in object position appear to have restricted scope relative to other quantificational phrases, and resist taking wide scope relative to an indefinite in subject position outside of apparently exceptional cases. Our goal in this paper is twofold. First, we aim to demonstrate that object CQPs *can*, in fact, take wide scope, even in sentences such as (2) and (3), where the surface scope is plausible. Second, we seek to identify the specific factors that give the impression that wide scope is ruled out in (2) and (3), but which license wide scope in contexts such as (9) and (10), and beyond. We begin by obtaining evidence in support of the judgments about the acceptability of the inverse scope readings for 'exceptional' surface-implausible sentences such as (9) and (10), and return to sentences such as (2) and (3) to determine whether the inverse scope reading is, in fact, available for them as well. We then manipulate factors that facilitate the availability of the inverse scope reading: the form of the subject indefinite and the object CQP, and the felicity conditions addressed in the discourse context.[10]

As a result, *any* theoretical account of the status of CQPs will have to take these findings into account. Although our ultimate goal is not to adopt or argue in favor of one particular theoretical approach, but instead to demonstrate the availability of the inverse scope reading and the factors that affect it, we note the following. If, in fact, inverse scope is allowed not only in exceptional cases, but in the surface-plausible cases as well, this would be a call

9 In the surface scope reading in (a), there is one single soldier who is standing on each of the atomic individuals comprising the plurality of more than ten government buildings. In the inverse scope reading in (b), there is a plurality comprised of more than ten government buildings, and each has the property of having a soldier stand on it.

10 The next order of business would then be to tackle the behavior of object CQPs interacting with *every* in downward-entailing (DE) environments, and the interaction between CQPs and negation. And, as a reviewer points out, there is also the issue of scope-splitting readings, which originally motivated the decompositional accounts, and the ameliorating effect of a non-upward entailing embedded environment, which is an observation crucial for M&S. Probing these additional environments experimentally could yield data that adjudicates between accounts, or demonstrates how they should be refined. As this is not the goal of this paper, and we cannot address all relevant environments at once, we leave these investigations to future research. We hope that by providing experimental support for the factors that affect the availability of readings of sentences with CQPs, we offer data that are relevant to such future pursuits.

for the stipulations concerning movement in the current versions of the decompositional accounts to be revisited. And if there are differences in acceptability between CQPs and other quantificational expressions, and between the implausible and plausible cases, then the GQ approach would have to be revisited. Whatever the case, our findings can also be taken to extend beyond instances of scope-taking object CQPs interacting with indefinites to scopal quantificational interactions in general.

If syntax/semantics proper is not preventing speakers from accessing the surface scope reading of the sentences we are considering, then what is? Let us begin by considering some (well-known) independent factors making it appear as if the surface scope reading is the only one available sentences with object CQPs, even while the inverse scope reading is *not* grammatically barred. The first two factors (charity and complexity) are general interpretational preferences that influence the interpretations available in scopal environments in general, and are not specific to CQPs, but play a key role in accessibility of the various interpretations of scopally ambiguous sentences. The last three (felicity conditions, indefinite type, and partitivity) are tied to aspects of the linguistic environment and discourse context of the target sentences, which can be manipulated to favor either the surface or inverse scope reading. We did our best to satisfy the felicity conditions on the use of CQPs in our experimental scenarios, and specifically manipulated the last two factors as independent variables across our experiments. Let us take each of these five factors in turn.

First, there is an assumption that speakers will be charitable and access a 'true' reading whenever they are able to do so. This Principle of Charity (Quine 1960) underlies the design of a number of experimental tasks. It is claimed to be operative in general, but Meyer & Sauerland (2009) claim that in (potentially) ambiguous sentences, it interacts with another principle, that of Truth Dominance, which predicts that if the more accessible reading makes the sentence true in a given situation, then speakers will judge the sentence to be true. Mayr & Spector (2012) predict that if an uncontroversially true reading is made available by the surface scope, and this reading entails the inverse scope reading, then speakers are predicted to judge the sentence true, based on the surface-scope reading.

Second, it has been argued that a less 'presuppositionally complex' analysis will be favored over others (Crain & Steedman 1985). This observation applies to the target sentences under consideration in the following way. Kurtzman & MacDonald (1993), following a proposal by Fodor (1982), demonstrated that a determiner phrase with an existential *a* in subject position is immediately interpreted as having a single referent and only later is this interpretation revised, if necessary.[11] Since the surface scope interpretation of the sentences in question here is interpreted as introducing one individual denoted by the subject, in lieu of multiple individuals (as the inverse scope reading might have it), then it would trigger a less complex representation relative to the inverse scope interpretation (that does not entail it), because it would potentially involve the accommodation of fewer individuals and events into the discourse context. Thus, we expect the surface scope

11 A reviewer asks what exactly this means—whether the indefinite is semantically treated as 'exactly one NP' (perhaps because of a quantity implicature), or if there is a covert singleton restrictor in the parse. We are agnostic about the precise implications of this claim, and simply follow Kurtzman & MacDonald in assuming that the parser's preference is to interpret the singular indefinite as referring to a single entity. One possibility is to interpret Kurtzman & MacDonald as describing a DRS (Discourse Representation Structure) construction principle along the lines of the ones proposed in Kamp & Reyle (1993).

reading to be preferred by default. As support, we note that research on the processing of quantificational sentences has shown that an inverse scope reading incurs a greater processing load (i.e., increased time to render a judgment) relative to the surface scope reading (Tunstall 1998, Anderson 2004). (See also Reinhart (2006) and Brasoveanu and Dotlačil (2015).)

Thus the first two reasons are inherently linked to interpretational preferences. These two factors together (surface scope as the preferred reading, coupled with Truth Dominance) explain why the informal 'hit-and-run' judgments in the previous literature take the inverse scope of object CQPs relative to subject indefinites to be less available, or even completely unavailable. The systematic nature of the experimental studies reported in this paper mitigates the effects of these two factors.

Third, there is the question of the felicity conditions and/or implicatures associated with the use of a CQP – an issue that we address via presentation of contexts supporting the use of sentences with CQPs. One might ask why a speaker would violate conversational maxims and say *more than three* when s/he could have been more specific and brief and used a bare numeral (e.g., *four* or *five*). Why mention *three* as a lower bound? And why mention the numeral at all, in lieu of a plural indefinite? If a speaker is evasivene or vague about reference and quantity, it might then be harder for a listener to access a specific interpretation of the CQP. If the CQP requires certain felicity conditions for its usage, then presenting speakers with sentences in isolation devoid of a context that licenses the use of the CQP renders the processing of these sentences more difficult, making it that much more challenging to interpret the object CQP as taking wide scope over a singular indefinite. (See Geurts & Nouwen (2007), Büring (2008), Nouwen (2010), Cummins *et al.* (2012), Coppock & Brochhagen (2013), a.o., for related observations with modified numerals such as *at least n*.) Fleisher (2015) notes that the intermediate scope reading of sentences with *fewer* and *every* (where the quantifier intervenes in between *–er* on the one hand and *little* and *many* on the other) does become more salient in scenarios that involve a threshold for completion, as in the following example.

(12) [*Context: An airport security screening room. Each bag must be checked by at least three inspectors before the plane can be loaded.*]
Fewer than three inspectors have checked **every bag**, so the plane cannot be loaded yet.
(Fleisher 2015: 162 (33a))

Here, we are easily able to access a reading in which *each/every bag* is the 'distributor', and the *inspectors* are distributed over. Thus, aspects of the context satisfy the felicity conditions on the use of a CQP, facilitating a reading other than surface scope, which might not otherwise be available.

Fourth, we might consider the form of the indefinite in subject position – a variable we manipulate. Certain indefinites are more likely than others to be interpreted specifically, and – as a result – to take wide scope. The judgment that a CQP in object position is unable to take scope over an indefinite in subject position most often arises from those sentences in which the subject is the indefinite *one*. Fleisher (2015) shares this intuition of the distinction between *one* and other indefinites, and notes that even for surface-scope-implausible sentences, where an object CQP *can* take scope over an 'a' indefinite in subject position, substitution of *some* or *one* for *a* renders the inverse scope unavailable. In fact, examples cited in the literature on the constrained scope of object CQPs have typically

included those with *one* and *some* in subject position. This same observation about the influence of the type of indefinite phrase should (and does) generalize beyond CQPs. Indeed, Tsai *et al*. (2014) have demonstrated that participants are significantly less likely to access an inverse scope reading of a sentence with a singular indefinite in subject position and a universal QP in object position if the indefinite is headed by *one* than if it is headed by *a*, leading them to conclude that *one* encodes an inference about specificity. If this is the case, then any probability that participants could accept a reading whereby an object CQP takes wide scope over a subject indefinite is diminished significantly if the indefinite is *one* (cf. examples (16) and (24) in Takahashi).

Fifth, just as the form of the subject indefinite may influence the extent to which it is interpreted specifically, so may the form of the object CQP – a second variable we manipulate. Putting the CQP in a partitive form (e.g., *three **of the** books*) might increase the extent to which it is interpreted specifically (i.e., as having determined reference), and therefore increase its chances of taking widest scope. In fact, in discussing sentences where an object CQP is able to take wide scope over sentential negation – sentences that his framework cannot handle – Takahashi (2006: 89, ftnt. 23) notes that putting the CQP in partitive form seems to facilitate the availability of the 'CQP > negation' reading. Why should this be? Geurts (2002) has argued that the "main duty" of β in a partitive 'α of β' is to help identify the relevant α. While β is not obligatorily interpreted as definite or specific, according to Geurts, it *is* obligatorily backgrounded (or presupposed, given the presence of the definite determiner heading the phrase in β), and is therefore likely to be interpreted specifically. Enç (1991) has also argued that partitives (either overt or covert) are necessarily specific, since they refer to a group that is a subgroup of the referent of the DP β contained in the partitive, and consequently, should be able to take wide scope. Farkas (2002) has also observed that partitivity is a strategy used to achieve determined reference, which in turn tends to yield wide-scope readings. Psycholinguistic evidence supports the role of overt or covert partitivity in facilitating inverse scope readings of scopally ambiguous sentences (Miller and Schmitt 2004; Musolino & Gualmini 2004).

To summarize, then, the puzzle is this. CQPs in object position appear to be constrained by default, unable to take wide scope over a subject indefinite, and thus unable to generate an inverse scope reading. However, this reading appears to be available in certain circumstances, as shown in (9)–(10). Current decompositional approaches (Fleisher 2015; Takahashi 2006), can only account for the apparently limited scopal range of CQPs, but not the availability of the surface scope reading in such 'exceptional' cases. At the same time, while approaches treating CQPs as generalized quantifiers (Mayr & Spector 2012) are able to account for the availability of the inverse scope readings, they cannot account for why the scopal range of CQPs in these sentences seems constrained by default. We have suggested that there may be an explanation for the limited availability of the inverse scope reading of the target sentences tied to processing and pragmatics factors. Our goal in this paper is to harness these factors to our advantage to provide experimental evidence bearing on this debate about the scopal range of object CQPs.

We present experimental evidence that participants not only judge the inverse scope reading to be acceptable for surface-scope-implausible cases such as those discussed above, but they also judge the inverse scope to be available – and quite robustly so – when the surface scope is false, but *not* implausible. Moreover, the factors we outlined above – in particular, the form of the indefinite and the felicity conditions for use of the CQP – appear to play a key role in facilitating the inverse scope reading, depending on the experimental

Table 1 5-point rating scale used in Experiment 1.

totally unacceptable	unacceptable	reasonably acceptable	acceptable	completely acceptable
1	2	3	4	5

context. These results thus bear directly on the theoretical approaches to the scope-taking ability of CQPs, since any theory of CQPs should be able to account for this pattern of results.

2. EXPERIMENT 1

The purpose of Experiment 1 was threefold:
(a) to establish an initial baseline of acceptability of the inverse scope reading of sentences with a singular indefinite in subject position and a CQP in object position where the surface scope is implausible (sentences such as (9) and (10))
(b) to probe the effect of the type of indefinite in subject position.
(c) to examine the role of partitivity in facilitating the inverse scope reading in sentences with and without CQPs.

2.1. *Participants*

68 undergraduates participated. Data from four of these participants were excluded due to the participants' non-native speaker status. The remaining participants were randomly and evenly assigned to four experimental conditions.[12]

2.2. *Design*

2.2.1. *Procedure* The experimental design was modeled after a Truth Value Judgment Task (TVJT, Crain & Thornton 1998). An experimenter narrated a series of stories, each of which was accompanied by a series of slides presented via Powerpoint. Each slide had a selection of images representing the entities involved in the story. The story was intended to favor one possible reading of a potentially ambiguous sentence, but to make an alternative reading accessible up until a certain point in the story, in order to satisfy the condition of Plausible Dissent (i.e., to satisfy a pragmatic felicity condition for evaluating a target sentence).

At the end of each story, the experimenter verbally delivered the target sentence, which was also printed on the screen. Participants were asked to judge the acceptability of the sentence, given the preceding context, on a five-point scale, using paper and pen(cil). They were provided with the labeled points in Table 1. Participants were instructed to rate the target sentence immediately, and not to change their responses later in the session.

12 Participants in all of the experiments were undergraduate students in introductory-level Linguistics and/or Cognitive Science classes, who received extra credit in their course in return for their participation. Only data from native speakers of English (as determined through systematically collected demographic information) were used. Experiments 1 and 2 were conducted in the first author's laboratory, with participants tested at individual computer stations. Experiment 3 was administered online using Alex Drummond's Ibex platform (https://github.com/addrummond/ibex).

2.2.2. *Stimuli* There were seven test sentences, five control sentences, and two filler sentences. (See Appendix A for all scenarios and target sentences in Experiment 1.) Although the total number of items is relatively small, given the factors tested and in comparison to the other experiments that follow, it is comparable to the number of items typically featured in TVJTs, and allows for a managaeable experimental session length. The entire experimental session took approximately 25 minutes, including a brief training session to acclimate participants to the procedure with non-target sentences. This amount was within the 30 minutes allotted for an in-lab experiment.

All test sentences featured a numerical quantifier phrase in the object position. Participants were randomly assigned to one of four between-subject conditions, based on whether the test sentence featured a CQP or a bare numeral phrase in object position (±CQP), and whether or not this phrase was in the form of a partitive (±partitive). In the two +CQP conditions, the object was a CQP; in the two –CQP conditions, it was a bare numeral phrase. The expression was always *more than two* (+CQP) or *three* (–CQP), so that the truth conditions and visual stimuli remained consistent across conditions. Thus, with the two between-subject conditions, the quantificational phrase in object position was as indicated in (13).

(13)

a.	*more than two books*	CQP, no partitive	(+CQP –PART)
b.	*more than two of the books*	CQP, with partitive	(+CQP +PART)
c.	*three books*	bare numeral phrase, no partitive	(–CQP –PART)
d.	*three of the books*	bare numeral phrase, with partitive	(–CQP + PART)

In all test sentences, the context presented in the story favored the inverse scope reading, and made the surface scope reading false. The stories were designed to satisfy the felicity conditions of the CQP and the partitive form, as discussed earlier.

There were three basic types of test sentences, based on the element interacting with the phrase in object position: an indefinite subject, a subject CQP, and sentential negation. The first sentence type (with the subject indefinite) is our key sentence type. The other two represent those in which the object CQP is claimed to be able to outscope the other indicated element, although acceptability of the inverse scope reading is predicted to not be robust. We included these sentences as a point of comparison, and to include variety within the experimental session and mask the identity of the target items.

Within the target subject indefinite cases, there were three types of sentences. The first featured an 'a' indefinite in subject position. In these sentences, the surface scope reading was implausible, given real world information, while the inverse scope reading was associated with a scenario that was not only consistent with possibilities in the world but also supported by the accompanying context. There were two such sentences in the set of test sentences, allowing us to demonstrate replicability of previous judgments for these sentence types. An example scenario and accompanying target sentence are presented in (14).

(14) 'a' Indefinite in Subject: Surface Scope Implausible and False

A convention for NY Times Bestsellers was being held. Many VIPs were expected to come and stay in the city during the convention, so Officer Hendricks, Officer Wilson, and Officer Murray were assigned as guards to two hotels where the VIPs were staying. Initially, all of the VIPs were expected to stay at only two hotels, since the city

did not want to pay the fees for more locations. Officer Hendricks and Officer Wilson were assigned to the Marriott, and Officer Murray was assigned to the Hyatt Regency. However, at the last minute, more VIPs decided to come, so a hasty arrangement was made to have some guests stay at the Embassy Suites hotel. The city officials knew that using more than two hotels would mean more fees, but they did not care; this convention was going to bring in a lot of much-needed revenue for the city. Officer Wilson was instructed to proceed to the Embassy Suites. At 9 am, each guard was standing at his post.
A guard was posted in front of [more than two (of the) / three (of the)] hotels.

The other target sentence types featured a 'one' indefinite and an 'a' indefinite, respectively (one sentence each). In each, both the surface and inverse scope readings were plausible, but only the inverse scope reading was true, given the preceding scenario. This contrast allowed us to probe whether a 'one' indefinite more strongly resists an object CQP taking scope over it. An example scenario and target sentence for a 'one' indefinite subject are presented in (15).

(15) 'one' Indefinite in Subject: Surface Scope Plausible but False
Last week, the local bike shop had two red tricycles, and both of them sold immediately – each one to a woman. This was a little surprising to the owner, because usually it's the dads who buy the tricycles in his shop. This week, the shop received a new shipment of five red tricycles. Based on last week's sales, the owner of the bike shop predicted that at least two red tricycles would be sold today, and that each one would be purchased by a woman, not a man. At 10 am this morning, a woman came to the shop, looked around, and bought a red tricycle for her son. At 11 am, another woman bought a red tricycle for her son, too. The owner of the bike shop began to wonder if his prediction was on target. At 2 pm, a man came in looking for a tricycle, but wanted a blue one, so he walked out without purchasing anything. At 4 pm, however, a woman came in by herself looking for a birthday present for her nephew. She tried to decide between a red tricycle and an orange scooter, and eventually bought a red tricycle. The owner was happy, because his predictions were right on.
One woman bought [more than two (of the) / three (of the)] tricycles.

The number of test sentences in Experiment 1 is thus admittedly small, but the experiment serves as a first pass to highlight the relevant factors, allowing us to then move on to more expanded data sets.

Control and filler sentences allowed us to control for response biases, to test for participants' ability to access surface- and inverse-scope readings, and to mask any commonalities among test sentences. Because we predicted that a 'false'/'unacceptable' reading would most likely be favored in the target contexts, we designed the control and filler sentences to vary participant responses and target the full range of the rating scale during the experiment session. The control sentences involved a scopal interaction between some combination of an indefinite, negation, a numeral phrase, a universal quantifier, and a CQP, but the context in which they were presented did not favor readings in which a CQP was intended to take wide scope. The filler sentences involved antecedent-contained deletion, and therefore quantification, but no scopal interaction between two operators.

2.3. *Results*

We begin with the non-target items. Participants patterned as anticipated: the average rating for sentences that we expected to be judged 'false'/'unacceptable' was 1.8, while the average for sentences we expected to be judged 'true'/'acceptable' ranged from 3.8 to 4.7. There was no difference among the four main test conditions for responses to these items within those conditions. These ratings serve as a baseline against which we can evaluate the ratings for the test items.

Since the response variable is ordinal, we used mixed-effects ordinal probit regression models to analyze the data. All models reported in this paper include the full fixed-effect structure (main effects and interactions) unless otherwise specified, and random intercepts for subjects. The experimental manipulations for the two fixed effects, namely CQP status (CQP vs. bare numeral; we will henceforth take 'bare numeral' to be the reference level) and partitivity status (−partitive vs. +partitive; we will take -partitive to be the reference level), were between subjects, so we will not include subject random slopes for any of the fixed effects. Furthermore, we do not include random item effects for this experiment, because there was such a small number of items per subject and condition (as described in the design section). When we estimate the models for 'a'-indefinite subjects with both scopes plausible, 'one'-indefinite subjects, and CQP subjects, we drop even the subject random intercepts, given that in those cases, there would be as many subject random effects as there are observations. For these three cases, we simply estimate ordinal probit models with fixed effects only. Most of the figures and all the statistical models in this paper have been obtained / estimated with *R* (R Core Team 2015), the *ggplot2* package (Wickham 2009), the *ordinal* package (Christensen 2012), the *lme4* package (Bates *et al.* 2013) and the *lmerTest* package (Kuznetsova *et al.* 2016).

The ratings for the test sentences (the target indefinite cases and the two other types for comparison) are presented in Figure 1 and Figure 2. Recall that the five-point scale presented to participants had "1" as 'completely unacceptable', "5" as 'completely acceptable', with three labeled intermediate, ordered readings from "2" to "4". The plots in Figure 1 provide a summary of the acceptability ratings for the bare numeral vs. CQP manipulation, while the plots in Figure 2 summarize the acceptability ratings for the –partitive vs. +partitive manipulation. In each case, we are interested in the relative distribution of the ratings, and how they compare with each other within and across the target conditions. This distribution can be seen easily at a relatively superficial level by observing the difference in shading in the columns.

A number of observations from the data stand out. First, in line with previous judgments, sentences in which the surface scope reading was implausible and the inverse scope reading was plausible and supported by the context (Column A) received an unquestionably acceptable rating across the board, regardless of the form of the object (bare numeral or CQP, ± partitive). In fact, the highest mean ratings for these target sentences arose from those sentences where a singular 'a' indefinite interacted with a CQP object (4.2 in partitive form, 3.9 in non-partitive form).

Second, the tall column of gray for '1' ratings for sentences with 'one' in subject position (Column C), indicates that these sentences received a consistently low, unacceptable rating, regardless of whether or not there was a CQP or a bare numeral phrase in object position, and irrespective of the partitive status of the direct object. These '1' ratings vastly out-span those for the 'a' sentences (Column B). This pattern is the first piece of evidence that a 'one' indefinite in subject position favors a specific reading of the subject indefinite and

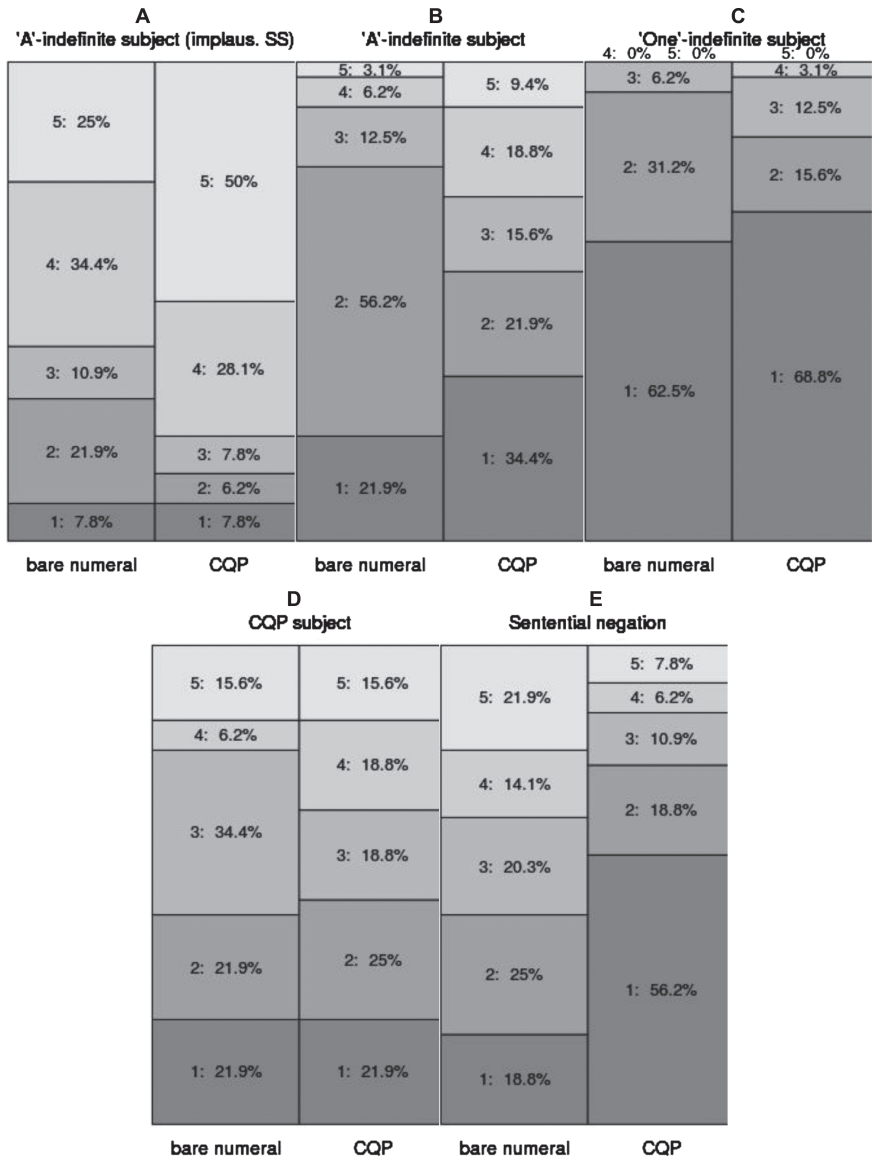

Figure 1 Acceptability ratings for the inverse scope of **bare numerals vs. CQPs** (noted at the bottom of each column) with respect to: (A)-(B) "a"-indefinite subjects ((A): implausible surface scope, (B): surface scope plausible but false); (C) "one"-indefinite subjects with surface scope plausible but false, (D) CQP subjects, and (E) sentential negation.

prevents the direct object from taking inverse scope.[13] Interestingly, while the inverse scope reading is available in principle for bare numeral direct objects, even sentences with an 'a'

13 This does not mean that a 'one' indefinite will *always* take wide scope, but rather that it more strongly resists an inverse scope reading than an 'a' indefinite.

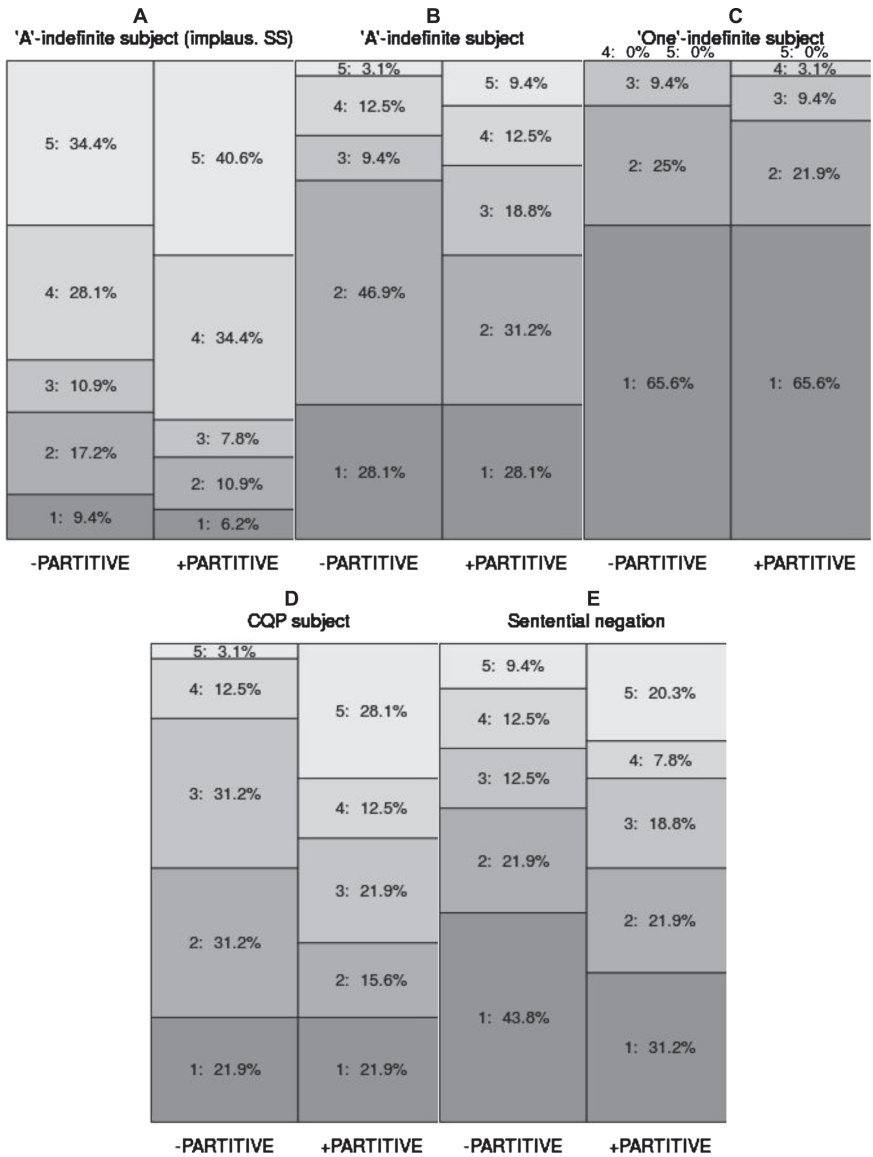

Figure 2 Acceptability ratings for the inverse scope of **non-partitive vs. partitive CQPs** with respect to: (A)-(B) "a"-indefinite subjects ((A): implausible surface scope, (B): surface scope plausible but false); (C) "one"-indefinite subjects with surface scope plausible but false, (D) CQP subjects, and (E) sentential negation.

indefinite in subject position and a bare numeral phrase in object position did not elicit high acceptability ratings for the inverse scope reading (left side of Column B). Although nothing grammatically prohibits a non-comparative bare numeral phrase from taking wide scope over an indefinite in subject position, the ratings appear to reflect the processing preferences favoring surface scope, as discussed earlier. A preference for the surface scope

reading is also reflected in the ratings for the sentences in which negation interacted with a quantificational object (Column E). This pattern thus serves as a reminder that the kind of indefinite chosen to investigate scopal interaction matters, and that if participants have the opportunity to judge the truth value or acceptability of a sentence based on the availability of the most acceptable reading (i.e., the surface scope reading), they will most likely do so.

As we had noted earlier, the sentences in which a CQP in subject position interacted with a CQP object (Column D) have only been discussed by Szabolcsi (1997), and are only of interest insofar as they gave us a glimpse of the full range of scopal possibilities for CQPs in both subject and object position. We simply point out here that an inverse scope reading of such sentences is possible in cases beyond those in which the surface scope is implausible. For these sentences, too, a wide spread of ratings was observed.

Finally, when the object was an overt partitive, regardless of whether it was a bare numeral phrase or a CQP, the ratings shifted to the higher end of the scale, resulting in the blocks for ratings of '4' and '5' spanning more surface area (as seen in Figure 2). The influence of partitivity can also be seen with sentences where an object CQP interacted with negation, as illustrated in Figure 3, where the results of the ordinal probit regression models with at least one significant or close to significant fixed effect are plotted. This plot indicates the kind of models we estimated: our ordinal probit regression models estimate 4 thresholds that partition the area under a standard normal density curve in 5 distinct sub-areas, corresponding – from left to right – to the probabilities of getting a rating of 1 through 5. The thresholds are fixed for all the 4 fixed-effect conditions. What changes from condition to condition is the center (mean) of the normal density curve: the more acceptable a condition is, the more it will be displaced to the right relative to the reference condition, which is bare numeral and –partitive (as we had indicated earlier). The main takeaway point from these graphs is that the worst case scenario is the CQP, −partitive condition, which skews the curve leftward. By contrast, the presence of partitivity makes inverse scope in uncontroversial cases more acceptable, shifting the bare numeral. +partitive condition to the right. Furthermore, in the model estimated for Experiment 1 data, the acceptability of inverse scope decreased significantly when switching from bare numerals to CQPs ($\beta = -1.19$, SE $= 0.32$, $p < 0.001$).

Focusing in on the CQP conditions alone, we think it is worthwhile drawing attention to some marginally significant results in the CQP conditions in particular, since we think it is possible that we are dealing with a lack of power, and that with a larger data set and an increased sample size of participants, these marginal effects might have reached significance. To begin, there was no significant interaction of partitivity and CQP status. However, when we estimate a model with main effects only (i.e., when we drop this non-significant interaction effect), the main effect of partitivity became marginally significant ($\beta = -0.4$, SE $= 0.21$, $p = 0.06$). In addition, there was a close-to-significant effect of partitivity for the CQP subject data ($\beta = 0.49$, SE $= 0.27$, $p = 0.07$). In the model estimated for the 'a'-indefinite subject data with an implausible surface scope, the CQP main effect was marginally significant ($\beta = 0.49$, SE $= 0.29$, $p = 0.09$), and was positive: the presence of a CQP made the inverse scope reading *more* acceptable. This main effect was clearly significant when we used the model with main effects only ($\beta = 0.56$, SE $= 0.21$, $p < 0.01$).

2.4. *Discussion*

There are three main takeaway points from Experiment 1. First, the form of the indefinite *subject* matters: a 'one' indefinite is more likely to elicit lower acceptability ratings than

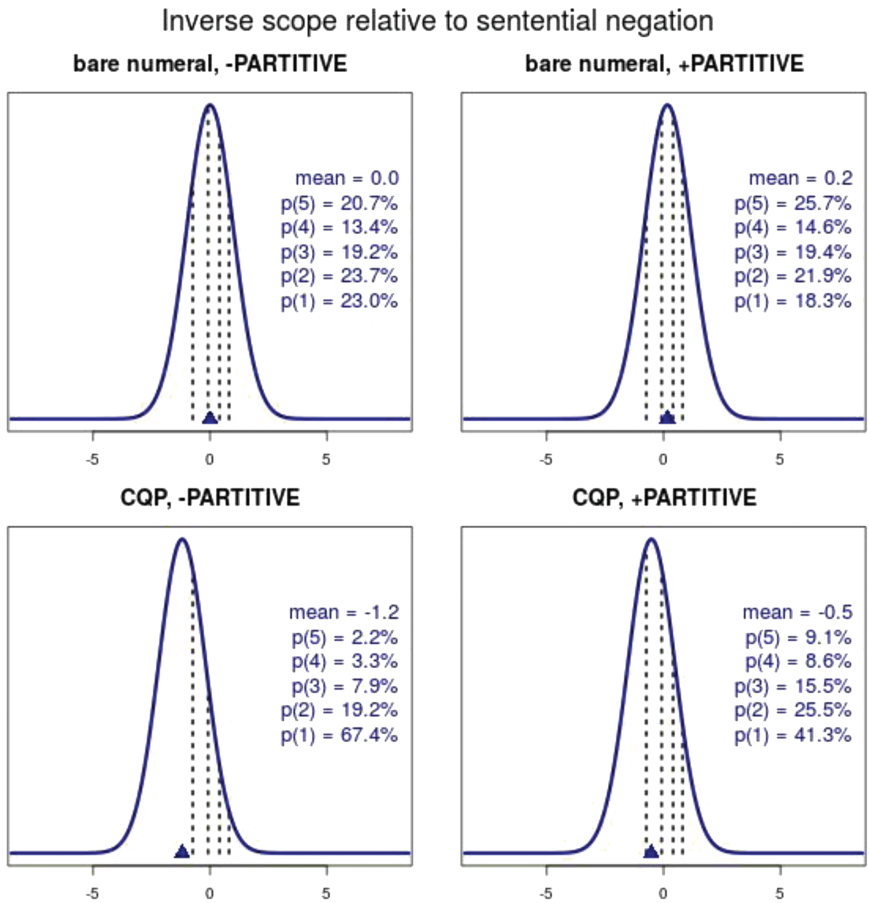

Figure 3 Plot of the ordinal probit regression model for the sentential negation test sentences in Experiment 1, as a way of illustrating the role of partitivity and bare numeral/CQP status.

'a', even in seemingly uncontroversial cases. Thus, testing for the availability of an inverse scope reading with a 'one' indefinite in subject position is stacking the deck against such a reading. Second, an object CQP can indeed take scope over a subject and generate an inverse scope reading. Furthermore, the inverse scope reading is not only available in the surface-scope-implausible cases, but also when a CQP occupies the subject position. Finally, there is a suggestion that partitivity has some effect on the availability of an inverse scope reading.

A key question we intended to address in Experiment 1 was whether acceptability of the inverse scope reading for sentences in which an object CQP interacts with an indefinite subject depends upon the surface scope being implausible with respect to real world knowledge. Recall that there was one sentence in Experiment 1 in which an object CQP interacted with a CQP in subject position, and another in which the object CQP interacted with an 'a' indefinite in subject position.[14] In each case, the surface scope was false, but

14 We leave aside the 'one' indefinite cases here, for reasons outlined in section 1.

not implausible. For each of these sentences, when the object CQP was in partitive form, 13 participants gave one or both of these sentences a 3 or above, and five judged both to be acceptable. When the object CQP was not in partitive form, 10 of the 16 participants judged at least one of these two sentences to be acceptable, and three judged both to be acceptable. Thus, the findings indicate that the CQP is able to take wide scope over a CQP subject for a contingent of participants in this experiment, and even this small data set illustrates that the current approaches to the representation of CQPs are insufficient, as they cannot account for the full range of data.

To follow up and determine whether the inverse scope reading is not only available, but also robustly so under the right circumstances, and well beyond those cases in which the surface scope is implausible, we conducted the next two experiments, which manipulate the key factors highlighted in Experiment 1, which we discussed in the introduction (type of indefinite subject, ±partitivity of the object CQP), while also manipulating the context and presentation of the stimuli to satisfy the felicity conditions on the use of the CQP and facilitate the availability and processing of the CQP. Combined, these experiments demonstrate without question that CQPs can take inverse scope over an indefinite subject, and at the same time highlight the role of the factors we have identified in supporting the inverse scope reading.

3. EXPERIMENT 2

3.1. *Participants*

32 undergraduates participated. Data from 3 of these participants were excluded due to the participants' non-native speaker status (n = 1) or participants pressing numerous invalid keys when entering responses on the response pad (n = 2).

3.2. *Design*

3.2.1. *Stimuli and Procedure* The experiment was administered in a lab. Stimuli were presented on an iMac using SuperLab stimulus presentation software and a response pad. The experimental session proper consisted of 59 trials, presented in fully randomized order in SuperLab. In each trial, the participants saw a screen presenting some configuration of shapes, accompanied by a sentence below the shapes. The participants were asked to judge whether the sentence was true or false, given the visual scene. Participants entered a 'yes' or 'no' response by pressing a button on the response pad as indicated. Errant button presses were discarded; there were eight of these overall, or .5% of the total number of responses. Similar approaches to eliciting truth values of sentences in a context of visual stimuli (i.e., shapes or dots in lieu of linguistic contexts) has been used effectively by a number of recent researchers (e.g., Geurts & Pouscoulous 2009, Chemla & Spector 2011, Geurts & van Tiel 2013). We thus had good reason to predict that such an approach might also prove fruitful with our target sentences. The experiment began with a brief training session to acclimate participants to the procedure. Each session lasted approximately 20–30 minutes.

Among the trials were 24 test trials: 6 each of sentences fully crossing type of subject (*a* v. *one*) and partitivity of CQP in object position (±partitive). The CQP was always *more than three (of the) N*. The rest of the items involved either scopal interaction between the subject and object (e.g., *a/one. . .every*, numeral phrase. . .*every*), or assessments of quantities or relations between objects in contexts in which the sentence would either be true or false (e.g., *between n and n + 2 circles are green*, *more than half or the circles are green*,

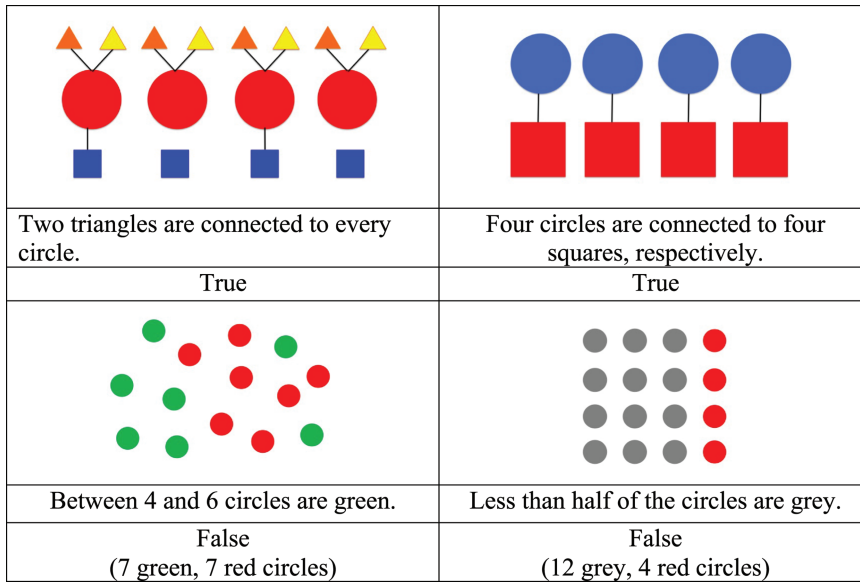

Figure 4 Examples of control/filler item displays, and the corresponding truth value of the target sentence, appearing in Experiment 2.

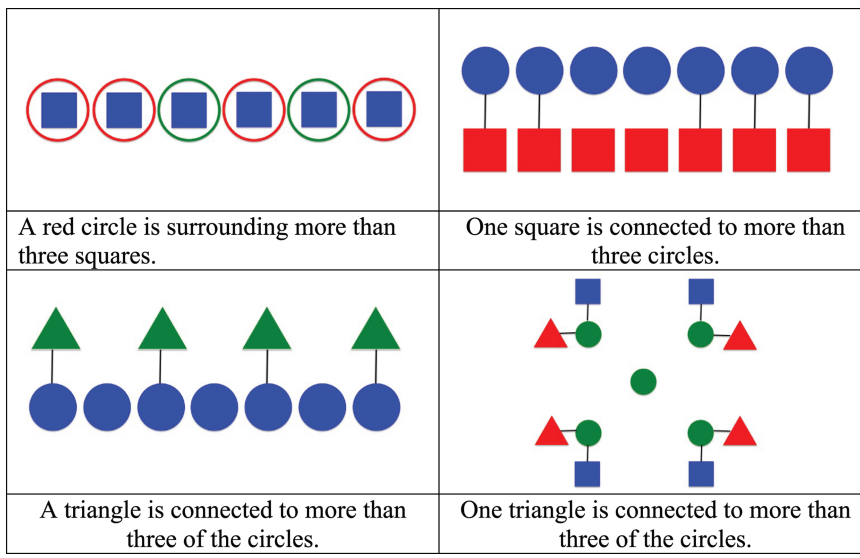

Figure 5 Examples of test item displays appearing in Experiment 2. All test sentences had the same truth values: SS: False, IS: True.

four circles are connected to four squares, respectively). Examples of control/filler and test displays are presented in Figures 4 and 5, respectively. The full set of test and control/filler sentences for Experiment 2 is presented in Appendix B.

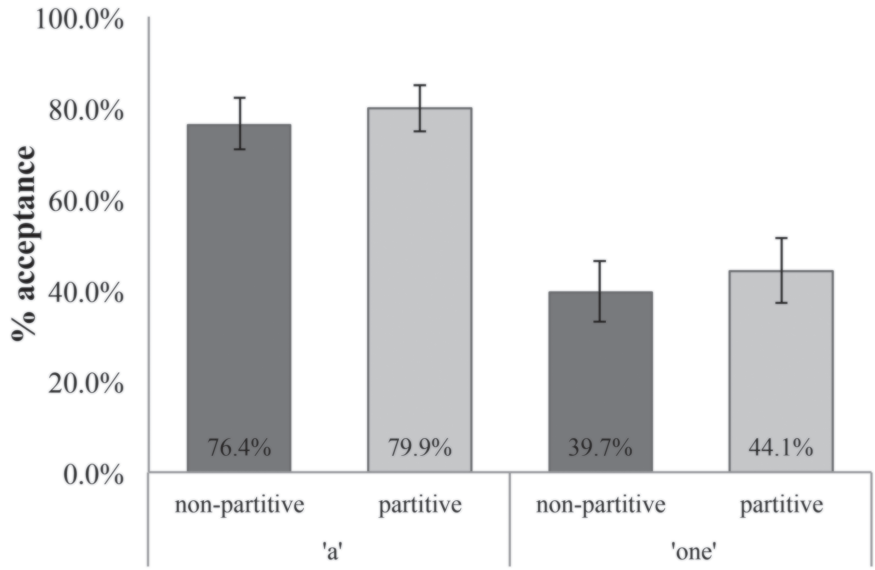

Figure 6 Average percentage of acceptance in each of the four test items types in Experiment 2.

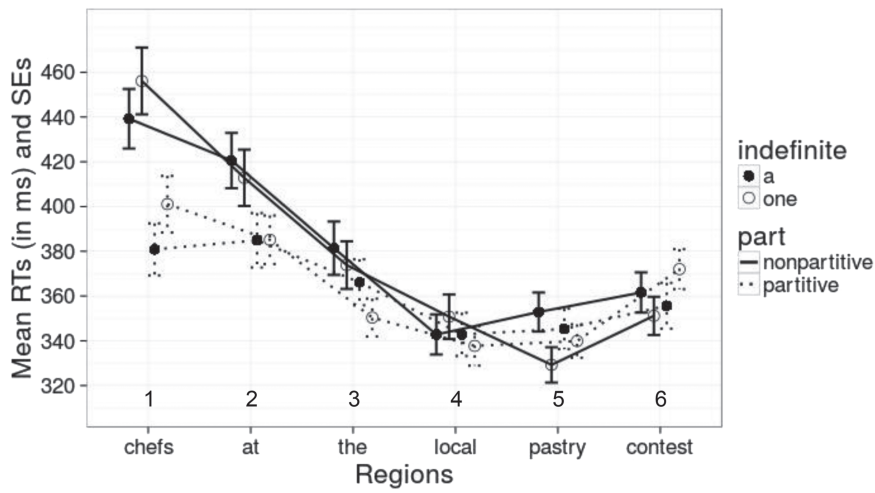

Figure 7 Mean readings times (RTs) in ms and standard errors (SEs) for the 6 regions of interest (ROIs) in Experiment 3.

3.3. *Results*

Participants responded as anticipated to the control and filler items. Percentages of acceptance for these sentences are indicated with each item type in Appendix B. With the CQP test items, participants accepted those with *a* in subject position over 75% of the time on average, while they accepted those with *one* in subject position approximately 40% of the time on average, as shown in Figure 6, including ±partitive status.

Because of the binary categorical nature of responses, we used a mixed-effects logistic regression model to analyze the data. There were no interaction effects (a Likelihood Ratio Test comparing the model with and the model without interactions yields $\chi^2(1) = .01$, $p = .91$), so we report here the main-effects only model. There was a highly significant main effect of indefinite type: $\beta = -2.89$, SE = 0.48, $p < .00001$. However, there was no main effect partitivity: $\beta = .35$, SE = 0.33, $p = .28$. We speculate that this may have been because the existence of all of the objects and their set membership were easily extractable from the visual display, and no information about set membership had to be held in working memory while considering the interpretation(s) and corresponding truth value of the target sentence: the visual stimuli could be viewed *en masse*, facilitating parsing of the scene.

3.4. *Discussion*

The results of Experiment 2 demonstrate without a doubt that experimental participants are able to access the inverse scope reading of sentences in which a CQP in object position scopally interacts with an indefinite in subject position. Furthermore, these results firmly establish that the type of indefinite subject matters: sentences with *one* in the subject position resisted the inverse scope reading relative to those with *a* in the subject.

We note, however, that an acceptance rate greater than 30% (and in some cases approximately 60%) with *one* and between 70 and 80% with *a* more than suggests that the grammar does not bar this reading because of the movement restrictions of the (components of the) object CQP. If that were the case, then participants would consistently judge as false those sentences that were paired with a context in which the surface scope was false and the inverse scope true. There is also no reason to think that an ungrammatical sentence that was deemed marginally passable in a particular context or experimental environment might generate such consistently high acceptance rates. As a point of comparison, for the three other scopally ambiguous control sentences with an indefinite subject in which the same scopal relation held (SS: F, IS: T), acceptance rates ranged between 57 and 75% (depressed from a ceiling level of 100% most likely for reasons we discussed earlier related to Truth Dominance and the processing of sentences with a singular indefinite in subject position). Thus, the acceptance patterns observed for the target sentences in Experiment 2 are comparable to those for uncontroversially scopally ambiguous sentences.[15] To further solidify the acceptability of the inverse scope reading of our target sentences, we conducted Experiment 3 – this time presenting the sentences in a text-based task, which placed more demands on participants' working memory.

4. EXPERIMENT 3

4.1. *Participants*

133 undergraduates participated. Data from 7 of these participants were excluded due to the non-native speaker status of the participants. Data from a further 7 participants were

15 One reviewer asks why we take the relatively high acceptance rates for inverse scope readings in our experiments as an indication that the grammar does not bar such readings, but rather that other principles might override economy principles. While we cannot rule out this possibility based on our evidence, we argue that in the absence of well-articulated hypothesis about what such principles would be and why they would yield comparable acceptance rates, we have no reason to doubt that the grammar is responsible for generating these typically hard to detect readings.

excluded because of low (<80%) accuracy of responses to filler items. This left us with a final sample size of 119 participants.

4.2. *Design*

4.2.1. *Stimuli* The stimuli featured in Experiment 3 were designed to be text versions of the stimuli included in Experiment 2: instead of shapes bearing some relation to each other, the stimuli in were short passages that made reference to individuals, with similar connections between these individuals, and the object and events connecting them. An example of a target item follows.

(16) **Scenario:** Four local pastry chefs were competing in a contest for the best wedding cake last night. The winner would have their cake featured in a big wedding, and pictured on the cover of Weddings Today. In the first stage of the contest, five tiered cakes were set out, and some of the chefs were invited to decorate them. The cake flavors were raspberry cream, strawberry cheesecake, lemon chiffon, French vanilla, and dark chocolate. Chef Nathan decorated the raspberry cream cake, Chef Olivier decorated the strawberry cheesecake, Chef Pierre decorated the lemon chiffon, while Chef Quincy had quit the contest because of a family emergency.
Sentence: I think that [a/one] cake was decorated by more than two (of the) chefs at the local pastry contest last night.

Target sentences all began with the lead-in *I think that*, as above, to provide a lead-in before participants read the subject indefinite. It should be apparent that this kind of item places more of a cognitive load on the participant than the items featured in Experiment 2 by requiring the participant to hold more information in their memory leading up to the target sentence. Moreover, since the target sentence was itself not displayed all at once, the presentation of this sentence placed an additional burden on working memory. We therefore predicted that we might see a difference in acceptability scores between Experiments 2 and 3, with more depressed rates of inverse scope acceptability in this experiment.

There were 16 test items, randomized with 11 unambiguously true and 22 unambiguously false fillers. The stimuli also included two additional filler items involving scopal interaction between *every* in subject position and a CQP headed by *fewer* in object position (SS: False, IS: True), to probe whether the processing and pragmatic factors we have identified as playing a role in facilitating the inverse scope reading with our target indefinite subject-object CQP sentences with *more* could also facilitate the availability of the inverse scope reading of sentences with a universal subject and an object CQP with *fewer* (a sentence type that has similarities with the current one in being claimed to bar the inverse scope reading). See Appendix C for complete stimuli for Experiment 3.

4.2.2. *Procedure* The experiment was administered online using an installation of the Ibex platform locally hosted on a server at the home institution of one of the co-authors. Participants read a background scenario displayed on a first screen, which was then followed by a target sentence, displayed by itself on a new screen. The target sentence was presented for self-paced, non-cumulative, moving-window reading (Just *et al.* 1982): at the outset, all words are masked by dashes; participants press the space bar to reveal one word at a time; as a new word is revealed, the previous one is hidden again (the letters are replaced with dashes again). After the sentence, participants then moved to a third and final screen where they were required to answer the yes/no question *Is that right?*, which asked them

to evaluate the target sentence against its background scenario. The experimental session proper was preceded by a brief training session to acclimate participants to this format.

4.3. *Results and Discussion*

Before analyzing the reading-time data, we dropped the data from 6 outlier participants whose mean reading times were more than two standard deviations away from the grand mean reading time for all subjects. We report here the results based on the data collected from the remaining 113 participants.

Figure 9 displays the raw reading times (RTs) and their associated standard errors (SEs) for the 6 regions of interest (ROIs) following our two experimental manipulations (sentence-initial indefinite subject and CQP object in partitive or non-partitive form). The first ROI is the common noun inside the CQP, which immediately follows the +/−partitivity manipulation towards the end of the target sentence (e.g., *chefs* in example (16) above).

These data indicate that there is a significant effect of partitivity: in the first 3 ROIs, non-partitive stimuli took more time than their partitive counterparts. In comparison, the indefinite manipulation *a* vs. *one* seems to have had little if any effect. These impressionistic generalizations are supported by statistical data analysis. Since the response variable is continuous (reading time), we use linear mixed-effects regressions to model the data. However, we do not analyze the raw RTs directly. First, we log-transform them to mitigate the right skewness characteristic of response time data; the empirical distribution of the log-transformed data is much closer to a normal (Gaussian) distribution, which is assumed by linear (mixed-effects) models. Second, following Trueswell *et al.* (1994), we residualize the log RTs by factoring out word length (measured in characters). The linear model used to obtain the residualized log RTs also includes word position as a predictor (in addition to word length) and intercept random effects for subjects. We use the residualized log RTs as the response variable in all linear mixed effect models (hence the small magnitude of the effects we will report). A series of Likelihood Ratio Tests we ran for each of the 6 ROIs determined that random effect structures richer than crossed random intercepts for subjects and items did not significantly improve data fit; we therefore dropped random slopes from the model. Similarly, a comparison of models with interactions and main-effects-only models indicates that interactions are not significant in any of the ROIs. Thus, we report here the results of linear mixed-effects models with fixed-effect structures that include only main effects for +/−partitivity and *a* vs. *one* indefiniteness, and random-effect structures that include only (crossed) random intercepts for subjects and items.

In ROI 1 (the common noun inside the CQP), there was a highly significant effect of partitivity ($\beta = -0.16$, SE = 0.02, p = $3 \bullet 10^{-13}$): there was a speed-up (indicating less processing difficulty) for +partitive CQPs relative to –partitive CQPs. There was also a significant effect of indefinite in the expected direction ($\beta = 0.04$, SE = 0.02, p = 0.04): there was a slow-down (indicating higher processing load) when the indefinite in subject position was headed by 'one'. In ROIs 2–4, there was only a significant main effect of partitivity ($\beta = -0.1$, SE = 0.02, p = $1 \bullet 10^{-7}$, $\beta = -0.07$, SE = 0.02, p = $9 \bullet 10^{-5}$, and $\beta = -0.05$, SE = 0.02, p = 0.008, respectively). There were no significant effects in ROIs 5 and 6.[16] Thus, the self-paced reading time results of Experiment 3 complement

16 There is a nearly significant effect of 'one' in ROI 5 in the unexpected direction ($\beta = -0.03$, SE = 0.02, p = 0.08). Given the relatively fleeting nature of this effect (it occurs in only one region) and its near significance, we will not discuss it further.

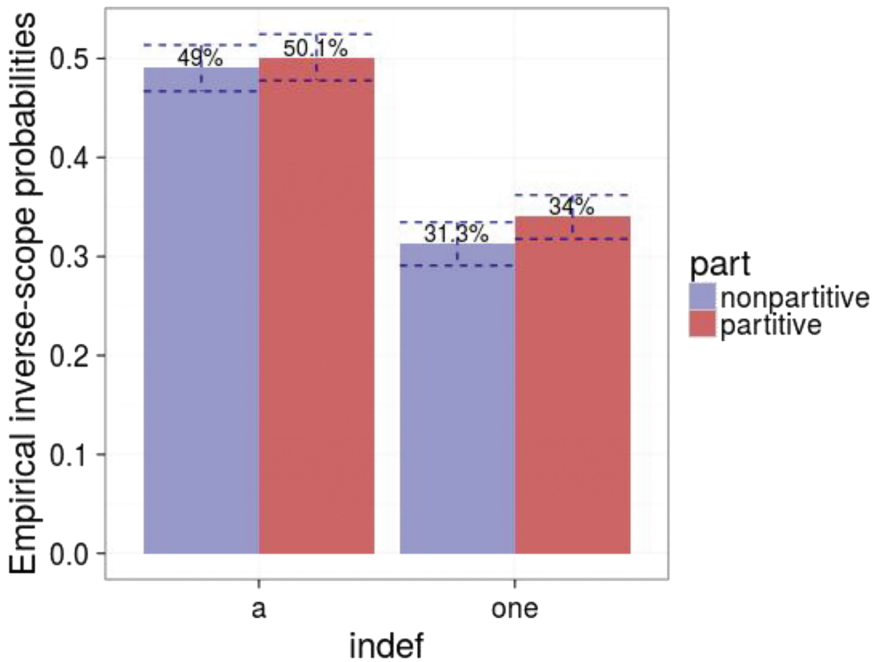

Figure 8 Empirical probabilities of inverse scope as confirmed by a 'yes' answer to the comprehension questions in Experiment 3.

the acceptability results of Experiment 2, in which the partitivity effects were neutralized as a result of the visual contexts, while the indefiniteness contrast between *a* and *one* surfaced robustly.

We now turn to an analysis of responses and times to render responses. The pattern for answers is qualitatively the same as for Experiment 2, as shown in Figure 8 below. Once again, we see a clear effect of indefiniteness, with an 'a' indefinite more easily allowing the CQP in object position to take inverse scope than 'one'. We suspect that the depressed acceptability rate for the inverse scope reading observed in Experiment 3 relative to that of Experiment 2 is a reflection of the increase in cognitive load and the extent to which participants' working memories were taxed in the more demanding self-paced reading task of Experiment 3. We also see no effect of partitivity in acceptability responses, just as in Experiment 2. These generalizations are confirmed by the data analysis. Thus, while partitive status facilitates processing, it does not affect acceptability judgments.

The best model (as determined by a series of Likelihood Ratio Tests) is a mixed-effects logistic regression model with main effects only (no interactions) and crossed random intercepts and indefiniteness random slopes for subjects and items. The only significant effect is the indefiniteness main effect ($\beta = -1.01$, SE $= 0.22$, p $= 6 \bullet 10^{-6}$), with acceptance less likely with *one* than with *a* in subject position. The analysis of response times (once again using linear mixed-effects models) yielded no significant effects, so we do not discuss them further.

Recall that we included two filler items in which *every* in subject position interacted with a *fewer* CQP in object position. The purpose of these two items was to probe whether the

processing and pragmatic factors we harnessed to our advantage in our target sentence types also had an effect with this type of sentence structure, which has played a role in discussions of restricted scope-taking ability. The *fewer* object CQP is also claimed to *not* be able to take wide scope over a universal quantifier in subject position. In the scenarios we presented to participants (as shown in example (17) below), we made the surface scope False and the inverse scope True, as with our target cases. We also satisfied the felicity conditions in the discourse context for the use of a *fewer* CQP, and placed the CQP in partitive form.

(17) Dr. X came up with a fun game for his math students. He placed 100 red tokens in a large bowl. He then asked each of the students in his class to come up to the bowl, randomly select 15 of the tokens, initial each of them, and place them back in the bowl. After each student did this, he shuffled the tokens around in the bowl before the next student's turn. After every student had a turn and had initialed 15 tokens each, Dr. X asked his class to think about how many tokens had each student's initials. He guessed himself that there might be 10 tokens that had every student's initials. One of the students then inspected all the tokens to see if he was right. When done inspecting, the student announced that 8 tokens had each set of student initials.
I think that every student initialed fewer than 10 of the tokens.

The manipulation of these factors appears to have facilitated the inverse scope reading, since participants accessed this reading between 48.7% and 65.5% of the time for the two items (58/119 and 78/119, respectively). This pattern of responses thus serves as a call to future researchers to probe the scope-taking ability of *fewer* with the goals of determining to what extent its scope-taking ability is indeed limited and whether negative quantifiers such as *fewer* (which are assumed to decompose) are subject to softer constraints on movement than has been previously thought. If indeed the scopal possibilities of such quantificational expressions is greater than was previously thought, and there are strong independent reasons to maintain a decompositional approach, then it is possible that the locus of the further revisions lies in Scope Economy, as Fleisher (2015) and Mayr & Spector (2012) have argued thus far.

5. OUTLINING AN ACCOUNT OF THE EXPERIMENTAL RESULTS

In this section, we briefly outline an account[17] of the effects we observed in the three experiments we conducted, whereby a CQP interacting with an 'a' indefinite in subject position yielded inverse scope acceptability judgments that were higher than expected given current decompositional theoretical accounts, and higher than for a 'one' indefinite. We also saw in Experiment 3 that a CQP in partitive form facilitated sentence processing.

The partitivity effect follows from the principles of referential success / support and parsimony (Crain & Steedman 1985, Altmann & Steedman 1988): encountering a partitive in a context that linguistically supports it, as in Experiments 1 and 3, i.e., in contexts in which a support set for the restrictor of the CQP has already been introduced, facilitates the processing of the partitive CQP (Experiment 3), and because of the anaphoric connection

17 We are grateful to two anonymous reviewers for their comments, which helped us evaluate the details and consequences of our suggested account.

established with the previous context, it increases its likelihood to take widest, i.e., inverse, scope (Experiment 1). Non-partitive CQPs incur a higher processing cost because their support set is not discourse familiar; or, possibly, because they mark their support set as unfamiliar in a context in which a plausible support set is available. The partitivity effect disappears in Experiment 2 because the visual context and the nature of the task in that experiment biased all CQPs towards an implicitly partitive interpretation.

Turning now to the 'a'/'one' contrast, let us be specific and assume a Dynamic Predicate Logic system (DPL; Kamp 1981, Heim 1982, Groenendijk & Stokhof 1991) with post-suppositions, along the lines proposed in Brasoveanu (2013). Post-suppositions are meaning components – for example, cardinality constraints contributed by modified numerals – that need to be satisfied *after* the regular at-issue meaning is semantically evaluated. In this way, the cardinality requirement receives a pseudo-wide scope relative to the maximization operators that are part of the at-issue content. This system was designed to account for van Benthem's problem (van Benthem 1986), whereby the logical representation of a sentence such as (18), in which both modified numerals are interpreted distributively and one of them scopes over the other, yields a reading that is distinct from the interpretation the sentence intuitively receives.

(18) Exactly three boys saw exactly five movies.

The most salient reading of sentences like (18) is a cumulative reading. This cumulative reading can be paraphrased as follows: consider the maximal number of boys that saw a movie and the maximal number of movies seen by a boy; there are three such boys and five such movies. Importantly, this reading is distinct from the distributive reading (or other readings): both cardinality requirements ($|\ldots| = 3$ and $|\ldots| = 5$) have simultaneous wide scope. Dynamic Predicate Logic with Post-suppositions was designed to allow these cardinality requirements to 'float' all the way up – or more precisely, to the end of – the at-issue sentential update, and be semantically evaluated there. We mark post-suppositions by superscripting them.

Analyzing the cardinality requirements contributed by modified numerals as post-suppositional captures the fact that cumulative readings of this sort are the default, most readily accessible readings for sentences with modified numerals. Distributive readings are derived by means of (covert) distributive operators, which trap post-suppositions in their scope. Since such readings require additional covert operators, they are predicted to be less salient, or less readily accessible – for instance, because of the extra processing cost associated with positing that such covert operators are part of the logical representation.

The intended cumulative reading for sentence (18) is provided in (19) and (20) below. The logical representation in (19) is compositionally derived, while the representation in (20) captures the intended cumulative reading. (σ is a maximization operator that extracts the maximal sum of individuals.) In the Dynamic Predicate Logic with Post-suppositions system, these two representations are truth-conditionally equivalent.

(19) $\exists^{|x|=3}[\mathrm{BOY}(x)]\ (\exists^{|y|=5}[\mathrm{MOVIE}(y)]\ (\mathrm{SEE}(x, y)))$

(20) $\sigma xy(\mathrm{BOY}(x) \wedge \mathrm{MOVIE}(y) \wedge \mathrm{SEE}(x, y)) \wedge |y| = 5 \wedge |x| = 3$

Returning to our 'a' vs. 'one' contrast, let us assume that the cardinality requirement contributed by *one* is a post-supposition. For both the 'a' and 'one' sentences, we have three possible representations: surface scope, inverse scope cumulative, and inverse scope distributive. These representations follow below for the kind of 'one' sentences we have

been investigating, and which are at the heart of theoretical approaches to comparative quantifiers.

(21) One student read more than three books.
(22) $\exists^{|x|=1}$[STUDENT(x)] ($\exists^{|y|>3}$[BOOK(y)] (READ(x, y))) surface scope
(23) $\exists^{|y|>3}$[BOOK(y)] ($\exists^{|x|=1}$[STUDENT(x)] (READ(x, y))) inverse scope cumulative
(24) $\exists^{|y|>3}$[BOOK(y)] δ($\exists^{|x|=1}$[STUDENT(x)] (READ(x, y))) inverse scope distributive

Because of the post-suppositional nature of the cardinality requirement contributed by *one*, both (22) and (23) yield the 'surface scope' reading. This is surprising for (23) because the logical representation gives the CQP inverse (wide) scope. However, even though the CQP takes inverse scope in (23), the post-suppositional cardinality requirement contributed by *one* still 'escapes' and is evaluated at the top level. In contrast, in (24), the distributivity operator δ keeps this cardinality requirement local: it blocks its post-suppositional behavior and requires it to take narrow scope relative to the CQP.

The corresponding representations for ordinary *a* indefinites are provided below.

(25) A student read more than three books.
(26) $\exists^{|y|>3}$[BOOK(y)] (READ(f(STUDENT), y))
(27) $\exists^{|y|>3}$[BOOK(y)] (READ(f(STUDENT, y), y))
(28) $\exists^{|y|>3}$[BOOK(y)] δ(READ(f(STUDENT, y), y))

For simplicity, let us assume a choice-function account of ordinary indefinites (Reinhart 1997, Kratzer 1998 a.o.). The 'unparametrized' choice function in (26) yields the surface scope reading. The 'parametrized' choice functions in (27) and (28) yield the CQP inverse scope reading – assuming 'parametrized' choice functions always act distributively when parametrized by sum individuals. Thus, we can see that in contrast to *a*, *one* more strongly resists CQP inverse scope because of its post-suppositional, inherently 'wide-scoping' nature linked to its cardinality. This increased resistance is due to the fact that more of the possible logical forms for 'one' + CQP sentences lead to a surface-scope-like interpretation compared to the possible logical forms for CQP sentences with *a* in subject position. Moreover, the logical form that leads to the CQP taking inverse scope over *one* is dispreferred for multiple reasons: (*i*) generating an inverse-scope representation requires postulating an extra (covert) operation by which the object CQP is shifted to a wide scope position; (*ii*) it is necessary to posit an additional (covert) distributivity operator that traps the post-suppositional cardinality requirement contributed by *one* and forces it to be semantically evaluated *in situ*; and finally, (*iii*) it might be reasonable to conjecture a 'maximize post-supposition' principle similar to 'maximize presupposition' to the effect that if there is a post-position that could be satisfied in the model / context under consideration, then the post-supposition should be satisfied—in which case there would be a preference for the 'one' cardinality requirement to project resulting in a surface-scope-like interpretation.

We believe an analysis along these lines is on the right track. However, there are still several open issues. First, the proposal in Brasoveanu (2013) is specifically targeted at 'superlative' modified numerals like *at least five*, not at bare numerals like *one* or comparative modified numerals like *more than three*. Extending this proposal to bare and comparative numerals leaves the differences in interpretation between these subclasses of numerals unaccounted for. Second, the interaction between numerals and negation was left open in Brasoveanu (2013), and also left open here, since we focus on the interaction between an object CQP and a subject indefinite. An anonymous reviewer notes that in

a sentence like *John did not meet one (single) student*, the cardinality post-supposition purportedly contributed by *one* cannot escape the scope of negation. We believe that this should ultimately be attributed to the distributive nature of negation, which traps post-suppositions in its scope. In dynamic semantics, negation universally (distributively) quantifies over output assignments; in situation semantics, a similarly quantificational definition for negation is proposed (see section 6 in Kratzer 1989). A more in-depth investigation along these lines is left for a future occasion.

6. GENERAL DISCUSSION AND CONCLUSIONS

We began this paper with the observation from previous literature that Comparative Quantifier Phrases (CQPs) appear to have a limited scopal range relative to other quantificational phrases, and appear to not be able to take inverse scope with an indefinite appearing in subject position. This restriction on their scope-taking ability seems surprising if they are treated as generalized quantifiers. At the same time, this restricted scopal range seemed so robust that it led Takahashi (2006) to propose that Comparative QPs in object position *obligatorily* take narrow scope relative to QPs in subject position (not just indefinites). The set of experiments reported here, however, make it patently clear that we must abandon this generalization. Not only can object CQPs take wide scope relative to an indefinite in subject position when the surface scope reading is conceptually implausible, but CQPs are also consistently judged to take wide scope and generate an inverse scope reading in other circumstances, once the processing factors and felicity conditions we identified at the beginning of this paper have been controlled for. Given the acceptability of the inverse scope reading of sentences in which an object CQP interacts scopally with an indefinite subject demonstrated across three independent experiments using different methodologies, we are led to conclude that the lack of wide-scope readings for direct object CQPs is not a hard constraint that should be captured in the grammar (syntax, semantics and/or their interface).

Instead, we argue that it is the outcome of (*i*) the two general processing preferences applying to scopal ambiguity and the resulting logical representations, (*ii*) the specific semantic contributions of the kind of indefinite interacting with the CQP (i.e., *a* vs. *one*), (*iii*) the form of the CQP itself (i.e., ±partitive), and (*iv*) the felicity conditions on the use of CQPs. Therefore, the preference of object CQPs to take surface scope may be accounted for within a more general theory of performance, along the lines of similar soft constraints on quantifier scope exhibited by other quantifiers. (See Ioup (1975), Van Lehn (1978), Micham et al. (1980), Gillen (1991), Kurtzman & MacDonald, (1993), Saba & Corriveau (2001), Higgins & Sadock (2003), Srinivasan & Yates (2009), AnderBois et al. (2012), among many others.) The evidence pushes the current decompositional accounts to modify fundamental assumptions about movement ordering and constraints, which would otherwise bar the inverse scope reading, and instead consider the modifications in the theory that are necessary to account for the licensing of the inverse scope reading of the target sentences discussed here. We suggest that future research should experimentally probe sentences such as these.

We ended our paper by proposing an analysis of the effects observed throughout the experiments, appealing to a dynamic semantic framework. Crucially, this framework freely allows inverse scope representations for object CQPs, but is still able to distinguish the way in which the cardinality constraint contributed by *one* has a different semantic behavior

than the meaning contribution made by the ordinary singular indefinite *a*. Thus, our experimental results call for a reevaluation of the syntactic-semantic treatment of CQPs and their scope-taking ability, and open up various lines for future experimental research. There are, to be sure, open questions that remain and a number of linguistic environments that we did not test in the space of this investigation. We see these as promising areas for future experimental research, for which we hope our current experimental research on scopal interaction with subject indefinites acts as a foundation.

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