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Scope and Binding

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Abstract

The first part of this article (Sections 1-5) focuses on the classical notions of scope and binding and their formal foundations. It argues that once their semantic core is properly understood, it can be implemented in various different ways: with or without movement, with or without variables.

The second part (Sections 6-12) takes up the empirical issues that have redrawn the map in the past two decades. It turns out that scope is not a primitive. Existential scope and distributive scope have to be distinguished, leaving few if any run-of-the-mill quantifiers. Scope behavior is also not uniform. At least three classes of expressions emerge: indefinites, distributive universals, and counters. Likewise, the bound variable interpretation of pronouns is joined by co-variation with situations. As a result, the classical notions of scope and binding are likely to end up as building blocks in the varied mechanisms at work in "scope phenomena" and "binding phenomena", and not as self-contained analyses of those phenomena.

1. Introduction to the core notion of scope

The core notion of scope in natural language is the same as in logic. The scope of an operator is that part of the formula (expression, sentence, text) on which the operator performs its characteristic action. If one operator is within the scope of another, their relative scope determines their order of operation. To illustrate, consider the following example from predicate logic, where scope is indicated by brackets and parentheses. (See Gamut (1991) for predicate logic, type theory, and other logical notions not explained in this text.)

(1) $\neg(\forall x[f(x)] \wedge h(x)) \vee k(a)$

The characteristic action of negation is to reverse the truth-value of its scope. In (1) the scope of $\neg$ is $\forall x[f(x)] \wedge h(x)$, so this is the part on which it performs its action; it does not affect $k(a)$. By the same token, $\forall$ and $\wedge$ perform their action earlier than $\neg$ ("earlier" in the sense that their outputs feed $\neg$) and $\vee$ operates after $\neg$ (the output of $\neg$ feeds $\vee$). Similarly, the characteristic action of $\forall$ is to check all possible assignments of values to the variables within its scope that are "linked" to it. In (1) the scope of $\forall x$ is $f(x)$. $\forall x$ does not operate on the x of $h(x)$, because it is not within its scope.

The bracketing in (1) reflects constituent structure: it records the steps in which the formula is built from its subformulae. The scope of an operator is simply the constituent that it is attached to; in linguistic terminology, its sister node. All properties of absolute and relative scope follow from this.

We may immediately add a caveat. In logics with a nimbler syntax it is possible to "arrest" the action of operators and thereby dissociate the chronological order in which they enter the formula from the order of their actual operation. This possibility is relevant to us because, technical details aside (see (26)-(27)), it is reminiscent of the possibility in natural language for operators to take action earlier or later than the constituent structure produced by some simple syntax might predict. Therefore in talking about natural language one has to distinguish between semantic scope and syntactic domain. The syntactic domain of an expression is defined with reference to c-command, maximal projections, feature inheritance, or similar notions. Many linguists entertain the following hypothesis:

(2) Hypothesis about Scope and Domain: The semantic scope of a linguistic operator

coincides with its domain in some syntactic representation that the operator is part of.

This hypothesis goes back to Reinhart's (1979, 1983) pioneering work on what she called syntactic domains for semantic rules. Reinhart's specific assumption was that the only relevant syntactic representation is surface structure, but the key idea is the more general one, namely, that syntactic structure determines semantic scope and does so in a very particular way. This is not the only possible view: for example, Farkas (1997) puts forth a non-structural theory of scope. So one important task for work on the syntax/semantics interface is to determine whether (2) is correct and if yes, exactly what kind of syntactic representations and notion of domain bear it out.

Another important task is due to the fact that it is not immediately obvious what linguistic expressions are operators. We illustrate this with a classical example. (3) can be paraphrased roughly as (4):

(3) Dogs barked everywhere.

(4) $\forall$x[relevant chunk of space(x)] [$\exists$y[dog′ (y) $\wedge$ barked′ (at x)(y)]]

It may seem straightforward that $\forall$ is contributed by *everywhere* and $\exists$ by *dogs*. However, Carlson (1977) argued convincingly that bare plurals are not existentially quantified phrases. For example, the quantifier that a bare plural supposedly contributes takes only the narrowest possible scope, unlike quantifiers contributed by overt morphemes. Carlson proposed that bare plurals denote kinds. The existential import associated with the bare plural is contributed by the predicate. *Bark* says that there exist barking realizations of the kind denoted by the subject. The narrowest scope observation then follows, because $\exists$ is buried in the interpretation of the verb and cannot enjoy the relative scopal freedom of freestanding operators.

This example highlights the fact that identifying the truth conditions of a sentence and detecting the work of some operator in it does not immediately tell us which expression, if any, contributes that operator. If Carlson's analysis is correct, any talk about the scope of a bare plural is incoherent – a bare plural is not an operator, nor does it contain one. An alternative analysis leads to the same conclusion. According to van Geenhoven (1998), bare plurals enter the sentence via predicate modification, and existential import is not the contribution of any lexical item but of a default operation known as "existential closure".

Although this article does not discuss bare plurals any further, it is going to discuss other "scope(-like)" phenomena where it is not obvious if there is a scope-taking operator in the sentence and if yes, where it comes from. Indefinites like *some dog* and *two dogs* are a prime case in point.

2. Generalized quantifiers and their elements: operators and their scopes

In many logics, operators are introduced syncategorematically. They are not expressions of the logical language; the syntax only specifies how they combine with expressions to yield new expressions and what their semantic effect is. They function like diacritics in the phonetic alphabet: ′ is not a character of the IPA but attaching it to a consonant symbol indicates that the sound is palatal (e.g. [t′]). In line with most of the literature we are going to assume that operators embodied by morphemes or phrases are never syncategorematic. But if *every dog* is an ordinary expression that belongs to a syntactic category (say, DP) then it must have a self-contained interpretation. This contrasts with the situation in predicate logic. In (5) the contribution of *every dog* is scattered all over the formula without being a subexpression of it. Everything in (5) other than *bark'* comes from *every dog*.

(5) $\forall x[\text{dog}'(x) \rightarrow \text{bark}'(x)]$

One of Montague's (1974) most important innovations was to provide a self-contained and uniform kind of denotation for all DPs in the form of generalized quantifiers. The name is due to the fact it generalizes from the first order logical ∀ and ∃ and their direct descendants *every dog* and *some dog* to the whole gamut, *less than five dogs*, *at least one dog*, *more dogs than sheep*, *the dog*, etc., even including proper names like *Spot*. (Terminology: we refer to syntactic units like *every dog* as quantifier phrases, noun phrases, or DPs. The label NP is reserved for the complement of the determiner, as in the schematic form *every NP*.)

Some DPs, especially names, are also individual denoters. Therefore they are scopeless in the sense that the different scopes we may attribute to them are truth-conditionally equivalent (Zimmermann 1993), although in other ways it is semantically profitable to subsume them under the rubric of generalized quantifiers. Such treatment makes semantic properties like monotonicity applicable to names, and makes it easy to explain how names conjoin with quantificational DPs. Because we are concerned specifically with scope, in the first half of this article we use DPs that cannot by any stretch of imagination denote individuals. (The theories reviewed here allow one to assign scope vacuously to names, but Fox (2000) proposes the principle of Scope Economy, which requires covert scope-shifting operations like Quantifier Raising to make a truth conditional difference. This makes interesting empirical predictions for VP-ellipsis and other phenomena.)

A generalized quantifier is a set of properties. In the examples below the generalized quantifiers are defined using English and, equivalently, in the language of set theory and in a simplified Montagovian notation, to highlight the fact that they do not have an inherent connection to any particular logical notation. The main simplification is that we present generalized quantifiers extensionally. Therefore each property is traded for the set of individuals that have the property (rather than the intensional analogue, a function from worlds to such sets of individuals), but the term "property" is retained, as customary, to evoke the relevant intuition.

(6) a. *More than one dog* denotes the set of properties that more than one dog has. If more than one dog is hungry, then the property of being hungry is an element of this set.

b. *More than one dog* denotes $\{P: |dog' \cap P| > 1\}$. If more than one dog is hungry, then $\{a: a \in hungry'\} \in \{P: |dog' \cap P| > 1\}$.

c. *More than one dog* denotes $\lambda P \exists x \exists y [x \neq y \wedge dog'(x) \wedge dog'(y) \wedge P(x) \wedge P(y)]$. If more than one dog is hungry, then $\lambda P \exists x \exists y [x \neq y \wedge dog'(x) \wedge dog'(y) \wedge P(x) \wedge P(y)](hungry')$ yields the value True.

(7) a. *Every man* denotes the set of properties that every man has. If every man is hungry, then the property of being hungry is an element of this set.

b. *Every man* denotes $\{P: man' \subseteq P\}$. If every man is hungry, then $\{a: a \in hungry'\} \in \{P: man' \subseteq P\}$.

c. *Every man* denotes $\lambda P \forall x[man'(x) \rightarrow P(x)]$. If every man is hungry, then $\lambda P \forall x[man'(x) \rightarrow P(x)](hungry')$ yields the value True.

The property *(is) hungry′* mentioned above has a simple description, but that is an accident. Properties might have arbitrarily complex descriptions:

(8) If every prof drinks or gambles, then the property of being an individual such that he/she/it drinks or he/she/it gambles is in the set of properties every prof has.

(9) If there is more than one dog that bit every man, then the property of being an individual such that he/she/it bit every man is an element of the set of properties more than one dog has.

(10) If every man was bitten by more than one dog, then the property of being an individual such that there is more than one dog that bit him/her/it is an element of the set of properties every man has.

Properties with simple descriptions and ones with complex descriptions are entirely on a par. We are not adding anything to the idea of generalized quantifiers by allowing properties of the latter kind. But once the possibility is recognized, quantifier scope is taken care of, as we'll now see.

In each case above, some operation is buried in the description of the property that is asserted to be an element of the generalized quantifier. In (8) the buried operation is disjunction; thus (8) describes a configuration in which universal quantification scopes over disjunction. (9) and (10) correspond to the subject wide scope, S>O and the object wide scope, O>S readings of the sentence *More than one dog bit every man*. In (9) the main assertion is about the properties shared by more than one dog, thus the existential quantifier in subject position is taking wide scope. In (10) the main assertion is about the properties shared by every man, thus the universal quantifier in object position is taking wide scope.

This is all there is to it:

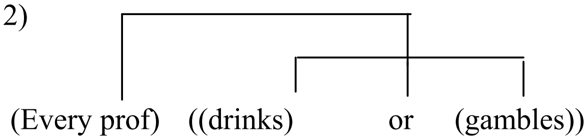
(11) The scope of a quantificational DP, on a given analysis of the sentence, is that part of the sentence which denotes a property that is asserted to be an element of the generalized quantifier denoted by DP on that analysis.

3. Scope and constituent structure

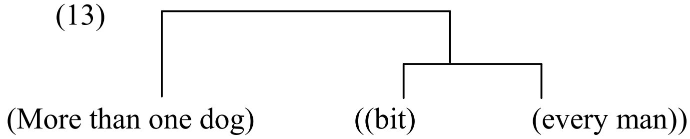
3.1 The basic idea

On this view the readings in (8), (9) and (10) correspond to the semantic constituent structures (12), (13) and (14), respectively:

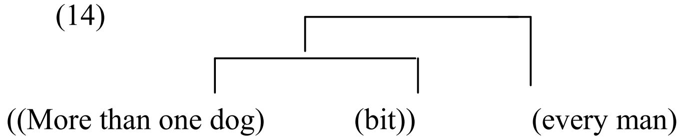
(12)



(13)



(14)



Given the hypothesis in (2) we have to ask how well these semantic constituents match up with syntactic constituents. Initial encouragement that a good match can be found comes from observing that wh-fronting creates coherent constituents similar to those we need:

(15) Who drinks or gambles?

(16) Who bit every man?

(17) Who did more than one dog bite?

In this section we consider three ways to implement the above ideas concerning scope. The Montague/May approach produces the above constituent structures in abstract syntax, whether or not there is independent purely syntactic evidence for it. The Hendriks approach dissociates scope from pure syntax in that it allows one to maintain whatever constituent structure seems independently motivated and it still delivers all imaginable scope relations. The proof theoretical perspective in Jäger (2005) and Barker (2007) offers a way to move between the above two as desired. The goals of this discussion are twofold. One is to introduce some fundamental technologies. Another is to show that there is no deep semantic necessity to opt for one technology or the other; the choices can be tailored to what one finds insightful and what the empirical considerations dictate.

3.2 The (first) proper treatment of quantification

We consider two derivations of *More than one dog bit every man* in an extensionalized version of Montague's PTQ (1974). Montague used a syntax inspired by but not identical to a categorial grammar and built sentences "bottom up". This was very unusual at the time when linguists used "top down" phrase structure rules, but today, in the era of Merge in Minimalism, it will look entirely natural.

We assume our verbs to denote functions of individuals (entities of type e). Because quantifier phrases do not denote individuals, they cannot serve as arguments of such verbs. In line with the reasoning above, quantifier phrases combine with expressions that denote properties, and the semantic effect of the combination is to assert that the property is an element of the generalized quantifier. The subject being the highest i.e. last argument of the verb, inflected verb phrases will denote a property anyway, so a subject quantifier phrase can enter the sentence without further ado. If the quantifier phrase is not the last argument, the derivation must ensure that a property-denoting expression is formed for its sake in one way or another; a point made very lucidly in Heim & Kratzer (1998, Chapter 7).

Montague's PTQ offers several ways to build the subject wide scope, S>O and the object wide scope, O>S readings of a sentence. Those chosen below will make the relation between Montague's, May's, and Hendriks's methods the most transparent. We start by applying the verb to placeholder arguments and building a sentence. Placeholders are interpreted as individual variables. Montague employed indexed pronouns as placeholders; we employ indexed empty categories *ec*. Properties (of type <e,t>) are then formed from this sentence by abstracting over the placeholders one by one. Abstraction is achieved by lambda-binding the placeholder variable. (If α is an expression, $\lambda x[\alpha]$ is an expression. $\lambda x[\alpha]$ denotes a function of type <b,a>, where $\underline{b}$ is the type of the variable $\underline{x}$ and $\underline{a}$ is the type of function value α. When applied to some argument β, the value of the function is computed by replacing every occurrence of $\underline{x}$ bound by λx in α by β. E.g. $\lambda x[x^2](3) = 3^2$.)

Each time a property is formed, a quantifier can be introduced. The later a quantifier is introduced, the wider its scope: other operators may already be buried in the definition of the property that it combines with. Montague's PTQ collapsed the two steps of lambda-binding a free variable and applying a generalized quantifier to the property so formed into a single rule of quantifying-in. To make the derivation more transparent, we disentangle the two steps, as do Heim & Kratzer (1998), who construe lambda abstraction as the reflex of the movement of the index on the placeholder. We follow PTQ in replacing the placeholder with the quantifier phrase in the surface string. This feature is syntactically unsophisticated and need not be taken too seriously; see May and Hendriks below. The derivation of the reading where the subject existential scopes over the direct object universal produces the following last step. The cardinality quantifier *more than one* will be abbreviated using $\exists_{>1}$.

(18) $\lambda P\exists_{>1}z[dog'(z) \wedge P(z)]$

$(\lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)]) =$

$\exists_{>1}z[dog'(z) \wedge \lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)]\,(z)] =$

$\exists_{>1}z[dog'(z) \wedge \forall y[man'(y) \rightarrow bit'(y)(z)]]$

Recall that the derivations are to be read bottom-up!

(19) Subject > Object reading

[$_t$ More than one dog bit every man] — <u>apply *more than one dog*</u>

$\exists_{>1}z[dog'(z) \wedge \forall y[man'(y) \rightarrow bit'(y)(z)]]$

[$_{<<e,t>,t>}$ more than one dog**]**

$\lambda P\exists_{>1}z\,[dog'(z) \wedge P(z)]$ — $\lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)]$ — <u>λ-bind subject x_2</u>

|

[$_t$ ec_2 bit every man]

$\forall y[man'(y) \rightarrow bit'(y)(x_2)]$ — <u>apply *every man*</u>

[$_{<<e,t>,t>}$ every man**]**

$\lambda Q\forall y[man'(y) \rightarrow Q(y)]$ — $\lambda x_1[bit'(x_1)(x_2)]$ — <u>λ-bind object x_1</u>

|

[$_t$ ec_2 bit ec_1] — <u>build sentence with</u>

$bit'(x_1)(x_2)$ — <u>two free vbls</u>

The derivation of the reading where the direct object universal scopes over the subject existential differs from the above in just one respect: properties are formed by λ-binding the subject variable first and the direct object variable second, which reverses the order of introducing the two quantifier phrases. The last step that introduces the universal is this:

(20) $\lambda Q\forall y[man'(y) \rightarrow Q(y)](\lambda x_3\exists_{>1}z[dog'(z) \wedge bit'(x_3)(z)]) = \forall y[man'(y) \rightarrow$
$\lambda x_3\exists_{>1}z[dog'(z) \wedge bit'(x_3)(z)](y)] =$
$\forall y[man'(y) \rightarrow \exists_{>1}z[dog'(z) \wedge bit'(y)(z)]]$

(21) Object > Subject reading

[$_t$ More than one dog bit every man] — apply *every man*
$\forall y[man'(y) \rightarrow \exists_{>1}z[dog'(z) \wedge bit'(y)(z)]]$

[$_{<<e,t>,t>}$ every man**]** — $\lambda x_1\exists_{>1}z[dog'(z) \wedge bit'(x_1)(z)$ — λ-bind object x_1
$\lambda Q\forall y[man'(y) \rightarrow Q(y)]$ |

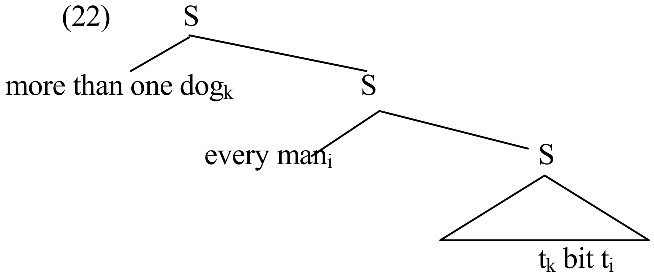
[$_t$ more than one dog bit ec_1] — apply *more than one dog*
$\exists_{>1}z[dog'(z) \wedge bit'(x_1)(z)]$

[$_{<<e,t>,t>}$ more than one dog]
$\lambda P\exists_{>1}z[dog'(z) \wedge P(z)$ — $\lambda x_2[bit'(x)(x_2)]$ — λ-bind subject x_2
|
[$_t$ ec_2 bit ec_1] — build sentence with
$bit'(x_1)(x_2)$ — two free vbls

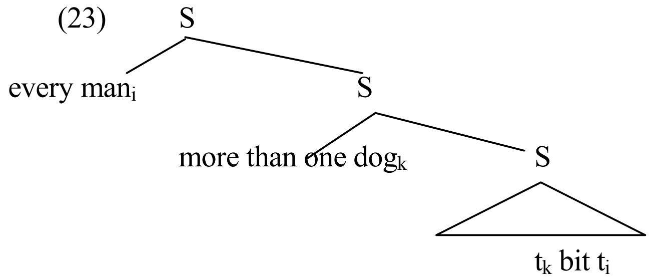
3.3 Quantifier Raising

Within generative syntax May (1977, 1985) first derives a syntactic structure leading to the surface string with quantifier phrases in argument positions. This structure is input to further syntactic rules whose operation feeds only semantic interpretation (Logical Form). Such a rule is Quantifier Raising (QR), which adjoins quantifier phrases to VP or to S (TP in more recent terminology). The scope of the adjoined quantifier phrase is its c-command domain. The definition of c-command is crucial for the details but for the bird's eye view we are taking here we simply assume that a phrase c-commands its sister relative to the first branching node above it. Crucial is the consequence that the higher a quantifier is adjoined, the wider scope it takes.

(22) S>O reading



(23) O>S reading



(22) is obviously parallel to Montague's (19) and (23) to Montague's (21). A syntactic difference is that Montague intersperses the steps that disambiguate scope with those that create the surface string, and May does not. A difference more important to us is that while May treats the phrases *every man* and *more than one dog* as normal categorematic expressions in deriving surface syntax, at LF these phrases behave like the syncategorematic operators of the predicate calculus: they directly bind traces that function as variables. This can be remedied by imagining that there is a lambda-binding step hidden between building an S and adjoining a quantifier phrase to it. With that, the parallelism between the two pairs of derivations is essentially complete. Reversing historical order we might look at Montague's grammar as one that builds the output of May's compositionally, without invoking movement. Heim & Kratzer (1998) show that a compositional strategy may even include movement, and within the copy theory of movement Fox (2002) reinterprets the lowest copy of QR as a parametrized definite description.

3.4 All the scopes, but a simple syntax

What emerges from the above is that any representation of the S>O and the O>S readings will have to boil down to the schemas in (24)-(25); similarly for any other pair of quantifiers. *P(x)(y)* is forced by the assumption that the natural language predicates at hand take individuals as arguments. The lambda-binding (predicate abstraction) steps are forced by the assumption that quantifier phrases denote generalized quantifiers. The two schemas differ as to which argument slot is lambda-bound first and which second.

(24) $QP_a(\lambda y[QP_b(\lambda x[P(x)(y)])])$ S>O

(25) $QP_a(\lambda x[QP_b(\lambda y[P(x)(y)])])$ O>S

One of the key insights in Hendriks (1993) is that it is possible to abstract these interpretive schemas away from the specific quantifier phrases QP_a and QP_b. This in turn allows one to dissociate the interpretive schema from the syntactic constituent structure of the sentence.

Replace QP_a and QP_b with variables A and B of the same type as generalized quantifiers (<<e,t>,t>) and abstract over them with λ operators. Because the variables A, B are not individual variables but are of the generalized quantifier type, the lambda expressions in (26)-(27) take quantifier phrases as arguments, rather than the other way around. The order in which the λA and λB prefixes appear determines the order in which the verb picks up its arguments, but it does not affect their scope, so it can be dictated by independent syntactic considerations; for example we may assume an invariant (S (V O)) structure. In both (26) and (27) the first quantifier phrase the lambda-expression applies to will be the direct object. The relative scope of the quantifier phrases replacing A and B is determined by their relative order within the underlined portions of (26)-(27):

(26) $\lambda B\lambda A[\underline{A(\lambda y[B(\lambda x}[P(x)(y)])])]$ schema of S>O

(27) $\lambda B\lambda A[\underline{B(\lambda x[A(\lambda y}[P(x)(y)])])]$ schema of O>S

This is the "nimbler logic" hinted at in Section 1 that allows one to arrest the action of a quantifier at the point it enters the formula and to release it where desired. The quantifier's action is released where it actually applies to an expression that denotes a property.

But where are these schemas coming from, if they do not simply record the phrase-by-phrase assembly of the material of the sentence? Hendriks proposes to assign flexible types to verbs, so that two versions of *bite* for example anticipate two different scope relations between the subject and the object. (26) and (27) are two interpretations for the same transitive verb P. Below is a constituent-by-constituent derivation of the O>S reading. The verb combines with both the direct object and the subject by functional application:

(28) *bit′*: $\lambda B\lambda A[B(\lambda z[A(\lambda v[bit'(z)(v)])])]$

every man′: $\lambda Q\forall y[man'(y) \rightarrow Q(y)]$

bit every man′: $\lambda B\lambda A[B(\lambda z[A(\lambda v[bit(z)(v)])])]\ (\lambda Q\forall y[man'(y) \rightarrow Q(y)]) =$

$\lambda A[\forall y[man'(y) \rightarrow A(\lambda v[bit'(y)(v)])]]$

more than one dog′: $\lambda P\exists_{>1}z[dog'(z) \wedge P(z)]$

more than one dog bit every man′:

$\lambda A[\forall y[man'(y) \rightarrow A(\lambda v[bit'(y)(v)])]]\ (\lambda P\exists_{>1}z[dog'(z) \wedge P(z)]) =$

$\forall y[man'(y) \rightarrow \exists_{>1}z[dog'(z) \wedge bit'(y)(z)]]$

This is the gist of Hendriks's proposal. More generally, he shows two important things. First, the different interpretations for the verb can be obtained systematically by so-called type-change rules, in this case, by two applications of Argument Raising, see (29). (26)-(27) are due to two different orders in which the subject and the object slots are raised, cf. the underlined segments. Second, all the logically possible scope relations in an arbitrarily multi-clausal sentence, including extensional—intensional ambiguities, can be anticipated by the use of three type-change rules: Argument Raising, Value Raising, and Argument Lowering. We ignore the last one, which is required for certain intensional phenomena. Below are extensionalized Argument Raising and Value Raising. The simplified version of Value Raising is nothing else than the good old type-raising rule that turns proper names into generalized quantifiers.

(29) Argument Raising:

If α' is the translation of α, and α' is of type <A,<b,<C,d>>, then $\lambda x_A\lambda w_{<<b,d>,d>}\lambda y_C[w(\lambda z_b[\alpha'(x)(z)(y)])]$, which is of type <A,<<b,d>,d>,<C,d>>, is also a translation of α, where A and C stand for possibly empty sequences of types such that if g is a type, <A,g> and <C,g> represent the types $<a_1, <\ldots <a_n,g>\ldots>>$ and $<c_1, <\ldots <c_n,g> \ldots>>$.

Simplified by taking A and C to be empty:

If α' is the translation of α, and α' is of type <b,d>, then $\lambda w_{<<b,d>,d>}[w(\lambda z_b[\alpha'(z)])]$, which is of type <<<b,d>,d>,d>, is also a translation of α.

(30) Value Raising:

If α' is the translation of α, and α' is of type <A,b>, then $\lambda x_A\lambda u_{<b,d>}[u(\alpha'(x))]$, which is of type <A,<<b,d>,d>>, is also a translation of α, where A stands for a possibly empty sequence of types such that if g is a type, <A,g> represent the type $<a1, <\ldots <a_n,g>\ldots>>$.

Simplified by taking A to be empty:
If α' is the translation of α, and α' is of type b, then $\lambda u_{<b,d>}[u(\alpha')]$, which is of type <<b,d>,d>, is also a translation of α.

Let us mention two other cases that involve the dissociation of the chronological order of introducing operators into the syntactic structure from the scope they take, and have been handled using very like-minded pieces of logical machinery. Cresti (1995) analyzes “scope reconstruction” using a combination of generalized quantifier type variables and individual type variables, to an effect very much like that of Argument Raising:

(31) How many people do you think I should talk to?

(i) 'for what number n, you think it should be the case that there are n-many people that I talk to'
(narrow scope, amount reading of *how many people*)

(ii) 'for what number n, there are n-many people x such that you think I should talk to x’
(wide scope, individual reading of *how many people*)

“Reconstruction” is so called because in (i) *n-many people* is “put back” into a lower position for interpretation. Cresti derives the two readings without actual reconstruction. In the derivations below, *x* is a trace of type e (individuals), and *X* is a trace of the same type as *n-many people* (intensionalized generalized quantifiers). Working bottom-up, each trace is bound by a λ operator to allow the next trace or the moved phrase itself to enter the chain. The lowest position of the chain is always occupied by a trace *x* of the individual type, but intermediate traces (underlined) may make one switch to the higher type *X*. The scope difference with respect to the intensional operator *should* is due to the fact that in (32) the switch from *x* to *X* takes place within the scope of *should*, whereas in (33) *should* has no *X* in its scope. Note that the direction of functional application is type-driven, i.e. in X λX.φ the second expression is applied to the first, whereas in X λx.φ the first is applied to the second.

(32) narrow scope:

$[_{CP}$ how many people $\lambda X[_{IP}$ ... think $[_{CP}$ $\underline{X}$ $\lambda X[_{IP}$ ... should $[_{VP}$ $\underline{X}$ $\lambda x[_{VP}$ ...x...]]]]]]

(33) wide scope:

$[_{CP}$ how many people $\lambda X[_{IP}$ $\underline{X}$ $\lambda x[_{IP}$ ... think $[_{CP}$ $\underline{x}$ $\lambda x[_{IP}$ ... should $[_{VP}$ ...x...]]]]]]

Moltmann & Szabolcsi (1993) use an idea very much like Value Raising to account for the surprising `librarians vary with students' reading of (34):

(34) Some librarian or other found out which book every student needed.
√`for every student x, there is some librarian or other who found out which book x needed'

Every student in the complement clause can apparently make the matrix subject referentially dependent; but under normal circumstances *every NP* is known not to scope out of its own clause. Moltmann & Szabolcsi argue that there is no need to assume that here, either. Instead, the complement of *found out*, which *book every student needed* receives a pair-list reading, `for every student, which book did he need' and as a whole scopes over the subject of *found out*, which is its clause mate. The result is logically equivalent to scoping *every student* out on its own.

While these works do not use flexible types for verbs, they illustrate the naturalness of the logical tools that Hendriks employs. Inspired by computer science, Barker & Shan (2006) associate linguistic expressions with their possible continuations. A continuation is the skeleton of a syntactico-semantic structure that the expression anticipates participating in. Continuized types are similar to Hendriks's raised types and to context change potentials in dynamic semantics.

3.5 Have your cake and eat it too

The general lesson is this. Once we assign a generalized quantifier denotation to quantifier phrases and understand the simple scenarios of their interaction, there are many different ways to implement those scenarios. They may be acted out in the syntactic derivation of the sentence, but they may as well be squeezed into the flexible types of the participating expressions. Consequently, we may create abstract constituents by movement, but we may alternatively stick to some independently motivated constituent structure. We may bind syntactic variables (placeholders, traces), but we may alternatively do without them and go “variable free”. Notably, Hendriks’s scope grammar is directly compositional, a property advocated in Jacobson (2002). Direct Compositionality means that each constituent built by the independently motivated syntax is immediately assigned its final and explicit interpretation.

The fact that one can take either approach is good news. But having to choose between them may not be so good, since both approaches offer their own insights. Barker (2007) makes the very important claim that it is in fact not necessary to choose. Building directly on Jäger’s (2005) proof theoretical proposal Barker points out that a grammar can deliver “direct compositionality on demand”. Here the long-distance (Montague/May/Heim & Kratzer style) and the local (Hendriks style) analyses arise from one and the same set of rules, none of which are redundant.

4. Quantifier phrases do not directly bind pronouns

We have seen that a linguistic theory may link quantifier phrases to variable-like syntactic expressions (traces), although this is not crucial. But predicate logical quantifiers do not only bind variables that might correspond to their traces in the syntactician’s sense. (35), which can be seen to translate one reading of (36), contains three bound occurrences of the variable x, of which the one in *room-of′(x)* corresponds to the pronoun *his*.

(35) $\forall x[\text{boy}'(x) \rightarrow \text{in}'(\text{room-of}'(x))(x)]$

(36) Every boy is in his room.

Is the relation between *every boy* and *his* a case of binding in the same sense as the relation between $\forall x$ and the *x* of *room-of′(x)* is, as has often been assumed? There is serious indication that the two at least have something in common. As observed in Reinhart (1983) contrasts like (36) versus (37) show that a quantifier phrase binds a pronoun if the pronoun is within its c-command domain and, therefore, scope (although see Barker & Shan 2008). Coreference between a name or other referring expression and a pronoun is different: it does not require c-command, see (38)-(39).

(37) That every boy was hungry surprised his mother.

#‘for every boy, that he was hungry surprised his own mother’

(38) Jeroen is in his room.

(39) That Jeroen was hungry surprised his mother.

Thus, inducing a bound variable reading in pronouns seems like one of the basic “scope actions” of quantifiers. But nothing in our account of the scope behavior of quantifier phrases interpreted as generalized quantifiers explains how they bind pronouns.

This is good news, because the bound reading of the pronoun in (36) does not come about in the same way as the binding of the *x*’s in (35). In (35) the three variables are all directly bound by $\forall x$ because, in addition to being within its scope, they happen to have the same letter as the quantifier prefix. In contrast, pronouns are not directly bound by quantifier phrases in natural language. In the well-known parlance of syntactic Binding Theory, pronouns have to be co-indexed with a c-commanding item in argument position (subject, object, possessor, etc.), not with one in operator position (the landing site of wh-movement or the adjoined position created by Quantifier Raising). The claim that syntactic binding is a relation between argument positions is grounded primarily in data about reflexives but it is thought to extend to pronouns and offers a simple account of strong and weak crossover. To see WCO in action, consider singular *a different NP*. Because it is not a pronominal, it helps exhibit the full range of scope effects (see Beghelli & Stowell 1997). (40) shows that the prepositional object *every girl* can scope over both the subject and the direct object.

(40) a. A different person sent a gift to every girl.
b. Vlad sent a different gift to every girl.

But none of the pronouns in (41) can be interpreted as linked to *every girl*:

(41) a. She sent a gift to every girl.
b. Her aunt sent a gift to every girl.
c. Vlad sent her gift to every girl.

Bach and Partee’s (1984) explanation is that there is simply no syntactic binding in (41), regardless of scope, because the argument position of the quantifier does not c-command the pronoun.

If the pronoun is directly linked to the c-commanding argument position and not to the quantifier itself, what is the actual operator that binds it? The operator that identifies the pronoun with a c-commanding argument position. The technologies for achieving "identification" are varied, but the interpretive result is always the same. (42) presents three equivalent metalinguistic descriptions of the bound pronoun reading of the VP *saw his/her/its own father*:

(42) a. be an individual such that he/she/it saw his/her/its own father
b. {a: a saw a's father}
c. λx[x saw x's father]

So the operator that binds the pronoun is the abstraction operator λ. Therefore in this article the quantifier phrase will be neutrally called the antecedent of the pronoun and will not be accorded the false title of the binder.

Once the property described in (42) is derived, it combines with a noun phrase denotation as other properties do, see (6) through (10), and the antecedent is specified:

(43) If every girl saw her own father, then the property of being an individual such that he/she/it saw his/her/its own father is an element of the set of properties shared by every girl.

Proof that the crucial factor in the bound variable reading of pronouns is not the presence of a quantifier phrase comes from the so-called sloppy identity reading of pronouns in ellipsis in coordination (Reinhart 1983). The interpretation of elided VPs matches that of the full VP, but it can do so in two ways. In the so-called sloppy identity reading, the "pronoun in the elided VP" is linked to the subject of the same, elided VP. Crucial to us is the fact that in (44)-(45) *did* can receive the bound variable pronoun reading (42), regardless of whether the subject of the full VP is *every boy* or *Kim*. This in turn shows that the full VP itself can have the (42) reading even if its subject is not a quantifier.

(44) Every boy saw his father, and every girl did too.
√ `…and every girl saw her own father' (sloppy)

(45) Kim saw his father, and every girl did too.

√ `…and every girl saw her own father' (sloppy)

In the so-called strict identity reading, the "pronoun in the elided VP" is linked to the subject of the full VP. (44) has no strict reading; on the strict reading of (45), every girl saw Kim's father. (The strict reading itself is not restricted to referential antecedents. It is available with quantificational antecedents too, if those c-command the ellipsis site, as in *Every boy discovered his mistakes before the teacher did [discover that boy's mistakes]*, see Gawron & Peters 1990; Szabolcsi 1992).

For lack of space this article cannot dwell on the Binding Theory; see Reinhart (2006) for a recent and comprehensive discussion.

5. Variable-ful and variable-free binding

5.1 Pronouns that start out as free variables

In most theories, Montague (1974), May (1977, 1985), Heim & Kratzer (1998), Büring (2005) among them, the derivation of (42) starts out with the pronoun interpreted as a free variable, i.e. one that is assigned an individual in the model by the current assignment. The exact shape of the next step depends on whether a placeholder (trace) is posited in the position that the pronoun should be linked to, or we simply have an as yet unsaturated argument of a function. If there is a placeholder, then the precondition for binding is that the variable translating the pronoun be identical to the one translating the placeholder; if there is simply an unsaturated argument slot, the pronoun's variable needs to bear an index identical to that of the prospective saturator of that argument slot. Then an abstraction operator binds both the placeholder/argument slot and the pronoun in one fell swoop and creates an assignment-independent (closed) expression. In Heim & Kratzer's (1998) and Büring's (2005) formulation these are written as (46)-(47). In syntax the Binder rules inserts the β binding prefix and transfers or copies the index *2* to β from the phrase that is slated to be the subject. (47) spells out the working of the Binder Index Evaluation rule. *g* is the current assignment of values to variables. g(2) is the individual that *g* assigns to the variable *2*. *g[2→x]* is an assignment that differs from *g* in that it assigns the individual *x* to variable *2*.

(46) $|[\text{ saw his}_2 \text{ father }]|^{M,g} = \lambda y[y \text{ saw } g(2)\text{'s father}]$

(47) $\|[\ \beta_2\ (\text{saw his}_2\ \text{father})\ ]\|^{M,g} = \lambda x[\lambda y[y \text{ saw } g[2\rightarrow x](2)\text{'s father}](x)] = \lambda x[x \text{ saw } g[2\rightarrow x](2)\text{'s father}] = \lambda x[x \text{ saw } x\text{'s father}]$

See article 43 [=Pronouns] for further details.

5.2 Pronouns that grab antecedents for themselves

Crucial to the binding technology just reviewed is that (i) operators manipulate assignments, (ii) pronouns and all other noun phrases come with indices, and (iii) pronouns start out as free (assignment dependent) variables and become bound (assignment independent) in the course of the derivation – a transition whose compositionality is dubious. Are these features necessary? Just as in the case of quantifier scope, once we understand the semantic core of the phenomenon it is easy to see that it can be implemented in more than one way. We sketch two different ways of building interpretations like (42) without the above features.

Reinhart (1983) argues that reflexives and bound pronouns are essentially the same thing: both receive bound variable interpretations strictly within the c-command domain (scope) of the binder and differ only as to locality. Szabolcsi (1987/1989, 1992) uses reflexives as a stepping-stone for a general theory that captures Reinhart's intuition with very different logical tools. The case of reflexives is striking, because reflexives are ungrammatical if they do not get bound. Therefore assigning them a free variable interpretation in the lexicon amounts to deliberately misinterpreting them in a way that has be straightened out by syntax. The null hypothesis is that expressions start out with correct interpretations. Szabolcsi proposes to place all the action into the interpretation of the reflexive. *Himself* in (48) is interpreted as an operation on functions that says, `I saturate the first argument of an (at least) two-place function, and its next argument will bind me'. The "next argument" part ensures that the antecedent c-commands the reflexive. As (49) shows, *saw himself* comes out as denoting a property parallel to (42).

(48) himself′ = $\lambda f\lambda x[f(x)(x)]$, where f is a variable of type <e,<e,t>>

(49) saw himself′ = $\lambda f\lambda x[f(x)(x)](\text{saw}') = \lambda x[\text{saw}'(x)(x)]$

Operations on functions as in (48) are known as combinators; this specific one is called a duplicator, because its entity argument appears twice in the description of the function value. Combinatory logic has the same expressive power as the lambda calculus, but builds the same meanings differently (Curry & Feys 1958; Quine 1960). Relevant to us is the fact that free variables in combinatory logic are name-like: they never get bound, because no operators manipulate assignments. If desired, a pronoun that is intended to remain free (deictic) can be interpreted as a free variable, and English *he* can be treated as ambiguous between the distinct variables *x*, *y*, *z*. To account for bound pronouns in the spirit of Reinhart, *he* will have a further lexical interpretation, one that is similar to that of reflexives. On this view the only important difference between *himself* and he_{bound} is that the latter ensures that the c-commanding antecedent is an argument of a higher predicate, cf. Principle B of the Binding Theory that prohibits pronouns from being bound within their local domain.

(50) $he_{bound}/him_{bound}' = \lambda h \lambda f \lambda x[f(hx)(x)]$, where h is a variable of type $<e,t>$ and f is a variable of type $<t,<e,t>>$

(51) (that) he_{bound} won′ $= \lambda h \lambda f \lambda x[f(hx)(x)](won') = \lambda f \lambda x[f(won'(x))(x)]$

The clause *that* he_{bound} *won* acts like one big reflexive: the subject of the matrix verb will be interpreted as the antecedent of he_{bound}. In other words, he_{bound} is a pied piper: its duplicatorhood "percolates" up to the clause (or other appropriate phrase) that contains he_{bound} and so anti-locality is ensured, because the pronoun cannot grab an antecedent within that clause. (We ignore the intensionality of *think*.)

(52) thought that he_{bound} won′ $= \lambda f \lambda x[f(won'(x))(x)](thought')$
$= \lambda x[thought'(won'(x))(x)]$

(53) Every boy thought that he_{bound} won′ =
$\lambda P \forall z[boy'(z) \rightarrow P(z)]\ (\lambda x[thought'(won'(x))(x)]) =$
$\forall z[boy'(z) \rightarrow thought'(won'(z))(z)]$

The derivation of *saw* his_{bound} *father* would proceed analogously, with his_{bound} having arguments whose types are a bit different from those of he/him_{bound}; compare the discussion in 5.3.

(54) $his_{bound}' = \lambda h\lambda f\lambda x[f(hx)(x)]$, where h is a variable of type <<e,t>, e> and f is a variable of type <e,<α,t>>

5.3 Pronouns as identity maps

One feature of the duplicator theory of reflexives and bound pronouns is that it avoids turning an assignment dependent expression into an assignment independent one. But there are other ways to achieve this. One is to treat free variables not as dependent on a chosen assignment but as functions from assignments (Sternefeld 2001, among others):

(55) $\|[x]\|^M = \lambda g[g(x)]$, where g is a variable over assignments

A formula with a free variable inherits this property, i.e. it is also a function from assignments: $\lambda g[f(g(x))]$. Quantifiers continue to manipulate assignments.

Another option is intuitively similar but it even eliminates the manipulation of assignments. It involves trading variables for identity functions, $\lambda x[x]$, for x of any type. Formulas with what used to be a free variable are traded for predicates: $\lambda x[f(x)]$.

This is the proposal adopted by Hepple (1990) and by Jacobson in a series of papers starting with 1992; see especially Jacobson (1999, 2000). Jacobson is dissatisfied with that feature of Szabolcsi's proposal that it retains the standard ambiguity of free pronouns (*he* ambiguously represents the distinct variables *x*, *y*, *z*, …) and even increases it (*he* versus he_{bound}). In Jacobson's version of variable-free semantics pronouns are identity maps, and this interpretation underlies all their uses.

(56) $he' = \lambda x[x]$, where x is a variable of type e

Sentences with n deictic pronouns come out as n-place predicates to be applied to some n-tuple of contextually salient entities, so the ambiguity of free pronouns is replaced by the contextual dependence of salience. The same identity map interpretation, aided by a combinator that Jacobson names **z**, participates in bound readings. Jacobson's **z** performs the same action that Szabolcsi builds into bound pronouns, compare (50)-(54) with (57), but **z** is a silent operator on verb meanings: a type-shifter. (Hepple interprets both reflexives and pronouns as identity maps. Jacobson does not say how she proposes to treat reflexives.)

(57) $\mathbf{z} = \lambda f \lambda h \lambda x[f(hx)(x)]$

(58) $\mathbf{z}\text{-saw}' = \lambda f \lambda h \lambda x[f(hx)(x)](\text{saw}') = \lambda h \lambda x[\text{saw}'(hx)(x)]$

Applied to *his father*, interpreted as $\lambda y[\text{father-of}'(y)]$ (we shall see shortly how this comes about), (58) delivers the desired bound reading for the pronoun:

(59) $\mathbf{z}\text{-saw(his father)}' = \lambda h \lambda x[\text{saw}'(hx)(x)](\lambda y[\text{father-of}'(y)]) = \lambda x[\text{saw}'(\text{the-father-of}'(x))(x)]$

One straightforward difference between Szabolcsi's and Jacobson's proposals is that only the latter can create duplicated readings in the absence of a reflexive or pronoun. Functional questions are one example where this is relevant. (60) employs **z**-*chase′* plus a new type <<e,e>,t> interpretation for *what*:

(60) What does no dog chase? Its muzzle.
For which function f, no-dog′ $(\lambda x[\text{chase}'(fx)(x)])$?
$\lambda z[\text{muzzle-of}'(z)]$.

Dowty (2007: 95-97) notes that the question-answer pair could acquire the same interpretation on Szabolcsi's approach if *what* was given the same <e,<e,t>>,<e,t>> type as the duplicator *its muzzle*, cf. (50)-(54).

(61) For which Q, no dog'(Q(chase'))?
$\lambda f \lambda x[f(\text{muzzle-of}'(x))(x)]$.

In Dowty's (61) the question itself is not functional, but it expects the answer quantifier to take narrow scope; the pronoun in the answer is responsible for duplication. So function talk may not be strictly necessary here, but it seems crucial elsewhere, e.g. in paycheck pronouns.

Another difference is that whereas both proposals can be easily extended to antecedent-contained deletion as in (62), analyzing it essentially as transitive verb phrase ellipsis (i.e. duplication), only Jacobson's will cover (63) as well:

(62) No dog obeyed every boy who Goldy did.

(63) No dog obeyed every boy who wanted it to.

In (62) the elided part is *obeyed*, whereas in (63) it is *obey him*. To see why this difference is critical we must fill a gap regarding what happens in Jacobson's theory when a pronoun first merges with an argument-taking predicate.

Let us start with *his father*. The relational noun *father* expects an argument of type e, but *he*/*his* being interpreted as $\lambda x[x]$ is of type <e,e>. Therefore *father* cannot apply to the pronoun. If we wish to maintain that merging expressions is always interpreted as functional application, the type of *father* has to be shifted from $\langle e,\alpha\rangle$ to $\langle\langle e,e\rangle,\langle e,\alpha\rangle\rangle$. This shift is performed by the Geach rule, i.e. Jacobson's combinator **g**. In (64) X/Y is the category of functors (syntactic functions) that expect an argument of category Y from the right and return a value of category X: $X/Y \cdot Y = X$. The category X^Y is mapped to the same type as X/Y, but functors of this category are syntactically inert. X^Y does not apply to arguments of category Y, it only serves as an argument of other functors that look for X^Y. Pronouns interpreted as identity maps have such "domain in the exponent" categories: *he* never applies to *Bill* but can be the argument of **g**(*father-of′*), for example.

(64) If f is an expression of category A/B, then **g**(f) is an expression of category A^C/B^C. $\mathbf{g} = \lambda h\lambda k\lambda y[h(ky)]$

(65) $\mathbf{g}(\text{father-of}') = \lambda k\lambda y[\text{father-of}'(ky)]$

(66) $\text{his father}' = \mathbf{g}(\text{father-of}')(\text{he}') = \lambda k\lambda y[\text{father-of}'(ky)](\lambda x[x]) = \lambda y[\text{father-of}'(y)]$

Likewise, predicates that take *him* or *his father* as an argument do so after undergoing a similar **g**-shift. ***z****-saw* is an exception because **z** incorporates **g**. However, if the pronoun had not been slated to be anteceded by the subject of *saw*, **g**(*saw*) would have been used:

(67) $\mathbf{g}(\text{saw}') = \lambda k\lambda y[\lambda x[\text{saw}'(ky)(x)]]$

(68) $\text{saw him}' = (\mathbf{g}(\text{saw}'))(\text{him}') = \lambda y\lambda x[\text{saw}'(y)(x)]$

To pave the way back to (63), notice that *his father* is interpreted the same as the function *father-of*, and *saw him* is interpreted the same as *saw.* These, in turn, are semantically the same as if the DP and the VP contained extraction gaps in their internal argument positions. Therefore, in Jacobson's theory there is no semantic difference between the elided phrases in (62) and (63). But Szabolcsi's theory does not produce an *obey him* interpretation for the elided phrase.

The identity function interpretation of pronouns gives rise to a problem that is not satisfactorily solved as of date. As Caroline Heycock has observed, (69) and (70) are logically equivalent. Therefore the theory predicts, incorrectly, that (71) has a reading that can be paraphrased as (72).

(69) $\lambda x[\text{mother-of}'(x)] = \lambda x[\text{friend-of}'(x)]$

(70) $\forall x[\text{mother-of}'(x) = \text{friend-of}'(x)]$

(71) His mother is his friend.

(72) For every (male) person, his mother is his friend.

One line of attack might be to require expressions containing free pronouns to be predicated of contextually salient entities, and to allow the functional use only as a last resort to avoid a type clash. But it is not obvious how to formulate this efficiently.

Jacobson offers elegant analyses for many hard nuts in binding theory, such as paycheck pronouns, i-within-i effects, copular connectivity, weak crossover, contrastive stress on bound pronouns, and compares them with variable-full alternatives. See Jacobson (1999, 2000), Kruijff & Oehrle (2003), Barker & Jacobson (2007), and references therein for related work.

A particularly interesting development of this line of research is Jäger (2005), who proposes a proof theoretic implementation of Jacobson's ideas. For LFG's "glue semantics" using linear logic, see Dalrymple (2001).

6. No scope for scope?

In the first part we discussed the classical notions of scope and binding, stressing their semantic core and the freedom in its grammatical implementation. What we did not ask is how well the predictions of the classical theory match up with the data.

This section borrows the title of Hintikka (1997). Our data and the conclusions overlap with but are not identical to Hintikka's.

One feature of the classical theory is that it treats all quantifier phrases alike. Thus, as soon as two expressions are deemed to be quantifier phrases they are predicted to exhibit the same scope behavior. Also, nothing but a stipulation prevents quantifier phrases from scoping out of their clauses, and the stipulation makes all of them clause-bounded. Another feature of the classical theory is that binding requires the argument position of the antecedent to c-command the pronoun. Unfortunately, these predictions are not borne out. The following small sample of data will drive this home.

In (73)-(74) *every show* easily scopes over the subject, but *more than one show* does not:

(73) More than one soprano sings in every show.

(74) Every soprano sings in more than one show.

In (75) *a famous soprano* appears to scope out of its clause, even an island, but in (76)-(77) *more than one soprano* and *every soprano* do not:

(75) Two reporters heard the rumor that a famous soprano owns a tiger.

(76) Two reporters heard the rumor that more than one famous soprano owns a tiger.

(77) Two reporters heard the rumor that every famous soprano owns a tiger.

In (78)-(79) the possessors *every soprano* and *no soprano* can both antecede the pronouns:

(78) Every soprano's keys are in her purse.

(79) No soprano's keys are in her purse.

In (80) *a problem* that is buried in a relative clause and is scopally dependent on *every soprano* can nevertheless antecede the singular pronoun. In (81) *more than one problem* can likewise support a co-varying reading, although a plural pronoun is perhaps preferred.

(80) Every soprano who had a problem wanted to solve it.

√'for every soprano and her problem, she wanted to solve it'

(81) Every soprano who had more than one problem wanted to solve them/?it.

√'for every soprano and her more than one problem, she wanted to solve them'

Scope and pronominal anaphora also present their joint surprises for the classical theory. In (82) *a great soprano* appears to both scope in the matrix clause and antecede the singular pronoun in the second conjunct, but in (83)-(84) *more than one soprano* and *every great soprano* do not:

(82) Taro thinks that a great soprano applied and wants to hire her.

(83) Taro thinks that more than one great soprano applied and wants to hire her. (Hire who?)

(84) Taro thinks that every great soprano applied and wants to hire her. (Hire who?)

Many of the developments of the past decades have been based on observations like these. Focusing on noun phrases, below we show that scope is not a primitive (existential scope, distributive scope, and the scope of the descriptive condition need to be factored out) and not a unitary phenomenon (at least bare indefinites, counting quantifiers, and distributive universals have to be distinguished). Likewise, binding relations are due to more than one mechanism (ones based on individuals, situations, and worlds, possibly also agreement). The upshot is not that the classical theory of scope and binding is simply wrong. Instead, it seems that there are few "scope phenomena" and "binding phenomena" that exemplify the classical notions in a pure form. The classical machinery retains its general significance more by offering building blocks for the differentiated theory or theories than by offering self-contained accounts of the particular empirical cases.

The issues reviewed here constitute part of a bigger picture. The articles in Szabolcsi (1997b) and much further work demonstrate that whatever quantificational phenomenon one looks at – branching readings, interaction with negation, distributivity vs. collectivity, intervention effects in extraction and negative polarity licensing (weak islands), event-related readings, pair-list questions, functional readings, and so on – one finds that certain DPs participate and others do not. This suggests that "scope taking", "quantification", and "binding" involve a variety of distinct mechanisms. Each kind of expression participates in those that suit its syntactic structure and its semantics. Szabolcsi (1997a) proposed the following heuristic principle; see the papers in Szabolcsi (1997b) for detailed discussion:

(85) What range of expressions actually participates in a given process is suggestive of exactly what that process consists in.

7. Scope judgments

Scope judgments are held to be notoriously difficult. Part of the difficulty may be an artifact of the classical theory: if one expects all quantifiers to behave uniformly, it is bewildering to find that they do not. Another reason may be that scope independent readings blur the picture, see Hintikka & Sandu (1997), Schein (1993) and Landman (2000). But it is indeed important to proceed carefully when obtaining judgments, now that we see that the diversity of scope behaviors may have theoretical significance.

Where there is a potential ambiguity, one of the readings is typically easy. This tends to be the one where the scopal order of quantifiers and other operators matches their linear order or surface c-command hierarchy. What is often difficult to tell is whether inverse scopal orders are possible. To investigate this it is useful to shut out the easy reading and, to borrow Ruys's (1992) slogan, to let the difficult one shine. For example, the easy, subject wide scope readings of the sentences below are implausible in view of encyclopedic knowledge:

(86) A pink vase graced every table.
A guard is posted in front of every building.

The fact that the sentences nevertheless make perfect sense indicates that the object wide scope readings are fine. At the same time, the fact that the variants below are less natural or even nonsensical confirms that the method still has some discriminating power:

(87) A pink vase graced all / none of the tables.
A guard is posted in front of all / none of the buildings.

Unfortunately, the easy reading can only be shut out if the difficult reading can be true without it. If the difficult reading entails the easy one, there is no shutting it out. In that case one tries to exploit some linguistic phenomenon, such as cross-sentential anaphora, that is contingent on a reading that the grammar produces, not just on what is entailed to be true. In (88), *it* cannot refer back to the unique missing marble whose existence can be inferred from the first sentence.

(88) I dropped ten marbles and found nine of them. #It must be under the sofa.

In this spirit, suppose we want to find out whether *two NP* and *two or more NP* are capable of taking inverse scope over *every NP* – but here the inverse readings entail the easy, linear ones. So, imagine two schools. In the parent-friendly school a teacher is fired if any parent complains.

In the teacher-friendly school a teacher is fired only if every parent complains. The following is reported:

(89) Every parent complained about two teachers. They were fired.

(90) Every parent complained about two or more teachers. They were fired.

Can we be in the teacher-friendly school? Speakers usually find it easy to judge that only (89) may describe an incident in the teacher-friendly school. Notice that the choice depends solely on whether *they* in the second sentence can be understood to refer to those teachers who every parent complained about. This in turn depends solely on whether the first sentence has the reading `there were two (two or more) teachers such that every parent complained about them'. In sum, this scenario seems to test just the scope judgment we are interested in; but the involvement of anaphora and the non-metalinguistic question make the task easier and more natural than it is to judge paraphrases or truth-values.

8. Existential scope versus distributive scope

8.1 The critical data

The following contrast may be taken to suggest that the scope of *every NP* is clause bounded, which is what May (1977) stipulates for all phrases that undergo Quantifier Raising, but that of *two NP* is not. (91) does not allow firemen to vary with buildings, but (92) allows the two buildings to be chosen independently of the firemen.

(91) Some fireman or other thought that **every building** was unsafe.
#`for every building, there is a potentially different fireman who thought it was unsafe '

(92) Every fireman thought that **two buildings** were unsafe.
(i) √`there are two buildings such that every fireman thought that they were unsafe'
(ii) √`for every fireman, there is a potentially different pair of buildings that he thought was unsafe'

Consider, however, the following. Although (93) allows revolving doors to vary with buildings (so *two buildings* supports a distributive reading), (94) does not allow firemen to vary with buildings. In that respect (94) is like (91).

(93) **Two buildings** have a revolving door.
√`for each building, there is a separate revolving door…'

(94) Some fireman or other thought that **two buildings** were unsafe.
#`for each building, there is a separate fireman…'

And conversely, (95), just as (92), has two readings. (i) is true in a scenario where sets of apples vary with children: say, each child gets three apples to eat (this possibility was first observed in Kuroda 1982). On reading (ii) the set of apples is chosen independently: a single contextually relevant set of apples is evaluated by all the children. (This under the assumption that *every* requires the NP-set to be non-empty. See Heim & Kratzer (1998, Chapter 6) for discussion. For context dependence, see Stanley & Szabó (2000).)

(95) Every child tasted **every apple**.
(i) √`every child had his/her own apples and tasted each of them'
(ii) √`there is a set of apples such that every child tasted each of its members'

The above observations were made more or less independently in Beghelli, Ben-Shalom & Szabolcsi (1997), Beghelli & Stowell (1997), Farkas (1997), Kratzer (1998), Reinhart (1997), Ruys (1992), and Szabolcsi (1997a), among others.

The comparisons indicate that *every NP* and *two NP* are parallel in their behavior, contrary to first impressions. Both support distributive readings, but only within their own clause, and both can be referentially dependent or, even clause-externally, independent. But **what** is their scope? The answer cannot be given using the classical notion of scope. The reason is that the classical theory talks about "the" scope of a quantifier phrase. But (91) through (95) suggest that *every NP* and *two NP* share one scopal property that is clause-bounded and another one that is not. Preliminarily, we may say that both phrases have clause-bounded "distributive scope" and unbounded "existential scope". Distributive scope corresponds to the domain within which the quantifier phrase can make indefinites referentially dependent; existential scope corresponds to the domain within which the set of individuals that the quantifier phrase talks about can be fixed.

Do all quantifier phrases have unbounded existential scope? The answer is No: for example, *two or more buildings* does not.

(96) Every fireman thought that **two or more buildings** were unsafe.
#`there are two or more buildings such that every fireman thought that they were unsafe'

Likewise, distributive scope is not always clause-bounded: *each NP* provides solid counterexamples:

(97) A timeline poster should list the different ages/periods (Triassic, Jurassic, etc.) and some of the dinosaurs or other animals/bacteria that lived in **each**. (Google)
√`for each period, some of the dinosaurs that lived in it'

(98) Determine whether **every number in the list** is even or odd.
#`for every number, determine whether it is even or odd'

(99) Determine whether **each number in the list** is even or odd.
√`for each number, determine whether it is even or odd'

Farkas (1997) observes that there is a third kind of scope to reckon with; she calls it the scope of the descriptive condition. The denotation of NP in *every NP* and *two NP* may be indexed to the world of any superordinate subject or to that of the speaker:

(100) Some boy imagined that **every violinist** had one arm.
(i) √`a boy imagined of every actual violinist that he/she had one arm'
(ii) √`a boy thought up an all-one-armed-violinists world'

(101) Some boy imagined that **two violinists** had one arm.

The scope of the descriptive condition cannot be equated with existential scope. This is shown by upward monotonic *two or more NP* and downward monotonic *no violinist*. Neither has unbounded existential scope, but their descriptive conditions can be indexed with the world of the speaker or of a superordinate subject.

(102) Some boy imagined that **two or more violinists** had one arm.

(103) Some boy imagined that **no violinist** had one arm.

The scope of the descriptive condition will not be discussed further here, but article 70 [=Indexicality and Logophoricity] should be relevant.

8.2 Inducing and exhibiting referential variation

Why did it initially seem that *every NP* has clause-bounded scope but indefinites (*some NP*, *two NP*) unbounded scope? The reason is that different questions were asked in diagnosing their scopes. In connection with universals the question was within what domain they can make other expressions referentially dependent (i.e. distributive scope). In connection with indefinites, the question was within what domains they can remain referentially independent of other operators (i.e. existential scope).

To take a closer look at the ability of one expression to induce referential dependency in another, consider the following diagram that depicts a situation where the S>O reading of *Every man saw some dog* is true (assume that there are altogether three men). The notion of a witness set will be useful in talking about it. A witness of a generalized quantifier (GQ) is a set of individuals that is an element of the GQ and is also a subset of the determiner's restriction set (Barwise and Cooper 1981). Any set of individuals that contains two dogs and no non-dogs is a witness of the GQ denoted by *two dogs*. The unique witness of *every apple* is the set of apples. The unique witness of *no dog* is the empty set. See Beghelli, Ben-Shalom & Szabolcsi (1997) for the discussion of referential variation in these terms.

Figure 1 shows a witness set of the wide scope quantifier *every man′*; each element of this witness is connected by the *see′*-relation to some witness or other of the narrow scope quantifier *some dog′*.

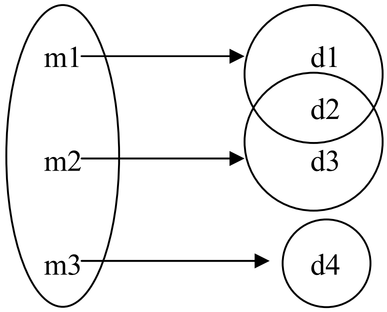


Figure 1 Scope and witness sets

A quantifier phrase can induce referential variation only if it has a minimal witness with more than one element – otherwise there is nothing to vary with), and it can exhibit referential variation only if it has more than one witness – otherwise it has no way to vary. The indefinite traditionally considered in the literature was singular *some NP*, whose minimal witnesses are singletons, and thus cannot induce referential variation. On the other hand, the fixed-reference universals that linguistic literature traditionally considered have unique witnesses, and thus cannot exhibit variation. These choices, probably influenced by first order logic, may explain why only one aspect of each was recognized. Plural indefinites and variable-reference universals (as in (96i)) thus play an important role in forcing the conceptual shift.

The position we are taking here, with Beghelli & Stowell 1997 on English, Szabolcsi 1997 on Hungarian, and work building on these (Lin 1998; Matthewson 2001) is stronger than the position taken in much of the literature that follows Reinhart (1997). We do not only make the existential and distributive scope distinction in the case of indefinites (and definites, to which the arguments seem to carry over) but also in the case of *every NP* type universals. We do not group the latter together with the so-called counting quantifiers such as *two or more NP*, *less than five NP*, etc. The motivation comes in part from the data described in Section 8.1, and is further discussed in 8.3-4. On the other hand, we are not aware of reasons to make the existential versus distributive scope distinction for *each NP* and for counting quantifiers. (*Most (of the)* and *the most* are the least well-studied from this perspective.)

The distinction between existential and distributive scope can be accommodated if we associate two different operators with the noun phrase, an existential and a universal one. We examine these in turn.

8.3 Existential scope, specificity, and Skolem functions

Fodor and Sag (1981) noticed that singular indefinites may have unbounded, island-free scope; in fact, they argued that if an indefinite escapes its own clause it takes maximal scope. Given this and the fact that this reading is best available with specific indefinites, i.e. those modified by a partitive (*a student of mine*), a relative clause (*a director that I know*) or the adjective *certain* (*a certain book*), they proposed that such indefinites are referential. Farkas (1981) countered this by observing that intermediate readings are possible; see Abusch (1994) for further examples.

(104) Each student has to hunt down every paper which shows that some condition proposed by Chomsky is wrong.

√`each student > some condition > every paper'

Reinhart (1997) captures the possibility of both maximal and intermediate scopes by using the structure-building rule of existential closure of choice function variables. Each choice function picks out an element of the set it applies to. E.g. it may be that f_1(dog′)=Spot and f_2(dog′)=King; or, if it applies to a set of sets of individuals, it may be that f_1(two′(dogs′)) = {Spot,King}and f_2(two′(dogs′)) = {Spot,Fido}. The intermediate reading of (104) will be explicated roughly as follows:

(105) $\forall x[\text{student}'(x) \rightarrow \exists f \forall y[(\text{paper}'(y) \wedge \text{shows-to-be-wrong}'(f(\text{condition}'))(y)) \rightarrow \text{hunt-down}'(y)(x)]]$

In words: For every student x there is a choice function f such that for every y that is a paper and shows the element that f picks from the set of conditions [proposed by Chomsky] to be wrong, x hunts down y. Here conditions vary only with students, not with papers.

Choice functions were first employed for interpreting specific indefinites by Egli & von Heusinger (1992). In motivating the use of choice functions Reinhart (1997) shows that existential quantification over individual variables would make the truth conditions of sentences involving material implication too weak. (Other problems caused by material implication are not solved by choice functions.) Existential quantification over witness set variables has the same effect as using choice functions, because choice functions pick out witnesses of the indefinites (Szabolcsi 1997a).

Kratzer (1998) argues against non-maximal scope existential quantification over choice functions. She suggests that intermediate readings are only felicitous when there is a contextually salient way of picking elements of the NP-set of the indefinite and pairing them with the individuals the wider-scoping quantifier ranges over. In the case of (104) this would be the way the professor assigned conditions to students. Many examples with intermediate readings in the literature even contain a pronoun within the indefinite's NP that is linked to the wider-scoping quantifier, e.g.

(106) Each professor rewarded every student who read a certain book that he wrote.
√'each prof_i > a certain book he_i wrote > every student'

Therefore, Kratzer proposes to use parametrized choice functions to interpret indefinites. These are Skolem functions that have both set and individual arguments. On her view the function itself is always contextually given, much like the reference of Fodor and Sag's maximal scope indefinites. Parametrization captures the possible dependence on some quantifier of how the function picks elements from the indefinite's NP-set. (104) will now be explicated as (107). The relevant change from (105) is in the underlined part of (107). The new *x* is bound by $\forall x$, and $\exists f$ has disappeared; if it were to be spelled out, it would be assigned widest scope.

(107) $\forall x[\text{student}'(x) \rightarrow \forall y[(\text{paper}'(y) \wedge \text{shows-to-be-wrong}'(\underline{f(x)(\text{condition}')})(y)) \rightarrow \text{hunt-down}'(y)(x)]]$

Winter (2004) makes a connection between the analyses of the wide existential scope of indefinites and of functional readings of copular sentences:

(108) The (only) woman that every man loves is his mother.

(109) The (only) function in the set {f: f maps every man to a woman he loves} is the function that maps every man to his mother.

He unifies Kratzer's (1998) and Jacobson's (1994) approaches in terms of Skolem functions of arbitrary arity. Steedman (2000) treats scope alternation and donkey anaphora using Skolem functions.

In Section 8.2 we argued that the existential versus distributive scope distinction extends to universals like *every NP*. This approach may allow for a unification of the context dependence of indefinite interpretation as in Kratzer (1998) with quantifier domain restriction as in Stanley & Szabó (2000). Stanley & Szabó argue that the domain of quantifiers is always contextually restricted, that this restriction may contain a variable linked to another quantifier, and that this restriction is specifically located in the NP, not the determiner. The similarity to indefinite interpretation is captured if in (110) *every child* is interpreted as *f(Pow(child'))* and *every apple* as *f(x)(Pow(apple'))*. The choice function *f* applied to the powersets of *child'* and *apple'* picks out the contextually relevant sets of children/apples (cf. the excursion), and the parameter *x* ensures that sets of apples vary with children:

(110) Every child ate every apple.

\`every child [who was at the excursion] ate every apple [that was given to her for that excursion]'

See below on the distributivity of *every NP*.

The issues concerning existentially closed versus contextually given choice functions, Skolemization, and the possibility to unify the treatment of indefinites and quantifiers are vigorously debated in recent literature. See Matthewson (1999, 2001), von Fintel (1999), Chierchia (2001), Schwarzschild (2002), Breheny (2003), and Schlenker (2006), among others.

8.4 Distributive scope

We have observed that distributive scope is clause-bounded, save for the case of *each NP*. (May (1985) attributes the extra-clausal distributive scope of *each NP* to focus.) Barwise & Cooper (1981) build distributivity into the interpretation of all noun phrases, but this does not seem useful even clause-internally. (111) shows that collective and distributive predicates can be coordinated when the subject is a definite or indefinite plural. This suggests interpretation (112), where P is a variable over sets of individuals and distributivity (indicated by **each**) is a property of the second predicate.

(111) Six friends watched a movie together and had a glass of wine.

(112) λP[watched-a-movie-together′(P) $\wedge$ had-a-glass-of-wine-**each**′(P)] (f(six′(friends′)))

See further article 50 [=Plurality].

Consider now *every NP* on the analysis proposed above. What accounts for the fact that *every NP* typically participates in distributive readings? Beghelli & Stowell (1997) argue that in those cases *every NP* appears in the specifier of a distributive functional head *Dist*. *Dist* universally quantifies over the set picked out by the (parametrized) choice function.

Suggestive evidence that the distributive operator does not originate in the lexical meaning of *every* but is contributed by a functional head in syntax is offered by Hungarian (Szabolcsi 1997a). DPs belonging to different quantifier classes occupy different surface syntactic positions in Hungarian. Some DPs can occur in more than one position and their behavior varies accordingly. Specifically the comparative quantifier *több, mint n gyerek* `more than *n* children' can occur in the position where *minden gyerek* `every child' canonically occurs, and if it does, its interpretation parallels that of *minden gyerek*: it has unbounded existential scope and it is exclusively distributive.

(113) In Spec, DistP:
Több, mint hat gyerek felemelte az asztalt.
more than six child up-lifted the table.acc
`More than six children each/*together lifted up the table'

It can also occur in another position where counting quantifiers canonically occur, and there it behaves like one of those: it has no unbounded existential scope and distributivity is not forced:

(114) In Spec, CountP:
Több, mint hat gyerek emelte fel az asztalt.
more than six child lifted up the table.acc
`More than six children each/together lifted up the table'

According to Beghelli & Stowell the fact that both silent *each* and *Dist* are heads explains why the distributive scope of definites, indefinites, and *every NP* is clause-bounded. See also Cecchetto (2004).

Not all universals are alike. *All the NP* is basically a definite plural, whereas *each NP* is more strongly distributive that *every NP* (again, see Beghelli & Stowell).

Important issues not explored here are the connection between distributivity and the singular feature, and the presence of event quantifiers in the immediate scope of distributive operators (Schein 1993; Beghelli & Stowell 1997).

9. Counting quantifiers

The existential versus distributive scope distinction does not extend to so-called counters, and to some of them it could not possibly extend. Recall that the value of, say, $f(five'(men'))$ is some set of five men. This way existential quantification over choice functions is basically the same as existential quantification over sets of a given cardinality. This only yields a truth-conditionally correct result if the determiner is upward monotonic in its scope argument.

(115) Five men walk = There is a set that contains five men and its elements walk.

(116) Fewer than five men walk ≠ There is a set that contains fewer than five men and its elements walk.

(117) Exactly five men walk ≠ There is a set that contains exactly five men and its elements walk.

Counters include *no NP, few(er than five) NP, many NP, more than five NP, more than n% of the NPs, at least/most five NP, five or more NP, more* NP_1 *than* NP_2*, exactly five NP*, and some others. In view of the above, only the upward monotonic among them could in principle have a separate existential scope component to their interpretation. But if the lack of extra-wide scope is any indication, (76) shows that even those do not have such a component.

Computing with definites, indefinites, and universals involves an individual or set of individuals serving as the logical subject of collective/distributive predication. In the case of counters, no set of individuals serves as a logical subject of predication. (114) basically means that there was an event of table lifting by children and the agent of this event, or each of its subevents, had cardinality greater than six. The intuition that counting is indeed the characteristic action of these quantifiers is corroborated by the grammaticality contrasts between *more than 50% of the NP*, a counter and *most of the NP*, not a counter (Szabolcsi 1997a) and by pyscholinguistic experiments (Hackl 2006).

(118) They read more than 50% of the books each.

(119) # They read most of the books each.

(120) There'll be more than 50% of the kids in the yard.

(121) # There'll be most of the kids in the yard.

Probably counters come closest to exemplifying generalized quantifiers in the classical sense (but see Hackl (2000) on comparative determiners and Hackl (2006) on *most*).

10. Clause internal scope behavior

Roughly three main classes of DPs have emerged from the foregoing discussion. The first two classes both have unbounded existential scope, but the distributive vs. collective readings of (in)definites depend on the predicate, whereas *every NP* associates with a special functional head, *Dist*. The third class is counters, possibly denoting run-of-the-mill generalized quantifiers.

The three main classes also differ clause-internally. In languages like English, where quantifier scope is rarely disambiguated by word order and intonation, this manifests itself in differences in the ability to take inverse scope. *Every NP* is an excellent inverse scope taker, see (122): it is the poster child for Montague/May/Hendriks style theories. Counters on the other hand do not take inverse scope over *every NP*, although they may over another counter, see (123)-(124):

(122) More than one soprano sings in every show.

√`every NP > more than one NP'

(123) Every soprano sings in more than one show.

#`more than one NP > every NP'

(124) At least two sopranos sing in more than one show.

?`more than one NP > at least two NP'

Downward monotonic DPs are especially reluctant to take inverse scope. Why this is so is not well-understood, but the fact explains an otherwise mysterious constraint on negative polarity item licensing, namely, that the licensor must c-command the NPI in overt syntax. See article 73 [=Negative Polarity Items and Positive Polarity Items].

(125) *He has ever missed no meal.

(126) No meal has he ever missed.

Definites and indefinites can take inverse distributive scope but not nearly as readily as *every NP*. The reasons are debated. They may lie in the semantics of predicates, or in the burden such sentences place on working memory (Reinhart 2006: 2.7.3).

(127) More than one soprano sings in those (six) shows.
?`more than one soprano each'

In Hungarian, where quantifier scope is disambiguated by word order and intonation, the members of the three classes of DPs occupy three distinct regions of the preverbal field; a remarkable cross-linguistic correlation:

(128) (In)definites > Distributives > Counters > Verb > … [same operator sequence reiterates]

Left-to-right order also determines scope order, therefore a preverbal counter may only outscope a distributive or an (in)definite if the latter occurs in the postverbal field. For details, see Beghelli & Stowell (1997); Szabolcsi (1997a); Brody & Szabolcsi (2003).

Since Hungarian quantifier phrases do not remain in their argument positions in surface structure, they call for a syntax that directly reflects scope assignment. On the other hand, as we have just seen, they do not simply line up in the desired scopal order but occur in designated positions reflecting a semantically flavored classification. Thus these positions are more like the landing sites of *wh*-movement than the adjoined positions created by Quantifier Raising. This explains that quantifier phrase movement in Hungarian is not subject to Scope Economy (Fox 2000): it happens regardless whether it has a disambiguating effect.

German, Japanese, and Mandarin are sometimes called scope freezing languages because (at least on the canonical Subject precedes Object order) they do not allow inverse scope. See Pafel (2006); Hoji (1985); Aoun & Li (1993); and Liu (1997). Unfortunately, not all descriptions take into account the diverse scope behavior of DPs.

Kayne (1998) argues that quantifier scope in English is also assigned in overt syntax, much like it is in Hungarian, but further leftward movements mask the results. Williams (2003) offers an alternative proposal concerning the cross-linguistic variation in how languages use overt syntax to express either case or scope relations.

11. Internal structure

Although the external scope behavior of DPs is very well studied, work on their internal structure and how it determines external behavior has not kept up with the new developments.

Because the choice function variable is of type <<e,t>, <<e,t>,t>> (or some generalization thereof), Reinhart (1997) suggests that it is essentially nothing but the determiner of the indefinite. In view of our argument concerning *every NP* and the larger class of expressions that pattern with it in Hungarian, the same should carry over to these. Then *some*,_*a(n), every*, etc. are not determiners. They may have different semantic roles or, in the spirit of Beghelli & Stowell, they may simply carry features that send the DP to the specifiers of particular functional heads. Winter's (2001) flexible DP hypothesis aims to explain what noun phrases play predicative or quantificational roles; it combines Reinhart's idea with type shifting principles (Partee 1986).

Zamparelli (1995), Krifka (1999), Hackl (2000), Nakanishi (2004), and Takahashi (2006) are pioneering proposals to tie together the compositional semantics and the external behavior of various kinds of noun phrases.

12. Pronouns as definite descriptions and co-variation with situations

12.1 Cross-sentential anaphora

Sections 4-5 were concerned with the classical theory of how DPs antecede ("bind") pronouns within their domain, typically defined with reference to c-command. The claims were illustrated using *every NP*, one of the few good citizens for the classical theory. We now turn to cases without c-command. The most extreme case is cross-sentential anaphora.

Quantifier phrases typically support cross-sentential anaphora by plural pronouns. Kamp & Reyle (1993) and Kadmon (1993) interpret *they* in both (129) and (130) as referring essentially to all the boys who were sad (maximal reference anaphora):

(129) Every boy was sad. They cried.

(130) More than one boy was sad. They cried.

The interesting cases are those where the anaphoric pronoun is grammatically singular and/or it does not have maximal reference in the above sense. Relevant from the perspective of this article is the fact that indefinites support such anaphora:

(131) A boy hid in the corner. He cried.

(132) Two boys hid in the corner. They cried.

Crucially, (131)-(132) are appropriate even if three boys hid in the corner but only one/two of them cried. This fact has been used to support the claim that indefinites are not quantificational, i.e. that the "indefinite determiners" are not existential quantifiers (Heim 1982; Kamp & Reyle 1993); or that they are quantificational but externally dynamic, in the sense that their binding scope extends over the incoming discourse (Groenendijk & Stokhof 1990). See articles 39 [=Dynamic Semantics] and 40 [=Theories of Discourse Relations] for detailed discussion.

In the case of *every NP* maximal and non-maximal reference coincide. *More than one NP* in English does not support non-maximal anaphora, but the Hungarian version that occurs in [Spec, DistP] does.

12.2 Co-variation with situations

Sometimes a pronoun receives a co-varying reading within the distributive scope of a quantifier phrase, but (the argument position of) the antecedent does not c-command the pronoun. This constellation is of particular interest to us. If the theory of binding as presented in the first part is correct, such co-varying readings cannot be bound ones.

The relevant reading of (133) is where donkeys vary with farmers and the pronoun's reference co-varies with the donkeys. A comparable reading with cross-sentential anaphora, where the pronoun falls outside the universal's domain, is not available; see (134):

(133) Every farmer who owns a donkey beats it.

(134) Every farmer owns a donkey. #It gets beaten.

Similar to (133) is (135), with an adverb of quantification or the antecedent-consequent relation replacing the determiner *every*:

(135) Always if a farmer owns a donkey, he beats it.

The classical approach to “donkey anaphora” as conceived by Lewis (1975), Kamp (1981/2002) and Heim (1982) takes (135) to be the paradigm case. On this view the adverb of quantification unselectively binds tuples (here: farmer—donkey pairs). The *if*-clause serves as the restriction and the main clause as the scope of the quantifier. Unselective binding means that exactly what variables the operator captures is not a design feature of the operator, it is determined in the course of the derivation of the given sentence. The indefinites introduce free variables and the pronouns co-refer with them. Furthermore (133) is assimilated to (135): the determiner *every* is essentially reanalyzed as *always*. The most striking problem with unselective binding as a general solution for donkey anaphora is known as the proportion problem. Although (133) and (135) have the same truth conditions, (136) and (137) do not. The determiner *most* counts donkey-owning farmers, never farmer—donkey pairs:

(136) Most farmers who own a donkey beat it.

(137) Usually/For the most part, if a farmer owns a donkey, he beats it.

So unselective binding should be restricted to adverbs of quantification. De Swart (1993) argues that even there generalized quantification over events is preferable.

The main alternative is to analyze “donkey pronouns” as definite descriptions, dubbed “E-type” or “D-type” pronouns (Evans 1980, Neale 1990b). Singular *it* is interpreted as `the donkey so owned’. This unfortunately introduces a uniqueness presupposition, unless this pronoun is construed, exceptionally, as number-neutral. Following Berman (1987), Heim (1990) uses situation semantics to eliminate the problem. Elbourne (2005) develops this proposal; on his account (133) is interpreted as (138):

(138) Every minimal situation involving a farmer owning a donkey extends to one where the unique farmer in the situation beats the unique donkey in the situation.

More generally, Elbourne argues that all pronouns are definite descriptions, and the descriptive content is retrieved from the context in the manner of interpreting elided NPs; Fox (2002) applies this strategy to the interpretation of “traces” of movement. See article 43 [=Pronouns].

Büring (2004) shows that the interpretation of the pronoun in (139)-(140) shares all the defining characteristics of donkey pronouns and extends Elbourne’s analysis to them:

(139) Every farmer’s donkey hates him.

(140) Two sisters of every farmer hate him.

Is co-variance with situations limited to cases where c-command fails? Kratzer (2006) argues that it is not; her position is compatible with Elbourne’s.

In sum, the initial expectation seems to be borne out. Donkey pronouns are not interpreted as bound variables, or as containing bound variables, linked either to *a donkey* or to *every farmer*; their reference simply co-varies with the relevant situations. But Barker & Shan (2008) argue for a novel approach to donkey anaphora. This relies on the decomposition of $p \rightarrow q$ into $\neg(p \wedge \neg q)$ and on the ability of indefinites to take extra-clausal scope. These afford an analysis where *a donkey* scopes over both the restriction and the scope of the universal but under the outermost negation. In plain first-order notation:

(141) $\forall x \neg \exists y[(\text{farmer'}(x) \wedge \text{donkey'}(y) \wedge \text{own'}(y)(x)) \wedge \neg \text{beat}(y)(x)]$

Thus the pronoun finds itself within the scope of the indefinite and can be bound by it, while the correct truth conditions are preserved. This proposal, if generally tenable, eliminates the need for co-variation with situations and re-evaluates the role of c-command in bound readings.

13. Conclusion

An important insight of the last two decades has been that both scope and binding phenomena are decomposable and descriptively diverse. To deal with the new facts the classical technologies have been supplemented with new ones, varieties of choice functions and situation semantics, among other things. We have probably accumulated a bigger toolkit than would be desirable, so enhancing theoretical coherence and technical parsimony is one task. Another is the syntax/semantics interface task of developing seriously compositional analyses not only on the sentence level but also inside quantifier phrases and even quantifier words.

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