Scope and Binding

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The first part of this article focuses on the classical notions of scope and binding. 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 focuses on 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 competes with co-variation with situations. As a result, the classical notions are likely to end up as building blocks in the varied mechanisms at work in "scope phenomenona" and "binding phenomena", and not as self-contained analyses of those phenomena.

I.The classical notions of scope and binding and their formal foundations

A.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 it 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:[1]

(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 $\underline{\forall x[f(x)] \wedge h(x)}$, so this is the part on which it performs its action; it does not affect $\underline{k(a)}$. 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 $\underline{\forall x}$ is $\underline{f(x)}$. $\underline{\forall x}$ does not operate on the $\underline{x}$ of $\underline{h(x)}$, because it is not within its scope.

Where does the bracketing in (1) come from? It 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. Each operator performs its action on the expression it is attached to; 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 "stall" 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-minded syntax might predict. Therefore in talking about natural language one has to distinguish, at least initially, between semantic scope and syntactic domain. The syntactic *domain* of an expression is defined in terms of c-command, maximal projections, feature inheritance, or other notions. If a sentence has several syntactic representations, the domains of expressions may vary from representation to representation. If the expression is an operator, the part of the structure on which the operator performs its action continues to be called its *scope*. Many linguists entertain the following hypothesis:

(2) Hypothesis about Scope and Domain: The 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

[1] See Gamut (1991) for predicate logic, type theory, and other logical notions not explained in this text, as well as for discussion of those that are merely defined, e.g. the λ operator.

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 in the case of natural language it is not immediately obvious what 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 is constrained to 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 comes from the stage-level predicate. Stage-level 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 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 existential closure.

What is the lesson to be learned from bare plurals? The generalizations concerning how noun phrases take scope will not extend to bare plurals, for the latter are not scope taking operators. But clearly there is a "scope phenomenon" in sentences with bare plurals that has to be accounted for, so the study of bare plurals is valuable from the perspective of the syntax/semantics interface in general and theories of scope in particular. Although this article does not discuss bare plurals any further, it is going to discuss other "scope(-like) phenomena" where it is not immediately obvious if there is a scope-taking operator in the sentence and if yes, where it comes from. Indefinites like some dog, two dogs are a prime case in point.

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

In many logics, operators are introduced syncategorematically. They are not among the expressions of the logical language; the syntax only specifies how they combine with expressions to yield new expressions and what the semantic effect of their introduction is. In this respect they are 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.[2] 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 most important innovations was to provide a self-contained and uniform kind of denotation for all DPs in the form of generalized quantifiers. They are so called because they generalize 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. Some of these, 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),[3] although in other ways it is semantically profitable to subsume them under the rubric of generalized quantifiers. 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.

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, 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 $\{P: |\text{dog}' \cap P| > 1\}$. If more than one dog is hungry, then $\{a: a \in \text{hungry}'\} \in \{P: |\text{dog}' \cap P| > 1\}$.
c. More than one dog denotes $\lambda P \exists x \exists y[x \neq y \wedge \text{dog}'(x) \wedge \text{dog}'(y) \wedge P(x) \wedge P(y)]$. If more than one dog is hungry, then $\lambda P \exists x \exists y[x \neq y \wedge \text{dog}'(x) \wedge \text{dog}'(y) \wedge P(x) \wedge P(y)](\text{hungry}')$ 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 $\{P: \text{man}' \subseteq P\}$. If every man is hungry, then $\{a: a \in \text{hungry}'\} \in \{P: \text{man}' \subseteq P\}$.
c. Every man denotes $\lambda P \forall x[\text{man}'(x) \rightarrow P(x)]$. If every man is hungry, then $\lambda P \forall x[\text{man}'(x) \rightarrow P(x)](\text{hungry}')$ yields the value True.

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[2] 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.

[3] The theories reviewed here allow to assign scope vacuously to names. Fox (2000) proposes the principle of Scope Economy, which requires Quantifier Raising to make a truth conditional difference. This makes interesting empirical predictions in connection with VP-ellipsis.

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 barked at every man, then the property of being an individual such that he/she/it barked at 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. 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 and the object wide scope readings of the sentence More than one dog barked at 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.

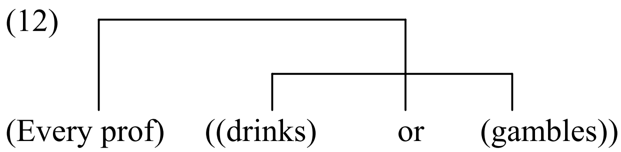
This is all there is to it:

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

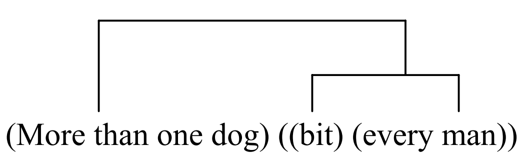
C.Scope and constituent structure

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

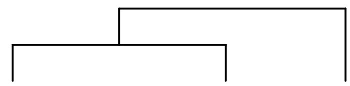
(12)



(13)



(14)



((More than one dog) (bit)) (every man)

In view of the hypothesis in (2) we have to ask how these semantic constituents match up with syntactic constituents. Initial encouragement that a good match is possible to find 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 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.

1.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).[4] 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. Given that the subject is the 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

[4] Montague (1974) differs from the below substantially in that it is an intensional theory. Intensional transitive verbs like *seek, imagine, owe*, etc. cannot take a type e argument as a direct object: they apply to the intension of the generalized quantifier denoted by the direct object. Thus *seek* will be of type <<s,GQ>, <<s,e>,t>> (using GQ to abbreviate the type of generalized quantifiers). Furthermore Montague "generalizes to the worst case" and treats all verbs uniformly. Extensional readings are obtained via meaning postulates; the postulate switches to *seek*$_*$, which is of type <e,<e,t>>. These issues are immaterial to us.

derivation must ensure that a property-denoting expression is formed for its sake in one way or another.[5]

Montague's PTQ offers several ways to build the S>O and the O>S readings of a sentence. The ones 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 lambda-binding the placeholders one by one.[6] 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) $\lambda P\exists_{>1}z[dog'(z) \& P(z)]\ (\lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)])$ =
$\exists_{>1}z[dog'(z) \& \lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)]\ (z)]$ =
$\exists_{>1}z[dog'(z) \& \forall y[man'(y) \rightarrow bit'(y)(z)]]$

(19) **(S>O)** **[$_t$ More than one dog bit every man]**
$\exists_{>1}z[dog'(z) \& \forall y[man'(y) \rightarrow bit'(y)(z)]]$

[$_{<<e,t>,t>}$ more than one dog] $\lambda P\exists_{>1}z[dog'(z) \& P(z)]$

$\lambda x_2\forall y[man'(y) \rightarrow bit'(y)(x_2)]$ — apply *more than one dog*; λ-bind subject x_2

[$_t$ ec_2 bit every man]
$\forall y[man'(y) \rightarrow bit'(y)(x_2)]$

[$_{<<e,t>,t>}$ every man] $\lambda Q\forall y[man'(y) \rightarrow Q(y)]$

$\lambda x_1[bit'(x_3)(x_2)]$ — apply *every man*; λ-bind object x_3

[$_t$ ec_2 bit ec_3]
$bit'(x_3)(x_2)$ — build sentence with two free vbls

The derivation of the reading where the direct object universal scopes over the subject

[5] This point does not originate with Heim & Kratzer (1989) but is very lucidly explained in their Chapter 7.
[6] If α is an expression, $\lambda x[\alpha]$ is an expression. $\lambda x[\alpha]$ denotes a function of type <b,a>, where b is the type of the variable x and a is the type of function value α. When applied to some argument β, the value of the function is computed by replacing every ocurrence of x bound by λx in α by β. E.g. $\lambda x[x^2](3) = 3^2$.

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

(21) **(O>S)** **[$_t$ More than one dog bit every man]**

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

[$_{<<e,t>,t>}$ every man] — $\lambda Q\forall y[man'(y) \rightarrow Q(y)]$ | $\lambda x_3\exists_{>1}z[dog'(z)\ \&\ bit'(x_3)(z)]$ — <u>apply *every man*</u> / <u>λ-bind object x_3</u>

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

[$_{<<e,t>,t>}$ more than one dog] — $\lambda P\exists_{>1}z[dog'(z)\ \&\ P(z)]$ | $\lambda x_2[bit'(x)(x_2)]$ — <u>apply *more than one dog*</u> / <u>λ-bind subject x_2</u>

[$_t$ ec_2 bit ec_3] — $bit'(x_3)(x_2)$ — <u>build sentence with two free vbls</u>

2.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 may 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

[$_S$ more than one dog$_K$ [$_S$ every man$_i$ [$_S$ t_K bit t_i]]]

(23) O>S

[$_S$ every man$_j$ [$_S$ more than one dog$_k$ [$_S$ t_K bit t_i]]]

(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 chronological 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. (We come back to the copy theory of movement in Section II.G.)

3.All the scopes, but a simple syntax

What emerges from the above considerations 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 and 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 the order 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 I.A that allows one to stall the action of the quantifiers at the point they enter the formula and to release it where desired. The action of the quantifiers is released where they actually apply 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 direct object. (26) and (27) are two interpretations for the same transitive verb P. Here 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: $\lambda B\lambda A[B(\lambda z[A(\lambda v[bit(z)(v)])])](\lambda Q\forall y[man'(y) \rightarrow Q(y)]) = \ldots =$
$\lambda A[\forall y[man'(y) \rightarrow A(\lambda v[bit'(y)(v)])]]$
more than one dog: $\lambda P\exists_{>1}z[dog'(z)\ \&\ P(z)]$
more than one dog bit every man:
$\lambda A[\forall y[man'(y) \rightarrow A(\lambda v[bit'(y)(v)])]]\ (\lambda P\exists_{>1}z[dog'(z)\ \&\ P(z)]) = \ldots =$
$\forall y[man'(y) \rightarrow \exists_{>1}z[dog'(z)\ \&\ bit'(y)(z)]]$

This is the gist of Hendriks's proposal. More generally, he shows two important things. First, the different interpretations for the verb need not be stipulated: they can be obtained systematically by so-called type-change rules, in this case, by two applications of Argument Raising. (26)-(27) are due to two different orders in which the subject and the object arguments 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 and C stand for possibly empty sequences of types such that if g is a type, $<A,g>$ and $<C,g>$ represent the types $<a1, <\ldots <a_n,g>\ldots>>$ and $<c_1, <\ldots <c_n,g> \ldots>>$.

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 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)

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.[7]

(32) narrow scope:
[$_{CP}$ how many people λX[$_{IP}$ ... think [$_{CP}$ X λX[$_{IP}$ ... should [$_{VP}$ X λx[$_{VP}$ ...x...]]]]]]
(33) wide scope:
[$_{CP}$ how many people λX[$_{IP}$ X λx[$_{IP}$ ... think [$_{CP}$ x λx[$_{IP}$ ... should [$_{VP}$ ...x...]]]]]]

Moltmann and Szabolcsi (1993) use an idea very much like Value Raising to account for the `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'

The surprising fact about (34) is that every student in the complement clause makes the matrix subject referentially dependent. Moltmann and Szabolcsi argue that every student does not scope out of its own clause. Instead, which book every student needed receives a pair-list reading, explicated as a generalized quantifier over questions inside of which every student takes wide scope. The latter is the direct object argument of found out and it scopes

[7] 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.

over the subject argument of found out, its clause mate. The result is logically equivalent to scoping every student out on its own.[8]

While these works do not use flexible types for verbs, they illustrate the naturalness of the logical tools that Hendriks employs.

4.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 alternatively be squeezed into the flexible types of the participating expressions. Inspired by computer science, Barker & Shan (2006) propose a convergent idea and associate linguistic expressions with their possible continuations. A *continuation* is the skeleton of a syntactico-semantic structure that the expression anticipates participating in.

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 that the independently motivated syntax builds 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 & Kratzter style) the and local (Hendriks style) analyses arise from one and the same set of rules, none of which are redundant. For every derivation in which an expression is bound at a distance or takes wide scope, there will be a syntactically and semantically equivalent derivation on which the semantic contribution of each constituent is purely local. The interconvertibility of the two styles of derivation does not simply follow from grafting a direct-compositional grammar onto an action-at-a-distance grammar; rather, the duality in the syntax-semantics interface follows from a natural symmetry in the grammar itself. The symmetry concerns rules of use and rules of proof in the Gentzen calculus. Roughly, rules of use connect expressions directly over long distances, and embody the global view. Rules of proof help characterize the contribution of individual expressions within a complex constituent. Barker enriches Jäger's grammar and also introduces rules of disclosure, which establish an explicit connection between the long-distance semantic effect of an element with its local denotation.

[8] Value Raising is beneficial when applied to quantifier phrases or wh-complements but overgenerates when applied to that-complements.

D.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 recall that 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) $\forall x[boy'(x) \rightarrow in'(room\text{-}of'(x))(x)]$
(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? 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. Coreference between a name or other referring expression and a pronoun is different: it allows but 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 one appearing on 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 extends to pronouns and offers a simple account of strong and weak crossover. (40) shows that the prepositional object every girl can scope over both the subject and the direct object. Beghelli & Stowell (1997) observed that singular a different NP must be within the scope of a phrase with the determiner every or each.

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

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

(41) She sent a gift to every girl.
Her aunt sent a gift to every girl.

Vlad sent her gift to every girl.

Bach & 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 one 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 termed the antecedent of the pronoun and will not be accorded the false title of the binder.

Once the property 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 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 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.[9]

[9] The strict reading is available with quantificational antecedents too, if they c-command the ellipsis site, as in (i), cf. Gawron & Peters (1990), Szabolcsi (1992):
(i) Every boy discovered his mistakes before the teacher did [discover that boy's mistakes].

E.Variable-full and variable-free binding

1.Pronouns that start out as free variables

In most theories, Montague (1974), May (1977, 1985), Heim & Kratzer (1998), Büring (2005) among them, the creation of (42) starts out with the pronoun interpreted as a free variable, 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) $|[$ saw his_2 father $]|^{M,g}$ =
$\lambda y[y \text{ saw } g(2)\text{'s father}]$

(47) $|[\ \beta_2$ (saw his_2 father) $]|^{M,g}$ =
$\lambda x[\lambda y[y \text{ saw } g[2\rightarrow x](2)\text{'s father}](x)]$ =
$\lambda x[x \text{ saw } g[2\rightarrow x](2)\text{'s father}]$ =
$\lambda x[x \text{ saw } x\text{'s father}]$

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, 1992) uses reflexives as a stepping-stone for the general theory. The case of reflexives is striking, because reflexives are ungrammatical if they do not get bound. Therefore assigning them a free variable

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Here the strict reading is of course also a bound variable one, so strict and coreferential can only be equated in the coordination case, where the subject of the antecedent VP does not c-command the ellipsis site.

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′ = $\lambda f \lambda x[f(x)(x)](saw') = \lambda x[saw'(x)(x)]$

Functional operations like the one in (48) are known as combinators; this specific one is 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 there are no operators that manipulate assignments.[10] A pronoun that is intended to remain free (deictic) can be interpreted as a free variable. English he can be treated as ambiguous between the distinct variables x, y, z. In the spirit of Reinhart, he will have a further lexical interpretation, one that is similar to that of reflexives. 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.

(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′ = $\lambda f \lambda x[f(won'(x))(x)]$

That he_{bound} won is a clause that acts like a 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 proceeds analogously, with his_{bound} having arguments whose types are a bit different from those of he/him_{bound}:

(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 $<e,<\alpha,t>>$

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[10] For the expression of propositional connectives and $\forall$, $\exists$ using only closed lambda terms (combinators) and equality, see Gallin (1975). E.g. Panta rhei is $\lambda x.\text{in-flux}(x) \equiv \lambda x.T$, where T(rue) is $\lambda x.x \equiv \lambda x.x$, so everything is $\lambda P[\lambda x.Px \equiv \lambda x.T]$. We do not discuss this further here.

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:

(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 now 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 as Szabolcsi's bound pronouns do, compare (50)-(54) with (57), except that **z** is a silent operator on verb meanings: a type-shifter.[11]

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

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

One straightforward descriptive 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 that requires this. The key part, $\lambda x[\text{chase}'(fx)(x)]$, is an instance of **z**-chase′.

[11] Hepple interprets both reflexives and pronouns as identity maps. Jacobson does not say how she proposes to treat reflexives.

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

Another descriptive difference is that whereas both proposals can be easily extended to antecedent-contained deletion as in (61), analyzing it essentially as transitive verb phrase ellipsis (i.e. duplication), only Jacobson's will cover (62) as well:

(61) No dog obeyed every boy who Goldy did.
(62) No dog obeyed every boy who wanted it to.

The difference between these is that in (61) the elided part is obeyed, whereas in (62) it is obey him. To see why this is critical we must fill a gap regarding what happens when a pronoun first merges with an argument-taking predicate.

Let us start with his father. Father expects an internal argument of type e, but he/his being interpreted as $\lambda x[x]$ is of type $\langle e,e\rangle$. 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 (63) X/Y is the category of functors 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 "superscripted functor" categories: he never applies to Bill but can be the argument of **g**(the-father-of′), for example.

(63) If f is an expression of category A/B, then **g**(f) is an expression of category A^C/B^C.
$\mathbf{g} = \lambda h\lambda k\lambda y[h(ky)]$
(64) $\mathbf{g}(\text{the-father-of}') = \lambda k\lambda y[\text{the-father-of}'(ky)]$
(65) $\text{his father}' = \mathbf{g}(\text{the-father-of}')(\text{he}') = \lambda k\lambda y[\text{the-father-of}'(ky)](\lambda x[x]) = \lambda y[\text{the-father-of}'(y)]$

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** subsumes **g**, so to speak. However, if the pronoun had not been intended to be anteceded by the subject of saw, **g**(saw) would have been used:

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

To pave the way back to (62), notice that his father is interpreted the same as the function the-father-of, and saw him is interpreted the same as the function 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 (61) and (62), 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, (68) and (69) are logically equivalent. Therefore the theory predicts, incorrectly, that (70) has a reading that can be paraphrased as (71).

(68) λx[the-mother-of′(x)] = λx[the-friend-of′(x)]
(69) $\forall x$[the-mother-of′(x) = the-friend-of′(x)]
(70) His mother is his friend.
(71) For every (male) person, his mother is his friend.

A plausible line of attack is to require that the default interpretation of expressions containing free pronouns be one where they are predicated of contextually salient entities, and to allow the functional interpretation only as a last resort when a deictic interpretation would lead to a type clash. But, as Pauline Jacobson (p.c.) observes, it is not obvious how to formulate this so as to allow for both readings in (72):

(72) The woman every man admires is his mother.
(i) `Every man admires his own mother'
(ii) `Every man admires his (e.g. Ram's) mother'

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. See the discussion at the end of Section I.C.[12]

II.Empirical issues and their theoretical consequences

A.No scope for scope?[13]

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.

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.

[12] For LFG's "glue semantics" using linear logic, see Dalrymple (2001).
[13] This borrows the title of Hintikka (1997). Our data and the conclusions overlap with but are not identical to Hintikka's.

In (73)-(74) <u>every show</u> can scope over the subject but <u>more than one show</u> cannot:

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

In (75) <u>a famous soprano</u> appears to scope out of its clause, even an island, but in (76)-(77) <u>more than one soprano</u> and <u>every soprano</u> 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 <u>every soprano</u> and <u>no soprano</u> 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) <u>a problem</u> that is buried in a relative clause and is scopally dependent on <u>every soprano</u> can nevertheless antecede a singular pronoun. In (81) <u>more than one problem</u> 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'

The two areas also present their joint surprises for the classical theory. In (82) <u>a great soprano</u> appears to both scope in the matrix clause and antecede the singular pronoun in the second conjunct, but in (83)-(84) <u>more than one soprano</u> and <u>every great soprano</u> 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.
(84) Taro thinks that every great soprano applied and wants to hire her.

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, 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:

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

B.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 and 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 tends to be 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 that is contingent on a reading that the grammar produces, not just on what is entailed to be true. For example, cross-sentential anaphora is such:

(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 <u>two NP</u> and <u>two or more NP</u> are capable of taking inverse scope over <u>every NP</u>. 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.

C.Existential scope versus distributive scope

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

Consider, however, the following. Although (93) allows revolving doors to vary with buildings (so two buildings participates in 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, while (95), just as (92), is true in a scenario where sets of buildings vary with firemen (each fireman considers those buildings that he is in charge of to be unsafe),[14] (95) also allows the set of buildings to be chosen independently, just as (92) does (the same

[14] To our knowledge, the variable-reference reading of universals was discovered by Katalin É. Kiss and first discussed in Farkas (1997). The reality of this reading is confirmed by the fact that Every child ate every apple does not make you think that the same apples were eaten over and over; see discussion below.

contextually defined set of buildings is evaluated by all the firemen).[15]

(95) Every fireman thought that **every building** was unsafe.
(i) √`for every fireman, there is a separate set of buildings…'
(ii) √`there is a set of buildings such that every fireman…'

The above observations were made more or less independently in Beghelli et al. (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 fully parallel in their scope behavior, contrary to first impressions. 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 on the list** is even or odd.
#`for every number, determine whether it is even or odd'
(99) Determine whether **each number on 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'

---

[15] 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 and Szabó (2000).

(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 the "Logophoricity" article should be relevant.

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). Fig.1 shows a witness set[16] 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′.

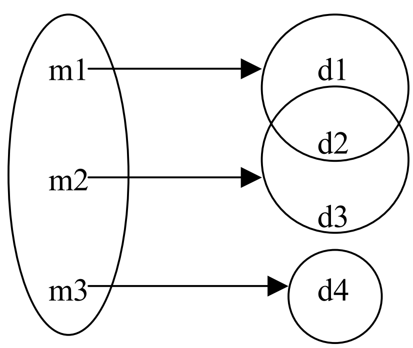

Fig.1

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

[16] A witness set 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). All GQs have at least one witness set. For example, 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 no dog is the empty set. See Beghelli et al. (1997) for discussion of referential variation in these terms.

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 related work building on these, especially on Mandarin, is in fact stronger than the position taken in much of the recent literature. 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 each NP and the so-called counting quantifiers such as two or more NP, less than five NP, etc. The motivation comes in part from the full parallelism of the data described in Section II.C.1, further discussed in II.C.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.[17]

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.

3.Existential scope, specificity, and Skolem functions

Fodor and Sag (1982) 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.[18] 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}. Notice that the values of the choice functions are witness sets of the generalized quantifiers some dog and two dogs. The intermediate reading of (104) will be explicated roughly as follows:

[17] Most (of the) and the most are the least well-studied from this perspective.

[18] Reinhart shows that by existentially quantifying over individual variables one could not get the truth conditions right. 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).

(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.

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 up with the individuals the wider-scoping quantifier ranges over. In the case of (104) this would be the way the professor assigned a condition to each of the 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 he wrote.
√`each prof$_i$ > a certain book he$_i$ wrote > every student'

Therefore, Kratzer proposes to use parametrized choice functions (Skolem functions that have both set and individual arguments) to interpret indefinites. 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 a quantifier of how the function picks elements from the indefinite's NP-set. (104) will now be explicated as (107). The relevant change from (106) is in the underlined part of (107); <u>x</u> is bound by <u>∀x</u>. <u>∃f</u> 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 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 II.C.2 we argued that the existential versus distributive scope distinction extends to universals like <u>every NP</u>. This approach allows 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. We propose that this is naturally captured if in (110) every child is interpreted as f(child′) and every apple as λx[f(x)(apple′)]:

(110) Every child ate every apple.
`every (child [who was at the excursion]) ate every (apple [that was given to him/her for the occasion])'

See below on the distributivity of every NP.

4. Distributive scope

We have observed that distributive scope is clause-bounded, save for the case of each NP. 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 distrributivity 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) ∧ had_a_glass_of_wine_**each**′(P)]
(f(six′(friends′)))

See further the article on "Mass terms and plurals".

Consider now every NP on the analysis proposed above. What accounts for the fact that every NP only participates in distributive readings? Beghelli & Stowell (1997) argue that every NP invariably 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. DPs belonging to different quantifier classes occupy different surface syntactic positions in Hungarian. Some DPs can occur in more than one position and their interpretations vary 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 (113) and also in another position where counting quantifiers canonically occur (114). In the former (spec, DistP) position its interpretation parallels that of minden NP: it has unbounded existential scope and it is unambiguously distributive (Szabolcsi 1997a).

(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 lifted up the table'

(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.

Not all universals are alike. All the NP is basically a definite plural, whereas each NP is more strongly distributive that every NP. We do not attempt an analysis of each NP here.

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).

D.Counters – true 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 a 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, as seen in (76), even those do not have one.

Counters do not genuinely participate in the collective/distributive distinction either. (113) 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. This contrasts with genuine collective/distributive predication, whose logical subject is an individual or set of individuals. The intuition that counting is indeed the characteristic action of these quantifiers is corroborated by interesting grammaticality contrasts between most of the NP and more than 50% of the NP (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 must be more than 50% of the kids in the yard.
(121) # There must 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).

E.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 definites and indefinites 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 (121): 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 (122)-(123):

(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. This explains an otherwise mysterious constraint on negative polarity item licensing, namely, that the licensor must c-command the NPI in overt syntax.

(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. This is not well-understood; the reason probably lies in the semantics of predicates.

(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 occupy three distinct regions of the preverbal field; a remarkable cross-linguistic correlation. Left-to-right order corresponds to scopal order, therefore a counter may only outscope a distributive or (in)definite if the latter occurs in the postverbal field. For details, see Beghelli & Stowell (1997), Szabolcsi (1997a), and Brody & Szabolcsi (2003).

(128) (In)definites > Distributives > Counters > Verb > … (encore)

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, 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.

F.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), 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.

G.Pronouns and traces as definite descriptions

1.Cross-sentential anaphora

Sections I.D-E 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) interpret they in both (129) and (130) as referring essentially to all the boys who were sad:

(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, the above 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; or that they are quantificational but externally dynamic, in the sense that their binding scope extends over the incoming discourse. See the articles on "Discourse representation Theory" and "Dynamic semantics" for detailed discussion.

In the case of <u>every NP</u> maximal and non-maximal reference inescapably coincide. <u>More than one NP</u> in English does not support non-maximal anaphora, but the Hungarian version exemplified in (113) does.

2. **Co-variation with situations**

In the cases to be reviewed in this section 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 Section I 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.

The co-varying reading is possible with counters also, although they may prefer a plural pronoun:

(135) Every farmer who owns more than one donkey beats them/?it.

There is a long tradition to analyze such "donkey pronouns" as definite descriptions (Evans 1980, Neale 1990). Singular <u>it</u> is then interpreted as `the donkey so owned', which introduces an unfortunate uniqueness presupposition. Following Berman (1987), Heim (1990) uses situation semantics to eliminate this problem. Elbourne (2005) develops this proposal; on his account (133) is interpreted as (136):[19]

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

Büring (2004) shows that the interpretation of the pronoun in (137)-(138) shares all the defining properties with donkey pronouns and extends Elbourne's analysis to them:

(137) Every farmer's donkey hates him.
(138) Two sisters of every farmer hate him.

In sum, the initial expectation is borne out. These 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.

Is co-variance with situations limited to cases where c-command fails? Kratzer (2006) argues that it is not. On her view, bound variable readings come about within very local agreement relations. Where this is not available, what looks like binding is indeed co-variation with situations or, in the case of de se pronouns, with worlds.

3.The copy theory of movement and trace conversion

We discuss this issue here because, although it is a technical one much like those in Section I of this article, its solution becomes natural in the context just developed.

The theories in Section I all assume that quantifier phrases are linked to plain individual variables serving as arguments of natural language predicates. The syntactic counterpart of this is the assumption that traces are plain individual variables. The copy theory of movement postulates, however, that each member of a movement chain is a full copy of the phrase spelled out in its highest position. In the case of Quantifier Raising this entails something like (139). Strikethrough indicates unpronounced copies:

(139) some boy_1 [every $book_2$ [~~some boy_1~~ read ~~every $book_2$~~]]

The problem is that (139) is uninterpretable. On one hand, read is a relation between individuals, so we have a type clash. But whatever the types, multiple copies for each quantifier phrase just do not make sense. Therefore all copies but the highest ones must somehow be deleted or converted into something semantically appropriate.

Much of the descriptive motivation for the copy theory comes from reconstruction, which may manifest itself in scope interpretation or in binding condition A/B/C effects (see Sportiche 2006 for a detailed overview). An interesting observation is that reconstruction may be obligatory for binding condition C without being so for scope. (140) is from Fox (2002). (140) allows for an S>O or an O>S reading as long as John≠him.

[19] 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. See the article on "Pronouns".

(140) Someone introduced him to every friend of John's.

Such cases suggest that after conversion the lowest copy retains the restriction (friend of John's) that is relevant to the condition C effect, but not the scopally relevant determiner. Fox (2002) proposes that the lowest copy be interpreted as a parametrized definite description. This may be obtained by syntactic trace conversion (141) or equivalently, following a suggestion by Paul Elbourne, by a semantic rule (142).

(141) Trace conversion:
Variable Insertion: (Det)(Pred) → (Det) [Pred $\lambda y(y=him_n)$]
Determiner Replacement: (Det)[Pred $\lambda y(y=him_n)$] → the [Pred $\lambda y(y=him_n)$]

(142) Semantic interpretation of the derived sister of a moved constituent:
In a structure formed by DP movement, DP_n $[_\varphi \ldots DP_n \ldots]$, φ is interpreted as a function that maps an individual, x, to the meaning of $\varphi[x/n]$. $\varphi[x/n]$ is the result of replacing the head of every constituent with the index n in φ with the head the_n, whose interpretation, $\|[the_n]\|$ is
$\lambda P[\ \|[the_n]\|(P \cap \lambda y[x=y]]$.

In this way the O>S reading of (140) is interpreted as (143) if John=him:

(143) (every friend of $John's_1$) λx[someone introduced him_1 to (the friend of $John's_1$ identical to x)]

Although Fox (2002) maintains the classical position that all DPs undergo Quantifier Raising (save for those that are scopeless in Zimmermann's (1993) sense) and it is therefore not straightforward to judge how his grammar meshes with the results reviewed in Section II of this article, the output of trace conversion definitely shares features with the Skolem functional analyses.

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