

Quantification and ACD: Evidence from Real-Time Sentence Processing

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Abstract

Quantifiers, unlike proper names or definite descriptions, cannot be given the semantics of referring expressions. This fact has triggered a long-standing debate in formal semantics and syntax as to the combinatorial means by which quantifiers are integrated into a sentence. The present paper contributes to this debate through an investigation of quantifier comprehension during real-time sentence processing. We present evidence showing that two potentially independent processes—the integration of a quantifier in object position and the resolution of antecedent-contained deletion (ACD)—are linked. Our data show, more specifically, that the resolution of a downstream ACD site is facilitated during real-time sentence processing if the upstream DP hosting the ACD site is quantificational but not if it is definite. We discuss these findings in the context of a QUANTIFIER RAISING-based approach and a type-shifting-based approach to quantifier integration. We argue that facilitation of ACD resolution by an upstream quantifier is only expected by theories, such as the QUANTIFIER RAISING approach, which employ the same mechanism for both processes. We then compare the QUANTIFIER RAISING-based account with a non-grammatical experience-based approach to our data, which attempts to explain the findings in terms of corpus frequencies. Although we cannot rule out such an alternative at this stage, we offer reasons to believe that an account that exploits QUANTIFIER RAISING has an explanatory advantage.

1 INTRODUCTION

It is a well-known fact about English that quantificational DPs exhibit essentially the same distributional properties in surface syntax as proper names and definite DPs.¹ From the perspective of compositional

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¹ Languages differ in the extent to which quantifiers and referring DPs have overlapping surface syntactic distributions. See *Szabolcsi (1997)*.

semantics, this is somewhat surprising since quantificational DPs differ in their semantics notably from definite DPs and proper names. Specifically, quantificational DPs do not refer. Hence, unlike definite DPs or proper names, their semantics cannot be given in the form of singular terms.² This notwithstanding, they seem to combine freely with predicates ranging over individuals. The fact that quantifiers can combine with such predicates indicates that natural language possesses a considerable amount of combinatorial flexibility. What the nature of this flexibility is and whether it should be located in the computational system itself or elsewhere is the topic of an ongoing debate.

A simple way to appreciate the generality of the puzzle is to consider how sentences such as those in (1)a–d are translated into predicate logic (PL).

- | | | | |
|-----|----|-----------------------|--|
| (1) | a. | Mary smiled | $S(m)$ |
| | b. | Somebody smiled. | $\exists x[S(x)]; *S(\exists x)$ |
| | c. | Mary likes John. | $L(j)(m)$ |
| | d. | Mary likes everybody. | $\forall x[L(x)(m)]; *L(\forall x)(m)$ |

Smiled and *likes* denote 1- and 2-place predicates of individuals, which can be interpreted as truth-valued functions. Their conceptual core is such that they can be thought of as naming properties of individuals. *Smiled* names the property that an individual such as Mary can be said to have if and only if Mary smiled. Similarly, *likes* names the relational property that a pair of individuals such as Mary and John have if and only if Mary stands in the liking relation to John. The PL translations in (1)a and (1)c encode this fact via function argument syntax where the capital letters *S* and *L* represent the 1- and 2-place predicates, while *m* and *j* are individual constants representing the arguments of these functions.

The quantified sentences in (1)b and (1)d are translated rather differently. The quantifiers *somebody* and *everybody* are translated as variable-binding operators $\exists x$ and $\forall x$. Importantly, they do not occupy the argument positions of the predicates *S* and *L*, unlike the individual constants in (1)a and (1)c. Instead, they are prefixed to open formulas in which a variable bound by the quantifier occupies the original

² Whether definite descriptions should be analysed like referring expressions or like quantifiers is controversial and has been a longstanding topic in the philosophy of language as well as natural language semantics (Russell 1905, etc.). It is uncontroversial, however, that a referential analysis of the semantics of quantifiers is not an option.

argument position; formulas in which a quantifier occupies an argument position of a predicate are simply disallowed in PL. It would amount to predicating S of $\exists x$ or L of $\forall x$ and m , which would be a category mistake— S and L are properties of individuals and not of quantifiers. To avoid category mistakes of this sort while maintaining that there is a predication relation, PL employs variables ranging over individuals, and it is these variables that occupy the argument positions of predicates rather than the quantifiers. The quantifiers themselves are dislocated to the periphery where they bind their associated variables. Thus, the quantified sentences in (1)b and d have a more complex PL translation than those in (1)a and c, which employ only individual constants.

Whether quantification in natural language should be analysed via variable-binding operators along the lines of the PL translations or some other way is a much-debated issue in the literature. This paper aims to contribute to this debate through an experimental investigation of quantifier comprehension during real-time sentence processing.

2 QUANTIFIERS IN OBJECT POSITION

Our investigation focuses on quantifiers that realize internal arguments, that is quantifiers in object position. Quantified objects provide a clearer testing ground for theories of quantifier integration than quantificational subjects because subjects are, for purely syntactic reasons, assumed to surface in a derived position.³ This makes it difficult to determine whether quantificational subjects can, in principle, combine directly with a predicate.⁴ For quantificational objects, the situation is less confounded and indeed there are different views as to whether the grammar allows for the option of combining them directly with a predicate or not.

For the purpose of the present paper, it is useful to classify the various proposals as to how quantificational objects are integrated into two main types—those that provide means for integrating quantifiers *in situ*, that is in internal argument positions, and those that do not.

A canonical articulation of a theory where quantifiers in internal argument positions are not interpretable is presented in Heim and Kratzer

³ The syntactic subject position SpecTP rather than in their base position (SpecVP under the VP-internal subject hypothesis), see Chomsky (1995).

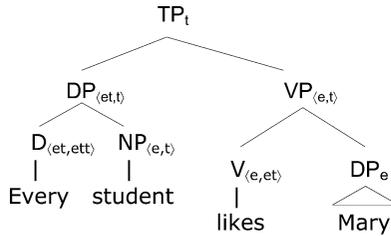
⁴ See Johnson and Tomioka (1998) for an argument that subject quantifiers are not interpretable in SpecVP.

(1998). The starting assumption, imported from Generalized Quantifier Theory (Barwise and Cooper 1981), is that quantificational DPs denote second-order predicates of type $\langle et, t \rangle$ (generalized quantifiers), which take expressions of type $\langle e, t \rangle$ as arguments, (2)a. Quantificational determiners, in turn, are of type $\langle et, ett \rangle$, that is when given a predicate, they return a generalized quantifier, (2)b.

- (2) a. $\llbracket \text{every student} \rrbracket = \lambda g \in D_{et}. \forall x [\text{student}(x) \rightarrow g(x)]$
- b. $\llbracket \text{every} \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{et}. \forall x [f(x) \rightarrow g(x)]$

Given this and standard assumptions about the semantic type of one-place predicates, the external argument position of a predicate is a position where quantifiers are in fact interpretable—not because the predicate can take the quantifier as argument but because the quantifier can take the predicate as argument, (3).⁵

- (3) Every student likes Mary.



- (4) $\llbracket \text{every student} \rrbracket (\llbracket \text{likes Mary} \rrbracket) = 1$ iff $\lambda g \in D_{et}. \forall x [\text{student}(x) \rightarrow g(x)] (\lambda y \in D_e. y \text{ likes } m) = 1$
 $= 1$ iff $\forall x [\text{student}(x) \rightarrow [\lambda y \in D_e. y \text{ likes } m](x)]$
 $= 1$ iff $\forall x [\text{student}(x) \rightarrow x \text{ likes } m]$

What is apparent in the computation in (4) is that even though the subject quantifier is interpreted in its thematic position, *liking Mary* is not predicated of the quantifier. Rather, the predication relation is mediated (in the semantics) via a variable. That is, *every student* takes a λ -expression as argument, which contains a variable bound by that λ -

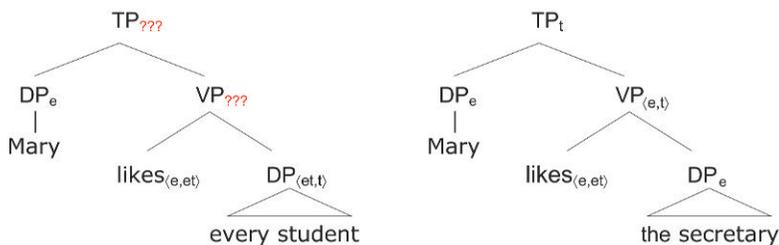
⁵ Here and throughout the paper, syntactic trees are simplified in a variety of ways that do not affect the points to be made. We assume, for instance, that clauses are projections of a Tense head but leave out the T⁰. We also assume that the most local clausal node for a quantifier is the local TP rather than the VP itself and we ignore the VP internal subject position.

operator. This variable is then bound by the quantifier and *liking Mary* is predicated over it. Proper names and definite descriptions (assuming a referential analysis), in contrast, can simply be taken as arguments by the VP and *liking Mary* is predicated of them directly.⁶

- (5) a. The secretary likes Mary.
- b. $\llbracket \text{likes Mary} \rrbracket (\llbracket \text{the secretary} \rrbracket) = 1$ iff $[\lambda y \in D_e. y \text{ likes } m]$
 $\llbracket (\iota x. \text{secretary}(x)) \rrbracket = 1$
 $= 1$ iff $\iota x[\text{secretary}(x)]$ likes m .

However, for quantifiers in object positions reversed predication of the sort described in (4) is not possible; the sister of a quantifier in object position has too many unsaturated argument positions to be in the domain of the quantifier. Transitive verbs, for instance, have two argument positions and are therefore of type $\langle e, et \rangle$. Hence, they cannot serve as the argument of an $\langle et, t \rangle$ function. Moreover, since they themselves cannot take the quantifier as argument, structures such as those in (6)a are uninterpretable, in contrast to ones with a definite description in object position, (6)b.

- (6) a. Mary likes every student.
- b. Mary likes the secretary.

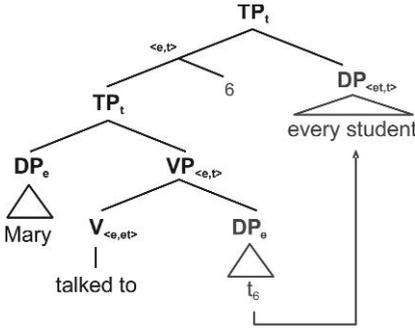


To explain how such sentences are nevertheless grammatical, Heim and Kratzer (1998) assume that quantifiers in object position are covertly displaced and adjoined to a clausal node, (7), see May (1977).⁷

⁶ To keep things more readable, we are abstracting away from the existence and uniqueness presupposition of the definite article.

⁷ Note that, following Fox (2002), it is assumed here that covert movement of the DP is to the right rather than to the left. For the purpose of semantic interpretation movement to the left is, of course, as good as movement to the right; the structure will be interpretable as long as the quantificational DP is adjoined to a clausal node.

(7) Mary talked to every student.



DP movement of this sort, commonly referred to as QR (QUANTIFIER RAISING), is assumed to leave behind a trace in object position which is co-indexed with the moved quantifier. The index on the quantifier, in turn, is tucked in between the targeted landing site of the movement operation, TP in (7), and the moved DP. To ensure interpretability of the resulting structure, it is assumed that the trace is interpreted as a variable that ranges over individuals, type *e*, while the index of the moved DP triggers a special composition rule called Predicate Abstraction, (8), which introduces a lambda operator that binds the movement trace (Heim and Kratzer 1998). The abbreviated calculation in (9) provides a summary of this theory.

(8) Predicate Abstraction

If α immediately dominates a bare index *i* and some node β , then $\llbracket \alpha \rrbracket^g = \lambda x. \llbracket \beta \rrbracket^{g[i \rightarrow x]}$,

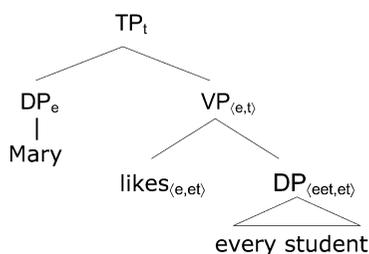
where *g* is an assignment function and $g[i \rightarrow x]$ a modification of *g* such that

- a. $\text{dom}(g[i \rightarrow x]) = \text{dom}(g) \cup \{i\}$
- b. $g[i \rightarrow x](i) = x$
- c. $g[i \rightarrow x](j) = g(j)$ for all *j* such that $j \in \text{dom}(g) \ \& \ j \neq i$

- (9) $\llbracket \llbracket \text{Every student } 6 \llbracket \text{Mary talked to } t_6 \rrbracket \rrbracket \rrbracket^g = 1$
 iff $\llbracket \text{Every student} \rrbracket^g (\llbracket 6 \text{ Mary talked to } t_6 \rrbracket^g) = 1$
 iff $\llbracket \text{Every student} \rrbracket^g (\lambda x. \llbracket \text{Mary talked to } t_6 \rrbracket^{g[i \rightarrow x]}) = 1$
 iff $\llbracket \text{Every student} \rrbracket^g (\lambda x. m \text{ talked to } g(6)) = 1$
 iff $\llbracket \text{Every student} \rrbracket^g (\lambda x. m \text{ talked to } x) = 1$
 iff $\forall x[\text{student}(x) \rightarrow m \text{ talked to } x]$

The other class of approaches to the problem of quantifiers in object positions employs flexible types. Rather than relying on syntactic movement, these approaches assume that the grammar can provide variants of each quantifier suited to particular combinatorial situations, including the situation where the quantifier appears in object position.⁸ When a quantifier serves as the direct object of a transitive verb, for instance, it needs to be of type $\langle e, et \rangle$ (the type of the determiner, in turn, needs to be $\langle et, \langle e, et \rangle \rangle$), so that it can take the transitive verb as argument and return a predicate denotation, (10).

(10) Mary likes every student.



- (11) a. $\llbracket \mathbf{every}_1 \mathbf{student} \rrbracket = \lambda g \in D_{et}. \lambda y \in D_e. \forall x [x \text{ is a student} \rightarrow g(x)(y)]$
 b. $\llbracket \mathbf{every}_1 \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{et}. \lambda y \in D_e. \forall x [f(x) \rightarrow g(x)(y)]$

As can be seen in the lexical entry in (11)b, $every_1$ works basically like the original $every$ ($every_0$), except that it takes on a function of type $\langle e, et \rangle$ as its second argument rather than a function of type $\langle e, t \rangle$. Importantly, the extra argument is not operated on by the quantifier and is simply passed on to the next higher node. Hence, assuming that $every$ has a second incarnation, $every_1$, does not commit one to a true lexical ambiguity thesis since $every_1$ can be derived from $every_0$ via type-shifting rule. Quite generally, in fact, it is possible to define a family of determiner meanings based on the simplest type (Level 0 meaning) as in (12), see Keenan (2005).⁹ (13)a,b,c exemplify how three versions of $every$, to be used for subjects, internal arguments of transitive verbs and inner-

⁸ Alternatively, one might assume that verbs come in two varieties, one that is equipped to combine with a type e object and one that is equipped to combine with a quantifier, see Montague (1974). Again the second version can be systematically related to what appears to be the basic meaning.

⁹ Keenan (2005) does not, in fact, rely on type-shifting rules. Rather, he assumes that determiners denote functions whose domain is disjunctively specified to cover all members of the family. Under this view, quantifiers never create type-mismatch problems (which would trigger type shifting or movement) because they are always immediately interpretable.

most arguments of ditransitive verbs, respectively, can be derived this way.¹⁰

- (12) For any determiner D with a Level 0 denotation, $\llbracket \mathbf{D}_0 \rrbracket$, of type $\langle et, ett \rangle$, there is a family of determiners D_n of type $\langle et, \langle \langle (n+1)e, t \rangle, \langle ne, t \rangle \rangle \rangle$ ($n = 0, 1, 2, \dots$) such that

$$\llbracket \mathbf{D}_n \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{(n+1)et}. \lambda \gamma_1 \in D_e. \dots, \lambda \gamma_n \in D_e. \\ \llbracket \mathbf{D}_1 \rrbracket (f) (\lambda x. g(x) (\gamma_1) (\gamma_n))$$

- (13) a. $\llbracket \mathbf{every}_0 \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{et}. \forall x [f(x) \rightarrow g(x)]$
 b. $\llbracket \mathbf{every}_1 \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{eet}. \lambda y_1 \in D_e. \llbracket \mathbf{every}_0 \rrbracket (f) (\lambda x. g(x)(y_1))$
 c. $\llbracket \mathbf{every}_2 \rrbracket = \lambda f \in D_{et}. \lambda g \in D_{eeet}. \lambda y_1 \in D_e. \lambda y_2 \in D_e. \llbracket \mathbf{every}_0 \rrbracket (f) (\lambda x. g(x)(y_1)(y_2))$

A moment of reflection reveals that the two approaches discussed propose essentially the same solution, though the means by which the resolution is obtained are quite different. In both cases, the object quantifier eventually combines with a λ -abstracted expression whose associated variable occupies the thematic position of the transitive verb and predication is mediated through that variable (quite similar to how quantificational subjects are analysed). They differ, however, in how the λ -expression is generated.¹¹ In the QR-based theory, syntactic movement is critically implicated because it is DP movement which generates traces and triggers the insertion of a λ -operator. According to the flexible types hypothesis on the other hand, it is the (type-shifted) quantifier which introduces the required λ -operator. Crucially, this happens

¹⁰ This analysis can also be extended to referring expressions if proper names and definite descriptions are not analysed as denoting an entity but as denoting the set of properties that the entity has. This will give them a Level 0 denotation of type $\langle et, t \rangle$, (10), and higher levels can be generated as in (12).

- (i) a. $\llbracket \mathbf{Mary} \rrbracket = \lambda f \in D_{et}. f(m).$
 b. $\llbracket \mathbf{the\ secretary} \rrbracket = \lambda g \in D_{et}. \exists! x [\text{secretary}(x) \ \& \ g(x)].$

Extending the treatment in (12) to all DPs, irrespective of whether their core semantic requires it or not, amounts to generalizing to the worst case.

¹¹ Note that the two proposals seem to differ also with regard to the external argument. According to the movement account, the thematic subject position is in the scope of the object quantifier, while the opposite is true for the flexible types approach. The analysis of inverse scope readings requires yet another type for the flexible types approach, $\langle eet, ett \rangle$, and assumptions about possible landing sites for the movement approach. Keenan (2005) assumes in fact a mixed system where DP movement is held responsible for inverse scope and flexible types account for integrating quantifiers in object position.

only in the semantics when the combination of object quantifier and transitive verb is given its interpretation. Hence, under this view, the syntactic structure of a sentence with an object quantifier remains unchanged.

Deciding which of the two types of approaches to prefer is a difficult task, as both successfully account for the grammaticality of sentences with object quantifiers and the evidence from word order is neutral. Indeed, proponents of both views can be found and the considerations that various practitioners take to be decisive are typically rooted in preferences for an entire framework.¹² The goal of the present paper is to introduce a new kind of evidence that is not crucially grounded in any theoretical framework. Before we get there, however, a brief review of another grammatical phenomenon of English, antecedent-contained deletion (ACD), is in order.

3 ANTECEDENT-CONTAINED DELETION

ACD refers to cases of ellipsis such as the one exemplified in (14) below, see Bouton (1970) etc.

- (14) a. John talked to every student that Mary did.
 b. John talked to every student [_{RC}that Mary did ~~talk to~~].

The sentence in (14) contains a relative clause which is attached to the direct object DP. The VP inside the relative clause is, however, elided as indicated in (14)b. Importantly, the antecedent of the elided VP seems to be the matrix VP, giving rise to a configuration where an elided constituent is contained inside the constituent that serves as its antecedent, hence the name ACD. This is schematically illustrated in (15)b, where we use boxes to indicate the elided constituent and the antecedent constituent.

¹² Proponents of the *in situ* approach include Montague (1974) [though Montague (1974) also had quantifying in], Hendriks (1993), Jacobson (1992), Jacobson (2008), Barker (2002), etc., as well as the proposal of Kempson *et al.* (2001), according to which the computational engine is insensitive to the referential v. non-referential distinction. Movement accounts can be found in May (1977), May (1985), Hornstein (1994), Heim and Kratzer (1998) and Fox (2003) among many others.

(15) John talked to every student [_{RC}that Mary did ~~talk to~~]].

Cases like (14) might invite one to try to avoid the issue of antecedent containment by postulating that it is only the verb and not the entire VP that is elided. However, it is easy to see that this is not a viable approach in general. Cases like (16), for instance, in which the elided constituent is a complex VP that embeds an entire infinitival clause, show that ACD is not confined to the elision of verbal heads.

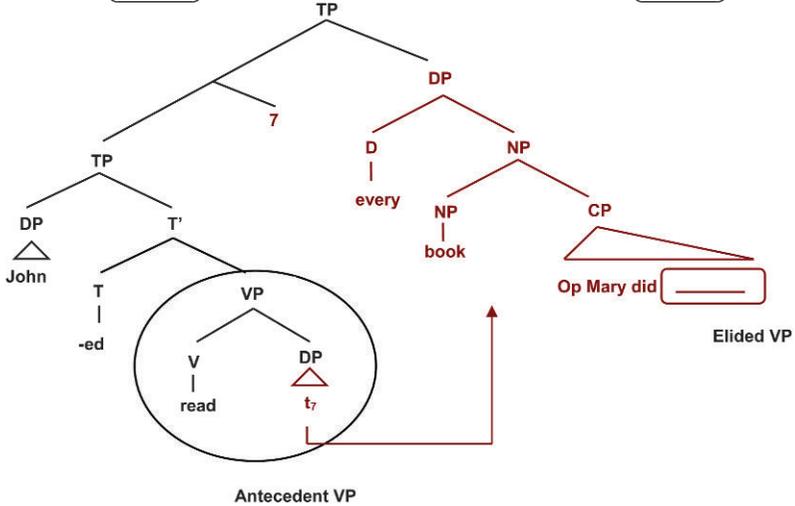
(16) a. John was willing to talk to every student that Mary was.
 b. J. was willing to talk to every student [_{RC}that M. was ~~willing to talk to~~]].

The fact that the VPs in (14) and (16) can be elided is rather unexpected since ellipsis is subject to a licensing condition which requires identity between the elided constituent and its antecedent, see Sag (1976). However, since a container cannot be identical to something it properly contains, identity between the matrix VP and the elided VP inside the relative clause should be impossible and the sentences should be ruled out.

That they are, nevertheless, grammatical means that these sentences have structural descriptions in which identity between the elided VP and the matrix VP can be established after all. Specifically, the composition of the matrix VP must be such that there is no containment at the relevant level of representation. Furthermore, the object positions (one inside the relative clause and one in the matrix) must be construed so that the two VPs can be identical once containment is undone even though the position is gapped inside the relative clause and realized by a full DP in the matrix.

The standard analysis of ACD, Sag (1976) and much subsequent work, relies on syntactic movement to provide the ingredients for a resolution of these two issues. Overt syntactic movement of the relative pronoun (alternatively a relative clause operator or NP copy) from the base position inside the VP to the left edge of the relative clause is assumed to be responsible for creating the object gap. The gap is assumed to be realized by a trace that is bound by the relative pronoun. On the other hand, covert movement of the DP hosting the relative clause is invoked for the purpose of resolving antecedent containment. This creates a configuration where the elided VP is no longer contained inside the antecedent VP and both VPs have traces in their object position, (17).

- (17) a. John read every book that Mary did.
 b. John $\boxed{\text{read } t_7}$ $_7$ [every book [OP₆that Mary did $\boxed{\text{read } t_6}$]].



As discussed in the previous section, movement of the host DP to a position above the matrix VP creates a gap which is occupied by a trace which is then interpreted as a variable bound by the moved DP. To ensure that the resulting structure furnishes VPs that support ellipsis, it is furthermore assumed that traces can be considered identical for the purpose of ellipsis licensing if they are bound from parallel positions, *Rooth (1992)*.

The covert movement of the host DP in (17) is just an instance of QR, that is the kind of movement that was also assumed to resolve the problem of a quantifier in object position in (7). Note, however, that the reason for moving the object is different here. Rather than to resolve a type mismatch, the movement happens in order to resolve antecedent containment. Hence QR of an object DP hosting an ACD site is independent of the semantic properties of the object DP itself, occurring even when the DP hosting the ACD site is definite, (18).

- (18) a. John read the book that Mary did.
 b. John read the book [_{RC}that Mary did read].
 c. John $\boxed{\text{read } t_7}$ $_7$ [the book [OP₆that Mary did $\boxed{\text{read } t_6}$]].

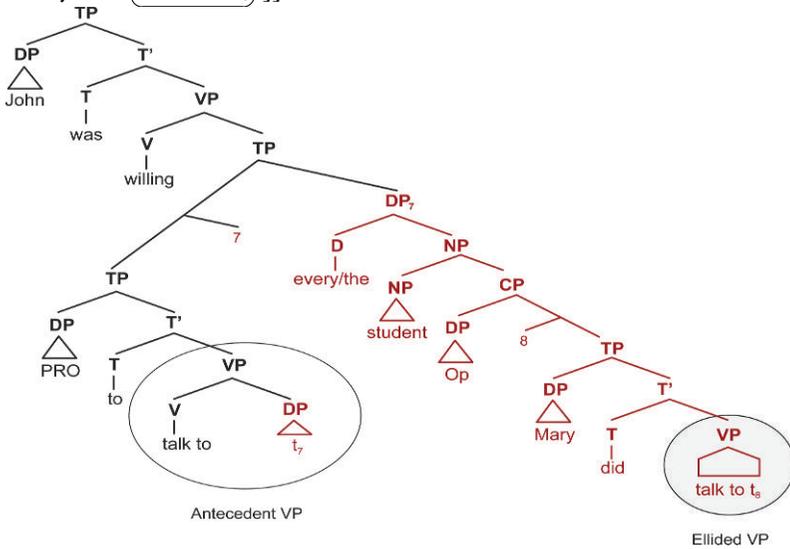
Note furthermore that the set of possible landing sites for ACD-triggered movement is potentially different from the set of landing sites for regular QR. To resolve a type mismatch of a quantifier in object position, the most local clausal node is an available landing site since the resolution of the type mismatch requires only that there be a trace in

object position and that the moved quantifier be adjoined to a clausal node.¹³ In the case of ACD-triggered movement, however, the landing site has to be high enough to undo antecedent containment. If the antecedent VP does not contain the most local clausal node, that node is a potential landing site for both type-mismatch-triggered QR and ACD-triggered QR. However, if the antecedent VP does contain the most local clausal node, that node is only available for type-mismatched QR. ACD-triggered QR needs to target a higher clausal node that allows for the resolution of antecedent containment. This can be seen clearly in the sentence pair in (19).

- (19) a. John was willing to talk to every student that Mary did talk to .
- b. J. was willing to talk to every student [_{RC}that M. was willing to talk to] .

In (19)a, the ellipsis site is marked with the auxiliary *did* and the ellipsis is resolved so that the local VP [_{VP} talk to ...] serves as the antecedent. To undo antecedent containment, it is sufficient to raise the DP to a clausal node above that VP, which is the same node targeted by raising a quantifier in object position to resolve a type mismatch, (20).

- (20) John was willing to talk to t₇ [₇every/the student [_{RC} that Mary did talk to t₆]].



¹³ In fact, under the assumption that movement is always to the most local landing site that yields a well-formed structure with the intended interpretation, the most local clausal node is the only possible landing site, see Fox (1995).

John) have been recommended by Mary (de re). (22)b can be understood in the same two types of ways; however, (22)c has only the de re reading—it can be used to report a state of affairs in which the books that John was willing to read happened to be also books that Mary was willing to read, but it cannot be used to report John’s willingness to read whatever book Mary was willing to read. In other words, when the elided VP is large enough so that its antecedent contains the modal operator *willing*, the DP hosting the ACD cannot be interpreted in the scope of that modal operator, precluding a de dicto reading. The standard analysis predicts this correlation; under this analysis, it is DP movement above the antecedent VP that resolves antecedent containment and this entails that the DP is no longer in the scope of the modal operator.

While approaches to ACD that rely on syntactic movement of the host DP can straightforwardly explain these fundamental properties of ACD, it is worth pointing out that alternative approaches are conceivable as long as they provide a structure in which there is no antecedent containment at the relevant level of representation and a way of establishing identity between the elided VP, which has an object gap, and an antecedent VP, which has a full DP object.¹⁴

An example of a non-movement-based approach to ACD that delivers these desiderata can be found in Cormack (1984) as well as in Jacobson (1992, 2008, etc.). In these approaches, which rely on a richer inventory of semantic composition principles, the object gap inside the relative clause in (23) is empty rather than occupied by a trace. Semantic composition can proceed via function composition, which combines the regular denotation of *read*, type $\langle e, et \rangle$ with a type-lifted version of the subject, type $\langle et, t \rangle$, (23c). The resulting denotation can be the input to the ‘Geach Rule’ producing a node of type $\langle ee, et \rangle$, (23d). The net effect is that the open argument position is passed on to the TP level inside the relative clause where it is filled by the relative pronoun, which, like all pronouns, is assumed to denote the identity function over individuals (type $\langle e, e \rangle$), (23)b–f.¹⁵

¹⁴ Baltin (1987) proposes a treatment of ACD in which relative clauses that host an ACD site are always extraposed. While this resolves the problem of antecedent containment, it does not resolve the question of parallelism since the antecedent VP has a full DP object, whereas the elided VP has a trace, as pointed out in Larson and May (1990). See Fox (2002) for a treatment of ACD that combines Baltin’s idea with the copy theory of movement, Chomsky (1995), in such a way that both issues are resolved.

¹⁵ See Jacobson (1992, 2008) for motivation to employ the Geach Rule in the composition of the relative clause rather than simple function composition.

- (23) a. John read every book which Mary did **read**.
 b. $\llbracket \mathbf{read} \rrbracket = \lambda x. \lambda y. y \text{ read } x$.
 c. $\llbracket \mathbf{Mary read} \rrbracket = \llbracket \mathbf{Mary} \rrbracket \circ \llbracket \mathbf{read} \rrbracket = [\lambda h \in D_{et}. h(m)] \circ [\lambda x. \lambda y. y \text{ read } x] = \lambda x. m \text{ read } x$
 d. $\llbracket \mathbf{which} \rrbracket = \lambda x \in D_e. x$.
 e. $\llbracket \mathbf{which Mary read} \rrbracket = \llbracket \mathbf{Mary read} \rrbracket (\llbracket \mathbf{which} \rrbracket) = \lambda x. m \text{ read } x$.

Eliding the VP inside the relative clause in (23), given that the object gap is never filled, amounts to eliding the transitive verb and thus requires finding an antecedent transitive verb with identical meaning. Such an antecedent can be readily found in the matrix verb without ever facing an issue of antecedent containment.

Cases like (24), on the other hand, where the elided material is more complex than just a lexical head, require the composition of an identical verbal complex in the matrix. This can be achieved via function composition. Specifically, rather than combining the matrix verb *read* with its object DP right away, it is first composed with the heads to its left in a step-by-step fashion ($\llbracket \mathbf{willing} \rrbracket \circ (\llbracket \mathbf{to} \rrbracket \circ \llbracket \mathbf{read} \rrbracket)$) to yield a complex verb *willing to read*, which can then serve as antecedent for the elided complex transitive verb.¹⁶ Inside the relative clause, a parallel composition produces a complex verb that is then Geach shifted to $\langle ee, eet \rangle$ and composition of the relative clause proceeds as before.

- (24) a. John was willing to read every book which Mary was **willing to read**.
 b. $\llbracket \mathbf{willing to read} \rrbracket = \lambda x. \lambda y. y \text{ is willing to read } x$.
 c. $\mathbf{g}(\llbracket \mathbf{willing to read} \rrbracket) = \lambda f \in D_{ee}. \lambda x. \lambda y. y \text{ is willing to read } f(x)$.
 d. $\llbracket \mathbf{Mary was willing to read} \rrbracket = \llbracket \mathbf{Mary} \rrbracket \circ (\llbracket \mathbf{was} \rrbracket \circ \mathbf{g}(\llbracket \mathbf{willing to read} \rrbracket)) = \lambda f \in D_{ee}. \lambda x. m \text{ was willing to read } f(x)$.
 e. $\llbracket \mathbf{which} \rrbracket = \lambda x \in D_e. x$.
 f. $\llbracket \mathbf{which Mary was willing to read} \rrbracket = \lambda x. m \text{ was willing to read } x$.

As in the simpler case discussed above, the issue of antecedent containment does also not arise here since the elided expression is a complex verb and not a verb with a trace. The antecedent to this elided verb is composed in the matrix by holding off on integrating the object DP that

¹⁶ To keep things more readable, we are abstracting away from the intensional properties of *willing* and the temporal properties of *was*.

hosts the ellipsis site until the complex verb *willing to read* is formed.¹⁷ Thus, the issue of antecedent containment is avoided in this system by analysing ACD as a case of (complex) transitive verb ellipsis and the issue of identity between a gapped and a non-gapped VP is resolved by delaying the integration of the object, (25).

- (25) a. John read every book Mary did read.
 b. John was willing to read every book Mary was willing to read.

Both types of approaches agree on the essential properties of ACD sentences even though the means by which the required structure is generated are quite different. They agree that the elided material cannot be contained inside its antecedent at the relevant level of representation and that an essential ingredient to warrant this is that the integration of the object DP is delayed until the antecedent constituent is formed. They disagree, however, as to the nature of the elided and antecedent constituent as well as the operations that allow delaying the integration of the object DP.¹⁸

For our purpose, the most salient difference between the two types of approaches is whether ACD resolution and object integration are seen as independent of each other. According to the type-shifting/function composition approach to ACD (TSH/FC), they are, since the elided constituent and its antecedent are (simple or complex) verbs. Thus integrating the object DP with the matrix verb (simple or complex) proceeds in whatever way it is assumed to proceed, given the semantic properties of the object DP. According to the movement approach, however, the two phenomena are linked since both can be dealt with using the same mechanism, namely QR.¹⁹ Thus, if the object DP is quantificational, QR occurs irrespective of whether it hosts an ACD site, and if there is an ACD site, QR occurs irrespective of whether the

¹⁷ See [Cornack \(1984\)](#) for suitable assumptions about intensional function composition that predict the Sag-Williams correlation between size of the ellipsis scope of the object DP discussed above.

¹⁸ The disagreement on the second point is less substantial than it might appear at first sight since the set of operations that the function composition approach to ACD calls upon to delay object integration are the same operations that it calls upon to deal with 'movement' dependencies in general.

¹⁹ That the two phenomena are in principle separable does not depend on the existence of a function-composition account of ACD, however. That is, it is a coherent (though to our knowledge nowhere actually endorsed) view to assume that quantifiers in object position are dealt with via flexible types but that ACD is resolved via movement. [Keenan \(2005\)](#) does not discuss ACD but could be extended in this way since both flexible types and DP (movement for the purpose of generating inverse scope) are assumed there.

object DP is quantificational. This difference is schematically summarized in the tables in (26), where we cross the two phenomena (\pm ACD and \pm Quantificational Object) and fill in the cells with the operations that are predicted to be necessary to deal with the various combinations of ACD and quantifiers in object position. We use TSH as a label for a type-shifting operation that is required by integrating a quantifier in object position and FC, ‘function composition’, as label for the operation that is necessary for large ACD resolution to construct the antecedent verb. FC in parenthesis marks that function composition is only required in the large ellipsis condition.

(26) a. Movement based Approach. b. Type-Shifting based Approach.

	-ACD	+ACD
-Quant	---	QR
+Quant	QR	QR

	-ACD	+ACD
-Quant	---	(FC)
+Quant	TSH	TSH+(FC)

Zeroing in on the lower right-hand cells, [+Quant,+ACD], we see that the movement approach requires one application of QR when both phenomena are instantiated, while the type-shifting/ function composition approach requires two separate operations, each dealing with one but not the other phenomenon. Thus, the two phenomena are predicted to be linked on the movement view and independent on the type-shifting/function composition view.

Even though the issue of (in)dependence between object quantifier integration and ACD resolution is theoretically straightforward, finding off-line evidence in support of one view or the other is not. Off-line judgments, as long as the same grammatical object is generated, are simply not sensitive to whether a single operation occurred or whether two separate operations occurred. The next section presents an experimental investigation of this issue in which we exploit aspects of real-time sentence processing that allow us to tease apart the two views.

4 PROCESSING ACD WITH AND WITHOUT QUANTIFICATIONAL HOSTS

The advantage that real-time sentence processing offers over off-line judgments lies in its inherent linear organization. It allows us to differentiate the two approaches in terms of the predictions they make for

sentences that combine both a quantifier in object position and an ACD site hosted by that quantifier. We argue, more specifically, that the QR view predicts that the two phenomena interact in how they affect sentence processing because they are necessarily linked, while the TSH/FC view predicts that they do not, since they are seen as independent.

To our knowledge, neither phenomenon has been studied systematically in the processing literature. The study of quantifier comprehension has been focused for the most part on processing aspects of inverse scope phenomena (Kurtzman and MacDonald, 1993; Tunstall, 1998; Anderson, 2004),²⁰ while the study of ellipsis comprehension has focussed, with one exception, on cases of ellipsis other than ACD. Frazier and Clifton (2005) report a questionnaire study in which ACD sentences were rated as less natural than minimally different sentences that had no ACD site and that this effect was larger the further downstream the ACD site was located from the antecedent.²¹ This suggests that ACD resolution incurs a processing cost, which is in agreement with the more general finding that processing a sentence that contains elided material is more costly relative to a baseline sentence that does not have ellipsis (Murphy, 1985; Shapiro and Hestvik, 1995; Frazier and Clifton, 2001; Frazier and Clifton, 2005; Anderson, 2004; Martin and McElree, 2008). This is unsurprising since processing an ellipsis site involves the resolution of an anaphoric dependency between ellipsis site and its antecedent. What the precise nature of the antecedent is and how it is accessed in real time are controversial issues in the theoretical and experimental literature. However, since the two approaches to quantifier integration and ACD we are concerned with are equally compatible with a variety of different views and since none speak directly to our cases, we will make only minimal assumptions, which are sufficient to provide a clear way of differentiating the two approaches under discussion.

We introduce these assumptions via a consideration of how a left-to-right parser's behaviour might differ across the sentences in (27).

- (27) a. Mary talked to the student that Bill liked.
 b. Mary talked to every student that Bill liked.
 c. Mary talked to the student that Bill did.
 d. Mary talked to every student that Bill did.

²⁰ See Warren and Gibson (2000) and Gordon *et al.* (2004) for recent work on how various types of DPs affect the processing costs of the relative clauses that host them.

²¹ Frazier and Clifton (2005) do not vary the determiner of the host DP in their study. They always use the existential quantifier *some* in their material. We thus do not have evidence from their study whether a particular choice of determiner has an effect on naturalness ratings of ACD. See Experiment 2 for related discussion.

(27)a contains neither a quantifier in object position nor an ACD site and thus functions as a baseline for the other sentences in the paradigm. (27)b and (27)c contain an object quantifier and an ACD site, respectively. As we have seen, this means that they are, in some form or other, more complex than (27)a. The nature of the complexity increase is, of course, specified differently by the two theories under consideration. According to the QR view, both (27)b and (27)c have a different and arguably more complex syntactic structure than (27)a, namely one in which the object DP is QRed. Additionally, (27)c contains an anaphoric dependency between the elided VP and the antecedent VP. According to the TSH/FC view, the additional complexity of (27)b and (27)c does not come from having a different syntactic structure from (27)a. Rather, (27)b can be seen as more complex than (27)a because the type of object is of a higher order and (27)c as more complex because it contains an additional anaphoric dependency between the elided verb and its antecedent that is absent in (27)a.

If the parser is sensitive to these types of complexities, one might expect an increase in processing cost associated with the respective positions for both (27)b and (27)c over (27)a.²² This expectation is based on the assumption that, all other things being equal, incremental parsing proceeds by postulating the simplest possible structure consistent with the evidence encountered so far and that switching to a more complex, and thus less preferred, parse is costly.²³ For the cases in (27)b and (27)c, it is the quantifier in object position and the ACD site which force the parser to postulate a more complex parse.²⁴ Note, however, that both approaches would be equally compatible with such processing costs since the precise nature of the complexity induced by these phenomena is potentially immaterial to making these predictions. Thus, it is not straightforward how to distinguish the two views based on (27)b and (27)c alone.²⁵

²² See Varvoutis (2006) for evidence that the parser is sensitive to the difference between a DP being referential or quantificational in situations of local ambiguity resolution.

²³ See for example Frazier and Rayner (1982) among many others.

²⁴ To say that a parse with an ACD site is more complex than a parse without an ACD site relies on a fairly general notion of a parse that includes anaphoric dependencies such as the one between the elided material and its antecedent.

²⁵ Arguably parses with an ACD site are more complex under the QR view of ACD than under the TSH/FC view since according to the former such sentences require both QR of the object DP and an anaphoric relation between the antecedent VP and the elided VP, while according to the latter, ACD parses differ from ones without ACD only in that they have an anaphoric dependency. However, whether or how this difference can be translated into a quantitative difference about increased processing costs is less straightforward.

Things are different, however, in the case of (27)d. According to the QR approach, (27)d contains two phenomena that require the application of the same operation, QUANTIFIER RAISING. The quantificational object requires QR for its integration, while the ACD site triggers QR in order to undo antecedent containment. In principle, neither of these triggers is dependent on the other. From the perspective of a left-to-right parser, however, they are expected to interact. Specifically, once the parser encounters the first trigger for QR and is forced to assume a less preferred parse containing a QRed object, the second trigger for QR is preempted—it would trigger an operation that has already occurred. Processing the ACD site should therefore be less costly for (27)d compared to (27)c in which QR has not already been triggered upstream of the ACD site.

The TSH/FC approach, on the other hand, does not make this prediction because object integration and ACD resolution are fully independent of each other. According to this view, integrating a quantificational object should be more costly than integrating a definite DP and integrating a relative clause with an ACD site should be more costly than integrating a relative clause without one—irrespective of whether the host DP is quantificational or not.

The two theories differ, then, with regard to whether they expect the semantic properties of the host of an ACD site to affect ACD resolution during real-time sentence processing. The next section presents two sentence processing studies that follow the logic laid out here.

4.1 *Experiment 1: processing ACD with and without quantificational hosts*

4.1.1 *Experimental design* Our first experimental design follows the logic discussed in (27). We manipulated two factors: ‘Determiner Type’ and ‘Ellipsis’. Determiners were either quantificational (*every*) or not (*the*) and ellipsis was either present (the VP was elided and marked by the auxiliary *was*) or absent (the VP was projected from a phonetically overt verb). This results in a 2×2 design exemplified in (28).²⁶

- (28) The understaffed general hospital was negotiating with ...
- a. **the** doctor that the nonprofit medical organization **funded**
 - b. **the** doctor that the nonprofit medical organization **was**

²⁶ To avoid the possible interpretation of the ellipsis marker *did* as a main verb (e.g. *John did the puzzle*), we used the past progressive for the matrix verb, *was* as the ellipsis marker, and past tense for the embedded verb.

- c. **every** doctor that the nonprofit medical organization **funded**
- d. **every** doctor that the nonprofit medical organization **was** ... in order to arrange for free vaccination clinics.

To study how sentences of this sort are processed in real time, we use the self-paced reading methodology, Just *et al.* (1982). Making precise predictions about increased processing costs that are due to a particular factor amounts to predicting slowdowns in reading time at a particular region relative to a baseline. For our factors and the two theories under consideration, the following predictions can be derived.

With regard to the determiner site both theories expect a slowdown associated with *every*, (28)c and d, compared to *the*, (28)a and b, on or after the determiner site. In a TSH/FC-based framework, a slowdown associated with *every* is expected since its presence informs the parser that a higher typed object needs to be integrated. In a movement-based framework, a slowdown is expected because the parser needs to assume a structure with a QRed object DP. Moreover, slower reading times associated with *every* would be open to a variety of other interpretations; most prominently it could simply be due to a difference in lexical frequency between *every* and *the*. Thus, any difference associated with the determiner site will not be informative for our purpose.

Things are different for the second area of interest, the VP inside the relative clause. The TSH/FC approach expects a slowdown in reading time associated with the ellipsis site in the +Ellipsis conditions compared to the –Ellipsis conditions since the ellipsis site informs the parser that an anaphoric dependency needs to be resolved. That is, we expect a main effect of Ellipsis on or after the ellipsis site, which is immediately to the right of *was*, such that the *was* conditions, (28)b and d, will show a slowdown compared to the *verb* conditions, (28)a and c. In a framework based on movement, however, we do not expect a main effect. Instead, this framework predicts an interaction associated with the ellipsis site such that the *the-was* condition, (28)b, will show a larger slowdown in reading time relative to its baseline *the-verb*, (28)b, than the *every-was* condition, (28)d, will show relative to its baseline *every-verb*, (28)c.

Note that due to the complexity of the phenomena in question and the imperfect time course of measurements taken during real-time sentence processing, it is *a priori* not clear for either framework where exactly to expect the predicted effects to surface. For the determiner site, the earliest we might find the effect is on the determiner site

itself. However, it might also be the case that we would find it on the following noun due to spillover. For the ellipsis site, the earliest point at which we might see a slowdown attributable to ACD resolution is when the parser has determined that the structure to be generated involves ACD. Since the ellipsis site itself has no phonetic exponent and the auxiliary *was* is consistent with a variety of continuations that do not involve ellipsis (e.g. it might be followed by a progressive), the earliest point at which the parser can make this determination is the first word of the adjunct in (28), for example *in*. Thus, we might find a slowdown on the first word after the auxiliary *was* or, again, somewhat delayed due to effect of spillover and complexity of integration. Because of this uncertainty, for the first experiment, we will treat the first word where we could see an effect attributable to our factors as the starting point of our regions of interest and correct for multiple comparisons accordingly when testing hypotheses on later positions.

4.1.2 Methods and materials We constructed 60 sentence templates following the sample paradigm in (28) (see Appendix I for a complete list of target items). Each sentence in a template employed either a definite article or *every* as the determiner of the object DP. This DP, in turn, hosted either a object relative clause without ellipsis or one with an ACD site. The ellipsis site was preceded by the auxiliary *was* while relative clauses that had no ellipsis used a lexical verb in its place. To prevent possible interference due to anaphoric down-stressing, which is subject to licensing constraints that are very similar to ellipsis (see Tancredi (1992) among many others), we chose lexical verbs that were different from the matrix verb. Adverbs and adjectives were inserted between the determiner of the object DP and the ellipsis/verb site in the relative clause to create a large enough separation between the two factors of interest (the determiner and the verb/ellipsis site were separated by seven words in all our items). This was done to prevent possible spillover effects due to a determiner from interfering with the processing of material in the second area of interest. After the verb/ellipsis site, the sentences had adjunct clauses, which varied in length between 7 and 14 words, to provide a spillover region for detecting possible processing difficulty associated with the ACD. To ensure that the adjuncts would serve as unbiased carrier material for spillover effects and not interfere with the factors of interest, they were constructed so that attachment of the adjunct was consistent for all sentences of a given template (either in the relative clause or in the matrix). Moreover, the adjuncts were

constructed so that over the first five words of the adjunct, its proper attachment was not discernible.²⁷

Target items were counterbalanced across four lists using a Latin Square design and combined with 32 sentences of an unrelated experiment as well as 60 filler sentences of various types resulting in a total of 152 experimental sentences. Non-target items included sentences that were similar to the target items in structure (employing relative clauses, elided material or covert movement triggers), in length and in containing quantifiers.

Fifty participants, consisting of MIT undergraduates and members of the larger MIT community, recruited and run through MIT's Behavioral Research Lab, were tested on Mac computers running the Linger software developed by Doug Rohde. All were native speakers of English and received \$10.00 cash compensation for their participation. Each trial began with a series of dashes marking the length of the sentence. Participants press the spacebar to reveal the next word of the sentence. Each press of the spacebar reveals a new word while the previous word is again replaced by dashes. The amount of time a participant spends reading each word is recorded (RT). After the final word of each sentence, a yes/no comprehension question appears, asking about information contained in the sentence. Participants respond by pressing keys marked on the keyboard. If an incorrect answer is given, the message 'Oops! Wrong answer!' appears on the screen to encourage participants to read more carefully. Participants are instructed to read sentences at a natural rate and to be sure that they understand what they read. They are also instructed to answer the questions as quickly and accurately as possible. Items were pseudo-randomized separately for each participant, with at least one filler sentence preceding each target. Before the experiment began, a set of practice items was presented. Participants took approximately 35 minutes to complete the experiment. Participants were instructed to take short breaks during the experiment to prevent effects of fatigue or habituation to the task.

4.1.3 Results Questions across the full experiment (targets and fillers) were answered correctly 86% of the time across participants; questions for experimental items were answered correctly on 82% of trials. A two-factor analysis of variance (ANOVA) crossing Determiner (*the* versus

²⁷ Given the parser's preference for low attachment (see Minimal Attachment, early closure, etc.), this likely means that the parser assumed over the first five words that the adjunct clause would be attached inside the relative clause, making any effects observed in that region unlikely to be driven properties of the adjunct.

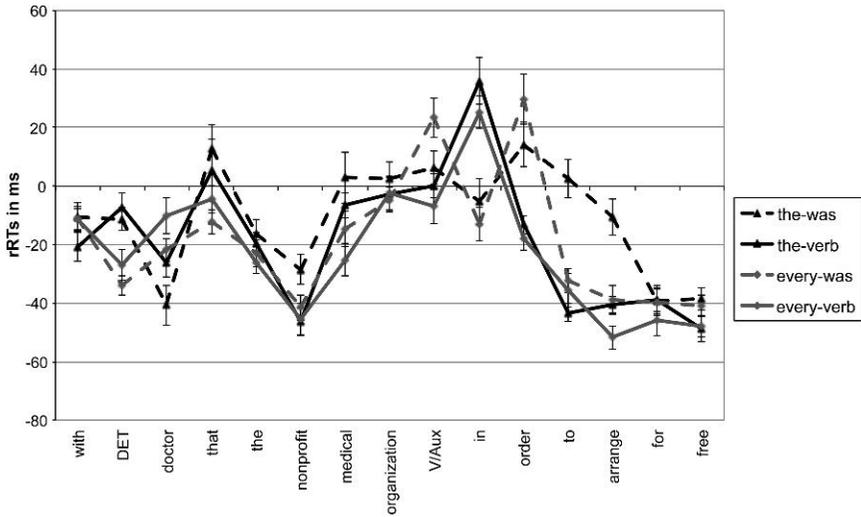


Figure 1 Average residual RTs for region of interest for Experiment 1 ($n = 44$).

every) with Ellipsis (Verb, Ellipsis) on the question-answering data revealed no significant differences. We excluded participants who did not answer more than 75% of the total items (targets and fillers) and more than 70% of the target items correctly. Six participants were excluded based on these criteria.

For all remaining participants, a regression equation predicting reading time from word length using all items was derived to adjust for differences in word length and differences in participants' natural reading rates. At each word position, the reading time predicted by the participant's regression equation was subtracted from the actual measured reading time to obtain a residual reading time. For each participant, residual reading times beyond two standard deviations from the mean for a given condition and position were excluded from analyses (less than 5% of the data). Additionally, six sentences had to be excluded due to a programming or computer error. Averaged word by word residual reading times (rRTs) in the region of interest are shown in Figure 1.²⁸

Visual inspection of the reading times at the determiner site marked as DET in Figure 1 reveals a crossing pattern such that on the determiner rRTs for *every* are below rRTs for *the* while on the noun after the

²⁸ See Raaijmakers *et al.* (1999) for discussion of why analyses by participants are appropriate for the type of counterbalanced design used in this paper. See Appendices I-A and I-B for items analysis and raw RT analysis of Experiment 1.

determiner the pattern is reversed. A repeated measures ANOVA with Determiner and Ellipsis as factors reveals a main effect of Determiner on DET ($F(1, 43) = 6.009$; $P < 0.05$) and a marginal main effect of Determiner on the following noun, which is, however, not significant after correcting for multiple comparisons. Post hoc testing of the two word region in question reveals that the rRTs for *every* and *the* differ significantly over the two word region. Specifically, a repeated measures ANOVA with Determiner, Ellipsis and Position (DET, DET+1) reveals a significant Determiner by Position interaction ($F(1, 43) = 10.246$; $P < 0.05$) such that rRTs for *every* increase at DET+1 relative to rRTs for *every* at DET while rRTs for *the* decrease. No other effects were found until the first word after lexical/auxiliary site (marked as V/Aux in Figure 1) inside the relative clause.

Visual inspection of the second region of interest starting with V/Aux reveals a crossing pattern over the first two words after V/Aux (P1, *in*, and P2, *order*, henceforth) such that on P1, rRTs for lexical verbs are higher than for the auxiliary, while the opposite is the case on P2. Repeated measures ANOVAs on P1 indicate a main effect of Ellipsis ($F(1, 43) = 4.73$; $P < 0.05$) on P1 and a main effect of Ellipsis on P2 ($F(1, 43) = 6.797$; $P < 0.05$).²⁹

The third region where we see an effect of our factors is on the third and fourth word after V/Aux, P3, marked by *to* and P4, marked by *arranged* in Figure 1. On both P3 and P4, visual inspection reveals that rRTs for sentences that have both a definite article and an ACD site (*the-was*) are higher than those for the other three conditions. A repeated measures ANOVA reveals a Determiner by Ellipsis interaction on P3, which remains significant after correcting for multiple comparisons, ($F(1, 43) = 7.987$; $P < 0.017$).³⁰ On P3 and P4, we find main effects of Ellipsis ($F(1, 43) = 5.619$; $P < 0.05$ and $F(1, 43) = 7.163$; $P < 0.05$, respectively), which, however, do not remain significant after correcting for multiple comparisons. Pooling rRTs of P3 and P4 reveals a main effect of Ellipsis ($F(1, 43) = 8.902$; $P < 0.017$) and a Determiner by Ellipsis interaction ($F(1, 43) = 6.121$; $P < 0.05$). We see the same effects in an analysis of the raw reading times and an analysis by items, albeit in a slightly noisier though still significant way, Appendices I-A and I-B.

²⁹ Since we do not have a priori reasons to exclude the V/Aux position as a point where we could see an effect of lexicality, that is difference between lexical verbs and the auxiliary, we might want to apply a Bonferroni correction for multiple comparisons (two comparisons for P1 and three for P2). If we apply such corrections, the main effect on P1 does not remain reliable ($p > 0.025$), while the one on P2 does ($P < 0.017$).

³⁰ We apply a Bonferroni correction of three comparisons given that the earliest point at which an effect of ellipsis can be expected is on P1, which is the first word that provides conclusive evidence for the presence of an ACD site in our items.

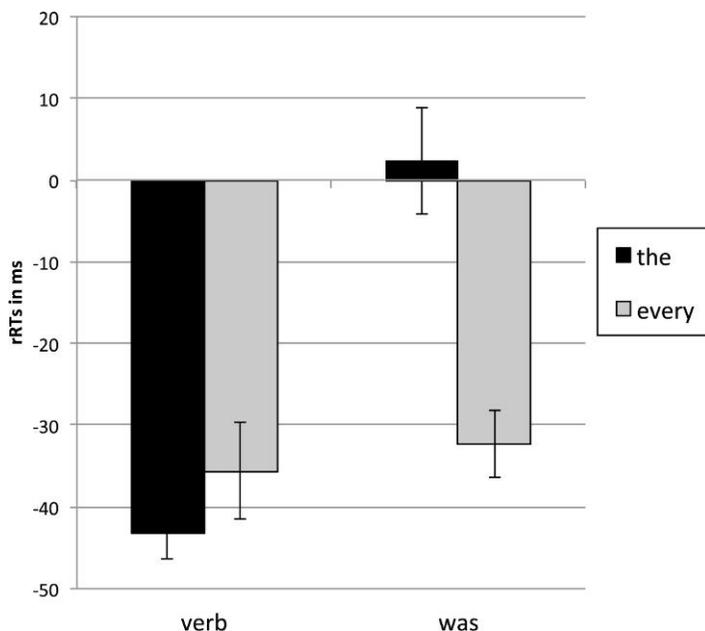


Figure 2 Residual RTs three words after V/Aux for Experiment 1 ($n = 44$).

To make the nature of this interaction more salient, we provide in Figure 2 a graph of rRTs from the site where we observe the interaction (three words after the V/Aux site).

As can be clearly seen in Figure 2, the interaction is driven by the fact rRTs for *the* increase markedly across the two Ellipsis levels while they do not for *every*. Post hoc pairwise comparisons show that average rRTs for *the-was* are significantly larger than any of the other three conditions. Looking specifically at the comparisons of interest, we see that *the-was* is significantly larger than *the-verb* ($t(43) = -3.239$; $P < 0.05$) and that *the-was* is significantly larger than *every-was* ($t(43) = 2.834$; $P < 0.05$), while *the-verb*, *every-verb* and *every-was* do not differ significantly from each other. Thus, the interaction is driven by the fact that rRTs for *the-was* are relatively high, while those for *every-was* are not different from the baseline conditions.

4.1.4 Discussion Our findings at the determiner site are difficult to interpret since both theories under discussion, albeit for different reasons, expected that integrating a quantificational DP would be more difficult than integrating a definite DP. Moreover, such an increase could be due to a variety of properties that differentiate *every* from *the* that

have nothing to do with a difference in combinatorial demands (lexical frequency, a difference in conceptual complexity, etc.) Thus, we cannot take this result as indicator for a difference in structural integration between *the* and *every*.³¹ To argue convincingly that the parser does integrate object quantifiers differently than it does definite DP objects, the evidence needs to come in the form of an interaction that takes a structural property of the sentence into account.

This type of evidence can be found in the second region of interest where the parser processes the VP of the relative clause and the subsequent material. Specifically, the Determiner by Ellipsis interaction we observe in the P3–P4 region post-V/Aux suggests that the choice of determiner affects ellipsis resolution in a rather specific way: upstream *every* facilitates downstream ACD resolution.³²

This facilitation effect is unexpected under the TSH/FC approach since integration of the host DP and ACD resolution are seen as independent. Under the QR approach to quantifier integration and ACD resolution, however, this interaction is expected. The reason is that the determiner properties can play a role in how the structure required for ACD resolution (which has the object DP QRed) is generated. Specifically, from the perspective of a left-to-right parser, it matters whether the ACD site is hosted by a quantifier. In the case where it is hosted by a definite DP, the parser encounters the evidence that QR is necessary only after determining that the VP of the relative clause is elided. Thus, the cost of processing the ACD site is in this case comprised of a cost for QR and a cost for resolving the anaphoric dependency between the elided material and the antecedent. When the ACD site is hosted by a quantificational DP, the *every-was* condition in our cases, QR of the host DP has already been triggered much earlier in the sentence, at the point where the parser encountered the quantifier in object position. Hence, there is no QR-related work left when the parser has determined that the relative clause VP is elided and an antecedent has to be found. Consequently, ACD resolution downstream of *every* should

³¹ Note that the absence of a reliable effect of quantifierhood on the quantifier in object position is not sufficient to conclude that the structural integration of a quantificational object is not different from the structural integration of a definite object DP. It could simply be that the parser is too well oiled a machine when it comes to processing an object quantifier in simple cases like the ones used in this study for us to see any difference between a definite and a quantificational object and that a difference is detectable only if the parser is put under additional pressure. See Varvoutis (2006) for evidence that in cases of local ambiguity resolution where a DP might either be the object of a main verb or the subject of an embedded clause (the so-called NP/S ambiguity), quantifierhood is indeed a factor that affects the parser's behaviour.

³² The main effects of Ellipsis over the first two words following the V/Aux site are consistent with both approaches under discussion.

incur less of a cost than it does when the ACD site is hosted by a definite DP. The type of interaction we observed in our data is precisely of this sort and thus expected by a QR-based approach.³³

To sum up, our data suggest that a quantificational host DP, which in our cases is constructed with the determiner *every*, facilitates ACD resolution downstream when compared with a definite host DP. We suggested that this effect can be understood within a theory that links quantifier integration with ACD resolution and remains unexpected within theories that do not.

Before accepting this particular interpretation of our findings, it is worth considering whether there are alternative explanations of the data that do not involve a difference in structural integration between definite DPs and quantifiers. One idea could be that *every* facilitates (relative to the definite article) the processing of an attached relative clause for very general structure-independent reasons.³⁴ Thus, if processing a relative clause is made harder by some means (e.g. through the presence of an ACD site), it seems natural to expect that the increase in processing cost will be less for relative clauses that are attached to an *every* DP relative to ones that are attached to a *the* DP.³⁵ Note, however, that there is no evidence of a general facilitatory effect of this sort in our data. In fact, rRTs are indistinguishable for the two determiner conditions until the point where we see the interaction nine words after the complementizer. Moreover, it seems rather implausible that the absence of a more widely detectable advantage for *every*-relative clauses is due to a floor effect everywhere else other than the region where we see the interaction. Specifically, we see clear evidence of increased processing costs for lexical verbs over auxiliaries followed by the reverse pattern immediately afterwards. If *every* facilitates processing of a relative clause across the board, it would seem that it should be detectable at least in this region. However, we do not see any evidence of this sort. Thus, we deem an alternative explanation of the interaction along these lines difficult to maintain. Nevertheless, we would like to strengthen our

³³ Note that our data are problematic for any approach to ACD that is not sensitive to the semantic status of the object DP. Hornstein (1995), for instance, proposes that all objects are moved to a functional projection for case reasons (A-movement). This is, as Hornstein points out, high enough to license ACD. Since case-driven movement targets quantificational DPs and definite DPs alike, Hornstein would not predict any difference in ACD resolution depending on the semantic status of the host DP.

³⁴ For example one might hypothesize that *every* requires a contextually or linguistically given domain restriction more so than a definite article. See von Stechow (1994) for arguments that quantifiers require domain restriction. It is unclear to us, however, why definite articles would have a less strong demand for domain restriction than quantifiers given that they presuppose uniqueness.

³⁵ See Levy et al. (2009) for evidence that processing an extraposed relative clause is easier if the host DP is more likely to appear with a relative clause modifier.

results by replicating the findings of Experiment 1 and expanding on them in a way that tests whether a more idiosyncratic property of *every* that might not have anything to do with its structural integration is responsible for its facilitatory effect on ACD resolution.

4.2 Experiment 2: processing local and non-local ACD

Experiment 2 serves as a replication and extension of Experiment 1. It is designed to first replicate the results of Experiment 1 with a different set of items and second to probe whether properties of *every* that govern its structural integration (as opposed to more idiosyncratic properties that have nothing to do with that) are responsible for the facilitation effect it has on processing a downstream ACD site.

4.2.1 *Experimental design* The design of Experiment 2 follows the logic of the Experiment 1 in that two factors, Determiner and Ellipsis-Size, which govern determiner properties and ACD, respectively, are crossed. It expands on the previous design through the addition of a third level to our Ellipsis factor. Specifically, we will have two types of ACD sites in addition to the No-Ellipsis condition, one whose antecedent is a local VP (Small-Ellipsis) and hence requires only local QR of the host DP and one whose antecedent is a non-local VP (Large-Ellipsis) and hence requires non-local QR. This results in a 2 by 3 design exemplified in (29).

- (29) The doctor was reluctant to treat ...
- a. **the** patient that the recently hired nurse **admitted** ellipsis)
 - b. **the** patient that the recently hired nurse **did** ellipsis)
 - c. **the** patient that the recently hired nurse **was** ellipsis)
 - d. **every** patient that the recently hired nurse **admitted**
 - e. **every** patient that the recently hired nurse **did**
 - f. **every** patient that the recently hired nurse **was**
- ... after looking over the test results.

As can be seen in the sample paradigm in (29), we use two types of auxiliaries (*did* and *was*) to govern the size of the elided material. When the ACD site is marked by *did*, the local and thus smaller VP projected by *treat* serves as its antecedent; the Small-Ellipsis conditions (29)b and c can be paraphrased as *The doctor was reluctant to treat the/every patient that the recently hired nurse treated*. However, when the ACD site is marked by *was*, the antecedent is the larger non-local VP. Thus, the Large-Ellipsis

conditions (29)c and f are paraphrased by *The doctor was reluctant to treat the/every patient that the recently hired nurse was reluctant to treat.*

The No-Ellipsis condition, (29)a and d, in combination with the Small-Ellipsis condition, (29)b and e, repeats the design of Experiment 1, albeit with a different auxiliary. Thus, for these conditions, we expect to replicate the pattern we have observed in Experiment 1. Most importantly, we expect to see a Determiner by Ellipsis-Size interaction, which is central to our argument, such that *every* in (29)e shows a facilitation effect on processing ACD given its baseline in (29)d, while *the* in (29)b does not.

Including the Large-Ellipsis condition, (29)c and f, adds an aspect to the design that allows us to examine the facilitation effect we have observed with *every* in a new way. To see what we have in mind, recall from Section 3 that quantifier scope and ACD resolution interact in an important way in that the size of the elided VP determines the minimal scope of the host DP.

Within a QR-based theory, this correlation is explained as a by-product of the fact that the object DP hosting an ACD site has to be moved above its antecedent VP to undo antecedent containment. For our cases in (29)c and f, this means that the object DP has to be QRed above the matrix VP to furnish a structure that allows for resolution of the ACD site marked by *was*. Importantly, this position is higher than the lowest position that allows for the resolution of the problem of a quantifier in object position. That position is inside the embedded infinitival clause. Thus, under the assumption that QR is to the lowest, most local position possible, raising the object quantifier to resolve the problem of a quantifier in object position is not sufficient to undo antecedent containment. This, as we will argue, has important implications for left-to-right parsing.

In Experiment 1, we have seen that an upstream quantifier facilitates the resolution of a downstream ACD site, while an upstream definite article does not. The explanation given by a QR-based theory is that, in the case of a quantificational host, part of the work necessary to resolve ACD—movement of the host DP above the antecedent VP—has already been completed before the parser determines that ACD is at issue. Thus, less work is involved in the resolution of an ACD site in comparison to when it is hosted by a definite DP. However, this is only the case if QR of the host DP-triggered upstream is high enough so that the landing site of the quantifier is above the antecedent VP. For the quantificational items in Experiment 1 and for (29)d, this is the case because the antecedent VP is small enough to be in the scope of a locally QRed object quantifier. Crucially, however, the situation is

different in (29)f. Here, the ellipsis site is resolved for a larger VP, which contains the lowest interpretable position for an object quantifier. (29)f, therefore, requires non-local QR of the host DP to resolve antecedent containment. Importantly, since the parser can determine that non-local QR is required only after the parser has encountered the auxiliary *was*, two processes rather than just one are triggered by the ACD site: the host DP has to be moved (yet again) to a higher landing site in order to undo antecedent containment and the anaphoric dependency between the elided VP and its antecedent has to be resolved. In this respect, then, (29)f is like (29)c and we do not expect facilitation of ACD resolution here, despite the fact that the ACD site is hosted by a quantifier. Thus, we expect an interaction such that *every-did* is facilitated in comparison to *the-did*, while none of the other *every*-conditions show an advantage.

Additionally, under the QR approach, we expect a main effect of Ellipsis-Size such that processing costs for the *was*-conditions to be higher than those for the *did*- and the *verb*-conditions because resolving a long-distance ACD site requires longer movement of the host DP and the retrieval of a more complex antecedent. Whether the ellipsis resolution by itself is in fact more costly, the more complex the antecedent is, is a controversial issue in the literature. Murphy (1985) presents evidence showing that reading times for sentences with VP ellipsis are longer if the antecedent is more complex. Frazier and Clifton (2001), on the other hand, do not find evidence for a comparable complexity effect on reading times, and Martin and McElree (2008) find no complexity effects (using a speed accuracy trade-off procedure) in either speed or accuracy of retrieving more complex antecedents with the sole exception that antecedents that involve more discourse entities lower accuracy of retrieval.³⁶ Since the evidence is split on this matter and, more importantly, since our cases are structurally quite different from the cases examined in these papers,³⁷ we remain agnostic as to whether any increase in processing cost for non-local ACD over local ACD is due to non-local QR, the higher complexity of the antecedent or a combination of the two. In both cases, we predict a main effect of Ellipsis-Size.

³⁶ Frazier and Clifton (2001) attribute the lack of a complexity effect to the existence of a cost-free copy operation ‘Copy α ’, while Frazier and Clifton (2005) attribute it to structure sharing. Martin and McElree (2008) suggest in addition that the lack of complexity effects on the speed and accuracy with which antecedents are accessed indicates that they can be directly accessed in memory, that they are ‘content-addressable’, in parallel with other representations that were formed before encountering the ellipsis site. Hence, there is no timing disadvantage for ellipsis sentences in more complex sentences.

³⁷ The above-mentioned studies all study cases of VP ellipsis that is resolved across (conjoined) clauses.

To summarize, we expect less of a cost increase due to ACD resolution for *every-did* relative to its baseline *every-verb* than we do for *the-did* relative to its baseline, *the-verb*, but we do not expect similar facilitation when comparing the relative costs of *every-was* and *the-was*.

The predictions of the THS/FC view for our paradigm are, again, different. Under this view, we do not expect the determiner to play any role in processing ACD, irrespective of whether the ACD site is resolved locally or non-locally. In other words, we expect a main effect of Ellipsis-Size and no interactions.³⁸

Finally, an explanation of the interaction we found in Experiment 1 that attributes the effect to a more idiosyncratic non-structural property of *every* would predict yet another pattern. For instance, if the interaction is due to a general facilitation effect of *every* on processing a relative clause, we should observe the same facilitation for both ellipsis conditions. Thus, we would expect overall higher rRTs for the ellipsis conditions compared to the No-Ellipsis condition but we would also expect facilitation for *every* in both cases. That is, both *every-did* and *every-was* should have lower rRTs than their counterparts *the-did* and *the-was*.

4.2.2 Methods and materials We constructed 60 sentence templates following the sample paradigm in (29), (see Appendix II for a complete list of target items for Experiment 2). The matrix clause was always in the past tense and either employed an adjective or passivized verb as the predicate that embedded an infinitival clausal to allow for large ellipsis resolution triggered by *was*. Embedded clauses were constructed so that the downstream ellipsis marker *did* was naturally interpreted to involve local ACD. In all other respects, the sentences were constructed following the design considerations detailed for Experiment 1.

These 60 items were counterbalanced across six lists using a Latin-square design and combined with 20 sentences of an unrelated experiment and 100 filler items of various types resulting in a total of 180 experimental sentences. Non-target items included sentences that were similar to the target items in structure (employing relative clauses, elided material or covert movement triggers), in length and in containing quantifiers of various types so as to minimize the possibility of an experimental bias favouring one or the other determiner.

³⁸ Just like in the case of the QR theory, an increase in processing cost for the non-local ACD cases relative to the local ACD cases could be attributed to the need for function composition alone or the combination of function composition and the higher complexity of the antecedent.

The sentences were presented following the same procedure as outlined in Experiment 1. Since the experimental sentences were fairly complex and unusual in structure, we added a rating task to our procedure. Specifically, we asked participants to rate each sentence that they just read word by word on a five-point scale as to how difficult the sentence was to understand asking ‘How difficult was the sentence to understand?’ (1 = very easy, ..., 5 = very difficult). Forty-eight undergraduate students from the Claremont colleges participated in this study and received either \$10 cash or course credit for their participation. All participants were tested on a Dell personal computer running the Linger software in the Psycholinguistics Lab at Pomona College.

4.2.3 Results Questions for experimental items were answered correctly on 85% of trials. No participants had to be excluded based on their accuracy rates, that is all answered more than 75% of the total items (targets and fillers) and more than 70% of the target items correctly. A repeated measures ANOVA crossing Determiner with Ellipsis-Size (none, small, large) on the question-answering data revealed no significant differences. Further analyses included only sentences whose follow-up question was answered correctly.

The average difficulty rating on the five-point scale across all experimental items (fillers and target items) was 2.22. Target items were rated on average only slightly higher at 2.54 (with a standard deviation of 0.74) suggesting that our sentences were well within the range of understandable sentences. When we compare ratings of our target items, we observe a main effect of Determiner ($F(1, 47) = 23.792$; $P < 0.05$), a main effect of Ellipsis-Size ($F(2, 46) = 43.092$; $P < 0.05$) and a significant Determiner by Ellipsis-Size interaction ($F(2, 46) = 6.351$; $P < 0.05$), which is driven by the fact that *every-did* sentences are rated easier than their *the-did* counterparts. This can be clearly seen in Figure 3.³⁹

Reading times of our sentences were analysed as in Experiment 1: we calculated residual reading times for each participant, trimming data points by condition and position if they were two standard deviations above or below the mean. Less than 5% of the data were trimmed by this procedure. Figure 4 presents average residual reading times for our six conditions.

³⁹ Post hoc tests show significant main effects of Determiner and Ellipsis-Size as well as Determiner by Ellipsis-Size interactions when comparing *verb* versus *did* ($F(1, 47) = 28.426$; $P < 0.05$; $F(1, 47) = 27.007$; $P < .05$; $F(1, 47) = 6.763$; $P < 0.05$) and *did* versus *was* ($F(1, 47) = 19.569$; $P < 0.05$; $F(1, 47) = 35.779$; $P < 0.05$; $F(1, 47) = 10.384$; $P < 0.05$) but only a main effect of Determiner when comparing *verb* versus *was* ($F(1, 47) = 84.777$; $P < 0.05$).

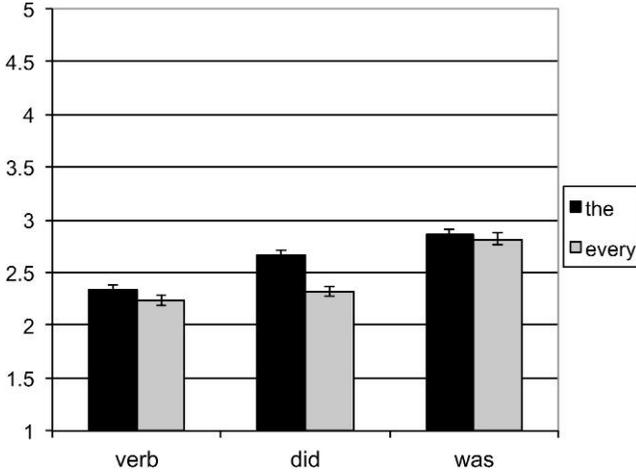


Figure 3 Average difficulty ratings on a five-point scale (1 = 'very easy', 5 = 'very difficult')

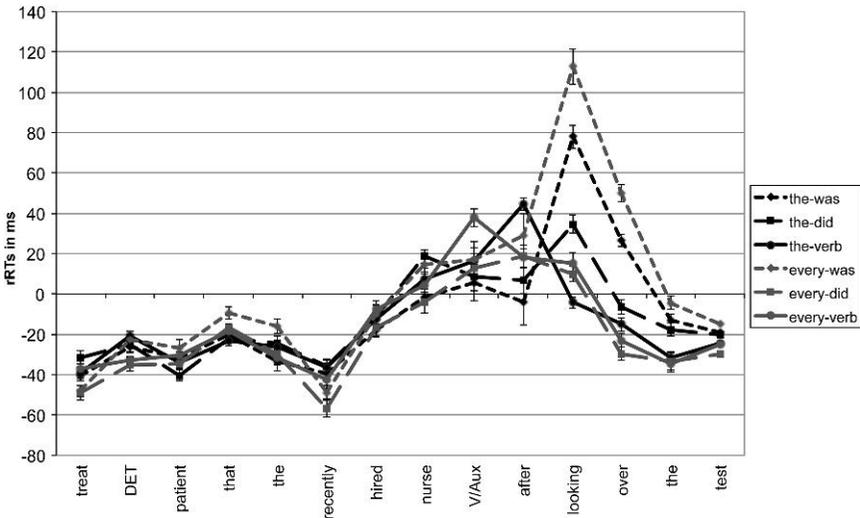


Figure 4 ACD resolution by Determiner and Ellipsis-Size ($n = 48$)

Visual inspection of the region we are interested in, the region that starts with the V/Aux site, reveals a complex crossing pattern over the first two words of that region followed by a prominent separation of rRTs that persists over the next two words before rRTs collapse again to comparable levels across all conditions. A repeated measures ANOVA (Determiner by Ellipsis-Size) reveals a main effect of Ellipsis-Size on the second and on the third word after the V/Aux position ($F(2, 46) = 13.059, P < 0.025$ and $F(2, 46) = 10.066; P < 0.017$,

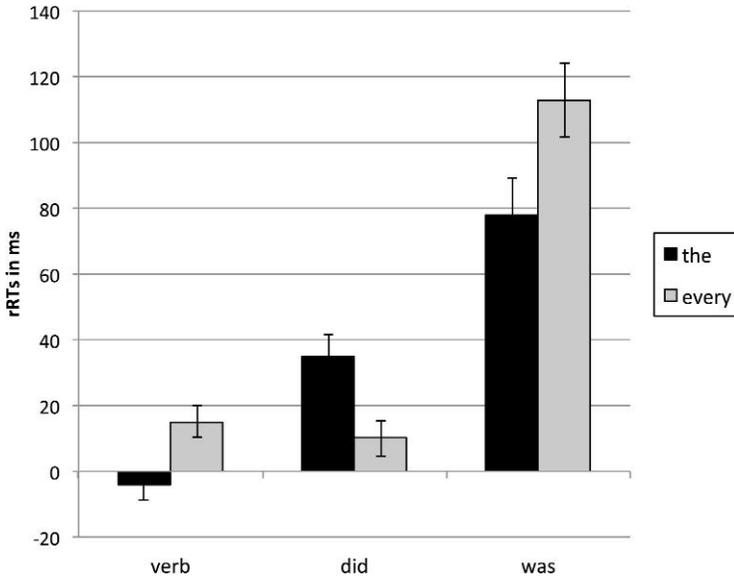


Figure 5 Pull-out graph of rRTs two words after V/Aux. ($n = 48$)

respectively) such that rRTs for the *verb* conditions are lowest followed by the *did* conditions followed by the *was* conditions.⁴⁰ We also observe a Determiner by Ellipsis-Size interaction on the second word after the V/Aux site ($F(2, 46) = 4.297$; $P < 0.025$), which, when pooling rRTs, persists over the entire region starting with the second word after the V/Aux position and ending with the fourth ($F(2, 46) = 5.276$; $P < 0.025$). As in Experiment 1, we see the same effects in an analysis of the raw reading times and an analysis by items, Appendices I-C and I-D.

To better understand what drives the interaction, we provide a pull-out graph of rRTs from that site in Figure 5. As is apparent from Figure 5, the interaction is driven by the fact that rRTs for the *every-did* condition are unexpectedly low given the steady increase we observe everywhere else when comparing rRTs for the No-Ellipsis, the Small-Ellipsis and the Large-Ellipsis conditions. In fact, it seems

⁴⁰ As in Experiment 1, we correct for multiple comparisons of 2 and 3 given that the earliest point at which we could have seen an effect of ellipsis is on the first word after V/Aux since only then is it certain that ACD is at issue. Note that if we take the location of the interaction in Experiment 1 into account treating it as the new location at which we predict the effect, the results of Experiment 2 would still require some correction for multiple comparisons. All results reported here apply the more conservative corrections but are also significant using the adjusted, less conservative standard based off of Experiment 1.

that the observed interaction is a product of two sub-interactions, each driven by the fact that rRTs for *every-did* are lower than those for *the-did*. Post hoc tests support this analysis. Specifically, a repeated measures ANOVA with Determiner (*the, every*) and Ellipsis (No-Ellipsis, Small-Ellipsis) reveals a significant interaction such that rRTs for *the* increase across the two Ellipsis levels, while the ones for *every* do not, ($F(1, 47) = 4.520$; $P < 0.05$). When we compare the Small and the Large-Ellipsis conditions across both determiners, we see again a significant interaction such that rRTs for *every* increase even more than those for *the* ($F(1, 47) = 5.908$; $P < 0.05$).⁴¹ The only case where the two determiners show comparable increases and thus only a main effect of Ellipsis-Size is when we compare the *verb* conditions (No-Ellipsis) with the *was* conditions (Large-Ellipsis), ($F(1, 47) = 26.664$; $P < 0.05$).⁴²

4.2.4 Discussion Experiment 2 serves two purposes: on the one hand, it replicates the facilitation effect of *every* on processing a downstream ellipsis site and, on the other, it tests a specific prediction of the QR theory as to the limits of such facilitation. More specifically, it tests the prediction that an upstream quantifier facilitates processing a downstream ACD site only if QR of the host DP is sufficient to also undo antecedent containment as required by the ACD site downstream. Whether this is the case depends on the size of the elided VP. In the case where the elided VP is the smallest, most local VP (local ACD), local QR of the host DP is sufficient and we expect facilitation by the upstream quantifier. However, if the elided VP is larger than that and thus takes an antecedent which includes the most local landing site for QR it is not sufficient and we do not expect facilitation by the upstream quantifier. The interaction we observe on the second word after the V/Aux site provides support on both counts.⁴³

Given these effects and in particular the nature of the interaction we observe for both the rating data and the reading time data, let us

⁴¹ We also observe a main effect of Ellipsis-Size here ($F(1, 47) = 17.502$; $P < 0.05$).

⁴² If we pool rRTs for the first and second word after DET, we observe the same main effect of *every* > *the* that we saw in Experiment 1. However, as discussed there, this effect could be due to a variety of factors other than triggering QR and does not help us distinguish between the theories under discussion.

⁴³ Note that the interaction in Experiment 2 occurs one word earlier than the interaction in Experiment 1 (though it stays significant when we pool rRTs for the second and third word after V/Aux) suggesting that the facilitation effect in Experiment 1 unfolds for some reason more slowly than in Experiment 2. A number of reasons could be responsible for this (the experiment was run on different equipment, with a different participant pool, there were more sentences involving ACD in Experiment 2, etc.). At this point, we do not have an explanation for this difference and we leave it to future research to pin down the temporal location of the effect.

reevaluate the theories under consideration. As in Experiment 1, the TSH/FC approach to quantifier integration and ACD is consistent with the observed main effect of Ellipsis-Size but would, again, not have predicted that the particular choice of determiner has an effect on ACD resolution. However, we see in both the ratings data and in the reading time data that *every* has a facilitation effect when combined with local ACD. This is inconsistent with the TSH/FC view.

The QR approach, on the other hand, seems further supported by these data. As before, the QR approach is consistent with a main effect of Ellipsis-Size because resolving ACD involves resolving an anaphoric dependency which is not required in the No-Ellipsis conditions. Looking at the interaction, we observe that the reading time results of the portion of Experiment 2 that repeats the design of Experiment 1 constitute a full replication of the interaction we found in Experiment 1: while rRTs for *the-did* are significantly higher than those for its baseline, *the-verb*, rRTs for *every-did* are not significantly higher than those for *every-verb*.⁴⁴ This shows that the ACD site in question incurs less of a processing cost in case the determiner of the host DP is *every*, which, in turn, suggests that *every* facilitates ACD resolution downstream here.

The fact that *every* does not facilitate ACD resolution in case of non-local ACD suggests that facilitation of ACD resolution is not due to a general structure-independent property of *every*. In fact, the absence of an interaction in No-Ellipsis/Large-Ellipsis comparison together with the presence of an interaction in the data that replicate Experiment 1 suggests that facilitation of ACD resolution by *every* interacts with the size of the elided VP in much the same way that quantifier scope interacts with the size of the elided VP. Specifically, in the case where the elided VP is small, local QR of the host DP is sufficient to undo antecedent containment but in the case where the elided VP is larger, non-local QR is necessary. Under the assumption that parser's initial determination as to how to integrate the host DP is governed by the local need to resolve the problem of a quantifier in object position (for which only local QR is necessary), it is expected that only local ACD is facilitated by the presence of *every*. That is, non-local ACD requires non-local QR but the parser cannot make that determination based on encountering *every*; it knows about the need for non-local QR only after reaching the non-local ACD site. Thus, just as is the case with a definite host DP, the non-local ACD site triggers QR of the *every* NP

⁴⁴ Post hoc pairwise comparisons show significant differences between *the-verb* and *the-did* ($t(47) = 2.146; P < 0.05$) but not between *every-verb* and *every-did*.

host in addition to a process of resolving the anaphoric dependency between the elided VP and its antecedent.⁴⁵

4.3 *Alternative explanations*

The pattern of RTs we have observed is complex and challenging to account for. We have argued that an essential ingredient in explaining it is a mechanism such as QR that links quantifier integration and ACD resolution. However, to arrive at a more complete assessment of our argument, it is useful to consider alternative explanations, which do not rely on specific assumptions about the structural integration of the host DP. Specifically, as an anonymous reviewer suggests, it is important to compare a QR-based explanation of the findings with an account in terms of corpus frequency. To facilitate the comparison of such an account with the QR-based theory, we spell out both approaches within a surprisal theory of parsing (see Levy (2008) among others).

A surprisal-based framework to parsing attributes processing difficulty to how expected an expression is in a given context. In our cases, the expressions of interest are a lexical verb, a local ACD site marked by *did* or a non-local ACD site marked by *was*, and the conditioning environment is either *the* or *every*. Defining expectedness as conditional probabilities allows us to state the basic tenets of an explanation of our results within a surprisal framework in terms of a ranking of conditional probabilities that mirrors the pattern of RTs in the region of interest. Specifically, we need to postulate (i) that the parser has encoded a lower probability of *did* occurring after *the* than after *every*, (ii) that the probability of *was* is comparable for both determiners but much smaller than the probability that a local ACD site follows *the* and, finally, (iii) that the probability of a lexical verb following *the* or *every* is comparable to the probability that a local ACD site follows *every*. These hypotheses are summarized in (30).

⁴⁵ It is not completely clear how to interpret the fact that rRTs for *every-was* increase more steeply than for *the-was* taking the Small-Ellipsis condition as baseline. One possibility is to see it as an indication that resolving a non-local ACD site is even more costly when the ACD site is hosted by a quantifier. We could make sense of this fact under the assumption that a second instance of reanalysis (a second instance of choosing a less preferred parse) incurs a greater cost than a first. That is, when the parser encounters *every*, it is forced to switch to a less preferred parse which has the object DP locally QRed to resolve the problem of a quantifier in object position. When it reaches the non-local ACD site marked by *was*, it is yet again forced to switch to a less preferred parse, namely one in which the object DP is QRed non-locally. When the non-local ACD site is hosted by a definite DP, however, the parser can determine at the point where QR is triggered, that is when the parser encounters the ACD site marked by *was*, also how far the object DP has to be moved. Thus, only one instance of reanalysis is necessary. Further research is necessary to show whether an analysis along these lines is on the right track.

- (30) a. $P(\textit{did—the}) < P(\textit{did—every})$
 b. $P(\textit{was—the}) \approx P(\textit{was—every}) \ll P(\textit{did—the})$
 c. $P(V—the) \approx P(V—every) \approx P(\textit{did—every})$

Both a frequency account and a QR account of the data are compatible with this probabilistic characterization of our contrasts. What differentiates the two are specific assumptions about the source of these probabilities: the former hypothesizes that the ranking of probabilities is a function of experience, while the latter hypothesizes that it is a function of grammatical knowledge-structures that require reanalysis are, all else being equal, less expected than ones that do not.

According to the QR view, local ACD is more expected following *every* than *the* because the structural configuration necessary to integrate a local ACD site has already been generated before the parser encounters the ACD site. However, only local ACD sites are more expected by QR in this sense. Non-local ACD sites are not because integrating *every* upstream does not force the parser to postulate a structure that would also allow integrating a non-local ACD site. Finally, from the perspective of QR, the No-Ellipsis cases are on a par with local ACD cases that are hosted by *every* since in none of them is reanalysis required when the VP of the relative clause is integrated.

According to a frequency-based view, it is the amount of experience a speakers has with our constructions that determines the level of expectedness. For this to be a feasible account, two requirements need to be met: the amount of experience has to correlate with the probability statements in (30) and it has to be sufficiently large so that speakers can plausibly keep track of it. We can estimate the amount of experience via corpus frequencies. Thus, under this view, we expect both that corpus frequencies for our six cases correlate with the probability statements in (30) and also that they are sufficiently represented in corpora to drive the parsers expectations.

What the correlation might look like depends on how we define the relevant notion of frequency. It seems pretty clear that absolute counts will not be very useful, nor will n-gram frequencies, since they would have to be calculated over sequences of seven words (the number of words between the determiner and the ACD site in our experimental material). Instead we will need a general notion of relative frequency that is based on construction types and that can be assumed to inform a left-to-right parser. In other words, we want a notion of relative frequency that allows the parser to estimate how likely it will encounter a local, non-local or no ACD site once it has parsed the determiner of the object DP. Such a notion can be derived by counting, for each

determiner separately, how often cases of local, non-local and no ACD occur in a corpus and divide it by the number of possible cases of local, non-local and no ACD.⁴⁶ Thus, for each determiner, we can divide the number of attached object relative clauses that contain a local ACD site by the total number of object relative clauses attached to that determiner, the number of object relative clauses with a non-local ACD by the number of object relative clauses and so on. This notion executes fairly directly the basic idea of surprisal and thus should allow for a straightforward translation of corpus frequencies into surprisal levels.

Let us first see whether corpus frequencies do in fact correlate in the way a frequency-based account needs them to. To do so, we conducted a corpus search of the Brown and Wall Street Journal corpora.⁴⁷ We found only 19 cases of ACD. Of these, six were hosted by a definite DP and only one by an *every* DP.⁴⁸ The remaining cases were comprised of four free relatives ('She ate what she could'.), seven other quantifiers ('The computers find all the key words they can, but the editors confirm every one'.) and one bare plural ('Maybe we recognize values the other guys don't'). We found no examples of non-local ACD and none of the local ACD sites were marked by *did* or *was*. Dividing the number of ACD cases by the number of object relative clauses for each determiner, we see that the relative frequency of a local ACD site for *the*, (0.0029), is indeed lower than for *every* (0.0370). We also observe that the relative frequency of a relative clause without an ACD site is higher for *the*, (0.9971), than for *every* (0.9630). This is, of course, not unexpected since *the* is much more frequent and thus has many more occurrences in which it hosts an object relative clause. Table 1 provides a summary of these findings.

If we take the negative log of these frequencies as our measure of surprisal (Levy 2008), we see that local ACD hosted by *the* (5.8445) is in fact less expected and should, thus, be more difficult to process than

⁴⁶ Note that this will give us a rather coarsely defined base rate since it will include relative clauses that cannot possibly host an ACD site. Ideally, we would want our base rate to be the number of actual cases of ACD divided by the number of potential cases of ACD. However, we do not see a feasible way of estimating the number of possible cases of ACD since it would have to factor in communicative intent—how likely it is that the meaning conveyed by an ACD construction was intended.

⁴⁷ The following Tregex search command was used to find potential cases of ACD: SBAR < / ^ WH.*-([0-9]+)%/#1%index << (VP < -NONE- << (.=empty < (/^-NONE- / ^ \ *T \ *-([0-9]+)%/#1%index))). The sentences that were produced by this search were subsequently classified by hand into genuine cases of ACD and sorted by hosting determiner.

⁴⁸ Of the six occurrences with *the*, two were cases of *the same*, which is arguably a quantificational expression. Taking these cases out of the definite article group and moving them into the 'other category' reinforces the main impression one gets from this table: ACD tends occur with quantifiers (but not necessarily with *every*)—a fact that is in line with the QR hypothesis as discussed below.

Brown & WSJ	Verb	Local ACD	Non-local ACD	ORC
The	0.9971 (2066) .0029	0.0029 (6) 5.8445	0 (0) NA	2072
Every	0.9630 (26) .0377	0.0370 (1) 3.2958	0(0) NA	27
Other	0.9943 (2108) .0057	0.0057 (12) 5.1742	0(0) NA	2120

Table 1 Combined corpus frequencies for object relative clauses, with no ACD, local ACD and non-local ACD by determiner from Brown and Wall Street Journal corpora. Absolute counts in parentheses, negative log frequencies in second line.

local ACD hosted by *every* (3.2958). This is in accordance with our reading time data. The fact that there are no cases of non-local ACD, on the other hand, means that we do not have a measure of surprisal here. Plausibly, this could be taken to mean that non-local ACD is such a rare construction that speakers will perform at floor level (slowest), which is again in sync with our reading time data.

However, to complete the account, we need to consider the full pattern including the No-Ellipsis cases. These are much more frequent than all other cases, thus their surprisal is much lower. We expect, then, that processing of the No-Ellipsis cases should be much easier than processing any of the ACD cases. This expectation is not borne out in the region of interest: the reading times in the *every-did* condition are indistinguishable from the reading times for the No-Ellipsis cases, even though local ACD hosted by *every* is much less expected.

To bring the frequency account in line with the reading times, we might postulate that the No-Ellipsis cases are above a frequency threshold (and thus below a surprisal threshold) that demarcates a region of expectancy within which speakers will perform at ceiling (fastest) during real-time sentence processing. This assumption allows us to avoid the unwelcome prediction that actual frequency counts (or surprisal values) are comparable whenever reading time data are comparable. However, this assumption alone is not sufficient. We also need to assume that the relative frequency of local ACD hosted by *every* is at that threshold since reading times for *every-did* were indistinguishable from reading times that are indicative of optimal performance. This seems implausible to us since ACD appears to be extremely rare.

We do not think that these remarks about the empirical feasibility of experience-based accounts of our data conclusively rule out such accounts. However, they do indicate that frequency-based approaches require rather specific auxiliary assumptions about how corpus frequen-

cies translate into reading times—assumptions that guarantee the following groupings *{the-verb, very-verb, every-did}*, *{the-did}* and *{every-was, the-was}*—in addition to the assumption that speakers do in fact track corpus frequencies of the magnitudes we found in our corpora for constructions that are as complex as ACD.⁴⁹

Putting aside these issues for the moment and granting, for sake of argument, that there is a sufficiently strong correlation between reading time data and corpus frequency (which one might find with a different definition of relative frequency or a different way of translating the frequencies into levels of expectedness), there is a more general epistemological consideration. The claim that corpus frequencies explain the reading time data requires that one can disentangle causality from correlation. This seems to us far from trivial here since there are no independent means of estimating the contribution of corpus frequency to processing data nor are there independent means of estimating the contribution of processing difficulty to corpus frequency. Both types of dependencies seem, *prima facie*, plausible. Thus, taking corpus frequencies as primitives in the explanation, as experience-based explanations do, amounts to accepting a strong and non-trivial assumption, namely that processing difficulty has at most a negligible effect on corpus frequencies.

The QR-based theory, by contrast, does not take either data set as a primitive in the explanation. Rather, it proposes an underlying factor that governs the perceived complexity of sentences with ACD during real-time sentence processing. This factor predicts the reading time data we have observed. Moreover, it can also help in explaining corpus frequencies if we assume that processing considerations constrain language production through, for example, audience design or production efficiency considerations. On such a principle, it would follow that, all things being equal, ACD would occur relatively less often if hosted by a definite determiner since, as we have seen, such structures are difficult to parse.⁵⁰ Note that this approach to understanding a correlation between reading times and corpus frequency does not expect the frequencies to be of certain minimal magnitude since, unlike the frequency approach, it does not rely on speakers being able to actually track frequencies. Should it turn out that ACD cases are in fact too rare

⁴⁹ For word-level phenomena tracking such low frequencies as we estimated from the corpus frequencies is not implausible. However, tracking how often complex constructions such as those involving ACD occur seems a rather different proposition and, given how rare such constructions are, one would like to see independent evidence that this can and is, in fact, done by speakers.

⁵⁰ Similar remarks apply to the correlation we have observed between the rating data and the reading time data and to other possible correlations such as the likelihood of a sentence completion to contain no ACD site, a local ACD site or a non-local ACD site.

to be plausible candidates for determining speakers' expectations during real-time sentence processing, this difference would constitute an additional advantage over a frequency-based theory.

In sum, a frequency-based account is grounded in the idea that the more experience a speaker has with a particular construction, the easier it will be for her to process that construction. It, therefore, expects corpus frequencies to correlate with reading times and it postulates that the correlation exists because speakers' tacit knowledge of corpus frequencies of ACD constructions determines their expectations during real-time sentence processing. This implies that corpus frequencies are taken as primitives in the account. The alternative, QR-based, view offers a different take on the matter. It does not propose to explain one data set in terms of another. Instead it proposes an explanation of two empirical patterns by advancing a specific hypothesis about a grammatical factor that underlies both comprehension in real time and production.⁵¹ On a simple comparison, then, we note that the QR approach can explain two sets of data, while the frequency-based approach can explain only one. Of course, in a state of incomplete knowledge considerations of this sort do not show that experience-based proposals are incorrect. More work is required to settle the matter.

5 General discussion and conclusion

The central question of our experimental investigation is whether quantifier integration and the resolution of ACD are independent. We argued that real-time sentence processing might prove particularly useful here because its inherent linear organization allows us to pit the two phenomena against each other in a way that more traditional offline measures do not. That is, from the perspective of a left-to-right parser, the question of independence between the two phenomena presents itself as the question whether processing an object quantifier upstream affects processing costs associated with resolving an ACD site downstream. Our evidence shows that this is the case.

The pattern of data we found in our studies is fairly rich. In agreement with recent processing studies of ellipsis resolution, we have seen that ACD sites are more difficult to process during real-time sentence processing than their respective baselines, which have no elided

⁵¹ The QR-based approach would extend to other conceivable measures of difficulty associated with ACD such as offline acceptability ratings or sentence completion patterns. For all cases, we would propose a specific factor that accounts for why local (and only local) ACD is facilitated by *every*—assuming that the reading time effects are present in those measures as well—rather than attempting to explain one pattern as a function of another.

material. The increased difficulty is evident both in reading time data (Experiments 1 and 2) as well as in difficulty ratings (Experiment 2). Importantly, we saw that the increase in difficulty is modulated by the choice of determiner in a rather particular way: the quantificational determiner *every* facilitates ACD resolution downstream when compared with the definite article *the* but only in case the antecedent of the ACD site is the most local VP. In other words, we found that facilitation of ACD resolution by *every* interacts with the size of the elided VP in much the same way that quantifier scope interacts with the size of the elided VP (Sag 1976; Williams 1977).

Long-distance interactions of this sort are predicted only if processing of the host DP and ACD resolution are linked in some way. We have argued for a structural interpretation of this link, which concerns the integration of different types of object DPs. Crucially, this is a main point of divergence between two types of approaches to quantifier integration and ACD resolution. According to the QUANTIFIER RAISING-based approach, the integration of the host DP and downstream ACD resolution are necessarily linked because both processes require the same structural configuration—QUANTIFIER RAISING of the object DP. According to the Type-Shifting/Function Composition approach, the structural properties of the host DP and ACD are independent. Under this view, integrating a quantifier in object position requires richer semantic composition but no restructuring of the syntactic tree, while ACD resolution requires accessing either a simple or complex verb (in case of non-local ACD), which can be done independently of how the object is integrated. Thus, the two phenomena are not expected to interact in the way we have seen in our data according to this view.⁵²

We believe that our results add to the body of evidence that constrains theories of quantifier integration to those that predict syntactic interactions between quantifier integration and other grammatical phenomena. However, at this stage, we cannot rule out alternative views—

⁵² Both approaches we have discussed agree that a quantifier in object position constitutes a genuine combinatorial problem. However, it has been argued in the literature that the problem can be avoided altogether using an event-semantic approach to verb phrases as in Kratzer (2003). In this framework, external arguments are introduced by a separate head, *v*, while internal arguments are treated as subjects of *V*. On the non-standard assumption that quantifiers are of type $\langle \text{est}, \text{st} \rangle$, this neutralizes any combinatorial differences between quantificational and referring objects. (Kratzer's quantifier denotations are non-standard not just in type but also in content as they impose a fairly elaborate set of conditions on the event argument. See Champollion (2010) for critical discussion. Our evidence is, *prima facie*, inconsistent with this claim. It is important to note, however, that it is not inconsistent with event-semantic approaches in general. In fact, see Bale (2007) for empirical arguments that even within an event-semantic approach to VP meanings, there is reason to believe that quantifiers cannot be interpreted *in situ*.)

including frequency-based accounts such as the one discussed in Section 4—and more research is necessary to determine the extent to which facilitation of the sort we have observed for *every* generalizes to other quantificational expressions and to other grammatical phenomena that have been postulated to interact with quantifier integration.⁵³ In this paper, we hope to have shown that such investigations can be fruitful and should be undertaken.

APPENDIX I-A: ITEMS ANALYSIS FOR EXPERIMENT 1

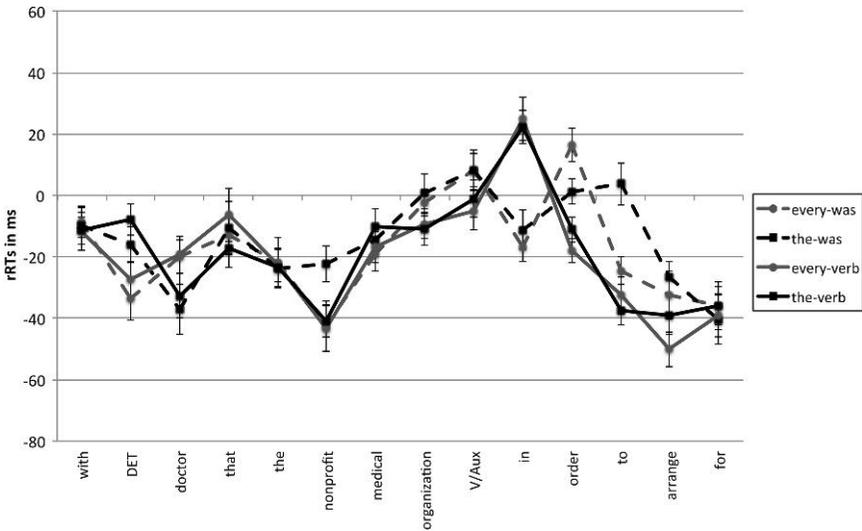


Figure A.1 Average residual RTs for region of interest for Experiment 1 by items ($n = 52$).

	in	order	to	arrange
Determiner	$F(1,51)=1.76$; P>0.05	$F(1,51)=1.31$; P>0.05	$F(1,51)=1.79$; P>0.05	$F(1,51)=6.58$; P<0.05
Gap size	$F(1,51)=7.19$; $P<0.05$	$F(1,51)=11.09$; $P<0.05$	$F(1,51)=19.76$; $P<0.05$	$F(1,51)=9.14$; $P<0.05$
Det \times gap	$F(1,51)=0.01$; P>0.05	$F(1,51)=0.35$; P>0.05	$F(1,51)=4.40$; $P<0.05$	$F(1,51)=0.61$; P>0.05

Table A.1 Test statistics for rRTs for Experiment 1 (region P1–P4)—by items ($n = 52$). Eight items were excluded due to lower than 75% accuracy rate.

⁵³ See Hackl *et al.* (2009) for evidence that definite DPs facilitate ACD resolution in certain intensional environments and Breakstone *et al.* (2011) for evidence that certain degree quantifiers facilitate non-local ACD in comparative constructions.

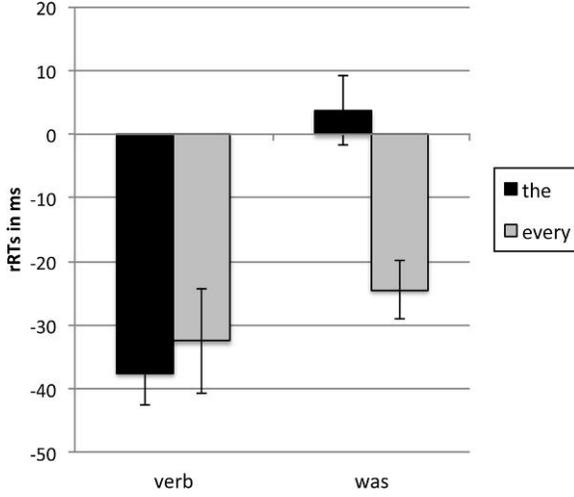


Figure A.2 Residual RTs three words after V/Aux for Experiment 1 by items ($n = 52$).

APPENDIX I-B: RAW READING TIMES FOR EXPERIMENT 1

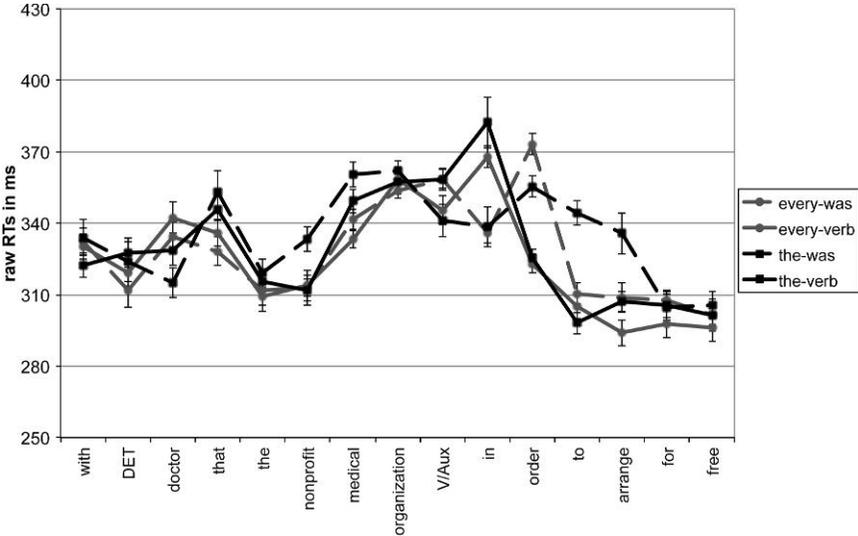


Figure A.3 Average raw RTs for region of interest for Experiment 1 ($n = 44$).

	In	Order	To	Arrange
Determiner	$F(1,43)=0.60$; P>0.05	$F(1,43)=0.59$; P>0.05	$F(1,43)=2.31$; P>0.05	$F(1,43)=3.48$; P<0.05
Gap size	P<0.05	P<0.05	P<0.05	P<0.05
Det × gap	$F(1,43)=0.25$; P>0.05	$F(1,43)=0.84$; P>0.05	$F(1,43)=6.86$; P<0.05	$F(1,43)=0.92$; P>0.05

Table A.2 Test statistics for raw RTs for Experiment 1 – V/Aux to P4 ($n = 44$).

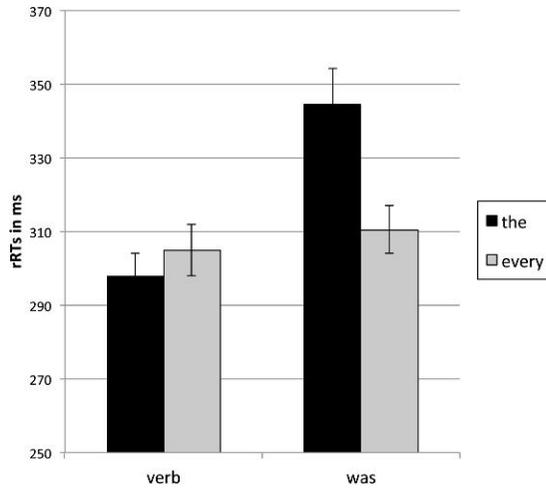


Figure A.4 Raw RTs three words after V/Aux for Experiment 1 ($n = 44$).

APPENDIX I-C: ITEMS ANALYSIS FOR EXPERIMENT 2

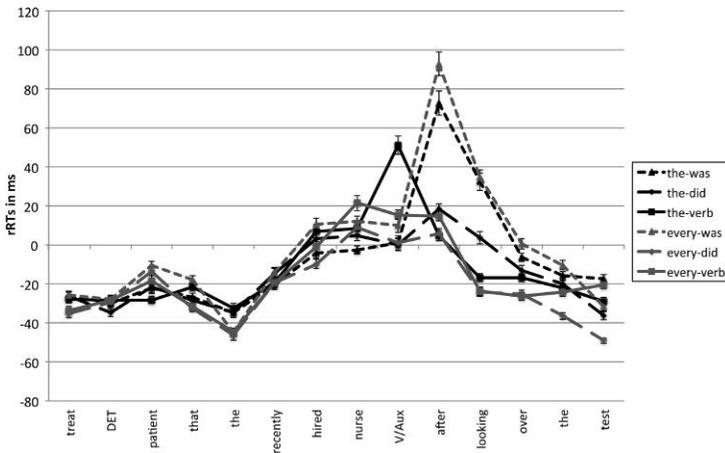


Figure A.5 Average rRTs for region of interest for Experiment 2 by items ($n = 52$).

	In	Order	To	Arrange
Determiner	$F(1,59)=1.50$; P>0.05	$F(1,59)=0.60$; P>0.05	$F(1,59)=3.90$; P>0.05	$F(1,59)=0.27$; P<0.05
Gap size	$F(2,58)=8.99$; P<0.05	$F(2,58)=16.08$; P<0.05	$F(2,58)=17.43$; P<0.05	$F(2,58)=6.44$; P<0.05
Det × gap	$F(2,58)=5.8$; P>0.05	$F(2,58)=1.29$; P>0.05	$F(2,58)=3.34$; P<0.05	$F(2,58)=1.18$; P>0.05

Table A.3 Test statistics for rRTs for Experiment 2 (region V/Aux to P3) by items ($n = 60$).

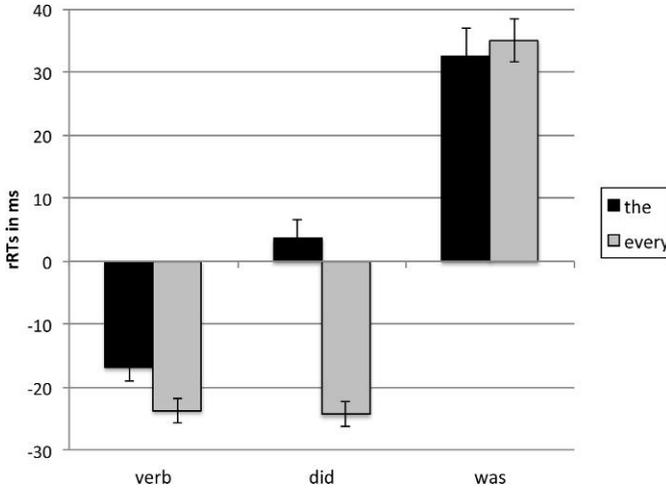


Figure A.6 Residual RTs two words after V/Aux for Experiment 2 by items ($n = 60$).

APPENDIX I-D: RAW READING TIMES FOR EXPERIMENT 2

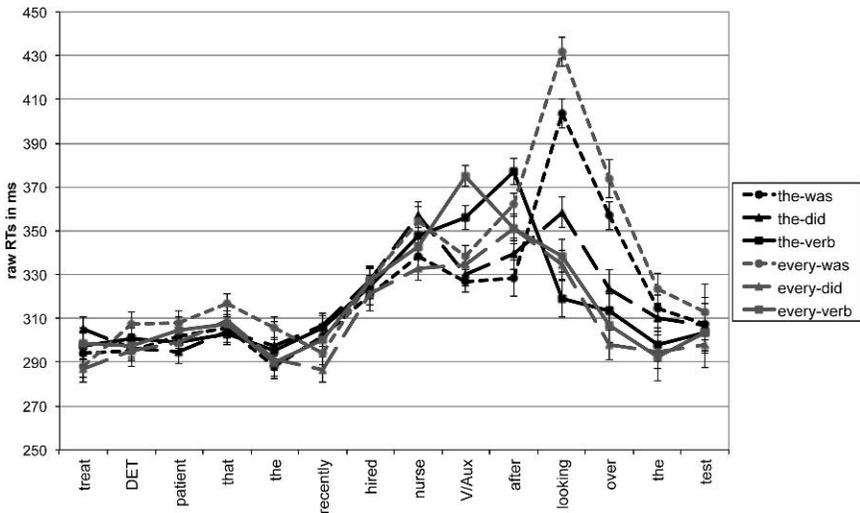


Figure A.7 Average raw RTs for region of interest for Experiment 2 ($n = 48$).

	In	Order	To	Arrange
Determiner	$F(1,47)=1.78$; P>0.05	$F(1,47)=0.63$; P>0.05	$F(1,47)=0.40$; P>0.05	$F(1,47)=0.43$; P<0.05
Gap size	$F(2,46)=5.36$; P<0.05	$F(2,46)=1.30$; P<0.05	$F(2,46)=13.33$; P<0.05	$F(2,46)=9.56$; P<0.05
Det × gap	$F(2,58)=5.8$; P>0.05	$F(2,46)=3.22$; P>0.05	$F(2,46)=3.76$; P<0.05	$F(2,46)=2.18$; P>0.05

Table A.4 Test statistics for raw RTs for Experiment 2 – V/Aux to P3 ($n = 48$).

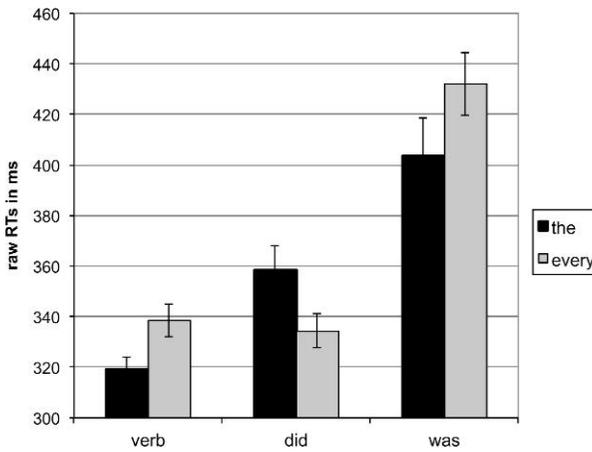


Figure A.8 Raw RTs two words after V/Aux for Experiment 2 ($n = 48$).

APPENDIX II-A: MATERIALS FOR EXPERIMENT 1

1. The understaffed general hospital was negotiating with the/every doctor that the nonprofit medical organization funded/was in order to arrange for free vaccination clinics.
2. The senior computer engineer was working on the/every problem that the newly trained technician missed/was because of the sudden influx of very unsafe computers.
3. The motivated newspaper reporter was writing up the/every story that the main news anchor fabricated/was in order to fill all twenty minutes of headline news.
4. The meticulous head surgeon was testing out the/every instrument that the recently hired nurse sterilized/was because a large number of instruments had been broken recently.

5. The ambitious rock collector was going after the/every fossil that the highly specialized geologist unearthed/was in order to win the national geological contest of the year.
6. The very successful photographer was interested in the/every lens that the aspiring art student bought/was in order to have a good class project.
7. The continually losing team was counting on the/every player that the newly formed league drafted/was in order to have a better next season.
8. The somewhat successful lawyer was talking to the/every witness that the senior police detective detained/was because of the new requirements on high ranking police officials.
9. The powerful company president was reading over the/every document that the newly hired assistant stamped/was before being asked to go on a coffee run for the company partners.
10. The poor graduate student was applying for the/every job that the recently graduated technician took/was after the living expenses in the area increased dramatically.
11. The anxious old farmer was rounding up the/every cow that the ignorant farm hand released/was during the confusion that resulted from the unexpected flash flood.
12. The frustrated young teacher was holding up the/every student that the noticeably stern principal questioned/was because of the suspicious activity that had been reported.
13. The famous talent agency was checking out the/every dancer that the traveling dance troupe hired/was because of the sudden shortage of dancers in the nation.
14. The small jazz band was negotiating with the/every bassist that the large symphony orchestra trained/was in order to increase their number of nationally competitive bassists.
15. The famous movie star was vying for the/every role that the young aspiring actress rejected/was in order to become more appealing to directors.
16. The ambitious and determined dentist was ignoring the/every paste that the overly competitive hygienist recommended/was because of the latest findings about tooth decay.
17. The entertainingly grumpy carpenter was waving around the/every hammer that the somewhat clumsy repairman hid/was after the fight about correct toolbox etiquette.

18. The unhappily starving pirate was digging up the/every treasure that the incredibly courageous adventurer buried/was before the adventurer was thrown in jail.
19. The noticeably uninformed jeweler was writing about the/every gem that the frustratingly methodical geologist stole/was in order to complete the official geological record.
20. The overwhelmed teenage babysitter was playing with the/every crayon that the very cheerful child hid/was because markers made the child cry very loudly.
21. The unexpectedly intelligent investor was selling off the/every stock that the rather foolish broker recommended/was because a psychic predicted that the stock market would crash.
22. The overworked medical intern was stressing out the/every resident that the bossy head nurse upset/was during the emergency drill in the middle of the night.
23. The successful private detective was running after the/every criminal that the incompetent police officer detained/was in order to meet the quota set by the police station.
24. The main staff secretary was tracking down the/every letter that the absent minded assistant wrote/was after the mislabeling incident that led to panic within the department.
25. The secretly unethical firm was wearing down the/every intern that the small nonprofit organization interviewed/was because of the sudden expansion of the organization.
26. The renowned dessert chef was pleased with the/every dish that the foolish bus boy ate/was during the final round of the international baking competition.
27. The sneaky old lady was bidding on the/every antique that the enterprising young retailer coveted/was in order to become the largest collector of classical coffee tables in the area.
28. The brilliantly trained pilot was flying the/every plane that the newly trained copilot examined/was in order to prepare for the final piloting examination.
29. The young and trendy stylist was critiquing the/every model that the senior fashion editor selected/was during the most prestigious fall fashion preview in the world.
30. The overly competitive young acrobat was watching the/every judge that the excellently trained gymnast impressed/was during the warm up session before the main event.

31. The exceptionally knowledgeable history teacher was discussing the/every battle that the pompously annoying writer described/was before it became clear that the writer was horribly misinformed.
32. The young but respected lawyer was interviewing the/every suspect that the very cautious judge jailed/was after the last portion of the trial had been concluded.
33. The very passionate young teacher was supporting the/every student that the rather pessimistic principal identified/was as soon as the unfortunate news was released to the school.
34. The very busy international banker was monitoring the/every account that the incredibly wealthy client opened/was after inheriting over ten million dollars from a dead relative.
35. The nervous teenage cashier was looking over the/every receipt that the unintentionally controlling manager filed/was while trying to help with the overall organization of the store.
36. The stressed casting director was talking to the/every actress that the incredibly frantic producer scolded/was so the movie production could begin as soon as possible.
37. The rather confused pharmacist was mixing up the/every prescription that the somewhat whiny clerk filled/was because the pharmacy was in complete disarray after the computer crashed.
38. The rather clever head detective was examining the/every gun that the ambitious crime investigator mentioned/was after all of the leads turned out to be dead ends.
39. The newest modeling agency was interested in the/every girl that the beauty pageant committee recommended/was after hearing about the new spring shapes and colors.
40. The ambitious grave robber was digging up the/every tomb that the very ambitious archaeologist uncovered/was despite the fact that the country had a death sentence for grave robbery.
41. The talent show coordinator was listening to the/every singer that the highly regarded choir trained/was after the announcement about the ten thousand dollar prize was made.
42. The avid newspaper reporter was tracking down the/every story that the overly eager journalist covered/was because of a long standing competition between the rivals.
43. The overly desperate accountant was looking up the/every statement that the anxious tax payer hid/was because the auditor was going to arrive within the next ten minutes.

44. The highly esteemed conductor was photo copying the/every piece that the auditioning music scholar played/was because of the comparative rarity of the composition style of the music.
45. The wealthy mortgage broker was interested in the/every deed that the real estate agent advertised/was since the current housing boom was soon predicted to end.
46. The artistic film producer was reading through the/every screenplay that the perpetually impatient director suggested/was in order to direct a movie that might receive international recognition.
47. The considerate stock broker was thinking over the/every investment that the naively eager client suggested/was even though the stock market was not in a very good position after the earthquake.
48. The new dance company was testing out the/every choreographer that the musical theatre troupe recommended/was because the theatre troop specialized in training choreographers.
49. The somewhat eccentric screenwriter was assisting with the/every manuscript that the recently published novelist wrote/was to submit to the local writing guild novel contest.
50. The elderly estate manager was checking out the/every heirloom that the greedy antique dealer sold/was after learning the price that authenticated antiques would sell for in the auction.
51. The careful young logician was copying down the/every proof that the rapidly aging mathematician reviewed/was in order to give a talk on the matter at the conference.
52. The meticulous financial analyst was writing up the/every report that the growing insurance company released/was because of the newest federal regulations on insurance companies.
53. The wealthy art director was bidding on the/every sculpture that the modern art museum liked/was in order to appeal to a more cubist crowd in the next exhibit.
54. The rotund circus ringmaster was pointing out the/every elephant that the specialized animal trainer chose/was in order to decide whether tigers or elephants should appear in the opening act.
55. The young bank teller was writing down the/every transaction that the overly meticulous manager oversaw/was because of they very strict bank policy concerning record keeping.

56. The terribly stubborn soccer referee was discussing the/every goal that the extraordinarily cocky player made/was during the championship game of the qualifying tournament.
57. The newly hired geography tutor was charting the/every mountain that the easily distracted student mentioned/was during the four hour long lesson that occurred once a week.
58. The newly hired professional valet was assisting the/every driver that the exceptionally observant doorman helped/was after the ballroom dance festival at the hotel was over.
59. The usually grumpy postal worker was visiting the/every house that the annoyingly chipper milkman served/was after the roads were completely redone making access to the neighborhood easier.
60. The newly trained young nanny was avoiding the/every hazard that the unfortunately overprotective mother feared/was after reading an article about the many dangers present to young children.

APPENDIX II-B: MATERIALS FOR EXPERIMENT 2

1. The lawyer was careful to remember the/every fact that the young defense attorney presented/did/was during the second cross examination period.
2. The investor was likely to research the/every company that his eager head manager liked/did/was based on the annual reports alone.
3. The doctor was reluctant to treat the/every patient that the recently hired nurse admitted/did/was after looking over the test results.
4. The soldier was determined to complete the/every exercise that his athletic drill sergeant designed/did/was before the squadron left for active duty.
5. The dentist was hesitant to examine the/every cavity that the weary head hygienist noticed/did/was on the Friday before the long weekend.
6. The babysitter was content to watch the/every child that her older half sister adopted/did/was once she found out how much she would get paid.
7. The pharmacist was determined to sell the/every drug that the sleazy pharmaceutical representative advertised/did/was once it was approved by the board of health.

8. The doctor was able to prescribe the/every medicine that his currently vacationing colleague advocated/did/was although he was somewhat reluctant to do so.
9. The father was persuaded to coach the/every practice that his athletically gifted son arranged/did/was even though he preferred to relax on weekends.
10. The banker was excited to take the/every break that her very lazy supervisor assigned/did/was while the manager was on vacation.
11. The clown was nervous to distract the/every bull that the slightly injured cowboy avoided/did/was during his first fully televised rodeo.
12. The medic was reluctant to rebandage the/every wound that the entirely incompetent doctor cleaned/did/was without using any of the new antiseptic.
13. The secretary was trained to manage the/every program that the intelligent young professional designed/did/was during her four years at college.
14. The sergeant was persuaded to hassle the/every recruit that the aggressive first lieutenant disliked/did/was throughout his time on the base.
15. The nurse was prepared to administer the/every test that the charming young medic expected/did/was since the attending doctor had fallen ill.
16. The pilot was willing to attempt the/every maneuver that his hot shot copilot performed/did/was during the annual air show in San Francisco.
17. The nurse was allowed to aid the/every patient that the fairly confused intern forgot/did/was during the two week training period.
18. The investor was excited to buy the/every stock that the incredibly intelligent intern found/did/was after the first one had doubled in just a week.
19. The mother was allowed to take the/every trip that her awfully shy child attended/did/was during the first three months of school.
20. The secretary was eager to assist the/every person that the old security guard greeted/did/was as soon as they arrived at the office.
21. The sergeant was supposed to chastise the/every soldier that the overly aggressive major harassed/did/was despite the official orders of the general.

22. The teacher was excited to help the/every student that the scruffy old janitor harassed/did/was during the fifteen minute morning recess.
23. The medic was content to accompany the/every doctor that the new surgical nurse hated/did/was during her three years at the hospital.
24. The manager was sure to like the/every intern that the unusually picky owner hired/did/was after a day of serious consideration.
25. The landlord was eager to accommodate the/every tenant that the newly promoted manager ignored/did/was the first time that he called.
26. The cashier was afraid to ignore the/every customer that the stressed out manager insulted/did/was during the end of the year sale.
27. The clown was careful to avoid the/every man that the intentionally mean entertainer insulted/did/was while performing in the small country town.
28. The author was likely to tell the/every story that his forgetful old father invented/did/was before his children moved out of the house.
29. The carpenter was committed to learning the/every trick that his extremely talented apprentice knew/did/was before starting on the newest project.
30. The dentist was ready to learn the/every technique that his well trained aide knew/did/was before coming in to work after the holiday.
31. The landlord was permitted to refuse the/every offer that his incredibly shrewd competitor made/did/was while he was in the hospital for surgery.
32. The banker was permitted to authorize the/every payment that the ambitious desk clerk made/did/was without checking with the head manager first.
33. The coach was reluctant to demonstrate the/every skill that the arrogant team captain mastered/did/was during the late summer training period.
34. The soldier was ready to study the/every battle that his overly ambitious comrade mentioned/did/was before taking his extended leave of absence.
35. The mother was eager to purchase the/every toy that the energetic preschool teacher mentioned/did/was during the incredibly hectic holiday season.

36. The referee was supposed to notice the/every foul that the attentive assistant coach missed/did/was during the important final playoff game.
37. The goalie was hesitant to play the/every game that the injured star defender missed/did/was because he was afraid to lose.
38. The carpenter was able to handle the/every tool that the horribly clumsy apprentice misused/did/was during their show on public television.
39. The pharmacist was ready to refill the/every prescription that her unnecessarily nosy boss needed/did/was until the new drug was on the market.
40. The artist was content to accept the/every grant that his somewhat reluctant agent offered/did/was in order to maintain their somewhat tentative friendship.
41. The realtor was sure to check the/every lock that her absent minded friend opened/did/was because of the recent rash of criminal activity.
42. The realtor was afraid to close the/every deal that the youthful company president outlined/did/was before he had a chance to read the paperwork.
43. The accountant was determined to balance the/every account that his most extravagant client overdrafted/did/was before he went on his annual vacation.
44. The boss was careful to copy the/every receipt that his inattentive eldest son overlooked/did/was after the totally unexpected tax audit.
45. The boss was nervous to attend the/every conference that his obnoxiously talkative employee planned/did/was during the exceedingly hot summer months.
46. The author was committed to editing the/every page that her very thorough publisher read/did/was even though she had not received her paycheck.
47. The lawyer was nervous to defend the/every case that his rather conservative employer rejected/did/was because the prosecutor had a very good case.
48. The babysitter was allowed to eat the/every snack that the constantly unhappy child rejected/did/was even though dinner was in less than an hour.
49. The father was supposed to record the/every performance that his busy first wife skipped/did/was during her move to a bigger apartment.

50. The artist was prepared to hire the/every model that the extremely successful sculptor snubbed/did/was before the big show in Paris.
51. The accountant was persuaded to allow the/every audit that his financially responsible colleague suggested/did/was because of the recent changes in company policy.
52. The pilot was hesitant to attempt the/every landing that his surprisingly panicky copilot suggested/did/was during the long flight to England.
53. The professor was trained to teach the/every subject that the pretentious science tutor suggested/did/was after graduating from the local teaching program.
54. The manager was afraid to contradict the/every decision that the recently rehired cashier supported/did/was because he knew that the owner liked it.
55. The teacher was permitted to detain the/every student that the often absent principal suspected/did/was after the school counselor spoke with him.
56. The referee was prepared to reprimand the/every player that the hot headed coach taught/did/was during the month long summer program.
57. The coach was able to hit the/every pitch that the overpaid star player threw/did/was during the last practice that he attended.
58. The goalie was sure to miss the/every shot that the highly skilled player took/did/was during the important tie breaker match.
59. The cashier was likely to inspect the/every bill that the painfully frugal customer used/did/was because the new cash register was not yet working.
60. The professor was committed to read the/every paper that her overzealous teaching assistant wrote/did/was before the fall semester came to a close.

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