

The syntax–semantics interface

Martin Hackl^{*}

Massachusetts Institute of Technology, USA

Received 26 October 2011; received in revised form 22 January 2013; accepted 22 January 2013

Available online 6 April 2013

Abstract

The study of the syntax–semantics interface is concerned with linguistic phenomena that are the product of interactions between principles of syntactic organization and principles of semantic interpretation. Such interactions abound in natural language and can be found in all subsystems of the grammar. This paper examines a particular subclass of such phenomena revolving around quantificational expressions. The central concern of the discussion are the grammatical mechanisms that mediate between the syntactic position a quantifier appears in and the semantic import it has on the sentence meaning. Of particular interest are cases where a quantifier is interpreted in a position that is different from the position it seems to occupy in the syntax. A leading hypothesis to explain cases of this sort, which exemplify a general property of natural language called displacement, is that they are the product of overt or covert movement operations. Empirical support for this approach is presented in the form of correlations between three grammatical phenomena – Quantifier Scope, Antecedent Contained Deletion, and Extraposition – which receive a uniform account under the above hypothesis. © 2013 Elsevier B.V. All rights reserved.

Keywords: Syntax–semantics interface; Logical form; Quantification; ACD; Extraposition

1. Introduction

The study of the syntax–semantics interface is concerned with those aspects of syntactic structure that have an effect on meaning composition and those aspects of meaning that have systematic effects on syntactic structure. Research in this area has produced a wealth of empirical and theoretical knowledge that is impossible to survey comprehensively within the limits of this paper, even if the discussion were confined to the main results or the foundational issues. However, many of the key issues can be illustrated by focusing on a set of interrelated topics concerning the syntax and semantics of quantificational expressions, which exemplify clearly and compactly what is at stake in the study of the syntax–semantics interface.

Before getting started, a few general remarks about the nature of the research in this domain are in order. The empirical goal of research on the syntax–semantics interface is to determine the extent to which the meaning of an expression depends on its syntactic properties and the extent to which its syntactic properties are a function of its meaning. The theoretical goal is to give a principled account of these interactions, rooted both in an understanding of the compositional processes made available by the language faculty and in an understanding of how these processes interact with the rest of the mind. At the current state of research, we do not have such an account nor do we have fail-safe criteria that identify all and only those phenomena that are a product of interactions of syntax and semantics. There are, however, clear and fairly uncontroversial cases that exemplify when syntax and semantics interact systematically and when they don't. These

^{*} Correspondence address: MIT Linguistics and Philosophy, 77 Massachusetts Avenue, 32-D966, Cambridge, MA 02139, USA.
Tel.: +1 6172539373.

E-mail address: hackl@mit.edu.

cases provide us with guidelines for how to structure the search for empirical evidence as well as how to construct theories that explain the phenomena of interest.

To see how fundamental and ubiquitous the interplay between syntax and semantics is to natural language consider simple examples like those in (1)a and b.

- (1) a. John kissed Mary.
b. Mary kissed John.

The two sentences in (1) are constructed from the same lexical material, *John*, *Mary*, *kiss*, and the past tense morpheme *-ed*, yet they mean different things. In both cases, *kiss* takes two proper names, *John* and *Mary*, as arguments to form a sentence describing a kissing event involving John and Mary. The difference in meaning concerns who is doing what to whom. In (1)a, *John* is the agent or instigator of the kissing event and *Mary* is the patient or recipient while in (1)b the roles are reversed. This difference in meaning corresponds to a difference in syntactic organization: in (1)a *John* is the syntactic subject and appears to the left of the verb while *Mary* is the syntactic object and appears to the right of the verb; in (1)b the opposite is the case. Thus, we observe a correlation between syntactic organization and meaning: the agent role of a verb like *kiss* is assigned to the subject position while the patient role is assigned to the object position.

However, not all aspects of syntactic organization have semantic repercussions. To see this consider the sentences in (2a) and (2b).

- (2) a. He kissed her.
b. She kissed him.

Here, the difference between subject position and object position is also marked using different forms of the third-person pronouns: *he* and *she* are used for the subject position, while *him* and *her* are used for the object position. This is an example of a phenomenon called structural case assignment, in which the subject position gets marked in one way, called nominative case, while the object gets marked in another way, called accusative case.¹

The sentences in (1) and (2) might suggest that case marking is causally related to both the semantic role of the nominals and their syntactic position. However, this is not the case. For instance, being marked nominative is not a requirement for carrying the agent role of a verb like *kiss*, nor does nominative marking stand in the way of carrying the patient role. This can be seen in the examples in (3).

- (3) a. He kissed her.
b. She was kissed by him.
c. I expected him to kiss her.

(3)a shows, again, the basic pattern of case assignment in an active sentence. Passivizing the sentence, (3)b, results in nominative case being assigned to the patient *she*² while (3)c shows that in a non-finite clause an accusative form (*him*) can carry the agent role of *kiss*. This suggests that nominative case marking is neither necessary nor sufficient for realizing a specific thematic role of a verb and, thus, a syntactic process that is not (directly) causally related to meaning composition.³

Semantic effects on syntax are just as ubiquitous as syntactic effects on meaning. For instance, the number of syntactic arguments that need to accompany a verb to form a full sentence is a function of the lexical semantics of the verb: *smile* requires one, *kiss* requires two, *give* requires three. Nevertheless, not all aspects of meaning are syntactically visible. A simple example of syntactic inertness of meaning can be seen when considering pairs of verbs like *frown* and *smile*. Clearly, these two verbs have rather different lexical meanings yet there seem to be no syntactic processes that are sensitive to these differences in meaning: both take one syntactic argument to form a complete sentence, both can at least marginally take a so called cognate object argument (*smile a (big) smile*, *frown a(n ugly) frown*), yet neither seems to be able to undergo passivization (**a (big) smile was smiled*, **a(n ugly) frown was frowned*), both can appear in the progressive form, etc.

These examples give but a first impression of the complexity that is characteristic of the interface between structure and meaning. To probe how deep and how systematic the interactions are between these two components of the grammar, we turn to the domain of quantifiers, which lend natural language much of its expressive power and which have shaped much of the discussion and theoretical development in the study of the syntax–semantics interface.

¹ In English, a morphologically impoverished language, case marking can be directly observed only on pronouns, though in other languages, it can appear on all nominals.

² The thematic subject, the bearer of the agent role, is realized in what is called the oblique by-phrase which, in English, requires the same form as the accusative (*him*).

³ To show that nominative case is generally semantically inert requires a more extensive discussion, which would lead us too far away here.

2. Quantifier Integration and Quantifier Scope

2.1. Quantifiers and the problem of quantifier integration

In the previous section we have seen that verbs introduce thematic roles such as agent and patient. We also saw that proper names and pronouns can serve as the arguments of verbs, carrying these thematic roles in the composition of sentence meaning. The class of expressions that can serve as verb arguments is not restricted to proper names and pronouns, of course. Definite descriptions, e.g. *the boy*, as well as quantificational expressions such as *no one*, *everybody*, *some girl*, *most boys*, *more than two students*, etc. can serve the same function, (4).

- (4) a. The boy kissed every girl.
 b. No one kissed more than two girls.
 c. Some girl kissed the boy.

Expressions that can serve as arguments of verbs are canonically referred to as determiner phrases (DPs) and semantically fall into two main groups: DPs that pick out individuals in the world (referring DPs) and DPs that don't (quantifiers). The first class contains proper names, pronouns, definite descriptions, among others. For instance, the proper name *Mary* can be analyzed semantically as referring to the individual known as Mary, while *the woman in the bright yellow hat* can be analyzed as referring to the most salient woman in a bright yellow hat in the conversational context. If that woman is Mary, then *Mary* and *the woman in the bright yellow hat* will have the same referent.

Quantifiers, by contrast, cannot be said to refer to individuals. Which individuals could we take to be the referents of expressions like *no girl*, *most boys*, or *more than two students*? Thus, rather than analyzing them as referring expressions, quantifiers are canonically analyzed as second order predicates (Frege, 1879; Barwise and Cooper, 1981; etc.). Whereas expressions that denote first order predicates take DPs as their arguments, second order predicates take other predicates as their arguments to form sentences. For instance, *no one* is true of a predicate it takes as argument as long as there is no individual that satisfies that predicate, *every boy* is true of a predicate if all the boys satisfy it, *more than two professors* is true of a predicate if the number of individuals that are both professors and satisfy the predicate is three or higher, etc.

The difference in meaning between referring DPs and quantificational DPs has a profound impact on sentence meaning and, as we will see, raises deep questions about the syntax–semantics interface. A first indication of this can be seen in the fact that sentences with quantifiers can be ambiguous when sentences employing a referring expression can't. Consider the example in (5).

- (5) John hasn't read more than two novels by Tolstoy.

The sentence in (5) is ambiguous. It can be understood to say that the number of novels written by Tolstoy that John has read is two or smaller but it can also be understood to say that there are more than two novels by Tolstoy that John hasn't read. Under the first reading, the sentence puts an upper limit on the Tolstoy novels John has read, i.e. the sentence would be false in a situation where John has read three or more. The second reading, by contrast, is consistent with such a situation. For instance, John could have read six novels by Tolstoy and the sentence would still be true as long as there are (at least) three he hasn't read, e.g. *The Cossacks*, *Sebastopol*, and *The Kreutzer Sonata*.

We can isolate the two readings of (5) by using more cumbersome variants, such as those in (6). (6)a unambiguously expresses the first meaning of (5) and (6)b unambiguously expresses the second meaning of (5).

- (6) a. It is not the case that John has read more than two novels by Tolstoy.
 b. More than two novels by Tolstoy are such that John hasn't read them.

These variants also give us a clue how to think about the origin of the ambiguity. The first reading arises when the negative operator *not* negates the sentence *John has read more than two novels by Tolstoy*. The second reading arises when the quantifier *more than two novels by Tolstoy* takes a negated predicate describing the things John has not read as argument. Modeling predicates as sets, an approximation which will do for our purpose, we can represent this idea a bit more formally. For instance, the predicate 'having been read by John' is a predicate of individuals and so can be thought of as denoting the set of things John has read (in set notation $\{x: \text{John has read } x\}$). The second order predicate *more than two novels by Tolstoy*, by contrast, is a predicate of predicates, rather than of individuals and so can be modeled as $\{P: |\{x: x \text{ is a novel by Tolstoy}\} \cap P| > 2\}$, or 'the collection of sets such that at least two of the entities in any set of the collection are also novels written by Tolstoy'. Thus, it could be true of predicates like $\{x: \text{Mary has read } x\}$, $\{x: \text{John has not read } x\}$, $\{x: x \text{ is written in}$

Russian}, etc. Putting these assumptions together using a loose mixture of predicate logic notation and English, we can represent the composition of the two readings of (5) as in (7).

- (7) a. $\neg [[\{P: |\{x: x \text{ is a novel by Tolstoy}\} \cap P| > 2 \}] (\{x: \text{John has read } x\})]$
 a.' $\neg [>2x[x \text{ is a novel by Tolstoy \& John has read } x]]$
 'it is not the case that there are more than two things that are both novels by Tolstoy and read by John'
 b. $[\{P: |\{x: x \text{ is a novel by Tolstoy}\} \cap P| > 2 \}] (\{x: \neg[\text{John has read } x]\})$
 b.' $>2x[x \text{ is a novel by Tolstoy \& John has not read } x]]$
 'there are more than two things that are both novels by Tolstoy and have not been read by John'

(7)a, which corresponds to (6)a, is a negative statement. It states that the second order predicate denoted by *more than two novels by Tolstoy* is not true of the predicate $\{x: \text{John has read } x\}$. Simplifying the formula by folding $\{x: \text{John has read } x\}$ into the predicative variable slot, P, of $\{P: |\{x: x \text{ is a novel by Tolstoy}\} \cap P| > 2\}$ we get the negative statement in (7)a': it can't be that John has read 3 or more novels by Tolstoy if the sentence is true.⁴ In (7)b, which corresponds to (6)b, negation is part of the predicate that *more than two novels by Tolstoy* takes as argument, $\{x: \text{John has not read } x\}$. Thus, the statement is true if the number of things that are both novels of Tolstoy and not read by John is three or higher.

The difference between the relative positions of the quantifier and negation in the composition of the sentence meanings is known as a difference in *scope*, and the ambiguity of sentences like (5) as a *scope ambiguity*.⁵ What we see, then, is that quantifiers can give rise to scope ambiguities. Referring expressions, by contrast, cannot. For instance, when we replace the quantifier *more than two novels by Tolstoy* with a referential expression like *Anna Karenina* or *Tolstoy's seventh novel*, the ambiguity disappears, (8). The sentence simply states that John hasn't read Anna Karenina/the seventh novel written by Tolstoy – irrespective of whether we use the basic sentence, (8)a, or one of its more cumbersome variants, (8)b and c.⁶

- (8) a. John hasn't read Anna Karenina/Tolstoy's seventh novel.
 b. It's not the case that John has read Anna Karenina/Tolstoy's seventh novel.
 c. Anna Karenina/Tolstoy's seventh novel is such that John hasn't read it.

Analyzing quantifiers as second order predicates can, thus, explain the semantic import quantifiers have on sentence meanings. It also helps us appreciate a fundamental puzzle associated with quantifiers.⁷ If quantifiers are second order predicates and, thus, require predicates (sets of individuals) to form sentence meanings, how are they able to realize argument positions of verbs, which require individual denoting expressions to form sentence meanings? Take the verb *kiss*, again. It denotes a relation between individuals, the agent and patient of a kissing event. We expect that forming a sentence with *kiss* requires two referring expressions, such as *John* and *Mary*, which denote individuals. What we, prima facie, don't expect is that we can form a sentence with quantificational expressions realizing the argument positions of *kiss*; the meaning of *kiss* is not that of relation between quantifiers. In other words it is puzzling that (9)b,c are as acceptable as (9)a.

- (9) a. John kissed Mary.
 b. No boy kissed Mary.
 c. Mary kissed every boy.

⁴ I will not introduce a rigorous meta-language to describe how meanings are composed. Instead, I will rely on a notation that reflects the main idea of how complex meanings arise as function of their parts in an intuitive way. In (7), for instance, negation is represented as a sentence level propositional operator, \neg , and the idea that the quantifier *more than two novels by Tolstoy* combines with a predicate with the help of brackets and parenthesis, $[\alpha](\beta)$, which is reminiscent of a widely employed notation to represent a function, α , applying to an argument, β . See e.g. Heim and Kratzer (1998) for an introduction to the formal techniques underlying the discussion presented in this paper.

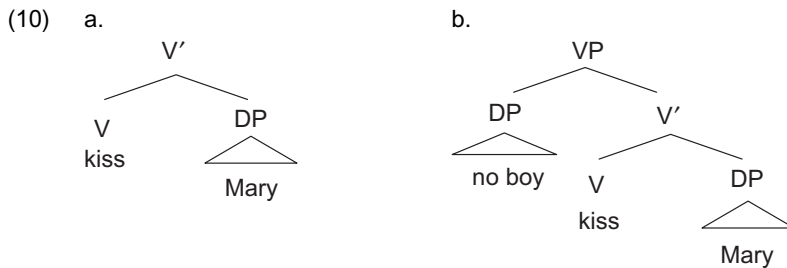
⁵ In Sections 2.2 and 2.3 we will see how this semantic ambiguity can be seen as a product of a covert syntactic ambiguity of (5), which is not reflected in the word order of the sentence.

⁶ As before, we can take to (8)b and c to correspond to two different ways in which negation can combine with the rest of the sentence, (8)b',c', respectively, however, the resultant meaning will be the same.

- (8) b.' $\neg [[\{x: \text{John has read } x\}] (\text{Anna Karenina})]$
 c.' $[\{x: \neg[\text{John has not read } x]\}] (\text{Anna Karenina})$

⁷ This puzzle does not depend on analyzing quantifiers as 2nd order predicates. Rather, it stems from the fact that quantifiers do not refer. Any model of quantifier meanings that recognizes this elementary fact will also run into the issue how quantifiers can serve as arguments. What is specific to the analysis of quantifiers as second order predicates is that no combinatorial puzzle arises for quantifiers in the subjects position of verbs as shown in (10). See Johnson and Tomioka (1998) for discussion.

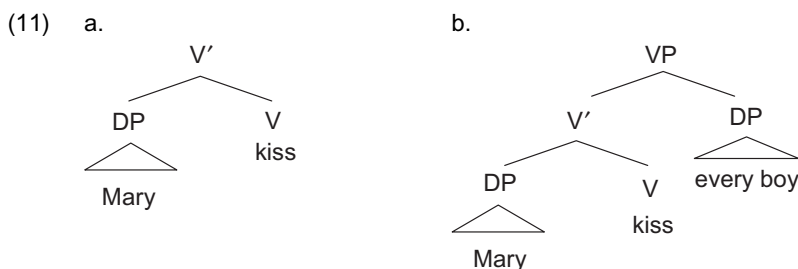
To solve this puzzle, we need to find a way of systematically constructing suitable predicates for the quantifiers to combine with from the remainder of the sentence. In (9)b the quantifier, *no boy*, is in subject position and the remainder is *kissed Mary*. We can construct the predicate $\{x: x \text{ kissed Mary}\}$ by assuming that *kiss* and *Mary* form a constituent, traditionally labeled V' . The meaning of this constituent is a result of *Mary* filling the inner argument position of *kiss*, thereby carrying the patient role in the kissing event described by the sentence, (10)a. *No boy*, which realizes the second (external) argument of *kiss*, the subject position carrying the agent role, can combine with this predicate. Thus, the syntactic requirements of the sentence are met: *no boy* can fill the subject argument position of the verb *kiss* (in the same way that a referring DP would), while *Mary* can fill the object argument position. The semantic requirements are also met: *no boy* can take the predicate *kissed Mary* as its argument. The result is a verb phrase, VP, which is a constituent that has all argument positions introduced by the verb *kiss* filled, (10)b.⁸



Thus, the reason that *no boy* can serve as external argument of *kiss* in (9)b is not that the predicate *kiss Mary* might have the denotation of *no boy* in its extension. Rather, it is because the second order predicate denoted by *no boy* might have the predicate denoted by *kiss Mary* in its extension.

The situation is quite different in (9)c. Here the quantifier *every boy* is the object of *kiss* and so carries the patient role of the kissing event described by the sentence. The remainder of the sentence *Mary kissed* is, however, not a constituent. This means that it cannot be directly composed to form a predicate (the set of things that *Mary* has kissed). This suggests, at first glance, that this sentence should be uninterpretable: *kiss* cannot directly combine with its object, *every boy* since it is not referring to an entity that could be the patient in a kissing event, nor can it directly combine with its subject, *Mary*. How, then, do these two expressions form the predicate $\{x: \text{Mary kissed } x\}$ which the quantifier *every boy* needs to combine with to generate the desired meaning?

One possible solution would be to argue that in (9)c, the VP has a different structure so that *Mary* is the first expression *kiss* combines with, (11)a, and *every boy* the second. However, this is simply moving the puzzle around, since we no longer understand how *Mary* can carry the agent role in the kissing event described by the sentence and *every boy* gets to carry the patient role, (11)b.⁹



What we need to solve the puzzle of how the object DP *every boy* is integrated into the sentence is a method that delivers a suitable predicate, $\{x: \text{Mary kissed } x\}$, from the remainder of the VP, *Mary* and *kiss*, fulfilling the semantic requirements of *every boy*, while maintaining that *Mary* serves as the external (subject) argument of *kiss* and *every boy* serves as the internal (patient) argument.

⁸ I will ignore the past tense morpheme *-ed* here. It is a realization of a tense operator which is structurally above the verb and its argument positions and locates the event described by the VP in the past.

⁹ Attributing the reversal in thematic role assignment to a difference in linear order by claiming that the patient role is assigned to the second argument when a quantifier is to the right of *kiss* simply turns the puzzle into the question why linear order matters with quantifiers but not with referring expressions.

The literature offers a variety of solutions to this puzzle. One type of response is to make the semantics of quantifiers more flexible so that they can assume one meaning in subject position and another, related meaning in object position.¹⁰ An alternative is to stick to the semantic assumptions we have made, including the fact that expressions mean the same thing regardless of their syntactic position and rely, instead, on the syntax to generate a structure that is interpretable. On this conception, a semantic property of quantifiers, i.e. the fact that they don't refer, triggers a change in syntactic structure.

2.2. Quantifier raising

Let us go back to the ambiguous sentence in (5), repeated below in (12), and the analysis we have given in terms of scope, focusing, for the moment, on the second reading where *more than two novels by Tolstoy* takes scope over negation. Recall that this reading is unambiguously conveyed by the more cumbersome sentence in (13)a which has a syntactic structure that corresponds rather closely to the logical structure of our semantic analysis repeated in (13)b.

(12) John hasn't read more than two novels by Tolstoy.

- (13) a. More than two novels by Tolstoy are such that John hasn't read them.
 b. $\{[P: |\{x: x \text{ is a novel by Tolstoy}\} \cap P| > 2]\} (\{x: \neg[\text{John has read } x]\})$

(13)a and b are structurally rather similar. In (13)a *more than two novels by Tolstoy* is the subject of the matrix clause while *not* is part of the embedded clause. This corresponds to the fact that in (13)b the highest operator is the second order predicate denoted by *more than two novels by Tolstoy*, which takes the negative predicate $\{x: \neg[\text{John has read } x]\}$ denoted by *are such that John hasn't read them* as argument. In fact, we can translate the latter into the former by assuming that *are such that* represents set abstraction, $\{x: \dots\}$, and that the pronoun *them* is translated as the abstracted variable.

The analysis we have just given for (13)a can be extended fairly straightforwardly to cases like those in (14), although there is no overt signal for set abstraction ('is such that') and no overt pronoun representing the abstracted variable.

- (14) a. It is unlikely that every ticket holder will win the lottery.
 b. Every ticket holder is unlikely to win the lottery.

To see how, note first that the sentences in (14) are closely related, yet they cannot be used as paraphrases of each other. The sentence in (14)a conveys that it is unlikely that all the ticket holders will win the lottery, a virtual guarantee as long as there are more ticket holders than there are winning tickets. In fact, it could be true even if there is somebody who holds many lottery tickets and thus is likely to hold a winning ticket, a state of affairs that would falsify (14)b. Just like the ambiguity with (5), the difference in meaning between (14)a and b can be understood as a matter of scope. In (14)a the quantifier *every student* is under the modal operator *unlikely* and in (14)b it is outside of it and thus taking a predicate that contains *unlikely* as argument, (15)b.

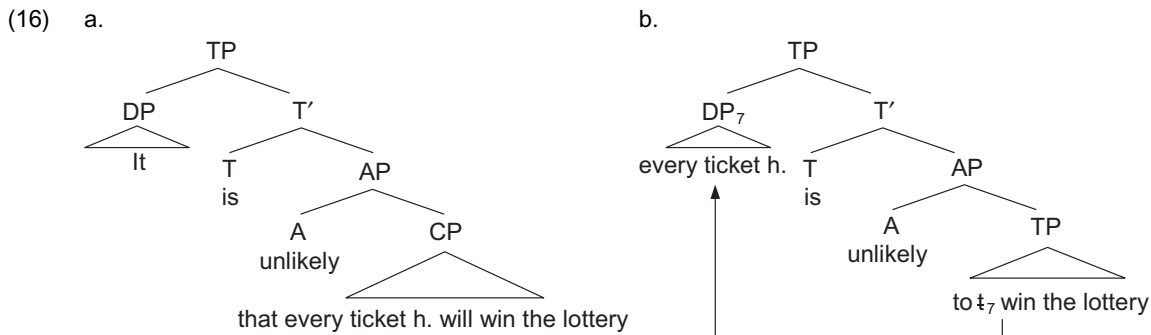
- (15) a. unlikely $\{[P: \{x: x \text{ is a ticket holder}\} \subseteq P]\} (\{x: x \text{ wins the lottery}\})$
 'It is unlikely that every x is st. if x is a ticket holder, x wins the lottery.'
 b. $\{[P: \{x: x \text{ is a ticket holder}\} \subseteq P]\} (\{x: \text{it is unlikely that } x \text{ wins the lottery}\})$
 'For every x , if x is a ticket holder then x is unlikely to win the lottery.'

Note that in both cases, the quantifier *every ticket holder* realizes the external argument of *win the lottery*. This is expected in the case of (14)a since *every ticket holder* appears in the canonical subject position of the clause describing the winning of the lottery event. However, in (14)b *every ticket holder* appears in the subject position of the matrix clause, yet it carries the agent role of the embedded clause. To understand how this can be, we can use essentially the same mechanism we have proposed for the analysis of (13)a. In this case, however, the syntactic trigger will be different. More specifically, sentences like (14)b are canonically analyzed as "Raising" constructions, in which the matrix subject is related to the thematic subject position of the embedded clause via a movement chain (Postal, 1974, etc.).¹¹ Movement chains are

¹⁰ See Hendriks (1993), Barker (2002), Keenan (2005) among others.

¹¹ See Jacobson (1990) for a view of Raising which accounts for the semantic import of displacement via function composition.

complex syntactic objects consisting of a “head” occupying the matrix subject position in (14)b and a tail, represented as a co-indexed trace, t_7 in (16)b, occupying the embedded subject position.^{12,13}



To derive the desired meaning from the structure in (16)b using the same mechanism we employed for (13)b, we simply need to attribute the set abstraction component to the head of the chain and the introduction of the variable to the tail of the chain. This is stated in (17), adapted from Fox (2003).¹⁴

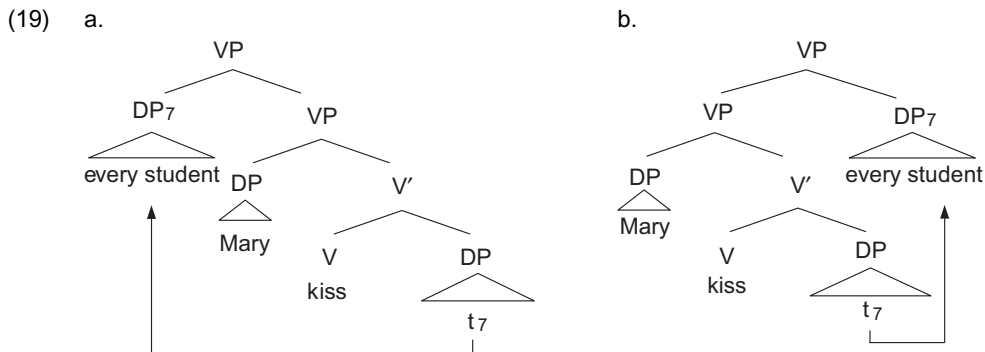
- (17) In a structure formed by DP movement, $DP_n[\varphi \dots DP_n \dots]$, the sister of DP_n , φ , is interpreted as a set characterized by the function that maps an individual, x , to the meaning of $\varphi^{[x/n]}$ where $\varphi^{[x/n]}$ is the result of substituting every constituent with the index n in φ with some DP referring to the individual x .

According to the rule in (17), the sister node of *every ticket holder* (that is, the part of the tree that combines directly with *every ticket holder*) in (16)b, is interpreted as the set $\{x: \text{it is unlikely that } x \text{ wins the lottery}\}$. This is exactly what our semantic analysis in (15)b postulated to generate the desired meaning.

Having seen how movement chains are interpreted, we can return to cases like (18) and develop an account of how the problem of quantifiers in object positions is resolved via syntactic movement.

- (18) Mary kissed every student.

Specifically, we can give a movement based account of object quantifier integration if we allow for the possibility of covert movement, i.e. movement that does not overtly affect the word order of the sentence (Chomsky, 1976; May, 1977, 1985, etc.). On this view, the object DP is moved from its base position, where it cannot be interpreted, to clausal node such as the top of the VP, where it can be interpreted, (19).¹⁵ This movement is traditionally called Quantifier Raising or, for short, QR.



¹² In more recent developments, movement is modeled in terms of integrating two copies of the same expression, Chomsky (1993, 1995) or, alternatively, as a product of internal merge, Chomsky (2004).

¹³ The trees in (16) follow current syntactic convention, i.e. clauses are analyzed as tense phrases, TPs (a constituent that contains the entire finite clause), and embedded clauses as complementizer phrases, CPs, a constituent that contains a TP as well as elements that mark embedding such as *that*.

¹⁴ This definition builds on the correspondence between sets and their characteristic functions. That is, we can model predicates either as sets or as truth-valued functions that map members of the set to True and non-members to False.

¹⁵ The trees in (19) abstract away from category labels and use a convention from Heim and Kratzer (1998) that gives the index on the head of the chain a separate node in the tree in order to make it more transparent how semantic composition proceeds when a movement chain is integrated.

The structures in (19) are in all crucial aspects parallel to the one in (16)b except that the relationship between hierarchical structure and word order is different. In (16)b the quantifier has been moved overtly and thus precedes material to the left of its base position while in (19) the quantifier is moved covertly, without affecting the word order of the sentence. Thus, there is no difference between drawing a tree in which the head of the movement chain is at the left periphery, (19)a, or at the right periphery, (19)b, since the head of the chain is simply not ordered with regard to the pronounced elements of the sentence.

For the purpose of semantic composition, the structures in (19) are analyzed in exactly the same way we analyzed (16) b. Thus, a solution of the problem of quantifiers in object position that relies on syntactic movement seems rather appealing from the perspective of semantic parsimony since the machinery we call upon to interpret object quantifiers is independently needed to account for phenomena such as the Raising construction in (16)b. However, this account brings to light another puzzle: clearly the surface word order cannot be what directly feeds into the semantics. Instead, this type of analysis relies on a syntactic level of representation providing the input to semantics, traditionally called Logical Form (LF), in which the position at which an expression is integrated is not necessarily overtly detectable.¹⁶

If the linear placement of a quantifier in a sentence is not a reliable indicator for the position at which it is integrated, what other diagnostics are there? In the next three sections, we will see three correlations involving quantifiers, which provides us with such diagnostics, and, which, at the same time, constitute a substantial body of empirical evidence that any theory of quantifier integration needs to explain.

2.3. Quantifier Scope and movement

We have already seen one diagnostic for the location of a quantifier when we studied the ambiguity in (5) and the contrast in (16). We can detect the position of a quantifier at LF relative to another operator if the interpretation of the sentence is different depending on the quantifier taking narrow (low) or wide (high) scope with regard to that operator. For a quantifier to have narrow scope with regard to an operator, the quantifier has to be part of the sister of the operator at LF. Conversely, a quantifier has wide scope with regard to an operator if the operator is part of the sister of the quantifier at LF.¹⁷

To illustrate, consider again our sentence in (5), repeated in (20) for convenience. As we have seen above, the sentence is ambiguous between wide and narrow scope reading of the quantifier *more than two novels by Tolstoy* relative to negation.

- (20) John hasn't read more than two novels by Tolstoy.
 a. $\gt 2x[x \text{ is a novel by Tolstoy} \ \& \ \neg [\text{John has read } x]]$
 b. $\neg [\gt 2x[x \text{ is a novel by Tolstoy} \ \& \ \text{John has read } x]]$

On the view we have developed in the previous section, this means that there has to be an interpretable position for *more than two novels by Tolstoy* which is above *not* as well as one that is below *not*. We can represent these two possibilities as in (21)a and b. In the structure in (21)a, the object quantifier is moved covertly to the top of the tree. Per the rule in (17), the sister node will denote the predicate $\{x: \text{John has not read } x\}$. This predicate will serve as the argument of the quantifier predicting the sentence to be true just in the case that more than two novels by Tolstoy have that property of John having not read them. In the structure in (21)b, the object quantifier is moved covertly to the verb phrase. This is an interpretable position on the assumption that the subject is base generated inside the VP and moved overtly to the TP.¹⁸ Given that all argument positions of the verb are filled inside the VP its meaning will be of the right type to serve as landing site for QR. That is, it will denote the predicate $\{x: \text{John has read } x\}$.¹⁹ Since this point is in the scope of *not*, the sentence will convey that it is false that John read more than two novels by Tolstoy.

- (21) John hasn't read more than two novels by Tolstoy.
 a. $[_{TP} [\text{more than two novels by Tolstoy}]_7 [_{TP} \text{John}_6 \text{ has not } [_{VP} t_6 \text{ read } t_7]]]$
 b. $[_{TP} \text{John}_6 \text{ has not } [_{VP} [\text{more than two novels by Tolstoy}]_7 [_{VP} t_6 \text{ read } t_7]]]$

¹⁶ Note that there are languages in which Quantifier Raising does take place in overt syntax, e.g. Hungarian (Szabolcsi, 1997).

¹⁷ This relation is traditionally stated in terms of the structural relation of c-command (Reinhart, 1983; etc.)

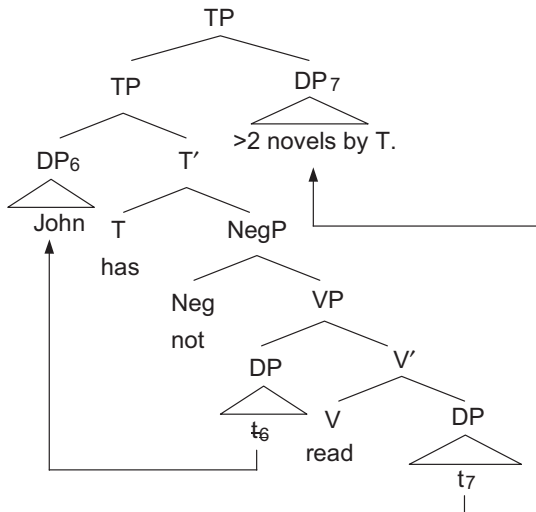
(i) α takes scope over β iff α c-commands β

(ii) A syntactic constituent α c-commands a syntactic constituent β iff β is α 's sister or contained by α 's sister.

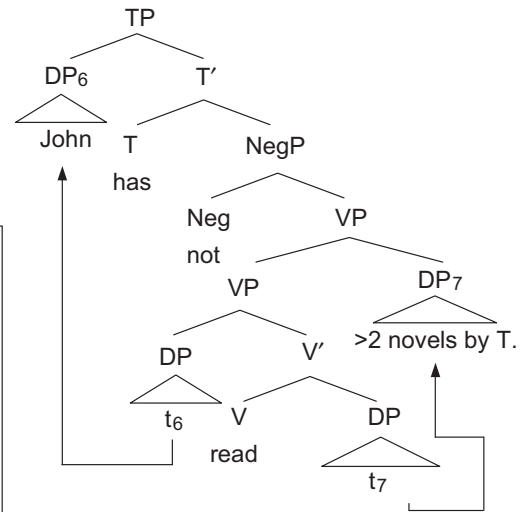
¹⁸ This movement is triggered by a syntactic feature of English that insures that the sister of T', the specifier of TP, needs to be filled in overt syntax.

¹⁹ More accurately, the VP will denote the predicate $\lambda x. g(6) \text{ has read } x$, where g is an assignment function and $g(6)$ is the local semantic value of the lower copy of *John*.

(22) a.



b.



Sentences that contain two quantifiers can be analyzed in a parallel fashion. For instance, the sentence in (23) is ambiguous. It can be used to describe a situation in which there is one rookie who was paired up against every veteran but it can also describe a situation in which every veteran got to play against some (possibly different) rookie.

(23) A rookie played against every veteran.

- a. $[_{TP} [a \text{ rookie}]_6 [-ed[_{VP} [every \text{ veteran}]_7 [_{VP} t_6 \text{ play against } t_7]]]]$
 b. $[_{TP} [every \text{ veteran}]_7 [_{TP} [a \text{ rookie}]_6 [-ed [_{VP} t_6 \text{ play against } t_7]]]]$

$\exists > \forall, \forall > \exists$
 $\exists > \forall$
 $\forall > \exists$

As sketched in (23)a and b, this ambiguity can be analyzed as a scope ambiguity in which the subject quantifier takes scope over the object quantifier, (23)a, or the object quantifier takes scope over the subject quantifier, (23)b. The latter reading is traditionally called the inverse scope reading since it is the result of inverting the scopal relation between the subject and the object.

However, as is well known, not all multiply quantified sentences are scopally ambiguous in this way. An important test ground for theories of quantifier integration is, thus, whether they can help us understand when inverse scope is possible and when it is not.²⁰

The hypothesis that the scope of a quantifier is determined by movement implies that Quantifier Scope should be constrained by the same principles that constrain the locality of movement. That is, we expect the following principle to constrain Quantifier Scope.

(24) Quantifier Scope and Movement

A quantifier α can take scope over β if there is an accessible landing site for (overt) movement originating from the base position of α that c-commands β .

A first example illustrating this constraint is given in (25). The sentence in (25) contains two quantifiers, which can, in principle, give rise to a scope ambiguity as we have seen in (23). However, in the example in (25) the inverse scope reading according to which each veteran can play a different rookie, is unavailable. The sentence can only be true if there is at least one rookie who beat all the veterans but lost against the volunteer, (25)a.

(25) A rookie won against every veteran but lost against the volunteer.

- a. $[a \text{ rookie} \dots [_{VP} [every \text{ veteran}]_7 [_{VP} \dots t_7]] \text{ and } [_{VP} \dots \text{the volunteer}]]$
 b. * $[every \text{ veteran}]_7 [a \text{ rookie} \dots [_{VP} \dots t_7] \text{ and } [_{VP} \dots \text{the volunteer}]]$

* $\forall > \exists$

²⁰ The body of evidence on quantifier scope is rather rich and cannot be covered here satisfactorily. See Szabolcsi (2010) and Ruys and Winter (2011) for comprehensive surveys.

Since there is nothing wrong with the truth-conditions that a structure with inverse scope would express, there has to be a structural (syntactic) reason that prevents *every veteran* to have scope over *a rookie*.

From the perspective developed above, we can look to pre-existing constraints on over movement. Notably, the sentence above contains a construction called coordinate structure: multiple arguments of the same type joined together with a conjunction (e.g. *and* or *but*). Indeed, it is well known that extracting an element out of just one of branch of a conjoined phrase is impossible (Coordinate Structure Constraint, CSC, Ross, 1967). This is illustrated in (26). (26)a is a simple case of question formation which involves moving the object of the verb *play*, realized as a *wh*-word, to the front of the sentence. (26)b is an attempt to extract a *wh*-word from just one of the two conjoined phrases. However, this is not possible.

- (26) a. Who did a rookie play against?
 b. * Who did a rookie play against and win two matches?

This is exactly as we would expect given (24). The unacceptability of (26)b shows that the position that *every veteran* would have to occupy to take scope over the subject quantifier cannot be reached by movement. Therefore, inverse scope for *every veteran* is unavailable in (25).²¹

The set of phenomena covered by the correlation in (24) is not limited to co-ordination. For instance, the sentences in (27) exemplify three types of constructions that do not allow non-local *wh*-extraction.²²

- (27) a. * Who did a rookie play in a game that featured?
 b. * Who did a rookie wonder whether he would play against?
 c. * Who was a rookie excited if he got to play against?

(24) leads us to expect that inverse scope for a corresponding object quantifier over the matrix subject should be equally impossible. This is indeed the case as shown in (28)a–c. None of these sentences can be understood in such a way that they would be true if each veteran gets his own rookie.

- (28) a. A rookie played in a game that featured every veteran. $*\forall > \exists$
 b. A rookie asked whether he could play against every veteran. $*\forall > \exists$
 c. A rookie was excited if he got to play against every veteran. $*\forall > \exists$

Yet another instantiation of (24) can be seen in (29). (29)a shows that the pronoun *her* cannot be construed as anaphorically dependent on the *wh*-operator *who*. That is, we cannot understand the question to ask for the identity of a female person such that she played against a friend of her father.²³ Likewise, the pronoun cannot be construed as anaphorically dependent on the object quantifier *every girl* in (29)b and, as expected by (24), this means that the quantifier cannot take scope over the subject and at the same time bind the pronoun inside the subject.

- (29) a. * Who₇ did a friend of her₇ father play against?
 cf. Who did a friend of Mary's father play against?
 b. * A friend of her₇ father played against every girl₇. $*\forall > \exists$
 cf. Every girl₇ played against (a friend of) her₇ father.

These data show that there is a substantial body of data supporting a correlation between Quantifier Scope and overt movement. However, the correlation is not perfect.²⁴ That is, not every scope position for a quantifier is also a possible landing site for overt movement, nor is every landing site for overt movement a possible scope position. Indeed, the formulation in (24) only demands that for a quantifier to be able to take scope at a particular position there has to be a landing site for movement at or above that position. This means that Quantifier Scope should be upper bounded by the same principles that govern the locality of movement. The hypothesis that Quantifier Scope is a result of movement offers

²¹ For a more complete discussion of this argument see Fox (2000).

²² The three environments in (28)–(27) are examples of three well-known types of islands for extraction called “complex NP”, “*wh*-”, and “adjunct” islands.

²³ The prohibition against co-indexation in (29) is known as Weak Cross Over (Postal, 1971).

²⁴ A well-known class of exceptions are so called specific indefinites which can take scope out of environments that are islands for movement, see Fodor and Sag (1982) and much subsequent work.

an explanation of this fact but, as it is stands, it is insufficient to account for cases where Quantifier Scope is more constrained than overt movement. There must be additional constraints governing Quantifier Scope.²⁵

A prominent proposal as to one of these constraints comes from Fox (1995, 2000) who studied cases such as the example in (30).

(30) A rookie admires every veteran and Mary does, too. $\exists > \forall, * \forall > \exists$

The sentence in (30) is a conjunction of two clauses, the first of which normally allows for an inverse scope. However, in this particular configuration the inverse scope reading is unavailable. The sentence can express the thought that there is at least one rookie who admires all the veterans and that Mary admires all of them as well but it cannot mean that for every veteran there is a possibly different rookie who admires the veteran while Mary admires all of them. Fox (1995, 2000) attributes the lack of inverse scope in (30) to a combination of two factors brought into play by the second conjunct. One factor has to do with the VP of the second clause being elided. VP ellipsis is an anaphoric process that allows a VP to be phonetically empty if there is a pronounced VP in the discourse that serves to identify the content of the elided VP, (31).

(31) Ellipsis Parallelism

A VP_E can be elided only if there is a pronounced antecedent VP, VP_A, that is identical to VP_E at LF.

Thus, the elided VP of the second conjunct is built from the same material as the VP of the first conjunct, as indicated in (32) via the angled brackets, and receives the same interpretation as its antecedent.

(32) A rookie admires every veteran and Mary does (admire every veteran), too.

The precise characterization of what it means for two VPs to count as identical at LF is a complex matter. For our purpose it is sufficient to assume that the identity condition can only be met if the object quantifiers (in this case, *every veteran*) in the pronounced and in the elided VP are interpreted in parallel positions: either both above the other operators, or both below. This can be seen, for instance, in the fact that sentences like (33)a do not have mixed readings in which one object quantifier has wide scope and the other narrow, even though mixed readings are allowed in principle, (33)b.

(33) a. A rookie admires every veteran and a referee does, too.
b. A rookie admires every veteran and a referee despises every veteran.

(31) demands that the elided VP and the antecedent VP have parallel LFs. The fact that inverse scope is not available for (30) a means that an LF in which the object quantifier takes scope over the subject is not available for one of the constituents. The constraint cannot come from the first clause since sentences of this sort, by themselves, are scopally ambiguous and thus, in principle, allow for the missing LF. This means, that the second conjunct is responsible. The lack of the second (inverse scope) reading suggests that it cannot support an LF in which the object quantifier is moved above the subject, (34)b.

(34) a. [Mary]₆ ... [VP [every veteran]₇ [VP[t₆ admires t₇]]]
b. * [every veteran]₇ [Mary]₆ ... [VP [VP[t₆ admires t₇]]]

Fox (1995, 2000) offers an account of this observation. Considering just the sentence *Mary admires every veteran*, moving the quantifier further than the most local interpretable position does not yield a new reading: *Mary likes every veteran* and *Every veteran is such that Mary likes him* do not differ in meaning, unlike the sentences in (23). Fox argues that this semantically vacuous movement is not permitted. Specifically, he suggests that moving a quantifier covertly is subject to two constraints. First, a locality constraint demanding that QR always targets the closest interpretable position, (35), and second, an economy condition prohibiting semantically vacuous movement of a quantifier. Since an in-depth discussion of Fox's principle of Scope Economy would lead us too far afield, we will use the simplified version in (36) as a stand in.

(35) Locality (Shortest Move)²⁶

The landing site of an instance of QR is the closest position in which the quantifier is interpretable.

²⁵ A much discussed restriction concerning quantifier scope but not overt wh-movement is that it is, for the most part, clause bounded (see Chomsky, 1975 and much subsequent work).

²⁶ See Rizzi (in press) for a survey of locality phenomena in natural language.

- (36) Scope Economy (Simplified)
Raising a quantifier covertly above another quantifier cannot be semantically vacuous.

The interplay of (35) and (36) rules out the LF in (34)b since the object quantifier (*every veteran*) cannot be moved from its lowest interpretable position (right above the VP) over the subject (*Mary*): this movement is semantically vacuous. It also predicts that whenever an object quantifier takes inverse scope with regard to the subject it does so in a step-by-step (successive cyclic) fashion rather than in one fell swoop. For instance, the LF that gives rise to the inverse scope interpretation for (37)a contains two instance of QR rather than just one, (37)b.

- (37) a. A rookie admires every veteran.
b. [every veteran]₇[a rookie]₆ . . . [t₇ [_{VP} [_{VP} t₆ admires t₇]]]

The first instance of QR in (37) moves the object quantifier from its base position to a position immediately above the VP, the most local clausal (hence interpretable) node dominating its base position. This instance of QR is motivated simply because *every veteran* is not interpretable inside the VP, as discussed in section 2.1. The second instance of movement, which raises *every veteran* from the intermediate position to a position above *a rookie*, is, again, to the closest clausal node and it is allowed, unlike in the second conjunct of (30)a, because it isn't semantically vacuous.²⁷

To summarize, the hypothesis that quantifier integration relies on covert movement implies a correlation between Quantifier Scope and (overt) movement. We have seen a variety of cases supporting this expectation but we have also seen that the correlation is not perfect. One instance is that Quantifier Scope is more constrained than overt movement. To account for this, we adopted a view in which QR obeys a strict locality constraint (shortest move) and a semantic economy constraint disallowing QR if it is semantically vacuous.²⁸ A consequence of this proposal is that non-local scope is possible for a quantifier only if the quantifier can be moved to the non-local position via a sequence of local movements (from clausal node to clausal node) where each instance of QR is semantically motivated.

2.4. Implications for processing Quantifier Scope

The empirical basis of the discussion in the previous section consisted in native speaker judgments regarding the grammaticality and availability of certain interpretations of quantified sentences. However, we would also like to understand how easy it is to access a given interpretation, not just whether the reading in question is in principle available. The theory we have sketched above can help us understand the contribution of one of the factors that likely govern the processing of quantified sentences: the structural complexity of a sentence under a given reading.

On the view that quantifier integration depends on movement, Quantifier Scope is a result of how far a quantifier has been moved. Movement, in turn, is subject to a locality constraint. This provides us with a natural way of comparing the structural complexity of surface and inverse scope LFs. Specifically, the LF that gives rise to the inverse scope reading is more complex than the LF that gives rise to the surface scope reading. The inverse scope LF requires one more instance of QR as can be seen in (38)a (surface scope) and (38)b (inverse scope).²⁹

- (38) a. A rookie admires every veteran.
b. [a rookie]₆ . . . [_{VP} [every veteran]₇ [_{VP} t₆ admires t₇]]
c. [every veteran]₇[a rookie]₆ . . . [_{VP} t₇ [_{VP} t₆ admires t₇]]]

On the assumption that the human parser is sensitive to this difference and prefers simpler structures whenever possible, we expect that, all things being equal, the surface scope reading to be more easily accessible than the inverse scope reading. Indeed this is what native speakers report when asked what sentences such as (38) can mean.

Of course, other considerations can override this preference. For instance, if the surface scope reading is pragmatically marked or impossible as in the sentences in (39), only the inverse scope reading will be readily accessible.

²⁷ See Fox (1995,2000), Cecchetto (2004), etc. for various applications and extensions of this proposal.

²⁸ The canonical view on overt movement is that it is subject to a parallel locality constraint but, driven by features that are attached to specific positions in the syntactic structure. For instance, wh-movement is driven by a wh-feature located in the left periphery of a clause. Thus wh-words can end up in positions that are not possible landing sites for QR.

²⁹ Note that this follows only if the grammar does not allow the subject to be interpreted in its base position inside the VP ("Q-Lowering"). See Johnson and Tomioka (1998) for evidence that this is indeed the case.

- (39) a. A rookie replaced every veteran.
b. A Modigliani is hanging in every room.

The fact that speakers prefer surface scope over inverse scope when both readings are equally plausible has been well documented in the psycholinguistic literature.³⁰ For instance, Kurtzman and MacDonald (1993) show that speakers prefer continuations that are consistent with the surface scope reading for sentences like those in (40)a and b (in parentheses are approximate percentages of continuations of type C1 and C2 chosen for sentences of the form in (40)a and b).

- | | | | | | |
|------|----|-------------------------------------|--|----|------------------------------------|
| (40) | a. | Every kid climbed a tree. | | b. | A kid climbed every tree |
| | C1 | The tree was full of apples. (.35) | | C1 | The kid was full of energy. (.8) |
| | C2 | The trees were full of apples. (.8) | | C2 | The kids were full of energy. (.3) |

These results could also be explained by a variety of other factors including a general preference for assigning wide scope to the leftmost element, the topic, or the DP carrying the agent theta role of the sentence. However, Kurtzman and MacDonald also show that the passive counterpart of the active sentences exemplified in (40) do not have a clear preference for one scope assignment over the other, (41).

- | | | | | | |
|------|----|------------------------------------|--|----|-------------------------------------|
| (41) | a. | Every tree was climbed by a kid. | | b. | A tree was climbed by every kid. |
| | C1 | The kid was full of energy. (.6) | | C1 | The tree was full of apples. (.6) |
| | C2 | The kids were full of energy. (.7) | | C2 | The trees were full of apples. (.6) |

The lack of a clear preference in passive sentences suggests that the accessibility of inverse scope is at least partly governed by a structural factor.³¹ More concretely, it might be related to the fact that the thematic subject of a passive sentence, the *by*-phrase, is not derivationally related to the thematic subject position inside the VP. Rather it is integrated into the syntactic structure similar to an adjunct suggesting that the *by*-phrase can be merged either below or above the syntactic subject without relying on movement. This would mean that, unlike in active sentences, the inverse scope LF can be generated without being structurally more complex than the surface scope LF.

Obviously, a lot more needs to be said and a lot more research needs to be done to understand which factors affect the parser's ability to access various readings of scopally ambiguous sentences. One of these factors likely concerns the structural complexity of competing LFs and the hypothesis that Quantifier Scope is a product of movement provides us with a metric to assess the contribution of this factor.

3. Quantifier Scope and Antecedent Contained Deletion

The previous section discussed a correlation between movement diagnostics and Quantifier Scope, which any theory of quantifier integration needs to explain. The approach we have focused on is based on extending the machinery we needed to explain the effects of overt movement on scope as seen in examples like (14) to all cases of quantifier integration. This seemed natural from a semantic perspective but less natural from a syntactic perspective because it relied on the existence of covert movement, QR. In this section we will see an independent argument for covert movement coming from a particular form of ellipsis called Antecedent Contained Deletion (ACD). Importantly, we will see that properties of ACD systematically correlate with Quantifier Scope providing further support for the view that Quantifier Scope involves a level of representation in which the position at which the quantifier takes scope does not correspond directly to the position that the quantifier appears in overt syntax. The section concludes with a review of some recent processing research showing that quantifier integration and ACD resolution interact in real time sentence processing in a way that is expected only if it is assumed that the two processes call upon a shared mechanism.

3.1. Antecedent Contained Deletion


Antecedent Contained Deletion (ACD) refers to cases of ellipsis such as the one exemplified in (42) below, see Bouton (1970), Sag (1976) among many others.

³⁰ E.g. Ioup (1975), Kurtzman and MacDonald (1993), Reinhart (1997), Tunstall (1998), Anderson (2004), among others.

³¹ Kurtzman and MacDonald (1993) interpret the combination of the results in these two experiments as showing that preferences for quantifier scope are governed not just by one principle. When they converge, as they hypothesize is the case in the active voice, speakers have a clear preference for surface scope, when they don't converge, as is the case in the passive voice, speakers don't have a clear preference.

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

The sentence in (42) contains a relative clause, which is attached to the direct object DP. The VP inside the relative clause is elided as indicated in (42)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 Antecedent Contained Deletion. This is schematically illustrated in (43).

- (43) John talked to every student that Mary did ⟨talk to⟩.
- 

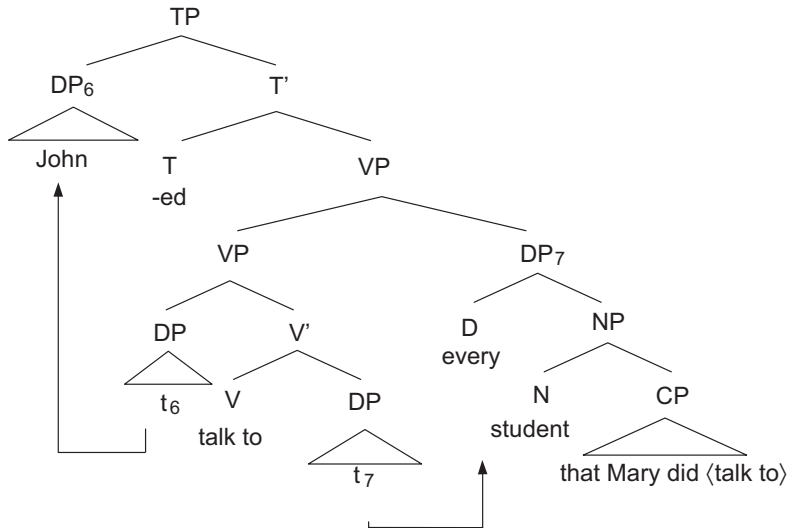
Structures of this sort are not limited to cases where a verb is left unpronounced. The examples in (44), for instance, show that the elided constituent can be larger. In (44)a the elided constituent contains the innermost argument of the di-transitive verb *introduce* and in (44)b the elided constituent is the VP headed by *willing* which contains a non-finite clause (*to talk to*).

- (44) a. John introduced Bill to every student that Mary did ⟨introduce Bill to⟩.
 b. John was willing to talk to every student that Mary was ⟨willing to talk to⟩.

The fact that the VPs in (43) and (44) can be elided is unexpected given the licensing condition on ellipsis in (31). Recall that this condition disallows ellipsis unless there is an antecedent VP that is identical to the elided VP at LF. However, the configuration in (43) and (44) should make it impossible to meet this condition because the elided VP is part of the object of the matrix VP and hence contained inside the antecedent VP. This should make it impossible to establish identity simply because a container can never be identical to something it contains. The fact that sentences of this sort are nevertheless perfectly grammatical must mean that they have structural descriptions in which the elided constituent is not contained in the antecedent.

We can see how this is possible if we assume that the object DP hosting the ACD site is raised covertly above the matrix VP before the relative clause is attached. This results in the structure in (45)b where identity between the matrix VP and the elided VP in the relative clause holds because there is no containment and all movement traces are bound from parallel positions.³²

- (45) a. John talked to every student that Mary did ⟨talk to⟩.
 b.



³² The structure of the relative clause is simplified in a number of ways here. For instance, relative clauses involve a gap, which is created by movement of a relative pronoun. Relative pronouns can be optionally realized in English with a wh-phrase as can be seen in (i). When there is no overt wh-phrase it is assumed that the position is filled by a silent version of the relative pronoun.

- (i) a. John talked to every student who Mary admired.
 b. ... every [student [_{CP} who₇ Mary admired t₇]]

As is apparent from the structure in (45)b, this instance of covert movement is the same as the movement we have assumed to integrate an object quantifier. Note, however, the reason for moving an object DP hosting an ACD site is in principle independent from the reason for moving an object quantifier. In the latter case, the reason is to resolve a type-mismatch. In the former case, it is to undo antecedent containment to create a structure that supports identity between the elided VP and the antecedent VP. This means that sentences which have a definite object DP that hosts an ACD site involve covert movement, even though semantically they can be analyzed as referring expressions and so do give rise to a type mismatch, (46).

- (46) a. John talked to the student that Mary did \langle talk to \rangle .
 b. [John₆ [_{VP} [_{VP} t₆ talked to t₇] [the student [that Mary \langle talk to \rangle]]]₇].

3.2. Quantifier Scope and ACD

We have seen that in order to allow for ACD resolution the ACD site cannot be contained inside its antecedent. The hypothesis that the required structural configuration is generated by moving the DP which hosts the ACD site leads us to expect another correlation involving quantifiers. Specifically, we expect that the size of the elided constituent correlates with the scope of the hosting DP as stated in (47) (Williams, 1974, 1977; Sag, 1976; etc.)

(47) Quantifier Scope and ACD

The scope of a quantifier hosting an ACD site is at least as high as the antecedent of the ACD site.

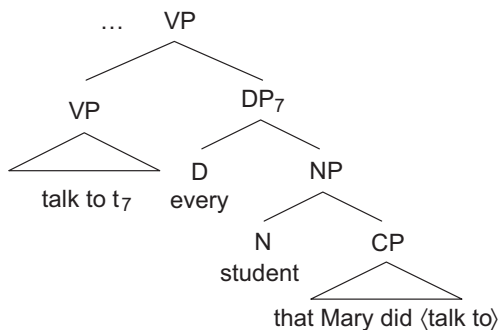
To see the empirical import of this correlation it is useful to control for the size of the elided VP. This can be done via a suitable choice of auxiliary marking the ACD site as shown in (48).

- (48) a. John was willing to talk to every student that Mary did \langle talk to \rangle .
 b. John was willing to talk to every student that Mary was \langle willing to talk to \rangle .

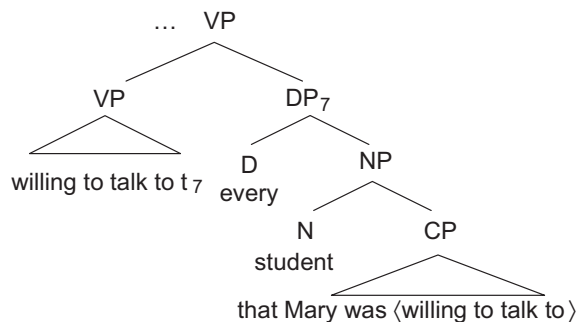
In (48)a the ellipsis site is marked with the auxiliary *did* and the ellipsis is resolved so that the local VP [_{VP} talk to . . .] serves as the antecedent. To undo antecedent containment it is sufficient to raise the DP just above that VP, (49)a – (50)a. In (48) b, by contrast, the ACD site is marked by the auxiliary *was*. This means that the ellipsis is resolved by taking the larger, non-local VP [_{VP} willing to talk to . . .] as the antecedent. For this to be possible, the hosting DP needs to move above that larger VP, (49)b – (50)b.

- (49) a. [John₆ was willing to [_{VP} [_{VP} t₆ talk to t₇] [the student [that Mary \langle talk to \rangle]]]₇.
 b. [John₆ was [_{VP} willing to [_{VP} t₆ talk to t₇] [the student [that Mary \langle talk to \rangle]]]₇.]

- (50) a.



- b.



Given these observations, we expect that the hosting DP has to take non-local scope above the matrix VP in cases like (49)b, while it can take narrow scope with regard to the non-local VP in cases like (49)a. Judgments that allow us to detect the relative scope of the quantifier with regard to the matrix VP are delicate for cases like (48) as they involve de dicto/de re ambiguities. A somewhat more straightforward test of our prediction is given in (51), which is based on an example of Fox (2003).

- (51) a. John denied being interested in every stock that we thought he was ⟨interested in⟩ but he admitted to being interested in some of them.
 $\neg [\forall x [x \in S \rightarrow j \text{ admits interest in } x]] \ \& \ \exists y[y \in S \ \& \ j \text{ interest in } y]$
- b. # John denied being interested in every stock that we thought he would ⟨deny being interested in⟩ but he admitted to being interested in some of them.
 $\forall x [x \in S \rightarrow \neg j \text{ interest in } x] \ \& \ \exists y[x \in S \ \& \ j \text{ admits interest in } x]$

The sentence in (51)a expresses a perfectly sensible meaning but the sentence in (51)b, if the elided VP is resolved as indicated, is contradictory. The reason why (51)b is contradictory is intuitively clear enough since it says that every stock that we thought John would not admit to being interested in, represented by S in the formula underneath (51)b, he did not admit to being interested in, but some of them he did, in fact, admit to being interested. (51)a, by contrast, is not contradictory. It is perfectly coherent to say that not all stocks we thought John would be interested in, represented by S in the formula underneath (51)a, are such that John admitted to being interested in while at the same time acknowledged that some of them he admit to being interested in. As is transparent from the formulas, the crucial difference between (51)a and b is that the quantifier has to take scope over the negative verb *deny* in (51)b but not in (51)a.³³ This is as expected by (47).

A parallel example can be constructed based on the ability of the negative verb *deny* to license so called Negative Polarity Items (NPIs) such as *anything* when they occur in its scope (Klima, 1964, etc.). Consider the contrast in (52)a and b.

- (52) a. John denied being responsible for ANYthing I said he was ⟨responsible for⟩.
 b. * John denied being responsible for ANYthing I said he would ⟨deny being responsible for⟩.
 cf. John denied being responsible for EVERYthing I said he would ⟨deny being responsible for⟩.

The sentence in (52)a is acceptable indicating that the NPI [*anything I said he was responsible for* . . .] is interpreted in the scope of *deny*. Indeed, (52)a says that nothing I said John was responsible for he admitted to being responsible for. (52)b, by contrast, is unacceptable (on the indicated reading where the elided VP is resolved to include *deny*). It cannot mean that nothing I said he would deny responsibility for he did deny being responsible for. This is, again, as expected since (52) b requires non-local ACD to resolve the ellipsis as indicated and thus requires the hosting negative polarity quantifier [*anything I said he would deny being responsible for*] to be integrated above *deny*.

We have seen but two instances attesting to the validity of (47) and, even though the sentences are rather complex and judgments are delicate, the results seem to be in accordance with the claim that the size of the elided VP in an ACD structure determines the minimal scope of the DP that hosts the ACD site. This is predicted under this analysis that ACD resolution requires covert movement of the hosting DP above the antecedent VP in order to resolve antecedent containment.³⁴

3.3. Implications for processing ACD

As we have seen, ACD provides us with a different motivation for covert movement of a DP than type mismatch or inverse scope – movement is required to resolve antecedent containment. Thus quantificational and non-quantificational DPs alike have to move and they have to move high enough to c-command the antecedent of the elided VP. This means that asymmetries regarding the integration site between referring DPs and quantificational DPs are neutralized under ACD. However, from the perspective of a left to right parser things might look differently nevertheless.

To see how this could be so, consider how a left-to-right parser would process a sentence with an ACD site that is hosted by a definite, non-quantificational DP compared to when the ACD site is hosted by a quantificational DP, (53).

- (53) a. Mary talked to **the** student John did ⟨talk to⟩.
 b. Mary talked to **every** student John did ⟨talk to⟩.

On the assumption that the parser postulates always the simplest possible structure consistent with the input it has encountered at a given point in time,³⁵ we expect a difference in behavior for the two sentences in (53). Specifically, in

³³ Interpreting *every stock* . . . under *deny* is possible because *deny* embeds a clause.

³⁴ For non-movement based approaches to ACD and the Sag-Williams Generalization see Cormack (1984), Jacobson (1992, 2008), among others.

³⁵ See Bever (1970), Frazier and Rayner (1982) among many others and Phillips (2003) for a review.

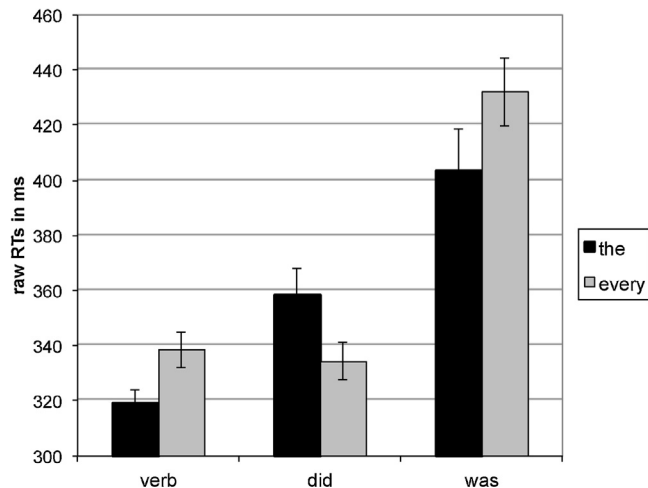


Fig. 1. Average reading times associated with VP of the relative clause.

(53)a the parser will postulate a structure in which the object is moved above the VP only when the ACD site is encountered. In (53)b, by contrast, the parser will postulate such a structure as soon as it has been determined that there is a quantifier in object position. That is, as soon as *every* is encountered. Importantly, on the assumption that both quantifier integration and ACD resolution rely on the object DP being raised above the VP, we expect that ACD resolution down stream of *every* should be less difficult than ACD resolution that is down stream of *the*. Hackl et al. (2012) investigated this prediction in a self-paced reading study. They compared sentences of the kind given in (54), which varied along two parameters: the determiner was either quantificational (*every*) or not (*the*) and the relative clause VP was either pronounced (no ACD) serving as base line, an elided VP with a local antecedent (local ACD), or an elided VP with a non-local antecedent (no-local ACD).

- (54) The doctor was reluctant to treat . . .
- | | |
|---|---------------|
| a. the/every patient that the recently hired nurse admitted | no ACD |
| b. the/every patient that the recently hired nurse did | local ACD |
| c. the/every patient that the recently hired nurse was | non-local ACD |
- . . .after looking over the test results.

Hackl et al. reasoned that if ACD resolution relied on the same mechanism as quantifier integration (QR), and if QR is governed by a locality constraint, it should be relatively easier to process a local ACD site down stream of *every*, but not to process a non-local ACD site. The reason is that integrating a quantifier in object position requires a parse of the sentence in which the object DP is moved to the edge of the local VP. This is sufficient for licensing a local ACD site but it is not sufficient to license a non-local ACD site. For that, the object DP needs to move above the non-local VP. Crucially, the parser can determine the need for local QR at the point where it encountered *every* but it can determine the need for non-local QR only once it has encountered the auxiliary marking the non-local ACD site (*was*). In other words, we expect facilitation of local ACD resolution by *every*, but no facilitation for non-local ACD resolution by *every*.

Fig. 1 shows that this prediction was indeed borne out in their experiment. We see for the definite article condition that processing a local ACD site was more difficult than the base line and that processing a non-local ACD site was even more difficult. For the *every* condition, by contrast, there was no increase in difficulty for the local ACD site relative to its base line while there was a marked increase in difficulty for the non-local ACD site. These data suggest, then, that quantifier integration and ACD resolution are linked during real time sentence processing in a way that parallels the correlation in (47).³⁶

4. Quantifier Scope, Extraposition and ACD

The previous section presented a correlation between the scope of a quantificational DP hosting an ACD site and the size of the elided constituent. At first sight, this correlation seemed unexpected since the two phenomena appear

³⁶ See Koster-Moeller et al. (2009) for an extension of the paradigm to intensional environments and Breakstone et al. (2012) to the domain of degree quantification.

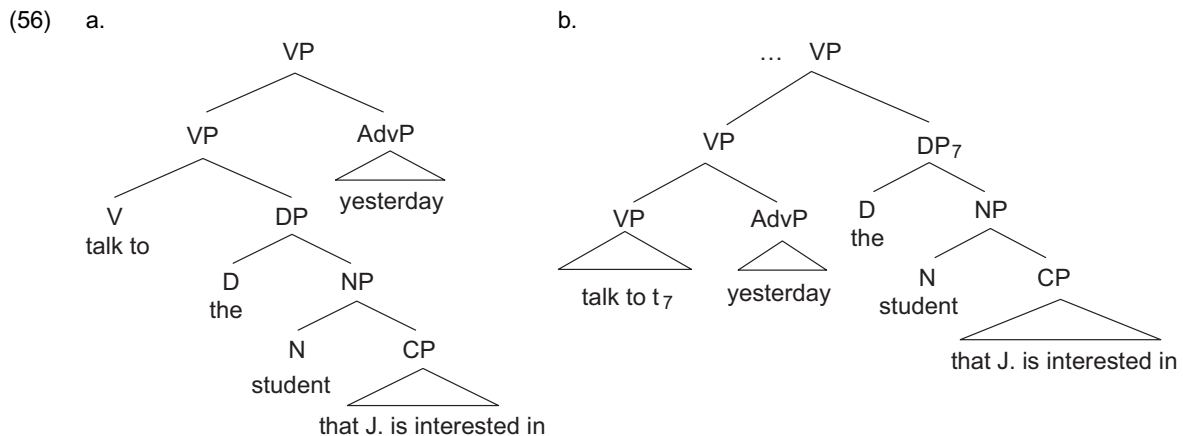
independent of each other. On closer examination, however, it turned out that both Quantifier Scope and ACD resolution rely on the DP being interpreted in a displaced position rather than in its thematic position. This shows that the grammar has a mechanism at its disposal, which allows for a DP to be integrated in structurally higher position than it appears in on the surface. This section expands on this result by examining how Quantifier Scope and ACD relate to a third grammatical phenomenon, Extraposition, which has been hypothesized to involve QR as well (Fox and Nissenbaum, 1999; Fox, 2002; Bhatt and Pancheva, 2007).

4.1. Extraposition

Consider the sentence pair in (55). In both (55)a and b the object DP *the student* is construed with a relative clause *that John recommended*. In (55)a the relative clause follows immediately the noun *student* that it modifies. In (55)b it appears to the right of the adverb *yesterday*, which modifies the VP. This process is referred to as relative clause Extraposition.

- (55) a. Mary talked to the student that John is interested in yesterday.
 b. Mary talked to the student yesterday that John is interested in.

The fact that Extraposition of the relative clause is possible is curious since it is not immediately obvious how to compose a meaning for the discontinuous constituent [*student*] ... [*that John is interested in*]. The proposal we have developed above offers an interesting perspective on this puzzle. Specifically, we can address the challenge if we assume that sentences like (55)b have a structural description in which the object DP is moved covertly to a structural position above the VP modifier *yesterday* before the extraposed relative clause is attached to the NP, (56)b.



Note that the configuration in (56)b is structurally identical to the configuration we have assumed for the ACD structures in (50). In both cases the object DP is interpreted in a displaced position that is higher than the VP it appears in surface syntax. As before, this requires a mechanism such as QR, which establishes a relationship between the thematic position of the object DP and the position it gets interpreted.

4.2. Quantifier Scope and Extraposition

The hypothesis that integrating an extraposed relative clause requires a structure in which the hosting DP is moved covertly by the same mechanism that is employed in the integration of quantifiers leads us to expect yet another correlation involving Quantifier Scope. Specifically, we expect the attachment site of the extraposed relative clause to correlate with the scope of the hosting DP as stated in (57) (Williams, 1974; see also Guéron and May, 1984; Fox and Nissenbaum, 1999; Fox, 2002, 2003; Hulsev and Sauerland, 2006; Bhatt and Pancheva, 2007).

(57) Quantifier Scope and Extraposition

The scope of a quantifier hosting an extraposed relative clause is at least as high as the position of the extraposed relative clause.

We can test this prediction in a variety of ways. One possibility is to employ a VP modifier that scopally interacts with the object DP. The sentence in (59)a is such an example. It uses a *before* clause with an elided VP as temporal modifier of the VP and it uses an indefinite DP as object which can either be interpreted as taking scope below the *before* clause, (58)b, or above the *before* clause, (58)c, producing once again a scope ambiguity.

- (58) a. John won a marathon before Bill did.
 b. John [_{Ant.VP} won a marathon] before Bill did <_{Elided.VP} win a marathon>
 $\exists t[\text{John won a marathon at } t \ \& \ t \text{ is before any time } t' \text{ s.t. Bill won a marathon at } t']^{37}$
 c. [a marathon]₇ John [_{Ant.VP} won t_7] before Bill did <_{Elided.VP} won t_7 >
 $\exists x(\text{marathon}(x) \ \& \ \exists t[\text{John won } x \text{ at } t \ \& \ t \text{ is before any time } t' \text{ s.t. Bill won } x \text{ at } t'])$

If a *marathon* is interpreted below the *before* clause it is part of the antecedent of the elided VP and thus interpreted inside the *before* clause, (58)b. This results in a reading that can be paraphrased as John having become a marathon winner before Bill became a marathon winner. If a *marathon* is interpreted higher than the *before* clause the interpretation is different. Under such a construal, (58)c, the sentence conveys that there is a marathon, say the Boston marathon, that John won before Bill won it. This is consistent with Bill having won his first marathon before John won his first.

We see, then, that sentences such as (58) are scopally ambiguous and we expect, given (57), that a relative clause attached to the object DP will disambiguate the sentence if it is extraposed, i.e. if it appears to the right of the *before* clause. This expectation is borne out as can be seen in (59).

- (59) a. John won a marathon that has a qualifying time of 3 hours 30 minutes before Bill did.
 b. John won a marathon before Bill did that has qualifying time of 3 hours 30 minutes.

The sentence in (59)a has a relative clause [*that has a qualifying time of 3 hours 30 minutes*] attached to *marathon* in its canonical position, i.e. immediately to right of the noun. Thus the relative clause is not extraposed and the sentence is scopally ambiguous just like (58)a. In (59)b, by contrast, the relative clause is extraposed, i.e. it appears to the right of the *before* clause and, as we would expect given (57), the sentence has only a wide scope reading. It can no longer express the thought that John won his first 3:30 qualifying marathon before Bill won his first marathon requiring a qualifying time of 3:30.

A different way of seeing the import of (57) is to study the effect of Extraposition on the relative scope between a scopally active verb such as *deny* and the DP hosting the extraposed relative clause. Consider the examples in (60), which are constructed off of our test cases in (51).

- (60) a. John vehemently denied being interested in every stock that was deemed high risk but he admitted to being interested in some of them.
 b. # John denied being interested in every stock vehemently that was deemed high risk but he admitted to being interested in some of them.

Both sentences in (60) employ the adverb *vehemently* which modifies the matrix verb *deny*. In (60)a, *vehemently* precedes *deny* thus having no affect on how the material in the complement of *deny* is integrated. In particular, it allows for the object DP *every stock* to be interpreted in the scope of *deny*. This is necessary for the entire conjunction in (60)a to be consistent. In (60)b, however, *vehemently* intervenes between *every stock* and the extraposed relative clause [*that was deemed high risk*]. Since *vehemently* modifies *deny* rather than *being interested* the extraposed relative clause must be attached outside of the matrix VP. According to (57), this means that the DP *every stock* is integrated above *deny* as well, and therefore takes scope over *deny*. However, as we have seen in the discussion of (51)b, wide scope of *every stock* is inconsistent with the content of the second conjunct since the sentence claims that every stock that was deemed high risk John vehemently denied being interested in but some of the stock deemed high risk he admitted to being interested in. Because this is the only interpretation that the structure of (60)b allows it feels distinctly odd, just as predicted by (57).

As in the case of ACD, we can construct yet another test case for (57) involving NPIs. Recall that the negative verb *deny* can license an NPI like *anything* in its scope, (61)a. Modification by *vehemently* does not interfere with this process unless it intervenes between *anything* and the relative clause it is in construction with, (61)b. This is just as expected by (57) since Extraposition to the right of a modifier of *deny* imposes non-local scope of the NPI that host the extraposed relative clause, which is inconsistent with the NPI being in the scope of *deny*.

³⁷ The formula assumes quantification over temporal variables symbolized by t , t' , etc.

- (61) a. John vehemently denied being responsible for ANYthing that had happened last night.
 b. * John denied being responsible for ANYthing vehemently that had happened last night.

These examples not only provide empirical support for (57), they also reveal a close parallel between Extraposition and ACD. Indeed, the analyses of ACD and of Extraposition we have presented, following Fox (2002), run for all intents and purposes in parallel. In both cases, a relative clause, which is in construal with an object DP, needs to be integrated outside of the VP containing the thematic position of the object DP. To allow for this, the object DP has to be moved to a suitable position giving it scope at the position where the relative clause comes in.

4.3. Extraposition and ACD

Given that ACD and relative clause Extraposition rely on similar structural analyses, we expect a correlation between the ACD site and the height (locality) of Extraposition as stated in (62) (Fox, 2002; see also Larson and May, 1990; Tiedeman, 1995; Wilder, 1995).

(62) **ACD and Extraposition**

A relative clause with an ACD site is extraposed to a position that is at least as high as the antecedent of the ACD site.

According to (62), ACD should be impossible if the relative clause cannot be extraposed. The example in (63)a, taken from Larson and May (1990), illustrates this fact. We see that a relative clause that is attached to the subject of the complement clause of *expect* can host an ACD site but only if it appears to the right of the material making up the embedded VP, (63)a. If the relative clause is not extraposed, ACD is unacceptable, (63)b.

- (63) a. I expect that everyone will visit Mary that you do ⟨expect to visit Mary⟩.
 b. * I expect that everyone you do ⟨expect to visit Mary⟩ will visit Mary.³⁸

Constructing a test for the non-local case is more complicated. Here is nevertheless a case that seems to support our expectation, although the judgments are more delicate. The sentence in (64)a combines a case of local ellipsis with a *because* clause that can be either understood to convey a reason for John denying something or for John being interested in something – the latter being the more natural reading. This is as expected since the relative clause hosting the local ACD site can be attached to the embedded VP thereby leaving the *because* clause the option of modifying the embedded clause or the matrix clause. In (64)b, however, the ACD site takes the non-local VP as antecedent. This means that the relative clause has to be extraposed to the higher VP, which, in turn, forces the *because* clause to modify *deny* giving rise to a less natural reading.

- (64) a. John denied being interested in every stock that we thought he was ⟨interested in⟩ because he had inside information.
 b. # John denied being interested in every stock that we thought he would ⟨deny being interested in⟩ because he had inside information.

These two data points provide us with little more than a first impression of what the empirical import of (62) might be.³⁹ Nevertheless, it is clear that if the perspective we have presented here is on the right track the correlations we have seen between Quantifier Scope and ACD, on the one hand, and Quantifier Scope and Extraposition, on the other, should be complemented by a third correlation between ACD and Extraposition.

5. Summary and conclusion

The study of the syntax–semantics interface is concerned with linguistic phenomena that are the product of interactions between principles of syntactic organization and principles of semantic interpretation. In the domain of

³⁸ Note that the unacceptability of (63)b cannot be attributed to the antecedent of the elided VP following rather than preceding the ellipsis site since this is in principle possible as examples like (i) show.

(i) I expect everyone that you do to visit Mary.

³⁹ See Fox (2002) for discussion.

quantifier integration, the main focus of this paper, the phenomenon of displacement – the fact that an expression can be and in some cases must be interpreted in a position that is distal to the position where its thematic role is expressed – plays a central role. The literature offers a variety of approaches to displacement phenomena that differ in the precise formulation of the syntactic and semantics principles that are assumed to give rise to displacement but also in how much of the work is done by the syntactic and how much is done by the semantic component of the language faculty. According to the approach presented in this paper, displacement phenomena are a product of syntactic movement, which could be either overt or covert. This hypothesis has led us to the discovery of a series of correlations between properties of quantifier integration (Quantifier Scope) and properties of various other grammatical phenomena ranging from overt movement, to ACD, to NPI licensing, and to relative clause Extraposition. These correlations constitute a substantial body of evidence that any theory of the syntax semantics interface needs to explain. On the view presented here, they are uniformly analyzed as involving (covert) movement and thus form a natural class. To determine whether this is on the right track we need to investigate a much larger set of empirical phenomena than we were able to cover here, phenomena that include data from traditional fields of linguistic inquiry but also data from the domains of language processing, language acquisition, and neuro-linguistics.

References

- Anderson, C., 2004. The structure and real-time comprehension of Quantifier Scope ambiguity. PhD dissertation, Northwestern University.
- Barker, C., 2002. Continuations and the nature of quantification. *Natural Language Semantics* 10, 211–242.
- Barwise, J., Cooper, R., 1981. Generalized quantifiers and natural language. *Linguistics and Philosophy* 4, 159–219.
- Bever, T.G., 1970. The cognitive basis for linguistic structures. In: Hayes, J.R. (Ed.), *Cognition and the Development of Language*. Wiley, New York, pp. 279–362.
- Bhatt, R., Pancheva, R., 2007. Degree quantifiers, position of merger effects with their restrictors and conservativity. In: Barker, C., Jacobson, P. (Eds.), *Direct Compositionality*. Oxford University Press, Oxford, pp. 306–335.
- Bouton, L.F., 1970. Antecedent contained pro-forms. In: *Papers from the Sixth Regional Meeting of the Chicago Linguistics Society*, Chicago Linguistics Society, Chicago, pp. 154–167.
- Breakstone, M., Cremers, A., Fox, D., Hackl, M., 2012. On the analysis of scope ambiguities in comparative constructions: converging evidence from real-time sentence processing and offline data. In: Ashton, N., Chereches, A., Lutz, D. (Eds.), *Proceedings of SALT 21* (Rutgers University), Cornell University, Ithaca, pp. 712–731.
- Cecchetto, C., 2004. Explaining the locality conditions of QR: consequences for the theory of phases. *Natural Language Semantics* 12, 345–397.
- Chomsky, N., 1975. Questions of form and interpretation. *Linguistic Analysis* 1, 75–109.
- Chomsky, N., 1976. Conditions on rules of grammar. *Linguistic Analysis* 2, 303–351.
- Chomsky, N., 1993. A minimalist program for linguistic theory. In: Hale, Keyser, S.J. (Eds.), *The View From Building*, vol. 20. MIT Press, Cambridge, MA, pp. 1–52.
- Chomsky, N., 1995. *The Minimalist Program*. MIT Press, Cambridge, MA.
- Chomsky, N., 2004. Beyond explanatory adequacy. In: Belletti, A. (Ed.), *The Cartography of Syntactic Structures*, Vol. 3. Structures and Beyond. Oxford University Press, Oxford, pp. 104–131.
- Cormack, A., 1984. VP anaphora: variables and scope. In: Landman, F., Veltman, F. (Eds.), *Varieties of Formal Semantics*. Foris Publications, Dordrecht, pp. 81–102.
- Fodor, J.D., Sag, I., 1982. Referential and quantificational indefinites. *Linguistics and Philosophy* 5, 355–398.
- Fox, D., 1995. Economy and scope. *Natural Language Semantics* 3 (3), 283–341.
- Fox, D., 2000. *Economy and Semantic Interpretation*. MIT Press, Cambridge, MA.
- Fox, D., 2002. Antecedent Contained Deletion and the copy theory of movement. *Linguistic Inquiry* 33 (1), 63–96.
- Fox, D., 2003. On logical form. In: Hendrick, R. (Ed.), *Minimalist Syntax*. Blackwell, pp. 82–123.
- Fox, D., Nissenbaum, J., 1999. Extraposition and scope: a case for overt QR. In: Bird, S., Carnie, J., Norquest, P. (Eds.), *WCCFL 18: Proceedings of the 18th West Coast Conference on Formal Linguistics*. Cascadia Press, Somerville, MA, pp. 132–144.
- Frazier, L., Rayner, K., 1982. Making and correcting errors during sentence comprehension: eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology* 14, 178–210.
- Frege, G., 1879/1997. *Begriffsschrift: Eine Der Arithmetische Nachgebildete Formelsprache des Reinen Denkens*. Verlag von L. Nebert, Halle.
- Guéron, J., May, R., 1984. Extraposition and logical form. *Linguistic Inquiry* 15, 1–31.
- Heim, I., Kratzer, A., 1998. *Semantics in Generative Grammar*. Blackwell, Oxford.
- Hendriks, H., 1993. *Studied flexibility*. ILLC dissertation series, Amsterdam.
- Hulsey, S., Sauerland, U., 2006. Sorting out relative clauses. *Natural Language Semantics* 14, 111–137.
- loup, G., 1975. Some universals for Quantifier Scope. In: Kimball, J.P. (Ed.), *Syntax and Semantics*, vol. 4. Academic Press, New York, pp. 37–58.
- Jacobson, P., 1990. Raising as function composition. *Linguistics and Philosophy* 13, 423–475.
- Jacobson, P., 1992. Antecedent Contained Deletion in a variable-free semantics. In: Barker, C., Dowty, D. (Eds.), *Proceedings of the Second Conference on Semantics and Linguistic Theory*, The Ohio State University, Department of Linguistics, pp. 193–213.
- Jacobson, P., 2008. Direct compositionality and variable-free semantics: the case of Antecedent Contained Deletion. In: Johnson, K. (Ed.), *Topics in Ellipsis*. Cambridge University Press, Cambridge, UK, pp. 30–68.
- Johnson, K., Tomioka, S., 1998. Lowering and mid-size clauses. In: Katz, G., Kim, S., Haike, W. (Eds.), *Proceedings of the 1997 Tübingen Workshop on Reconstruction*. Sprachtheoretische Grundlagen für die Computer Linguistik, Tübingen, Germany, pp. 185–206.
- Keenan, E., 2005. In situ interpretation without type-mismatches. Ms, UCLA.

- Klima, E., 1964. Negation in English. In: Fodor, J., Katz, J. (Eds.), *The Structure of Language: Readings in the Philosophy of Language*. Prentice-Hall, Englewood Cliffs, NJ, pp. 246–323.
- Koster-Moeller, J., Gottstein, A., Hackl, M., 2009. Processing opacity. In: Riester, A., Solstad, T. (Eds.), *Proceedings of Sinn und Bedeutung*, vol. 13, Stuttgart, pp. 171–185.
- Kurtzman, H.S., MacDonald, M.C., 1993. Resolution of Quantifier Scope ambiguities. *Cognition* 48, 243–279.
- Larson, R., May, R., 1990. Antecedent containment or vacuous movement: reply to Baltin. *Linguistic Inquiry* 21, 103–122.
- May, R., 1977. *The Grammar of quantification*. PhD dissertation, MIT.
- May, R., 1985. *Logical Form*. MIT Press, Cambridge, MA.
- Phillips, C., 2003. Parsing: psycholinguistic approaches. In: Frawley, W. (Ed.), *International Encyclopedia of Linguistics*. 2nd ed. Oxford University Press, Oxford, pp. 248–254.
- Postal, P., 1971. *Crossover Phenomena*. Holt, Rinehart and Winston, New York.
- Postal, P., 1974. *On Raising*. MIT Press, Cambridge, MA.
- Reinhart, T., 1983. *Anaphora and Semantic Interpretation*. Croom Helm, London.
- Reinhart, T., 1997. Quantifier Scope: how labor is divided between QR and choice functions. *Linguistics and Philosophy* 20, 335–397.
- Rizzi, L. Locality. In: Rizzi, L. (Ed.), *Special Issue of Lingua “Syntax and Cognition: Core Ideas and Results in Syntax”*, in press.
- Ross, J.R., 1967. *Constraints on variables in syntax*. PhD dissertation, MIT. Distributed by IULC. Reprinted as: *Infinite Syntax!* Ablex, Norwood, NJ, 1986.
- Ruys, E.G., Winter, Y., 2011. Scope ambiguities in formal syntax and semantics. In: Gabbay, D., Günthner, F. (Eds.), *Handbook of Philosophical Logic*. 2nd ed. John Benjamins, Amsterdam, pp. 159–225.
- Sag, I., 1976. *Deletion and logical form*. PhD dissertation, MIT.
- Szabolcsi, A. (Ed.), 1997. *Ways of Scope Taking*. Kluwer, Dordrecht.
- Szabolcsi, A., 2010. *Quantification*. Cambridge University Press, Cambridge, UK.
- Tiedeman, R., 1995. Some remarks on Antecedent Contained Deletion. In: Haraguchi, S., Funaki, M. (Eds.), *Minimalism and Linguistic Theory*. Hituzi Linguistics Workshop Series, vol. 4. Hituzi Syobo, Japan, pp. 67–103.
- Tunstall, S.L., 1998. *The interpretation of quantifiers: semantics and processing*. PhD dissertation, University of Massachusetts, Amherst.
- Wilder, C., 1995. Antecedent containment and ellipsis. *FAS Papers in Linguistics* 4, 132–165.
- Williams, E., 1974. *Rule ordering in syntax*. PhD dissertation, MIT.
- Williams, E., 1977. Discourse and logical form. *Linguistic Inquiry* 8, 101–139.