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INTERPRETING LOGICAL FORM*

0. Introductory Comment

In constructing the semantics of a language it has been customary ever since Tarski for the interpretative clauses – those which mention the semantic terms truth and satisfaction – to be defined with respect to the notion *sentence of the language*. Thus part and parcel of giving a semantics is to provide an adequate definition of this notion, and the provision of such is among the responsibilities of the syntax of the language. The class of sentences of a language can be roughly identified as the set of syntactic objects – phrase markers – rooted by the category S, as this is determined by the best, that is, the most empirically adequate, theory of syntax. In interpreting these objects, the semantic clauses will specify the conditions which must hold for truth to obtain, where in what this consists is determined, in the context of a sentence's syntactic construction, compositionally in terms of the denotations of the sen-

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tences's parts. So, if we take the subject noun phrase of *Philby was a spy* to denote an individual and the predicate verb phrase to denote a collection of individuals, then its truth conditions are characterized metalinguistically as follows:

$$\text{"Philby was a spy" is true iff Philby} \in \{x \mid x \text{ was a spy}\}.$$

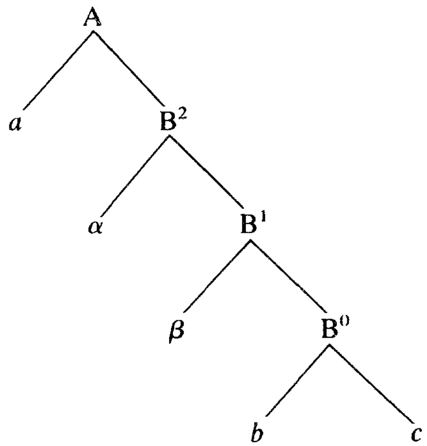
The traditional tasks of semantics, then, amount to a proper specification of the syntactic structure of a language, and a proper specification of the application of the semantic terms to the syntactic representations so specified.

In this paper I will explore in this vein what I consider to be the most adequate theory of syntax and the properties of its semantic interpretation. On this theory, the syntax generates a level of syntactic representation, Logical Form, and it is to sentences at this level to which the semantic clauses are applicable. I have elsewhere extensively discussed the syntactic motivation for this theory (May (1985)). My purpose here is to investigate more carefully certain aspects of its semantics, focusing on the interpretation of quantification, and in particular exploring certain issues pertaining to scope (or the lack thereof) and the first-orderizability of natural language quantification. Section 1 will be devoted to the issue of the *symmetry of scope*, as considered from the perspective of its syntactic representation, as opposed to the asymmetry of semantic interpretation. Section 2 elaborates a symmetrical theory of quantificational interpretation, initially broached by Higginbotham and May (1981), in which *absorbed quantifiers* are introduced. Section 3 introduces the notion of *resumptive quantifiers* in the interpretation of certain multiple generalization and multiple numerical sentences. Section 4 explores application of the semantics developed for resumptive quantification to certain subtleties of wh-questions, while Section 5 extends the analysis from singular to plural expressions. Finally Section 6 examines the relation of resumptive quantification to branching quantification. In each of these sections, my concern will be to make explicit both the syntactic and semantic structures involved in interpreting Logical Form.

1. THE STRUCTURE OF SCOPE AND ITS INTERPRETATION

Consider the configuration (1). Does α symmetrically or asymmetrically c-command β, where both α and β are syntactic adjuncts of B?

(1)



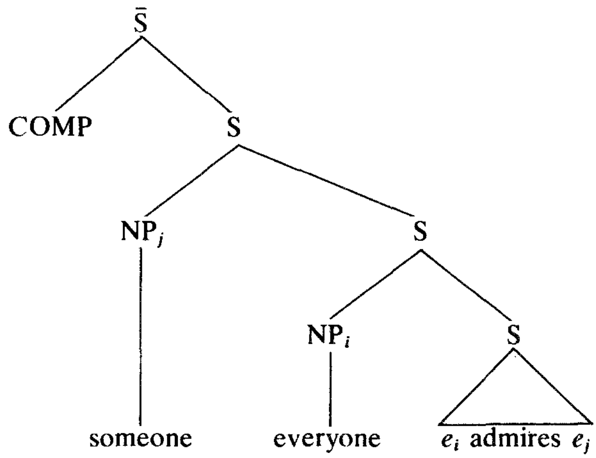
My interest in this configuration stems from the application to it of the definition in (2):

(2) The scope of $\alpha =_{\text{df}}$ the c-command domain of α.

Clearly how we assess the c-command relations in (1) will fundamentally affect how we understand quantificational scope to be grammatically represented.

Suppose that we take (1) as a configuration of asymmetric c-command. This will be so if we reason as follows. Since the first branching node dominating α, namely B^2 also dominates β, α *c*-commands β. But as the first branching node dominating β, namely B^1, does not dominate α, β does not c-command α. Structure like (1) are relevant to the assessment of quantificational scope if we assume that sentences of multiple generalization, such as *Everyone loves someone*, have syntactic representations at Logical Form of the form (3):

(3)



In the theory of May (1977), and in much subsequent work, scope and binding are determined with respect to such syntactic configurations, derived by transformational mappings, dubbed QR, taking S-Structure as their input. Construing the empty categories as logical variables, relative to definition (2) the representation in (3) is univocal, with the universal phrase *everyone* having scope narrower than the existential *someone*. The prefixed phrases in (3), however, could have been attached in the opposite order. This derivation would represent a distinct univocal interpretation of *Everyone loves someone*, in which the universal phrase has broader scope. The roots of the classic ambiguity of multiple generalization are to be found, on this theory, in the *syntactic description* of such sentences, turning on a particular property of transformational adjunctions – namely that phrases may be adjoined to a given category in any (hierarchical) order.

Recently I have come to doubt whether it is correct to view configurations such as (1) in the fashion just described. While I believe that the syntactic characterizations of scope and binding, as given by (2) and other ancillary definitions, are fundamentally correct, I now believe that it was improper to view the relation of α and β in (1) as asymmetric c-command. Rather I am now of the opinion that this configuration is to be properly seen as one of *symmetric* c-command. The difference in syntactic interpretation arises when we replace the "branching node" definition of c-command drawn from the work of Reinhart (1976, 1983) with a formulation of the definition supplied by Aoun and Sportiche (1983):

(4) α c-commands $\beta =_{df}$ every maximal projection dominating α dominates β, and α does not dominate β.

I take the maximal categorial projections to be the maximal $\bar{X}$-levels of the phrasal and clausal categories – in traditional parlance NP, VP, AP, PP, S and $\bar{S}$.[1] In order to properly calculate the c-command relations in configurations of the form (1), such as (3), it is first necessary to clarify the status of the multiple occurrences of S that we find in such structures. S, as noted, is a maximal categorial projection (of INFL). As in May (1985), a *projection* is understood as a set of nodes, or category segments, occurring in a given phrase-marker. Thus in (3) the S-projection level is made up of three member nodes, and it is only categories which are

[1] Here following Chomsky (1986), assuming the articulation of S and S as projections of INFL and COMP, respectively, found in that work. In taking S as maximal I differ from the assumptions of May (1985), but not critically so.

dominated by the entirety of this class which can be said to be dominated by the maximal projection. Since neither α nor β in (1) is dominated by the S-projection, but only by proper subparts, both categories will have their c-command domains demarcated by $\bar{S}$, the sole maximal projection which dominates them. Consequently, (3), and more generally structures of the form (1), are configurations of *symmetric* c-command.[2]

The view just outlined of adjunction in the context of $\bar{X}$-theory is presented in May (1985). The reader is referred to that citation, as well as to Chomsky (1986), for fuller discussion of its theoretical foundations and empirical extensions. For my purposes in this paper I will accept it as fundamentally correct, in order to observe its consequences for the treatment of natural language quantification. The most significant change wrought by this view is in the fashion by which grammatical structure determines evaluation, as we can no longer view the configuration (1) as representing relative scope. Since each of the adjoined phrases c-commands the other, neither can be said to have *syntactically* broader scope than the other, since the notion of relative scope itself is an asymmetric notion. What is represented by (3) are only the *absolute* scope domains of *everyone* and *someone*, which for both is $\bar{S}$. But if (3) itself cannot be said to be disambiguated, so that relative scope is not situated in the syntax, from whence the ambiguities of quantification? The place to look for an initial answer, I believe, is to trace relative scope to the freedom inherent in variant courses of assignment of interpretations to configurations of the form in (1).

To see this more explicitly, we begin by defining the following notions over LF-representations of bounded complexity. We let $\Pi = \{S_1, \ldots, S_n\}$; that is Π is an S-projection. Then:[3]

(5) S_i $(1 \leq i \leq n)$ is a *sentential function* $=_{df} \exists S \in \Pi$ $(S \neq S_i \wedge S$ dominates $S_i)$
S_i is a *sentence* $=_{df} S_i$ is not a sentential function.

These definitions, at first glance, may strike one as unusual, in that they do not mention that a sentential function must contain an occurrence of a

[2] Scope structures of the form (1) are also distinguished in that they are *non-bivalent*, in the sense that they contain categories, the adjuncts, which are neither included in nor excluded from other categories in the structure. A category *includes* another category iff it dominates every node in the category; it *excludes* it iff it dominates none of its member nodes. (These definitions follow Chomsky (1986).) So in (3), the S-projection neither includes nor excludes its NP-adjuncts.

[3] These definitions would have to made somewhat more precise to cover wh-constructions as well.

variable free. This is unnecessary, however. Consider the cases. If there has been no LF-movement we have the structure $[_S \text{NP VP}]$; this is a *sentence*, because of the distinctiveness clause. A structure in which there is a complex projection, such as $[_{S_1} \text{NP}_i [_{S_0} \ldots e_i \ldots]]$, must contain a trace which is bound. This simply follows from the characterization of the transformational operation by which such structures are derived; to wit, trace theory of movement rules. S_0, in which the trace is contained free, is a sentential function, as the other member of Π, S_1, dominates it. S_1, in which the trace is bound, is a sentence, as it is not dominated by any other member of Π. We thus see that the trace here has just the properties normally ascribed to variables in standard logical calculi.

The application of these definitions to (6):

(6) $[_{\bar{S}} [_{S^2} \text{NP}_i [_{S^1} \text{NP}_j [_{S^0} \ldots e_j \ldots e_i \ldots]]]]$

shows S^0 and S^1 to be a sentential functions, and S^2 to be a sentence, as no other nodes of Π dominate it. *Sentence*, therefore, is defined with respect to the entire projection, *sentential function* with respect to the projection's subparts. We now define the following notion, where O stands for operators occurring in $\bar{A}$-positions.

(7) σ is a Σ-*sequence* $=_{\text{df}} \forall O_i, O_j \in \sigma$, O_i c-commands O_j and O_j c-commands O_i.

In (6) $\langle \text{NP}_i, \text{NP}_j \rangle$ form a Σ-sequence.[4]

With respect to a model $\mathbf{M} = \langle D, F \rangle$, D a domain of individuals and F an assignment to the nonlogical elements, we define g as a sequence of members of D. The following semantic clauses can be given for *everyone* and *someone*, where φ_i designates a sentential function containing just x_i free.

(8) g satisfies **everyone**$_i$ φ_i iff every sequence g' satisfies φ_i, where g' differs from g in at most the value assigned the ith place.

g satisfies **someone**$_i$ φ_i iff some sequence g' satisfies φ_i, where g' differs from g in at most the value assigned the ith place.

Assumed, without statement here, is the usual truth clause in terms of satisfaction of a sentence by every sequence.

Formally, suppose that the semantics of LF contains a schema of the

[4] If you like, mutual c-command can be equated, for our purposes, with government, although there may be reasons for taking this latter notion as stronger; May (1985), Chomsky (1986).

form (9), which generates, relative to **M**, the satisfaction clauses of the quantifiers Q of the language:

(9) $[\![Q_i\colon \varphi_i]\!]^g \leftrightarrow [\![\varphi_i]\!]^{g'}$, for Q-many g'.

That is, a sequence g satisfies a quantified formula just in case for **Q**-many sequences g', which differ from g in at most the ith-place, g' satisfies φ_i.

Of course this schema as stated is much too narrow for any kind of general applicability to natural language. Although of value in characterizing general phrases such as *everyone*, *someone* and *no one*, it is a schema of *unrestricted quantification*. Natural language quantification, however, is typically *restricted*, so we replace (9) by (10):

(10) $[\![Q_i\colon \varphi_i\, \psi_i]\!]^g \leftrightarrow [\![\varphi_i]\!]^{g'}$, for Q-many $[\![\psi_i]\!]^{g'}$.

We read (10) as stating that g satisfies a quantified formula iff φ is satisfied by **Q**-many sequences g', which differ from g in at most the ith place, and which also satisfy ψ.

As is well-known there is a perfectly general method for applying the satisfaction clauses for quantifiers to sentential functions of many variables. What makes this possible is that φ, as mentioned in the clauses, is required to contain just a single variable free; it may contain others which are bound. By each clause in turn satisfaction is determined for one further variable, relative to those sequences which satisfy the sentential function whose interpretation had just proceeded, until a sentence is composed, which contains no further variables free. While by this way of iterating the application of the quantifier clauses a dependency is induced for any particular interpretation, there are no inherent constraints among the quantifier clauses themselves which limit how they may apply sequentially. For a sentential function $\varphi_{i,j}$ we can, in principle, consider variation either with respect to the ith or jth places first, the difference in order leading (for appropriate choices of quantifiers) to distinct interpretations. Normally however the order of application of the clauses is constrained by the scope dependency relations encoded in the syntax of the structures to which they apply, so that there is a mirroring of syntactic ordering in the semantic ordering. Our current claim, however, is that the syntax no longer imposes such constraints; in a sense we are eliminating a redundancy in the semantics of multiple quantification by just letting the interpretations be those consistent with the possible permutations of the quantifier clauses. Thus the ambiguity we ascribe to *Everyone loves someone*, for instance, will be fully accounted for in terms of the relative orderings of the satisfaction clauses for *everyone* and *someone*, and will ultimately be semantically characterized in exactly the same way regardless of whether we take the relative scope relation to be syntactically represented or not.

Summarizing to this point, the theory I will be considering is one in which the canonical scope configuration (1), and its extensions, is a syntactic configuration of symmetric c-command of the adjoined phrases. The Σ-sequence these quantificational expressions form is indeterminate with respect to *order* of interpretation, and thus is consistent with *any* interpretation which can arise relative to the possible orderings of the satisfaction clauses corresponding to the quantifier words of LF.[5] Hence what we think of as relative scope is no longer to be located in the syntactic description of quantification, and thus arising as a function of the freedom of transformational operations, but rather in the semantics, a result of the freedom inherent in the application of the semantic clauses. Bear in mind, however, that what is at stake here is *not* the representation of absolute scope domains; there is a large body of evidence supporting the notion of LF-movement itself (see May 1985, Chapter 1). Indeed, it is only when sequences of quantifiers agree on their absolute scope domains – that is, form a Σ-sequence – that the variation in scope resulting from different applications of the quantifier clauses can arise. What *is* at stake is the fundamental syntactic ambiguity of representations having the configuration in (1), and one indeed may wish to contend with the notion that Logical Form, as the level of grammatical representation subject to semantic interpretation, is no longer to be conceived of as disambiguated. This should disturb, however, only insofar as we take disambiguation as an *a priori* constraint on logical syntax. If we take it rather as an empirical claim, then the theory in question embeds the claim that the representation of scope and binding by the syntax is not one which represents relative-scope. Indeed I believe that disambiguation is too strong a constraint on the relation of syntax and semantics. I find more plausible a criterion suggested by Higginbotham (1985):

(11) There is an LF-representation Γ for S such that Γ means p.

(11) holds on our current view of a multiple generalization structure like (3). That is, there *is* an LF-representation of the sentence *Everyone loves someone* which represents the '$\forall\exists$' reading, and one which represents the '$\exists\forall$' reading. They just happen to be, on this theory, the *same* LF-

[5] See May (1985, 1988), where an extensive range of arguments for this view are presented.

representation. I take it that this is an empirical result within the constraints laid down by (11); it weighs on the issue of "how much" is represented at LF of the logical structure of a language. And it is towards resolving this issue which I take it that research on Logical Form within the context of the syntax and semantics of natural language is primarily devoted.

2. Absorption and the Semantics of N-*ary* Quantifiers

The point I have been making regarding the symmetry and asymmetry of scope is a perfectly general one, in that it can be freely transposed into other perspectives on the semantics of quantification. For instance, it is naturally characterized within the theory of generalized quantifiers, in which quantifiers are interpreted as functions of a certain type, by the iterative application of those functions. On this way of looking at quantifiers, espoused in papers by Higginbotham and May (1981), Barwise and Cooper (1981), Van Benthem (1983a) and Keenan and Stavi (1986) among a considerable range of references in the recent linguistic literature, our semantic gaze is shifted from sequences of individuals, central to the satisfaction clauses, to sets of individuals which stand as the arguments of quantificational functions. Thus, in the simplest, unrestricted, case, generalized quantifiers are functions f: $P(D) \rightarrow 2$, which, following Mostowski (1955), respect just the size of sets, and not the identity of their members. Formally, these are functions f for which

$$f(X) = f(m(X)),$$

for all automorphisms m of D, $X \subset D$, a condition which guarantees that the quantifiers defined in this manner are logical. Restricted generalized quantifiers, those which we need for the interpretation of natural language, are functions f: $P(D) \times P(D) \rightarrow 2$, which, analogously, respect just the sizes of the sets they relate – formally functions for which

$$f(X, Y) = f(m(X), m(Y)),$$

for all automorphisms m of D, X, $Y \subset D$. These latter functions are sometimes called *relational* generalized quantifiers; the following are definitions of the classical quantifiers as such relations between sets:

$$\begin{array}{ll} Some(X, Y): X \cap Y \neq \emptyset & No(X, Y): X \cap Y = \emptyset \\ Every(X, Y): X - Y = \emptyset & Not\ every(X, Y): X - Y \neq \emptyset. \end{array}$$

The application of these conditions can be illustrated by interpreting *Every star twinkles at night*, where we proceeds by setting X equal to

$\{x \mid x \text{ is a star}\}$,

and setting Y equal to

$\{y \mid y \text{ twinkles at night}\}$,

and then requiring that (12) hold for truth to obtain:

(12) $\{x \mid x \text{ is a star}\} - \{y \mid y \text{ twinkles at night}\} = \emptyset$,

In correspondence to LF-representations, the value of X will always be determined by the contents of the phrase moved at LF, while the value of Y will always be determined by the sentential function which resides within the scope of that phrase. To iterate the application of $f_i(X, Y)$ to $f_j(X', Y')$, we let the value of Y be $X' \cap Y'$, such that $f_j(X', Y') = 1$.

With this much in mind, consider again an LF-representation of the form (13),

(13) $[_{\bar{S}} [_S \text{NP}_i [_S \text{NP}_j [_S \varphi_{i,j}]]]]$,

which contains the Σ-sequence $\sigma_{i,j} = \langle \text{NP}_i, \text{NP}_j \rangle$, and where f_i and f_j are the interpretations of its members as restricted generalized quantifiers. Then $[\![\sigma_{i,j}(\varphi)]\!] = f_i(f_j(\varphi))$ or $f_j(f_i(\varphi))$, that is, f_i can apply to the set for which $f_j(\varphi) = 1$, or vice versa. The point, then, simply put, is that members of a Σ-sequence can be interpreted in any order possible for their interpreting functions, where as before, this semantic ordering is determined by general rule. For an LF-structure containing an n-membered Σ-sequence $\sigma_{1,\ldots,n}$, there will be $n!$ possible permutations of the order of functional application. Taken this way, a Σ-sequence determines the relevant interpreting functions, which may order themselves, in terms of their application, in any well-formed sequence whatsoever.

Explicating the semantics of LF via generalized quantifiers, it turns out, makes apparent certain properties of quantification which allow us to take a somewhat different view of the interpretation of multiple generalization than that just sketched.[6] It is a view which allows, in a certain

[6] Generalized quantifiers, note, explicate the semantics, *not* the syntax, of LF. Thus, their function may be understood as to characterize the metaquantifiers '**Q**-many' which appear in the satisfaction clauses. The connection between them can be effected by noting that for $f(X) = 1$, where f interprets some quantificational determiner, the members of X – the satisfiers of **Q** – will constitute just Q-many individuals which satisfy φ. By attaching the theory of generalized quantifiers to the semantics of quantification in this way we can take advantage of its generality to legitimize satisfaction clauses for other quantifiers, such as *no* and *not every*, or *many* and *few*, by requiring for no, not every, many or few sequence(s) g' that they differ from g, with respect to some restriction, in at most the ith-place. From this perspective our semantic competence of quantification would be adequately described via

sense, semantic scope to be as symmetrical as syntactic scope. The need for a general semantic theory of symmetrical scope finds its antecedents in the inquiries of Higginbotham and May (1981) into crossed binding 'Bach–Peters' sentences:

(14) Every pilot who shot at it hit some Mig that chased him.

The problem here is well-known. If scope is represented asymmetrically, then the narrower scope quantifier cannot bind, as a bound variable, the pronoun contained within the broader scope phrase, which, in virtue of having broader scope, is outside its c-command domain. Thus if the *every*-phrase has broader scope, *it* cannot be a variable bound by the narrower *some*-phrase. Of course this problem disappears if the proper structure associated with (14) at LF is one of symmetric c-command, since then *it* would reside within the c-command domain of *some Mig that chased him* simultaneously with *him* residing within the c-command domain of *every pilot who shot at it*. Higginbotham and I derived the relevant structures by *Absorption*, a structural readjustment of asymmetric structures into symmetric ones, although observe at once that any *rule* of this sort can be entirely dispensed with, as the structural configuration which properly represents bound variable anaphora is now directly generated at LF by the functioning of LF-movement itself, as described in Section 1. The importance of Bach–Peters sentences extends, however, beyond the syntax to the semantics, as Higginbotham and I noted. This is because, under the standard interpretation of multiple quantification, the asymmetry of scope will simply reassert itself in the semantics, because of the recursive, successive, application of either the satisfaction clauses or the corresponding generalized quantifiers. The semantics still requires that we interpret the quantified expressions *in some order*; consequently the pronoun contained within the phrase with broadest (semantic) scope cannot be *interpreted* as a bound variable. Thus, if the *every*-phrase in sentence (14) is interpreted with broader scope, then the pronoun *it* contained within still cannot be a variable bound by the more narrowly interpreted *some*-phrase. Hence, while binding, to wit c-command, is *necessary* for bound variable anaphora, it is not *sufficient*. For sufficiency we must also require that the

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ascriptions of knowledge of the satisfaction clauses; the generalized quantifiers are implicated just as a tool to explicate the semantic import of such semantic clauses. (I take it that sentiments such as these is what lies behind Higginbotham (1988).) Other perspectives are possible, of course, but I leave these issues aside, as they will not affect the content of what comes below.

pronouns can be properly construed with respect to the semantic clauses. In Higginbotham and May a way is proposed to attain this sufficiency; to see it, we need consider the nature of generalized quantifiers a bit more deeply.

Lindström (1966) provides a classification of generalized quantifiers which allows them to be segregated along two axes – by the adicity of their arguments and by the kinds of sets those arguments denote. A quantifier type for Lindström is a finite sequence of integers, where cardinality of the sequence indicates adicity and ordinality of its members types of sets. The simplest type is $\langle 1 \rangle$, a function of a single set of individuals; you will recall them as the unrestricted generalized quantifiers described above. Increasing cardinality, the next most complicated type is $\langle 1, 1 \rangle$, functions of two sets of individuals. These are the restricted generalized quantifiers, which also apply to sets of individuals, differing from their unrestricted counterparts only in their adicity. Varying ordinality, we derive the corresponding unrestricted and restricted types $\langle 2 \rangle$ and $\langle 2, 2 \rangle$, which apply to one and two sets of *pairs* of individuals, respectively; that is, to relations rather than predicates. Formally, the former are functions $f: P(D \times D) \rightarrow 2$, while the latter are functions $f: P(D \times D) \times P(D \times D) \rightarrow 2$, which, in either case, respect automorphisms of their domains.[7] It should be apparent that this method of classification can be extended to n-ary cases along either dimension.

It is clear and well-established that first-level quantifiers, those holding of sets of individuals, have broad application to natural language. What was shown initially in Higginbotham and May (1981) was that there is also significant applicability of second-level quantifiers, those holding of pairs of individuals, but, it turns out, only if they are of a special type. This special type are called *absorbed quantifiers*, because where they do exist in natural language they derive solely from the combination of a number of simple quantifiers into a single complex one.[8] More precisely, they derive from the combination of n-many unary quantifiers into a single n-ary quantifier. So, for instance, from a pair of unary functions f_i and f_j of single variables, the binary absorbed quantifier $f_i f_j$ of pairs of variables can be derived.

Such absorbed quantifiers, it turns out, inherently incorporate certain

[7] Higginbotham and May (1981) point out there are a number of ways in which this condition can be satisfied for quantifiers of many places. See Van Benthem, (1988), De Mey (1987) and especially Sher (1989a) for insightful discussion of the logicality of these sorts of quantifiers.

[8] Also see Keenan (1987) who elaborates on this point.

properties of their unary counterparts. For instance they preserve the logicality of their constituent parts; thus a binary quantifier $f_i f_j$ is logical (i.e., respects automorphisms) iff its components f_i and f_j are. Absorbed quantifiers also incorporate certain properties which arise, for their unary components, only from their extrinsic relations; in particular, they encode their scope. It is this encoding which allows the desired sufficiency of the previous paragraph for bound variable anaphora to be attained in the proper way, since in Bach–Peters sentences the pronouns are both construed as bound variables *relative to a fixed scope of the binding quantifiers*. Thus, suppose that we have the absorption of f_i and f_j into $f_i f_j$, and that f_i and f_j are unrestricted functions. Then we have, for all relations $R \subset D \times D$, the type $\langle 2 \rangle$ binary absorbed quantification:

$$f_i f_j(R) = f_i(\{a \in D \mid f_j(R'a) = 1\}),$$

where $R'a$ denotes the counter-domain of R:

$$\{b \in D \mid \langle a, b \rangle \in R\}.$$

If $f_i = \textbf{everyone}$ and $f_j = \textbf{someone}$, we would then obtain (15) as an interpretation of *Everyone loves someone* by the binary quantifier $\forall\exists$:

(15) $\textbf{everyone}\ (\{a \in D \mid \textbf{someone}\ (\textbf{love'}\boldsymbol{a}) = 1\})$.

That is, *every* applies to that set of individuals who love some individual. Now suppose, to get closer to the heart of the matter, that f_i and f_j are restricted functions, then we have, for all relations R, $S \subset D \times D$, the type $\langle 2, 2 \rangle$ binary absorbed quantification:

$$f_i f_j(R, S) = f_i(\text{dom } R, \{a \in D \mid f_j(R'a, S'a) = 1\}),$$

where dom R denotes the domain of R on D. Setting R as

$$\{\langle a, b \rangle \mid \textbf{man}(a) \wedge \textbf{woman}(b)\}$$

and S as

$$\{\langle a, b \rangle \mid \textbf{love}(a, b)\},$$

we obtain (16) as the interpretation of *Every man loves some woman* by application of the restricted binary quantifier $\forall\exists$:

(16) $\textbf{every}\ (\text{dom } R, \{a \in D \mid \textbf{some}\ (R'a, S'a) = 1\})$,

which is equivalent to

(17) $(\{a \in D \mid \langle a, b \rangle \in R\}, \{a \in D \mid R'a \cap S'a \neq \emptyset\})$,

which in turn is equivalent to

(18) $\{a \in D \mid \langle a, b\rangle \in R\} - \{a \in D \mid R'a \cap S'a \neq \emptyset\} = \emptyset,$

which is just a way of expressing that the set of men is contained within the set of individuals who love a woman.

Turning now to the Bach–Peters sentences, we just proceed in a manner parallel to that just described, by application of a binary restricted quantification, except that here its restriction is more complex. Thus for (19),

(19) Every pilot who shot at it hit some Mig that chased him.

we set R as

$\{\langle a, b\rangle \mid a$ **a pilot who shot at** $b \wedge b$ **a Mig that chased** $a\}$

and S as

$\{\langle a, b\rangle \mid a$ **hit** $b\}$

and arrive at truth conditions via $\forall\exists$ which require that every pilot who shot at some Mig that chased him hit that Mig. The important point to note here is that in the abstract giving the value of R, all of the variables occur as *bound* occurrences, including those corresponding to the pronouns. Thus, as desired the occurrences of the pronouns in a Bach–Peters sentences are both syntactically and semantically bound. (See Higginbotham and May (1981) for the details of the treatment.)

The success of the absorption approach to Bach–Peters sentences stems from the fact that such quantifications apply, so to speak, *en bloc* to all free positions within its scope. In this sense we have removed the offending asymmetry inherent in scope, although some care is needed here, since the postulated absorbed quantifiers still encode an interpretive dependency between their constituent parts. Put a little differently, for a restricted quantifier, while the restrictions are free of order – as they are conjoined – the quantifier (determiner) elements are not. They are ordered, so that in general $f_i f_j \neq f_j f_i$, as is apparent from inspection of the previous examples. The absorbed quantifiers, so to speak, build-in the essential notion captured by scope – the dependency between the actual quantifiers themselves – but exclude from this dependency what is inessential, the relation between the quantifier's restrictions. The problem with scope, of either the syntactic or semantic sort, is that, as standardly conceived, these aspects are conflated. Notice that once this is observed, there is hardly any reason to assume that scope is involved in the interpretation of multiple quantification, since whenever scope is apparent, we can effect an equivalent interpretation by an absorbed quantification. That is, the semantics of absorption allows us to 'elevate' scopal interpretations into absorbed interpretations. Let us say, following Higginbotham and May (1981), that a binary quantification which is equivalent to a scopal counterpart is *separable*.[9] $\forall\exists$, for instance, is separable, since the interpretation it imposes is equivalent to that arising from applying $\forall$ to $\exists$. The instance of this quantifier interpreting Bach–Peters sentences does not counterexemplify its separability, note, since in this case there is no scopal counterpart. The importance of the separability result is that it allows us to interpret *all* instances of the scope configuration above by *binary*, (more generally, n-ary) quantifiers, since by doing so we are guaranteed not to lose any interpretations that would otherwise be available via scope, (and in fact we will gain some not otherwise available via scope). The idea now is that LF-representations containing Σ-sequences of quantifiers are directly interpreted by absorbed quantifiers of a degree which matches the number of members of the sequence. This can be implemented formally as follows.

We define $\xi^{f_i f_j}$ as the permutation class of binary quantifiers generated from functions f_i and f_j, $f_i \neq f_j$; more generally we define $\xi^{f_1,\ldots,f_n}$ as the class of n-ary quantifiers generated by n-many unary quantifiers. For a sentence containing an n-membered Σ-sequence σ_n, we take $[\![\sigma_n(\mathrm{S})]\!]^{\xi^{f_1,\ldots,f_n}}$ to be the *class of interpretations* assigned to $\sigma_n(\mathrm{S})$ with respect to $\xi^{f_1,\ldots,f_n}$, where $\mathrm{Card}(\xi^{f_1,\ldots,f_n}) = n!$ That is, if an LF-representation contains an n-membered Σ-sequence, it will be interpreted by n-ary quantifications. Such quantifications will apply with respect to modified definitions of sentence and sentential function:

(20) S_i $(1 \leq i \leq n)$ is a *sentential function* $=_{\mathrm{df}} \forall \mathrm{S} \in \Pi$ $(\mathrm{S} \neq \mathrm{S}_i \rightarrow \mathrm{S}$ dominates $\mathrm{S}_i)$
S_i is a *sentence* $=_{\mathrm{df}} \forall \mathrm{S} \in \Pi$ $(\mathrm{S} \neq \mathrm{S}_i \rightarrow \mathrm{S}_i$ dominates S).

So, for example, *Every man loves some woman*, as represented in (21),

(21) $[_{\bar{\mathrm{S}}}\,[_{\mathrm{S}}$ some woman$_i$ $[_{\mathrm{S}}$ every man$_j$ $[_{\mathrm{S}}$ e_j loves $e_i]]]]$.

contains the Σ-sequence $\langle$*some woman*$_i$, *every man*$_j\rangle$, so that $\xi^{f_i,f_j} =$ $\{$**some**$_i$, **every**$_j$: woman$(x_i) \wedge$ man(x_j), **every**$_i$, **some**$_j$: woman$(x_i) \wedge$ man$(x_j)\}$. That is, (21) is interpreted by the binary restricted quantifiers $\langle$**every**$_i$,

[9] In Higginbotham and May (1981), separability is limited to *intersective* quantifiers, those for which $f(X, Y) = f(X, X \cap Y)$. These quantifiers are the *conservative* functions of Van Benthem and Keenan and Stavi, and correspond, in the formally distinct system of Barwise and Cooper, to the property of *living on* a set.

some$_j$⟩ and ⟨**some**$_i$, **every**$_j$⟩, which apply to the open sentence e_i *loves* e_j. More formally, let $f_1, \ldots, f_n$ be an arbitrary sequence of determiner interpretations for a given structure $\sigma_n(\psi)$, and let $X_1, \ldots, X_n$ be their corresponding set restrictions, so that, if $\mathrm{NP}_i = [\mathrm{DET}_i\ \bar{\mathrm{N}}_i]$, then $X_i = [\![\bar{\mathrm{N}}]\!]$. Furthermore, let $Q[f_1, \ldots, f_n]$ be the corresponding n-ary quantifier. An interpretation for $\sigma_n(\psi)$ is $Q[f_1, \ldots, f_n](R, S)$, where $R = \{\langle a_1, \ldots, a_n\rangle \mid a_1 \in X_1 \wedge, \ldots, \wedge\ a_n \in X_n\}$ and $S = \{\langle a_1, \ldots, a_n\rangle \mid [\![\mathrm{S}]\!]^{g'} = 1\}$, where g' assigns $a_1, \ldots, a_n$ to $x_1, \ldots, x_n$.[10] Thus LF-representations containing single quantifier elements will be interpreted by unary quantifications, those with two by binary quantifications, and so on for more complicated structures, provided that the structural constraints on Σ-sequence formation are obeyed. The relation of these latter type of construals to interpretations which would otherwise be effected by scopally ordered unary quantifications is, in turn, specified by the provisos of the separability condition.[11]

We thus generalize the Higginbotham and May Absorption results to the scope configuration (1); that is to any configuration in which we have a Σ-sequence. Notice that because we directly associate Σ-sequences with n-ary quantifiers, relative scope has been eliminated not only in the syntax (because of the symmetry of c-command), but also in the semantics, as we no longer have the successive application of the quantificational clauses (functions). Rather relative scope has, so to speak, been built into the very semantics of the quantifiers themselves. We cannot, however, eliminate the notion of relative scope altogether, although where it is observed, it is expressed *both* syntactically and semantically. Consider *Everyone believes that someone is a spy*, with *someone* understood as standing inside both *everyone* and the matrix predicate. At LF, this is represented by adjoining each of these NPs to the clauses of which they are immediate constituents:

(22) [everyone$_i$ [e_i believes that [someone$_j$ [e_j is a spy]]]].

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[10] Thanks are due to G. Chierchia for showing me the exact wording for this formulation.

[11] Recent work by Clark and Keenan (1987) brings up certain problems, relative to separability, which arise under the Higginbotham and May semantics. They propose a reformulation of absorbed quantifiers as ⟨1, 1, 2⟩ functions; i.e. as holding among two properties and a relation. Intuitively, the difference in the Clark and Keenan semantics is that the restrictions on the quantifiers are not joined to form a relation, as they are in the Higginbotham and May formulation. While their approach applies correctly to the simple cases of multiple quantification, it clearly cannot be extended to Bach–Peters sentences, as Clark and Keenan recognize, as the restrictions on the quantifiers are relations, not predicates. The problem here is that the invariance condition governing the derivation of absorbed quantifiers has not been finely enough specified; see May (in preparation) for discussion of this issue.

Here *everyone* asymmetrically c-commands *someone*, which is reflected directly in the (univocal) interpretation which results from the scopally dependent application of the relevant unary quantifier clauses. For (22), $\xi^{f_n} = \emptyset$, as it is not associated with any Σ-sequence.

3. Resumptive Quantifiers

While the generality of the treatment of quantification just proposed is attractive, it is not entirely correct, as there are interpretations of sentences whose logical forms exhibit the scope configuration, but which are not expressed by the semantics as given thus far. Exemplary of the problematic cases are the sentences in (23):

(23)a. Nobody loves nobody.
 b. Exactly one person loves exactly one person.

The interpretation of these sentences which interest me are where there are null and singleton extensions of the relation *love*, respectively. Thus (23a) is true, on this construal, just in case there are no individuals standing in the lover-lovee relation, so its truth requires that there be an unloving world, while the truth of (23b) requires that there is exactly one such pair in this relation. This interpretation, bear in mind, is *not* that associated with the plausible first-order renderings in (24); for the moment I will constrain myself to discussion of (23a) by way of example:

(24)a. $\neg\exists x \neg\exists y$ (x loves y)
 b. $\neg\exists y \neg\exists x$ (x loves y).

We immediately derive the equivalence of these formulae to those in (25):

(25)a. $\forall x \exists y$ (x loves y)
 b. $\forall y \exists x$ (x loves y).

Since both of these allow the *love* relation to be non-null, they cannot represent the interpretation we are seeking. These latter interpretations, it should be observed, are just those which arise from interpreting (23a) by the binary quantifications $\langle \mathbf{no}_i, \mathbf{no}_j \rangle$ and $\langle \mathbf{no}_j, \mathbf{no}_i \rangle$, interpretations which are logically distinct – hence the disequivalence of (25a) and (25b).

While neither of these formulae properly characterizes the construal of interest, it *can* be expressed by the following first-order formula:

(26) $\forall x \forall y \neg$(x loves y).

It seems dubious, however, that (26) could be the logical *representation* of

Nobody loves nobody, as it fails to preserve compositionality. While the interpretation of the sentence under consideration involves two quantifiers and two negations, (26) contains two quantifiers but only one negation. Such a fundamental abrogation of compositionality is not evident, however, if we drop the assumption that the interpretation we want is one in which the logical elements display logical dependencies; that is, scope. What I will suggest is that the proper analysis of examples like (23) actually involves not two, but only one quantifier, albeit a quantifier of many variables. Moreover, the exact structure of this quantifier will be determinable in a fully compositional fashion on the basis of the syntactic structures at LF in which we find occurrences of Σ-sequences.

The idea I will be exploring can be most readily perceived by way of illustration. Suppose that *Nobody loves nobody* is interpreted as in (27):

(27) $\mathbf{NO}x, y(x \text{ loves } y)$

That is, we form up, just in case all the quantifiers in a Σ-sequence match, a single quantifier of just the number of variables as there are quantifiers in the sequence. The one you see in (27) is a *pair*, (as opposed to binary) quantifier of type $\langle 2\rangle$, (or $\langle 2, 2\rangle$ if understood as restricted), as it applies to relations. Intuitively the truth conditions assigned to (27) by the semantics of this quantifier requires that there is no pair of individuals who satisfy the *love* relation. And this is just the interpretation we are looking for here.

To state this more formally, suppose that f_1^i is the unary function corresponding to the ith member of $\sigma_n = \langle Q_1, \ldots, Q_n\rangle$. Suppose further that for any i, j, $Q_i = Q_j$. Then $f_{1,\ldots,n} \in \xi^{f_1,\ldots,f_n}$, which thus now includes, in addition to the binary quantifiers generable from σ_n, an additional single quantifier of n-many variables. More generally, we have the metalinguistic rule:

$$f_1^1, \ldots, f_1^n(\varphi_{1,\ldots,n}) \Rightarrow f_{1,\ldots,n}^1(\varphi_{1,\ldots,n}),$$
$$\text{where } \forall_{i,j}\ (1 \leq i, j \leq n) f_i = f_j.$$

(Note that only the adicity of f is relevant to the identity condition, and not the position in the sequence it interprets.) On this way of looking at things, the interpretation-class of an n-member Σ-sequence will be restricted to the quantificational functions over n-many variables which can be constructed from the constituent members of the corresponding Σ-sequence. So, for instance, if the sequence consists of $\langle no_i, no_j\rangle$, then the class of interpreting quantifiers generated by the rule above contains two binary quantifiers – $\langle \mathbf{no}_i, \mathbf{no}_j\rangle$, and $\langle \mathbf{no}_j, \mathbf{no}_i\rangle$ – and the pair quantifier

$\mathbf{no}_{i,j}$, as the identity condition is satisfied. All of these quantifiers, note, take sets of pairs as their arguments. On the other hand, if the sequence contains $\{every_i, some_j\}$, then only the two binary quantifiers $\langle \mathbf{every}_i, \mathbf{some}_j \rangle$ and $\langle \mathbf{some}_j, \mathbf{every}_i \rangle$ are generated, as the identity condition is not satisfied in this case.[12]

We give the satisfaction clause for quantifiers of multiple variables in longhand as follows:

(28) g satisfies $Q_{1,\ldots,n}\varphi_{1,\ldots,n}$ iff **Q**-many sequences g' satisfy $\varphi_{1,\ldots,n}$, where g' differs from g in at most the values assigned to the 1st–nth places.

For an n-tuple quantifier this clause requires that sequences vary not on a single individual variable, but simultaneously with respect to n-tuples of individual variables. Hence for a pair quantifier, by this definition variation will be with respect to pairs of variables. Truth, then, will require satisfaction of a relation by n-many pairs of individuals drawn from the Cartesian product of the domain and the counter-domain. The instances of the satisfaction schema relevant to the examples in (23) are given in (29):

(29) g satisfies $\left\{\begin{matrix}\textbf{NO} \\ \textbf{EXACTLY ONE}\end{matrix}\right\} x, y$ (x loves y) iff $\left\{\begin{matrix}\text{no} \\ \text{exactly one}\end{matrix}\right\}$ sequence g' satisfies x loves y, where g' differs from g in at most the values assigned to x and to y.

By this semantics (23a) will be true just in case there is no pair of individuals who love one another, that is, only if the love-relation is null. Similarly the truth of (23b) requires that there be only a single pair of lovers. But suppose there happened to be a second individual who loves two people; (23b) is then false, under the intended interpretation, as there is more than one pair of individuals standing in the requisite relation. This contrasts with the interpretation under which the subject phrase is understood to have broader scope, which is true in this situation. It only requires that there be exactly one person who is, so to speak, an exactly-one-person-lover, and hence is compatible with there being individuals who love more than one person.

[12] We can generalize this characterization in obvious ways to apply to *sub*-sequences. It would then apply to the interpretation of sentences such as *A professor introduced nobody to nobody*, giving the construal that there is no pair of individuals such that some professor introduced them. Thanks to G. Chierchia for bringing this to my attention.

To summarize, in terms of generalized relational quantifiers the class we are interested in is just that generated by taking X and Y in $f(X, Y)$ to be sets of n-tuples of individuals. The standard unary quantifiers will thus be where we have 1-tuples, while the pair quantifiers will be where we have 2-tuples, and so on. In any of these cases, however, the defined relation between the sets remains constant. For example, the pair quantifier **NO** is defined just as unary **NO**, except that rather than requiring a null relation between sets of individuals, it requires that there be a null intersect between sets of *pairs* of individuals. Pair quantifiers are just members, from the semantic point of view, of an inductive class of simple quantifiers, f_n, for n-many variable places; that is, they are the case when $n = 2$ variable places, while unary quantifiers are where $n = 1$ variable place. Formally, these quantifiers can be characterized in a manner parallel to that of binary quantifiers above, as functions f: $P(D \times D) \times P(D \times D) \to 2$, which respect automorphisms of $D \times D$; that is, their interpretation is invariant with respect to permutations of pairs. Thus, the logicality of the pair cases is no different from that of the unary case, in that for these quantifiers, the pairs are treated essentially monadically, as individuals. Let $f_1, \ldots, f_n$ be an arbitrary sequence of determiner interpretations for a given structure $\sigma_n(\psi)$, and let $X_1, \ldots, X_n$ be their corresponding set restrictions, whose values are determined as above. Then $Q[f_{1,\ldots,n}]$ is the corresponding n-tuple quantifier. $Q[f_{1,\ldots,n}](R, S)$ is an interpretation for $\sigma_n(\psi)$, where $R = \{\langle a_1, \ldots, a_n\rangle \mid a_1 \in X_1 \wedge, \ldots, \wedge\, a_n \in X_n\}$ and $S = \{\langle a_1, \ldots, a_n\rangle \mid [\![S]\!]^{g'} = 1\}$, where g' assigns $a_1, \ldots, a_n$ to $x_1, \ldots, x_n$.

While pair quantifiers and binary quantifiers share certain properties – for instance, as is apparent from the above characterization, both are type $\langle 2, 2\rangle$ functions – they also differ in certain fundamental ways. In particular, these differences stem from only the binary quantifiers being complex – whereas the binaries are composite, the pairs are not. Since pair quantifiers are non-composite, it makes no more or less sense to speak of their decomposability, or of encoding interpretive dependencies than it would be for their unary counterparts. But for binary quantifiers, as we have seen, these are relevant semantic distinctions. Pair quantifiers are distinguished in part by being, as a class, *inseparable*. While for certain pair quantifiers, for example $\mathbf{every}_{i,j}$, $f_{i,j}(\mathrm{S}) = f_i(f_j(\mathrm{S}))$, so that

$$\forall x, y\ (x \text{ loves } y),$$

is equivalent to

$$\forall x \forall y\ (x \text{ loves } y),$$

(and similarly for $\mathbf{some}_{i,j}$), other pair quantifiers are not decomposable in this sense. As we have seen already, *no* is an instance of a pair quantifier which has no (compositional) equivalent in terms of unary quantifiers, so that for it $f_{i,j}(S) \neq f_i(f_j(S))$. Pair quantifiers, as opposed to binary quantifiers, are also *independent*, so that for a pair quantifier formed from f_i and f_j, $f_{i,j} = f_{j,i}$. For binary quantifiers, on the other hand, in general $f_i, f_j \neq f_j, f_i$. These differences follow just from binary quantifiers being composite quantifiers of many variables, as opposed to pair quantifiers, which are non-composite. Hence, while in virtue of their application to relations, we can classify the pair quantifiers as in the same genus as binary quantifiers, they remain of a different species.

One way of classifying quantifiers is in terms of their inferential patterns; they may be increasing, decreasing or neither. Increasing quantifiers are those for which the set to which they apply can grow indefinitely without variation in truth value – they place no upper limit on the size of the domains to which they apply. Decreasing quantifiers are those which can shrink indefinitely and retain constancy of truth – they place no lower limit on the size of their domains. (See Barwise and Cooper (1981).) As developed, the assumption is that pair quantifier formation is universal, applying to quantifiers which partake of any of these types of inferential relations. Given this universality of pair quantifier formation, and its extension beyond the classical quantifiers, we can consider a question which I have thus far left open – is the identity condition on the formation of n-tuple quantifiers a condition on syntactic or semantic identity? The litmus test for this are examples like (30), as Richard Larson points out to me:

(30) a. Few detectives solved few crimes.
b. Not many detectives solved few crimes.

The question is whether (30b) shares the pair interpretation with (30a). To my ear it does not; hence we can conclude that the identity condition is syntactic.

By taking the condition as syntactic, in a sense what we are saying is that one of the occurrences of the quantifier is *resumptive*. Normally the semantic role of resumptive pronouns is as occurrences of variables; we can think of the occurrence of resumptive quantifiers similarly as variables, bound by the derived pair quantifier. Thinking of the formation of pair quantifiers in this way is highly reminiscent of ideas of Heim (1982), who argues that indefinites should be treated as variables. A primary application of Heim's analysis is to the semantics of donkey sentences, such as *Every owner of a donkey beats it*, which on this view are captured by (31):

(31) $\forall x, y$ (x is owner of y) x beats y.

This will be true just in case for every pairing of a donkey and a donkey-owner, the former beats the latter. This analysis accords with our intuitions, since if there are donkey owners who beat some, but not all, of their donkeys, then *Every owner of a donkey beats it* will be false, as not every donkey is beaten by its owner. While the issue of "donkey anaphora" is one of vexing complexity, it may prove fruitful to explore incorporating this approach to donkey sentences within the semantics of n-tuple quantifiers by holding that indefinites can be resumptive to any other quantifier, as opposed to definites and other quantifiers, which can be resumptive only to identical determiners. Other applications of resumptive quantifiers can be observed in certain cases of Bach–Peters sentences, such as those with double definite determiners:

(32) The pilot who shot at it hit the Mig that chased him.

Among the interpretations of this sentence is one in which its truth requires that there is a unique pairing of a pilot and a Mig, such that the former shot at the latter and the latter chased the former, (and no other pilots or Migs were shooting or chasing). It is this construal which is given by the pair quantifier $\mathbf{the}_{i,j}$, which carries over the standard uniqueness presupposition associated with the unary definite determiner.[13]

In developing the semantics of resumptive quantifiers I will assume that they arise in the presence of sequences of identical quantifiers, and that the formation of such quantifiers is completely general across determiner types. The semantic effects will only be apparent, however, for those sequences of quantifiers for which this is the only way of expressing scopal independence. Thus the interpretation of the quantifiers in the binary quantification $\langle \mathbf{every}_i, \mathbf{every}_j \rangle$ are already independent, in the sense that its interpretation does not depend on relative scope; to wit, its equivalence to $\langle \mathbf{every}_j, \mathbf{every}_i \rangle$. In turn these quantifiers are equivalent to pair quantification $\mathbf{every}_{i,j}$. On the other hand, as noted, the two binary quantifiers $\langle \mathbf{no}_i, \mathbf{no}_j \rangle$ and $\langle \mathbf{no}_j, \mathbf{no}_i \rangle$ are not equivalent, hence the interpretation of each is dependent upon relative scope. And here the pair quantifier $\mathbf{no}_{i,j}$, which does express an in-

[13] The comments here are presaged by remarks in unpublished notes of Thomason (1977); also see Higginbotham and May (1981), Section 3.

dependent interpretation, is equivalent to neither of its binary counterparts.

Let us say, then, that associated with a Σ-sequence is a class of interpretations comprising those in which the quantifiers are *dependent* and those in which they are *independent*. These are the only possible *types* of quantifier interpretations. Dependent interpretations are characterized by the semantics of n-ary quantifiers, independent interpretations by the semantics of n-tuple quantifiers. For those Σ-sequences in which the quantifiers are identical, the class of interpretations $[\![\sigma_n(\mathrm{S})]\!]^{\xi}$ is now extended to $n!+1$, as there can only be one independent interpretation associated with a given Σ-sequence. On the other hand, where there is non-identity, $[\![\sigma_n(\mathrm{S})]\!]^{\xi} = n!$, as before.

The independence property of resumptive quantifiers brings up an issue of their relation to another class of quantifiers which are also independent, namely branching quantifiers.[14] This issue is of particular interest in the current context because in previous work I have suggested, as has van Benthem (1983b), that the 'unloving world' interpretation of *Nobody loves nobody* is an instance of branching quantification. (See May (1985), Chapter 4.) Using the illustrative branching notation, we would represent the intended construal as follows:

(33)
$$\begin{array}{lcl} \neg\exists x & \diagdown & \\ & & x \text{ loves } y \\ \neg\exists y & \diagup & \end{array}$$

In this formula, not only do the quantifiers not exhibit scope dependencies, neither do the negations, hence avoiding the interdefinability encountered when the quantifiers are linearly ordered. Intuitively then (33) expresses that there are not any x's, nor are there any y's, such that the former loves the latter – that is, that the relation *love* has a null extension. On the semantics of branching, as given by Barwise (1979),

[14] The most well-known discussions of branching quantification are to be found in Hintikka (1974) and Barwise (1979). I will rely primarily on the latter discussion, along with that of Sher (1989a, 1989b), because of its greater generality and because I find, along with Fauconnier (1975), that the branching status of Hintikka's examples is highly suspect.

decreasing quantifiers like *no* are interpreted by the second-order schema:

(34) $$\exists X \exists Y[\mathbf{Q}x(x \in X) \wedge \mathbf{Q}y(y \in Y) \wedge \forall x \forall y(\varphi(x, y) \rightarrow x \in X \wedge y \in Y)].$$

The independence of the quantifiers in this formula arises from the occurrence of $\mathbf{Q}x$ and $\mathbf{Q}y$ on either side of a conjunction; it is second-order in virtue of the presence of the initial existential quantifiers over sets. Applying this to the example at hand results in the following interpretation:

(35) $$\exists X \exists Y[\mathbf{NO}x(x \in X) \wedge \mathbf{NO}y(y \in Y) \wedge \forall x \forall y(x \text{ loves } y \rightarrow x \in X \wedge y \in Y)].$$

Formally, this indeed gives precisely the desired interpretation. In this case at least, the truth conditions provided by branching quantification are equivalent to those assigned under the semantics of resumptive quantification.

The point of the preceding paragraph, it turns out, is rather more general, since as Sher (1989a, 1989b) points out, the interpretation of decreasing branching quantifiers is not irreducibly second-order, but in fact expresses a weaker first-order condition. The essential property of branching quantification is that the relation between the domain and the counter-domain be uniquely what Sher calls 'each/all'. That is branching strictly requires that for a given relation φ, that *each* member of the domain bears φ to *all* members of the counter-domain. That there must be just this type of relation is what is specified by the semantics Barwise gives for *increasing* quantifiers:

(36) $$\exists X \exists Y[\mathbf{Q}x(x \in X) \wedge \mathbf{Q}y(y \in Y) \wedge \forall x \forall y(x \in X \wedge y \in Y \rightarrow \varphi(x, y))].$$

This formula says that there are two Q-many membered sets, such that each member of the former set stands in the relation φ to all members of the second; cf. the internal occurrence of the universal quantifiers. The schema for decreasing quantifiers, (34), however, says something weaker. It requires only that there are two Q-many sized sets, such that for any pair of individuals standing in the relation φ, that the former be a member of one of the sets and the latter a member of the other. While this is certainly true when there is an each/all relation between the domain and counter-domain, it is not uniquely true of such relations. In fact, more generally this description is satisfied so long as there is *any relation*, including the null relation, between the two sets. Thus as Sher observes, Barwise's schema for decreasing quantifiers is equivalent to the following first-order condition,

$$\mathbf{Q}^1 x \exists y \mathrm{P}(x, y) \wedge \mathbf{Q}^2 y \exists x \mathrm{P}(x, y),$$

and hence does not, in fact, express a second-order interpretation for decreasing quantifiers at all.

Returning to multiple negative quantification, when *no* is plugged into Sher's condition we obtain

$$\mathbf{NO}x \exists y(x \text{ loves } y) \wedge \mathbf{NO}y \exists x(x \text{ loves } y)$$

which entails both

$$\neg \exists x \exists y(x \text{ loves } y)$$

and

$$\neg \exists y \exists x(x \text{ loves } y),$$

each of which is equivalent to

$$\forall x \forall y \neg(x \text{ loves } y),$$

which is exactly what is expressed by the pair interpretation of *no* formulated above, and shows its equivalence to the branching interpretation. The point here of course extends beyond this particular demonstration, since in general whenever $\mathbf{Q}^1 = \mathbf{Q}^2$, the interpretation assigned under the semantics of decreasing branching quantification will be equivalent to the interpretation by resumptive quantification. This is because both express Sher's first-order condition; for resumptive quantifiers which are distinct from their binary counterparts, this is plainly so, since if there are Q^1-many individuals x for whom there is an individual y, such that $\varphi(x, y)$, and vice versa for Q^2-many individuals y, then there must be just Q-many pairs of individuals who stand in φ. But despite their equivalence, the semantics of resumptive quantification cuts up the semantic pie rather differently than the semantics of branching. This is because the resumptive interpretation is applicable regardless of whether the quantifiers are inferentially decreasing, increasing or neither. Its occurrence is dependent only upon whether the identity condition on Σ-sequences is satisfied. In contrast, Barwise's (first-order equivalent) branching semantics is limited to just those quantifiers displaying the first pattern of inference, and as such it expresses only a sub-case of the more inclusive semantics of resumptive quantification. The semantics of resumptive quantification, therefore, embeds a rather different claim as to the extension of independent first-order quantification in natural language than does the semantics of branching quantification. Insofar as this claim is empirically justified, branching for decreasing quantifiers, at least as characterized by the constraint found in Barwise (1979), would be superfluous for the semantic analysis of natural language.

The importance of resumptive quantifiers, therefore, is that they introduce a class of quantifiers which are both *independent* and *first-order*, that is, non-scopal but linearly expressible with variables only over individuals. This runs counter to the standard assumptions regarding independent quantificational interpretations, which link independence to lack of first-orderizability. While the discussion of the preceding paragraphs illustrates that certain cases conjectured to be higher-order are not, the question remains open as to whether there are strictly second-order independent quantifier conditions in addition to the first-order condition revealed here. I will return to this question in some detail in the Section 6, turning now, however, to another application of resumptive quantification which pertains to aspects of the interpretation of singular wh-phrases.

4. Absorbed and Resumptive Wh-Questions

Under the semantics of wh-questions developed in Higginbotham and May (1981), May (1985, Chapter 2, 1988), associated with a wh-question like (37):

(37) Who left,

is a *question* **Q** on a domain D, a family of sets of assignments of truth-values to pairs (x *left*, a), for every $a \in D$. Call each such set in **Q** a *theory* T. An *answer* to **Q** is a sentence whose truth is inconsistent with some member T of **Q**. The sentence in (38),

(38) John left,

counts as an answer to (37), as its truth is inconsistent with those theories in which falsehood is assigned to (x *left*, *John*), as does (39),

(39) John left and Mary left,

since it is inconsistent with those theories in which both (x *left*, *John*) and (x *left*, *Mary*) are assigned falsehood.

In the general case **Q** is a *total* assignment of truth-values to pairs, so that relative to a domain of cardinality n, there will be 2^n theories in **Q**.

More usually, however, we eschew such an exhaustive enumeration in favor of a *partial* **Q**, $\mathbf{Q}^-$, a sub-family of theories of total **Q**s. Evaluating a wh-question relative to some $\mathbf{Q}^-$ expresses the more natural circumstance of limited informational structure relative to which questions are posed.

With respect to such partial structures, call an answer to $\mathbf{Q}^-$ a *satisfactory answer* if it is *not* inconsistent with every theory in $\mathbf{Q}^-$. Suppose that the pair (*x left*, *John*) = 0 in every $T \in \mathbf{Q}^-$. Then *John left* would not be a satisfactory answer to *Who left*, because it could not possibly relieve our ignorance about what actually holds relative to the informational structure of $\mathbf{Q}^-$. Relief from ignorance would only be possible if under at least one alternative theory (*x left*, *John*) = 1; that is, only if $\mathbf{Q}^-$ allows for alternative situations to be the case. Only then would *John left* be a satisfactory answer, as then there will be at least one assignment with which it is not inconsistent. Notice that under these definitions that *John runs*, even though it is not inconsistent with any theory, *is not* a satisfactory answer to *Who left*, since it is not even an answer in the first place, which requires that it be inconsistent with at least *some* $T \in \mathbf{Q}$, which it is not.

Thus among possible answers we characterize those which are satisfactory as well as those which are *unsatisfactory*, answers which are inconsistent with every theory and hence could not possibly provide any relief from ignorance. More generally, we call an answer *unacceptable* if unsatisfactory for every **Q**. So for instance, contradictions would be unacceptable answers, since they would be inconsistent with every theory T for any $\mathbf{Q}^-$ formed from an arbitrary **Q** on D. Among the satisfactory answers we can more finely distinguish *complete* answers from *incomplete* answers: An answer is complete if inconsistent with all but one theory, and incomplete otherwise. That is, a complete answer provides a complete relief from ignorance, an incomplete answer leaves other alternatives as open possibilities. Finally, we can distinguish *direct* answers from *indirect* answers. The former are answers which contradict an assignment of falsehood, while indirect answers are those which contradict an assignment of truth. Thus, while *John left*, is a direct answer to *Who left*, *John didn't leave* is an indirect answer.

Turning now to singular Wh-questions, they have the property of presupposing that they have at least one satisfactory answer. (This excludes for them any $\mathbf{Q}^-$ which consists of just a single theory, as they cannot have any satisfactory answers.) A strong presupposition is carried, however, by wh-questions containing determiner wh-phrases, as in (40):

(40) Which man left.

For this case the presuppositions call for a single answer – as opposed to their monomorphemic counterparts, multiple answers like (39) violate assumptions inherent in their use. To incorporate this stronger presupposition, suppose that an admissible $\mathbf{Q}^-$ for determiner wh-questions contains only those theories in which one pair $(\psi(x), a)$ is assigned truth, for some $a \in D$. Then (38) will be a satisfactory answer to (40), as it will not be inconsistent with that theory in which (*x left*, *John*) is assigned truth, but (39), the multiple answer, will be unsatisfactory, as one or the other of its components will be inconsistent with every $T \in \mathbf{Q}$. I will refer to the restriction just formulated as the singular presupposition.

With this much background, we can observe the role of binary and resumptive operators in wh-questions by turning our attention to multiple singular wh-questions, especially as they occur with determiner wh-phrases, as illustrated by (41):

(41) Which man loves which woman.

Its LF-representation is as in (42):

(42) $[_{\bar{S}}$ which woman$_j$, which man$_i$ $[_S\ e_i$ loves $e_j]]$.

In this structure both wh-phrases are in COMP; cf. May (1985, Chapter 5) for structural details. Consequently, they mutually c-command, and hence form a Σ-sequence. It is, moreover, a Σ-sequence which satisfies the identity condition, so that interpretations are assigned relative to a binary wh-operator, $\langle \mathbf{which}_j, \mathbf{which}_i \rangle$, and a pair wh-operator, $\mathbf{which}_{i,j}$.[15] To a certain extent the interpretations assigned will be non-distinct. Since each operator binds two variables, the questions formed will be relative to relations, so that in either case we have truth-assignments to pairs (*x loves y*, (a, b)), for $a, b \in D$. Relative to a domain of cardinality n, a total multiple $\mathbf{Q}$ will consist of $2^{n \times n}$ theories, (although we may wish to limit this to $2^{(n \times n)-n}$ by including disjointness conditions.) Multiple $\mathbf{Q}^-$ are, as before, sub-families of $\mathbf{Q}$. Where the difference between the two types of questions arises is in the presuppositions which are introduced by the differing operators. Pair operators, recall, are members of an inductive class of simple operators, so that $\mathbf{which}_{i,j}$ is just the second degree operator of the class of which the unary wh-operator is the first-degree operator. As such it carries along the presuppositions associated with this class, in particular the singular presupposition excluding multiple answers. This is not so for binary wh-operators, which not being

[15] For the binary condition there will actually be two operators, but they will be equivalent and hence determine the same class of partial questions.

part of this class, do not carry its presuppositions. Rather it carried only the weaker presupposition, comparable to the unary monomorphemic wh-words. As a result, interpreting (41) by a binary wh-operator will admit both single and multiple satisfactory answers, as in (43):[16]

(43)a. John loves Mary
b. John loves Mary and Bill loves Sally.

The binary interpretation of (41) note is more inclusive than the pair interpretation, and hence in this case has the effect of masking the resumptive interpretation.

It turns out, however, that there are certain wh-questions which allow us to isolate this latter interpretation. This is when not just the determiners are identical, but rather the entire noun phrase.[17] An example, from Higginbotham and May (1981), is (44):

(44) In *Gone with the Wind*, which character envies which character.

Here the multiple answer (45b) is inappropriate, as compared to the single answer (45a):

(45)a. Ashley Wilkes envies Rhett Butler.
b. Ashley Wilkes envies Rhett Butler and Melanie Wilkes envies Scarlett O'Hara.

As above, the singular presupposition, now brought along by the resumptive pair wh-operator, is implemented by requiring that any $\mathbf{Q}^-$ contain only theories in which is only one pair (x *loves* y, (a, b)) which is assigned truth. This will properly distinguish the examples in (45) respectively as satisfactory and unsatisfactory answers to (44). Note that the presupposition associated with the interpretation of (44) imposes exactly the same requirement as that imposed for truth on (46) by the resumptive pair interpretation; cf. discussion of (23b) above.

(46) Exactly one character envies exactly one character.

---

[16] Not just any multiple answers, however – note that *John loves Mary and John loves Sally* is *not* an acceptable answer to (41). What is required here is that there be a unique pair of individuals in each member of the complex answer. This can be accomplished by admitting only assignments of truth-values to (x *loves* y, (a, b)) where each of the individuals is unique relative to other assignments.

[17] Actually the condition is a bit different, as Howard Lasnik points out to me. He notes that *In* Gone With the Wind, *which male character admires which female character* shares the singular presupposition with the example in the text, indicating that the relevant notion of identity pertains to determiner-noun pairs solely.

That is, the resumptive interpretation requires that there is exactly one pairing of characters, such that the former admires the latter.

5. Plural Resumptive Quantification

In the previous sections I was concerned with the application of resumptive quantification to singular noun phrases. In this section I turn to aspects of the semantics of plural noun phrases, in particular as found in multiple numerical sentences such as (47):

(47) Two detectives solved two crimes.

On the semantics developed thus far, a number of distinct interpretations can be attributed to this sentence. Two are the scopal interpretations. They allow either for a total of four crimes to have been solved (each detective solved two distinct crimes) or for a total of four detectives (each crime is solved by two distinct detectives), depending upon whether *two detectives* or *two crimes* is understood with broader scope. Or, to be more precise, on whether (47) is interpreted by the quantification $\langle \mathbf{two}_i, \mathbf{two}_j \rangle$ or by the quantification $\langle \mathbf{two}_j, \mathbf{two}_i \rangle$. It is tempting to see (47) as also be interpreted by a resumptive quantification $\mathbf{two}_{i,j}$, (equivalently $\mathbf{two}_{j,i}$). On this semantics (47) will be true just in case there are two pairings of a detective and a crime, such that the former solved the latter. That is, the semantics require that there be two assignments of values to pairs of variables, such that the relation *x solved y* is satisfied under each assignment. (47), therefore, will be correctly characterized as true in the circumstance depicted in (48):

(48) d_1 ———————— c_1
d_2 ———————— c_2

The intended interpretation can be represented as in (49):

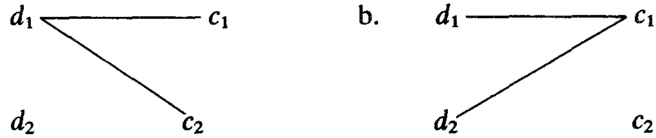
(49) $\mathbf{TWO}x, y\ (\text{detective}(x) \wedge \text{crime}(y))\ x \text{ solved } y.$

The interpretation is that provided by the satisfaction clause given in (50):

(50) g satisfies $\mathbf{two}\ \varphi_{i,j}$ iff two sequences g' and g'', g', g'' distinct, satisfy $\varphi_{i,j}$, where g' and g'' differ from g in at most the values assigned to the ith and jth places.

(The notion of 'distinct' will be made explicit below.) Note that the scopal interpretations described above are semantically distinct from this interpretation, as they allow up to four detectives and four crimes, respectively.

Assuming that resumptive quantification, at least in the sense thus far defined, is involved here can be shown, however, to be incorrect, as (47) is false in both of the circumstances depicted in (51):

(51)a. 

In each of these situations, as in (48), there are two pairings of a detective and a crime standing in the requisite relation, and hence (47) ought be true. But clearly *Two detectives solved two crimes* is false in these circumstances, since in (a) only one detective solved crimes, while in (b) only one crime was solved by detectives. Thus **TWO**x, y is not a resumptive quantifier in the basic sense defined above for singular phrgses, as truth in this case is not invariant under the transformation of the relations in (48) and (51), which are automorphisms of one another. Intuitively, the problem here is that resumptive quantification is sensitive only to how many pairs of individuals stand in a certain relation. What the example here shows is that plural resumptive quantifiers must satisfy more stringent conditions than this, conditions which impose greater structure on a relation in order for truth to obtain. Thus, rather than being sensitive simply to arbitrary pairs of individuals, they are sensitive to whether such pairs are *disjoint*; that is, to whether they have any members in common. To see what is involved here, consider this from the perspective of the satisfaction clauses for these quantifiers.

Normally, the statement of the satisfaction clauses for quantifiers of a single variable turns on variation in the assignment of individuals to that variable. Thus a sequence g', relative to the assignment to the variable free in a formula $P(x)$, differs from a sequence g if and only if a distinct individual is assigned at most to x. In extending the treatment to the pair case, the satisfaction clauses will comparably turn on variation with respect to multiple variables. There are two ways to state in what this variation consists, however. On the *strong* interpretation, a sequence g', relative to assignments to the variables free in a formula $P(x, y)$, differs from a sequence g if and only if distinct individuals are assigned to x and to y. On the *weak* interpretation, which has been implicitly assumed thus far, it is just required that there be distinct assignments to the pair $\langle x, y\rangle$. The difference between strong and weak satisfaction is that only for the latter is the assignment $\langle a, b\rangle$ distinct from the assignment $\langle a, c\rangle$ – while these are surely distinct pairs, they are not pair-wise disjoint. We characterize strong satisfaction by imposing the following condition:

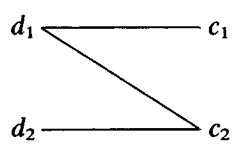
(52) $$g(x_1, \ldots, x_n) \simeq g'(x_1, \ldots, x_n) =_{\mathrm{df}} \exists x_i (1 \leq i \leq n) g(x_i) = g'(x_i).$$

By this definition a sequence g is *non-distinct* from a sequence g', relative to variations in assignments of values to only $x_1, \ldots, x_n$, just in cases there is some variable x_i among $x_1, \ldots, x_n$ assigned the same value in both g and g'. This means that sequences distinctly satisfy a formula if and only if distinct values are assigned to each and every free variable by each of the sequences; if this is so, then the sequences *strongly* satisfy the formula.

In general, then, weak satisfaction of a relation requires that it can be satisfied by any pairings drawn from $D \times D$, while strong satisfaction requires that the relation can be satisfied only by distinct pairings. In this latter case the satisfaction clauses are stated not simply with respect to assignments, but rather with respect to *distinct* assignments. To a large extent the classes of weak and strong quantifiers cleave along the dimension of whether they are morphologically singular or plural, so that the singular quantifiers considered in the previous sections are weak, while the plurals taken up in this section are strong. For instance, for the plural resumptive interpretation of *Two detectives solved two crimes*, it will now be false with respect to (51a) and (51b), but true with respect to (49), the desired result. This is because the assignment $\langle d_1, c_1 \rangle$ is non-distinct from the assignments $\langle d_1, c_2 \rangle$ and $\langle d_2, c_1 \rangle$ respectively, and consequently there are not the required two distinct assignments in the situations depicted in (51a) or (51b) which satisfy *x solved y*. Notice interestingly that quantifiers which might seem to be semantically uniform will differ along the weak/strong dimension depending upon whether they are singular or plural. Thus both *Exactly one detective solved exactly one crime* and *Exactly two detectives solved exactly two crimes* are false relative to (51a) and (51b). But for this to be so the former must be weak and the latter strong.

Notice that the relation between assignments we are concerned with cannot be construed as an equivalence relation, as transitivity fails. If it were an equivalence relation, *Two detectives solved two crimes* would be false in the situation depicted in (53), contrary to fact:

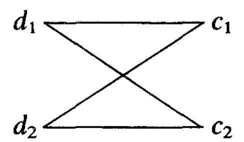
(53)



This is because all of the pairings in (53) are equivalent – $\langle d_1, c_1\rangle$ would be equivalent to $\langle d_1, c_2\rangle$, which in turn is equivalent to $\langle d_2, c_2\rangle$, which in turn ought to be equivalent, by transitivity, to $\langle d_1, c_1\rangle$. But then there would not be two distinct verifying assignments. On the other hand, if the relation at hand is just non-distinctness, then it fails to follow that $\langle d_1, c_1\rangle$ and $\langle d_2, c_2\rangle$ are non-distinct. Consequently, *Two detectives solved two crimes* is true in (53), since these are distinct assignments which satisfy *x solved y*.

Now consider a class G made up all non-distinct assignments g to the variables $x_1, \ldots, x_n$ which show in a predicate φ. G then will be a set of n-tuples, any pair of which share an assignment on some coordinate; for a binary relation this means that the same assignment is made to either x or y, inclusively. A relation $\varphi_{i,j}$ can now be said to be *directly satisfied* iff the non-distinctness classes G of assignments $g_{i,j}$ contain just one member; the relation is indirectly satisfied if the cardinality of G is greater than one. The satisfaction clauses can then be defined to apply relative to a designated member g^* of G. So, for instance, *x solved y* is directly satisfied by (49), as $G_1 = \{\langle d_1, c_1\rangle\}$ and $G_2 = \{\langle d_2, c_2\rangle\}$, where $g_1^* = G_1$ and $g_2^* = G_2$. On the other hand, *x solved y* is directly satisfied by (53), as we have $G_1 = \{\langle d_1, c_2\rangle, \langle d_2, c_2\rangle\}$ and $G_2 = \{\langle d_1, c_1\rangle, \langle d_1, c_2\rangle\}$, and from each of these classes a designated member can be chosen, so long as those chosen do not form a non-distinctness class themselves. Similarly, the relation is indirectly satisfied by (54):

(54)



This is intended to represent a situation in which while it is so that each detective solved each crime, their doing so was mere happenstance – it just so happened that detective one solved crimes one and two and that detective two did likewise, without in any way working in concert. *Two detectives solved two crimes* will be true with respect to (54) under the interpretation imposed by (50) because it will only ever be possible to draw, from the four non-distinctness classes of assignments, two distinct pairings which satisfy the relation. Hence we have $G_1 = \{\langle d_1, c_1\rangle, \langle d_1, c_2\rangle\}$, $G_2 = \{\langle d_1, c_1\rangle, \langle d_2, c_1\rangle\}$, $G_3 = \{\langle d_2, c_1\rangle, \langle d_2, c_2\rangle\}$ and $G_4 = \{\langle d_1, c_2\rangle, \langle d_2, c_2\rangle\}$ – note that adding any other pair to any of these classes would render it no longer a non-distinctness class. From these classes we can find either the distinct sequences assigning $\langle d_1, c_1\rangle$ and $\langle d_2, c_2\rangle$, or those assigning $\langle d_1, c_2\rangle$ and $\langle d_2, c_1\rangle$) satisfying *x solved y*; any other pairings would form non-distinctness classes. Notice that for the first two pairs of assignments $g_1^* = g_2^*$ and $g_3^* = g_4^*$, and similarly for the latter two pairs, the designated member of G_1 is the same as that of G_4, and that of G_2 the same as that of G_3. The common thread which runs between all of these vagaries is that none of them impute any connection between the actions of the two detectives. They are all 'happenstance' construals, where the interpretations assigned relative to the situations in (53) and (54) are indirect vagaries of the direct pair interpretation of *Two detectives solved two crimes* satisfied by the bijective relation depicted by (49).

The semantics of strong resumptive quantifiers can be applied to certain other puzzles involving plural quantifier phrases, which, like numerical expressions, in some sense project measures on their domains. One is an intriguing puzzle concerning *most* and donkey anaphora, and is due to Heim (1982). Recall that donkey sentences with standard quantifiers, like *Every owner of a donkey beats it*, can be fruitfully analyzed as involving a pair quantifier, as in (31):

(31) $\forall x, y$ (x is owner of y) x beats y.

A natural extension of this analysis is to treat the sentence *Most owners of a donkey beat it* as in (55):

(55) $\mathbf{MOST}x, y$ (x is owner of y) x beats y

On this interpretation the truth-conditions require that for most pairings of a donkey with a donkey owner, the former beats the latter. Unfortunately, this description will hold in (56) if we assume that o_4, who owns six donkeys beats all of them, but that none of o_1, o_2 or o_3, who are also donkey-owners, beats the single donkey he owns:

(56)
$$\begin{array}{lcl} o_1 & & d_1 \\ o_2 & & d_2 \\ o_3 & & d_3 \\ o_4 & \text{———————} & d_4, \ldots, d_9. \end{array}$$

This is because six out of the nine pairs of donkeys and donkey-owners in (56) are in the beating relation; hence most of the pairs stand in this relation. But this is contrary to fact, as *Most owners of a donkey beat it* is quite plainly false in the circumstance described.

This is only so, however, if *most* is treated as a weak binary quantifier; it is not so if treated as strong. This is because the assignment of the pair $\langle o_4, d_4 \rangle$ is non-distinct from the assignment of $\langle o_4, d_5 \rangle$, and so on, for d_6 through d_9. The members of this non-distinctness class of assignments are distinct, however, from the assignments of $\langle o_1, d_1 \rangle$, $\langle o_2, d_2 \rangle$, $\langle o_3, d_3 \rangle$, and since of these, three out of four are not donkey-beaters, it follows, correctly now, that *Most owners of a donkey beat it* is false. Its truth requires that a majority of donkey-owners also be donkey-beaters, regardless of the number of donkeys they may be cruel to.[18]

5.1. *Articulating the Semantics*

The semantics for the resumptive numerical sentences of the sort we have been considering can be given as follows:

$$f(R, S) = 1 \text{ iff } f(K, S) = 1, \text{ where } K \text{ is a } \textit{distinct subset} \text{ of } R.$$

The latter notion can be defined as follows. Suppose that K is a subset of ordered pairs of the domain D, such that $\varphi(x, y)$. Now let

$$K^D = \{x \mid \exists y\varphi(x, y)\}$$

and

$$K^{\bar{D}} = \{y \mid \exists x\varphi(x, y)\}.$$

That is, K^D and $K^{\bar{D}}$ are the domain and counter-domain of φ, respectively. Then, for some $K \subset R$

$$K \text{ is } \textit{distinct} =_{\text{df}} \forall x, y \in K^D \forall w, z \in K^{\bar{D}}\ (x \neq y \wedge w \neq z).$$

While these latter definitions are given for the case of a pair resumptive quantifiers, they can be generalized easily to resumptive quantifiers over n-tuples of arbitrary adicity. In the unary case, note, the distinct image of a set will be itself; since there is no distinction to be made between K^D and $K^{\bar{D}}$, the condition will (vacuously) require that all the members of K be different from one another.

The semantics can be further restricted by having the resumptive quantifiers apply not just to the distinct images of their arguments, but rather to *maximally distinct* images:

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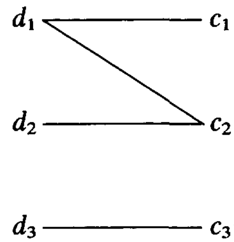
[18] Suppose that with respect to the structure of donkey-owning in (56) that o_4 who is the multiple donkey owner, doesn't beat all of the donkeys he owns. Barry Richards brings to my attention that many, but not all, people find *Most owners of a donkey beat it* false in this situation, truth requiring rather that each of the donkey owners beat all of the donkeys they own. It is not altogether clear to me at this point exactly how to incorporate the universal force into the semantics developed above; but see Rooth (1987) for some suggestions on how to proceed. Another problem with this treatment is pointed out by R. Fiengo. He notes if donkey-sentences are treated in the way described, then *Which owner of a donkey beats it* ought to be synonymous with *Which owner of which donkey beats it*, which is clearly not the case.

K is *maximally distinct* $=_{\text{df}} K$ is distinct $\wedge\ \forall$ *distinct* $K' \neq K(|K'| \leq |K|)$.

The semantics will now establish that truth can obtain only if the quantifier applies to a largest subset K of S containing only distinct pairings of individuals. Applicability of this articulation is to be found in such complicated situations as that depicted in (57):

(57)



Relative to this structure there are sets of distinct assignments constructable which are of different orders. For instance we have $\langle d_1, c_2\rangle$, $\langle d_3, c_3\rangle$ on the one hand, and $\langle d_1, c_1\rangle$, $\langle d_2, c_2\rangle$, $\langle d_3, c_3\rangle$ on the other, but it is only the latter collection which constitutes a maximally distinct set. Consequently we have it that relative to (57),

(58) At most two detectives solved at most two crimes

is false and

(59) At least three detectives solved at least three crimes

is true, as it is only the maximal set which matters for truth, and this set contains three, and not two, pairings of detectives and crimes.

The maximality condition, it turns out, can be subsumed under a narrower restriction on the *size specificity* of numerical quantifiers. Suppose that for some distinct $K \subset R$,

$$n(R, S) = 1 \text{ iff } |R^D| \geq n \wedge |R^{\bar{D}}| \geq n \wedge |K \cap S| \geq n.$$

(This condition is for the common 'at least' sense of numericals; the 'exactly' and 'at most' senses result by uniformly substituting '$=$' and '$\leq$' respectively.) The idea here is that resumptive numerical quantifiers not only specify how many n-tuples must stand in a relation for truth, but also specify how many individuals can be relatees. Thus (58) is false relative to (57), since there are more than two detectives and two crimes, but, on the other hand, (57) verifies (59), as there is the required minimum of three detectives and three crimes. The semantics also makes (58) false in the following situation, in which it is intended that each detective separately solved one hundred different crimes:

(60) d_1 ———————— $c_1, \ldots, c_{100}$
d_2 ———————— $c_{101}, \ldots, c_{200}$

Falsity here ensues because there are more than two crimes; in fact, there are two hundred. (60) also falsifies (61),

(61) Exactly two detectives solved exactly two crimes,

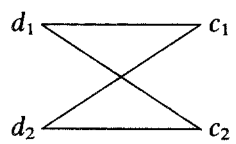
but, in fact, verifies (62),

(62) At least two detectives solved at least two crimes,

as the size-specificity requirement places only a *minimum* bound in this case, as opposed to a *maximal* bound in the case of *exactly two* and *at most two*. This just reflects, for the resumptive case, the fact that *at least n* is an increasing determiner, while both *at most n* and *exactly n* are non-increasing. Thus while the former is insensitive to growth of domain, the latter are not, and it is just the properties of these non-increasing quantifiers which require this articulation of the semantics of resumptive quantification.

Size-specificity, bear in mind, subsumes the maximality condition, but not the basic distinctness constraint, which is independent. Its independence can be observed by noting that it is called into play even when size-specificity is satisfied. Recall the situation depicted in (54),

(54)



(54) with respect to which (58), (61) and (62) are all true, even though there are four, and not two, pairings of individuals. In particular, there are not *precisely* two pairings, as the semantics of (61) would require, but there are precisely *two distinct* pairings, and it is this which is required for truth.

The picture being painted of the semantics of resumptive numerical quantifiers can be construed intuitively by thinking of it being composed of three parts: A size-specification, a quantificational force and a distinctness condition. This last property seems to be the most general, perhaps a contribution of the plurality of the sentence, while the former two appear more specific to numerical, or perhaps, more generally, measure, quantification, as they need not be distinguished in order to provide a proper semantics for the standard, classical quantifiers.

5.2. *Collective Construals*

The interpretations we have this far been considering of our prototypical sentence *Two detectives solved two crimes* fall under what are commonly called *distributive* construals. Intuitively this is because there is no presumed connection between the events of crime-solving by each of the detectives; rather they constitute spatio-temporally disjoint occurrences. Semantically this is expressed in the satisfaction clause for the quantifier **TWO**, which in the resumptive case requires that there be two distinct n-tuples of individuals for whom the relevant n-place predicate holds. The satisfaction clause given as (50) above specifies, therefore, a *singular* interpretation when applied to *Two detectives solved two crimes*, as it requires that there must be two (or, in the general case, n-many) sequences satisfying a singular relation, that is a relation which holds of individuals. In contrast to such singular/distributive interpretations, morphologically plural sentences such as we are considering may also be understood *collectively*. The difference here is that it is presumed that there is a connection between the events of crime-solving – in fact the presumption is that the detectives acted together, in concert, so that rather than constituting multiple singular events, the crime-solving constitutes a single plural event. With respect to this single event, the detectives are understood to be acting as co-agents in the solving of the two crimes, understood as co-objects, while on the distributive interpretation no such connections are assumed. Now on the collective construal it will be the case that both detectives participated in solving both crimes, so that (55) will depict a situation under which *Two detectives solved two crimes* is true. Indeed it will depict the *only* situation under which it is true, collectively understood. Consequently it would be inappropriate to treat this construal via resumptive quantification, although it would appear to be appropriate to take it as a case of branching quantification, as suggested by Carlson (1980). Recall that essential branching requires that a formula be satisfied solely by situations manifesting an each/all relation, an interpretation characterized by (63), and satisfied in (55), where $X = \{x \mid \text{detective}(x)\}$ and $Y = \{y \mid \text{crime}(y)\}$:[19]

[19] Actually (63) applies only if the numerical expression has the monotone increasing 'at least' sense, since there is no branching semantics defined under Barwise's treatment for the non-monotone 'exactly' sense. Westerståhl (1987), citing van Benthem, gives a strictly second-order semantics for the non-monotone case in terms of relational generalized quantifiers.

(63) $\exists X \exists Y[\mathbf{TWO}x\,(x \in X) \wedge \mathbf{TWO}y\,(y \in Y)$
$\wedge\, \forall x \forall y\,(x \in X \wedge y \in Y \rightarrow \varphi(x, y))]$.

While treating the collective interpretation via branching would be formally correct, I think that approaching it in this way in fact misses the relevant difference between the distributive and collective interpretation. That is, if we consider these two construals only with respect to the relation between individuals depicted in (55), then the difference between them must devolve upon whether truth obtains just in this circumstance (collective) or not (distributive). But, as just discussed, the relevant distinction is not this at all, but rather turns on how individuals are understood to fulfill the thematic roles of a predicate's argument structure. This is not a distinction, however, that the semantics of branching can capture. It is only concerned with whether a particular type of relation – the each/all relation – holds between the individuals, regardless of whether they happen to stand in this relation because they acted in concert or by mere happenstance. Thus the semantics of branching quantification is not, in fact, sufficiently structured to distinguish the collective interpretation from an instance of the distributive interpretation.

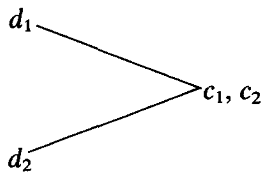
Rejecting branching, therefore, as an approach to characterizing collective construals, we need to adopt some other approach. For our purposes here it will do to assume a mereological structure, recently popularized in the literature by Link (1983, 1987) and others, in which the domain of the model is populated, intuitively, not only by atomic individuals of the sort normally countenanced, but also by sums of such individuals. Such individual sums are themselves to be understood as individuals, just as much able to bear thematic roles as atomic individuals. Thus while the subject NP in *John lifted the piano* denotes an atomic individual as agent of the action, the subject of *John and Bill lifted the piano*, on its NP-conjunction construal, denotes an individual sum, composed of John and Bill, as co-agents of the action. Individual sums, denotations of plural noun phrases, are to be distinguished carefully from the collections serving as denotations of predicates, in that the latter do not bear thematic roles, but are rather collections of individuals who bear such roles. While individual sums are also collections of (atomic) individuals, the members themselves do not bear thematic roles. Rather it is the sum which bears the role, and hence as such can stand as argument of a predicate. Such individual sums can be denoted not only by conjunctions of (atomic) individual denoting expressions, but also by other plural noun phrases such as plural pronouns, and definite and demonstrative noun phrases. Such entities many also be denoted, I presume, by numerical expressions, where the numeral fixes the atomic number of the sum – *two detectives*, for instance, denotes an individual sum whose atomic number is 2. The collective construal of *Two detectives solved two crimes* will then be just that interpretation in which the two NPs each denote individual sums, and it will thus be true just in case the detectives, acting as co-agents, solved the crimes, as co-objects.

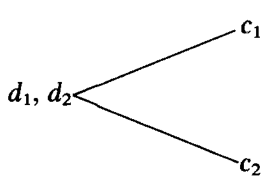
The view of numerical phrases which emerges from this is that they are ambiguous between expressions which quantify over individual atoms and expressions which denote individual sums. The former is distributive and singular, the latter is collective and plural. The two types of construals can be mixed, so that we have the interpretations represented in (64), where I represent expressions denoting individual sums by '$\|\alpha\|^n$', for some atomic number n:

(64)a. **TWO**x (detective(x)) x solved $\|$ crimes $\|^2$

b. **TWO**y (crime(y)) $\|$ detectives $\|^2$ solved y.

(64a) will be true just in case for each of two detectives there is a single pair of crimes that they both solved, while (64b)'s truth requires that for each of two crimes, there is a single pair of detectives who solved both of them. The situations depicted in (65) and (66) satisfy these conditions, respectively:

(65)


(66)


(These interpretations perhaps become more salient if a demonstrative is added to one or the other of the numerical phrases. Thus, *Two detectives solved those two crimes* and *Those two detectives solved two crimes* more clearly indicate the intended construals.) These construals have a commonality with the singular interpretation in that they entail that there are two events of crime solving, as well as a commonality with the plural interpretation, in that each event involves either co-agents or co-objects of solving – hence their mixed interpretive status.[20]

6. BRANCHING QUANTIFICATION

A resumptive use of the quantifier *most* is to be found in multiple generalization sentences such as (67), adapted from Barwise (1979):

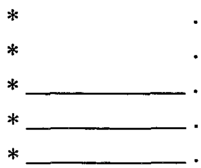
(67) Most stars are connected to most dots.

Under the semantics of strong resumptive quantification, as represented by (68),

(68) $\mathbf{MOST}x,\ y\ (\text{star}(x) \wedge \text{dot}(y))\ x$ is connected to y,

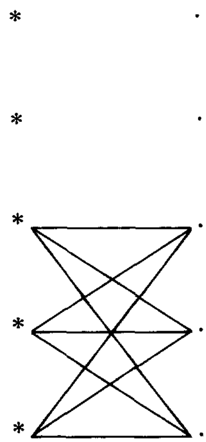
for truth to obtain there need only be some connection between the stars and the dots; all that is required is that at least three disjoint pairs are connected. Hence, as in the above treatment of multiple numerical sentences, (67) is vaguely interpreted, and is true both with respect to (69) and (70):

(69)



[20] My comments here are not meant to preclude the possibility that a more thorough rethinking of the semantics of collective construal is called for. Considerations raised in Schein (1986) raise many issues regarding the role of sets or set-like objects in the interpretation of collective plurals, which he seeks to replace by an approach which takes both numerical expressions and thematic roles as predicates of event arguments. Schein's approach has much to recommend it, not least of which is that it makes explicit the logical role of thematic structure relative to the notion of event, which at best is only explicated under our approach implicitly with respect to the semantics of quantification and reference. Schein points out that once this type of interpretation is in place, it can be extended to cases of the sort discussed here. So, for instance, *Two mathematicians proved two theorems* can be analyzed, roughly, as 'There is an event whose participants are two mathematicians and two theorems which is a solving event by the former of the latter", where truth obtains under any way of relating the mathematicians and the theorems which satisfies this description. It should be noted, however, that Schein has to build into his system a quantificational semantics for standard (atomic) individuals in order to account for the scopal construals of sentences such as that above. It thus becomes a more general issue whether it is appropriate to analyze 'sum' interpretations under a generalization of the analysis of collectives, as Schein would have it, or as a generalization of the analysis of distributives, which employs just the calculus of individuals, as I have proposed here.

(70)



A similar example is brought to my attention by Barbara Partee:

(71) Most men I know are married to most women I know.

To my ear the truth-conditions of this sentence range vaguely over monogamous and polygamous situations.

Things become somewhat more interesting, however, when the interpretation of (67) is contrasted with that of (72), again adapted from Barwise:

(72) Most of the stars are all connected to most of the dots.

This sentence, which differs essentially only in the presence of the quantifier word *all* attached to the verb phrase, is true only with respect to (70). That is, its truth requires that the stronger each/all condition be satisfied – in other words, it is an instance of essential branching quantification. In this regard (72) differs from the cases discussed in previous sections, which express at best pseudo-branching, and which consequently do not provide any reason to maintain branching as part of the quantificational resources of natural language in any fundamental sense. But the case here indicates that matters are more subtle – that while natural languages do not exhibit any instances of *covert* branching quantification, there are instances of *overtly marked* branching. It is the overt presence of *all* which explicitly marks the each/all condition. The question which arises, then, is how can the role of this element be integrated into the semantic composition of examples like (72)?

Let us suppose that *all* (as well as *each*) when attached to a verb phrase determines that the predicate applies to atomic individuals. That is, it is to be understood as a 'distributor' introducing a universal quantifier over the atomic members of a sum. To represent this semantically, I borrow from Link (1987) a two-place predicate, '$\cdot\Pi$' which in effect partitions an individual sum into its atomic parts.[21] Thus we read '$x \cdot \Pi y$' as 'x is an atomic part of the individual sum y' – note that the variable y must range over individual sums, since only they can be partitioned into atoms. The role of *all* and *each* can now be characterized as turning a predicate φ into a distributed predicate $D\varphi$ which denotes:

$$\{y \mid \forall x\, x(\cdot\Pi) y\, \varphi(x)\}.$$

I will assume that this operation generalizes to all positions which occur free within the (syntactic) scope of the distribution elements, making it, in this sense, unselective. So, for instance, for a two-place relation under the scope of a distributor, we obtain

$$\{\langle x, y\rangle \mid \forall w, z(w(\cdot\Pi)x \wedge z(\cdot\Pi)y)\varphi(w, z)\}$$

as a derived relation.

Turning now to the case at hand, I assume that at LF *all* is attached to VP, and hence has its scope delimited as narrower than the *most*-phrases, which have been extracted and adjoined to S. Consequently, *all* will effect partitionings relative to the subject and object positions, both of which reside free within its scope. This gives the predicate

$$\forall w, z(w(\cdot\Pi)x \wedge z(\cdot\Pi)y)\ w \text{ is connected to } z,$$

which expresses the each/all condition, as applied to a pair of individual sums. The variables which occur free in this predicate will then in turn be bound by the broader scope partitive *most*-phrases. These phrases, however, cannot be treated as normal quantifier phrases – as '**most**x' and '**most**y' – given the analysis of distributed predicates, as such quantifier phrases apply only to atomic individuals, while the variables free in the above expression range over individual sums. So construed *most* cannot bind into a predicate under the scope of *all*; hence we must treat the interpretation of these phrases in a rather different fashion.

A distinguishing characteristic of phrases with determiners like *most* is that they effect measures of groups, and this must be expressed in their semantics in some fashion. One way to do this, of course, is through the semantics of the simple atomic quantifier *most*. It can also be made concrete in another fashion by allowing the formation of measure operators on partitions of individual sums. Using the current case as an example, we have the measure operator '**most** Π' defined as follows,

[21] In fact Link introduces a general partition operator and an atomic partition operator, with the former corresponding to *all* and the latter to *each*. I will ignore this subtlety here.

(where, as before, the brackets indicate atomic number):

$$x(\mathbf{most}\,\Pi)y =_{\mathrm{df}} \|x \cap y\| > \|y - x\|.$$

The *most*-phrase can now be taken as the existential closures of such measured partitions, giving the following translation:

most of the stars $\Rightarrow \exists x\, x(\mathbf{most}\Pi)$ the stars.

Under this semantics, the truth of '*most*(φ)' will require that there is a 'most-sized' individual sum which satisfies φ, (where φ may be a distributed predicate or not). Since most-sized is usually not atomic-sized, the variables bound by *most* under this interpretation will run freely over both atomic and sum individuals. Putting this together with the treatment of *all*, we arrive at the following interpretation for *Most of the stars are all connected to most of the dots*:

(73) $\exists x(x(\mathbf{most}\Pi)\text{the stars})\exists y(y(\mathbf{most}\Pi)\text{the dots})\forall w, z(w(\cdot\Pi)x \wedge z(\cdot\Pi)y)$ (w is connected to z).

(73) states that there are most-sized partitions of the stars and the dots, such that each atomic member of the former is connected to each atomic member of the latter. It is therefore true just in the sort of situation characterized by (71), and false with respect to (70), and hence expresses an essential branching condition.

Given that the treatment of branching attributes its occurrence to aspects of compositional structure, we would expect the semantic definition of branching to be a general one, applicable regardless of the quantifiers involved. An impediment to this generality, however, is apparently placed by sentences such as (74):

(74) Few of the stars are all connected to few of the dots.

The reason for this is that, under the proposed semantics for (74), given in (75), this sentence comes out as true with respect to (70):

(75) $\exists x\,(x(\mathbf{few}\Pi)\text{the stars})\,\exists y\,(y(\mathbf{few}\Pi)\text{the dots})$
$\forall w, z\,(w(\cdot\Pi)x \wedge z(\cdot\Pi)y)$ (w is connected to z).

This is because in the relation depicted by (70), there is a sub-relation whose domain and counter-domain are 'few-sized' sets of stars and dots, S' and D' – the bottom two stars and the bottom two dots – such that each member of S' is connected to every member of D'. The desired generality can be acquired, however, by following suggestions of Sher (1989a, 1989b) that branching is applicable only with respect to *maximal* sets. While for increasing quantifiers like *most* the effects of this condition will not be apparent, they will be for decreasing quantifiers like *few*. In particular, (74) will now come out as false in the situation just described, since S' and D', while few-sized, are not the maximal sets of stars and dots which stand in the each/all relation. Note that these considerations, when taken in conjunction with those in Section 5.1, indicate that the maximality condition is not a particular property of branching quantification, but rather arise from deeper properties of the semantics of plurality.

The treatment of branching envisioned here, I should point out, applies regardless of whether the quantified phrase is partitive or not. Following Heim (1982) among other references, I will assume that partitivity is distinguished only with respect to pragmatic conditions governing their use in familiar, non-novel contexts, and that their semantics are just the same as their non-positive counterparts. Thus the points I have made thus far regarding branching quantification could just as well have been illustrated with non-partitive expressions, (although perhaps certain aspects of the partitives make for more salient expression of the desired interpretations). Alternatively, one might hold that partitives actually semantically differ from non-partitives in some way. For instance, it might be assumed that they simply denote sums of certain sizes, where the group over which the sum ranges is contextually fixed, (an analysis indicated, for instance, in brief comments by Link (1987).) Suppose we designate such expressions by '$\delta x\, x \cdot \Pi$NP', which denotes a sum individual made up of δ-many atoms which are parts of the sum denoted by NP. The interpretation of *Most of the stars are all connected to most of the dots* would then be as in (76):

(76) $\forall w, z\ (w \cdot \Pi(\mathbf{most}x\ x \cdot \Pi\text{the stars}) \wedge z \cdot \Pi(\mathbf{most}y\ y \cdot \Pi\text{the dots}))\ w \text{ is connected to } z).$

While this will certainly be true of (70) (and false of (69)), since it requires that every atom of a most-sized sum of stars be connected to all atoms of a most-sized sum of dots, the problem is that its negation, (77), is also true of (70).

(77) $\neg\forall w, z\ (w \cdot \Pi(\mathbf{most}x\ x \cdot \Pi\text{the stars}) \wedge z \cdot \Pi(\mathbf{most}y\ y \cdot \Pi\text{the dots}))\ w \text{ is connected to } z).$

This is because just as we can find in (70) most-sized groups of stars and dots for which there is an each/all relation, namely the bottom three, we can also find such groups, for instance the middle three stars and the middle three dots, for which it will not be the case that every pair of a star and a dot are connected. But plainly the negation of (72) is false in

(70):

(78) Most of the stars aren't all connected to most of the dots.

The negation of (73), however, will ascribe the correct truth-conditions:

(79) $\neg\exists x\ (x(\mathbf{most}\Pi)\text{the stars})\ \exists y\ (y(\mathbf{most}\Pi)\text{the dots})$
$\forall w, z\ (w(\cdot\Pi)x \wedge z(\cdot\Pi)y)\ (w \text{ is connected to } z)$.

This interpretation requires that there be no way of partitioning up the stars and dots into most-sized groups which stand in the each/all relation. But clearly in (70) there is such a partitioning; hence the falsehood of (78). We thus must reject any analysis in which the *most*-phrases can be denoting expressions which can stand inside the scope of the universal quantifiers introduced by the distributing expression.[22]

Transposed into the terminology of individuals and individual sums I am exploiting here, the analysis of branching presented is, from the semantic point of view, similar to that of Barwise (1979). The treatment differs from Barwise's, however, in its emphasis on showing how branching can arise as a function of the *composition* of sentences of a certain form. Branching results, on the analysis here, from particular aspects of a sentence's *syntactic* construction, turning on the presence of certain types of elements and constructional properties. Of particular importance is the role of *all* as a distributor and the restrictions it places on the variables which occur free within the predicate to which it applies.[23] Under Barwise's analysis restrictions on branching arise from a different source, keyed to inferential properties of the quantifiers. So, for instance, true second-order branching is limited just to monotone increasing quantifiers, and is excluded, for the reasons discussed in Section 3, for decreasing quantifiers like *few*. On the analysis here, the key to branching quantification resides in it being determined in a purely compositional fashion. Where the building blocks of this interpretation are not explicitly marked – for instance by the presence of *all* – the resulting quantificational conditions will be first-order, although the first-order quantifiers will bifurcate between those which display dependencies – the n-ary quantifiers – and those which do not – the independent, resumptive quantifiers. Moreover, because of the compositional nature of the analysis, it extends to the full class of generalized branching structures

[22] I am grateful to Bill Ladusaw for apprising me of the problems surrounding the analysis just described in the context of branching quantification.

[23] Or other elements such as floated *each* and the distributor introduced by reciprocal *each other*. On the latter see Heim, Lasnik and May (to appear).

discussed in Sher (1989a, 1989b), who points out that there is a whole range of explicitly marked second-order branching conditions, besides the each/all condition introduced by *all*, which are introduced by some partitioning operator on the verb phrase. These cases are beyond the scope of Barwise's analysis. The occurrence of branching, therefore, is fundamentally determined by *syntactic*, and not semantic, conditions. By treating branching in this way it is possible to *explain* just why and where this particular semantic condition will obtain – it is simply to be found just where there are multiple partitioning, which arise only in the presence of elements with very particular semantic roles.

7. Concluding Comment

In these investigations I have been exploring the implications for the semantics of natural language of taking the logical form of multiple quantification to be symmetrically represented. The dependencies of relative scope, which are no longer be expressed syntactically at Logical Form, are semantically characterized through absorbed quantification. Additionally those configurations of quantifiers at LF – Σ-sequences – which allow of free relative scope ordering also allow, when satisfying an appropriate identity condition, of another type of interpretation, resumptive quantification. These quantifiers were shown to be both independent – that is, not scopally related – and first-order, and to apply quite generally to morphologically singular and plural quantified noun phrases. The semantics of resumptive quantification, however, does not exhaust the interpretive possibilities of multiple generalization sentences meeting the identity condition, which shows up in the analysis of plural sentences, which call for a more highly articulated semantics for resumptive quantifiers. To account for collective construals individual sums are introduced into the domain as their denotations, alongside of individual atoms. Plural noun phrases are therefore to be divided into two types. The first are exemplified by quantifier phrases, such as *many students* or *two detectives*. They range over atomic individuals, and are, in the defined sense, singular. When sequences of such phrases satisfy the identity condition they may be interpreted resumptively. The second class are denoting expressions, whose denotations are non-atomic individual sums. Included in this class are the definite plurals and plural pronouns, as well as numerical expressions, which reside ambiguously in both this and the former class. Under this interpretation they express collective construals. Moreover, plurals can be understood to existentially quantify over the non-atomic entities to which the latter sort of expressions refer. This latter construal is implicated in the analysis of configurations in which true branching quantification is observed. Examination of these cases showed, however, that while branching is found in natural languages, it is only found when explicitly indicated in the sentences overt form, and as such fixing on this interpretation is strictly compositional. In general, then, natural language quantification, relative to our assumptions regarding its logical form, falls within the confines of a first-order theory, even when independent, except where certain syntactic devices such as floated quantifiers come into play and determine a more highly structured interpretation not expressible in first-order terms.

REFERENCES

Aoun, J. and D. Sportiche: 1983, 'On the Formal Theory of Government', *The Linguistic Review* **2**, 211–36.

Barwise, J.: 1979, 'On Branching Quantifiers in English', *Journal of Philosophical Logic* **8**, 47–80.

Barwise, J. and R. Cooper: 1981, 'Generalized Quantifiers and Natural Language', *Linguistics and Philosophy* **4**, 159–219.

Benthem, J. van: 1983a, 'Determiners and Logic', *Linguistics and Philosophy* **6**, 447–78.

Benthem, J. van: 1983b, 'Five Easy Pieces', in A. G. B. ter Meulen (ed.), *Studies in Modeltheoretic Semantics*, Foris Publications, Dordrecht.

Benthem, J. van: 1989, 'Polyadic Quantifiers', *Linguistics and Philosophy* **12**, this issue, 437–464.

Carlson, L.: 1980, 'Plural Quantification', ms., MIT, Cambridge, Mass.

Chomsky, N.: 1986, *Barriers*, MIT Press, Cambridge, Mass.

Clark, R. and E. Keenan: 1987, 'The Absorption Operator and Universal Grammar', *The Linguistic Review* **5**, 113–136.

Fauconnier, G.: 1975, 'Do Quantifiers Branch', *Linguistic Inquiry* **6**, 555–78.

Heim, I.: 1982, *The Semantics of Definite and Indefinite Noun Phrases*, Doctoral dissertation, University of Massachusetts, Amherst, Massachusetts.

Heim, I., H. Lasnik and R. May: (to appear), 'Reciprocity and Plurality', ms., UCLA, University of Connecticut and University of California, Irvine. To appear in R. May (ed.), *Grammar and Interpretation*, MIT Press, Cambridge, Mass.

Higginbotham, J.: 1985, 'On Semantics', *Linguistic Inquiry* **16**, 547–94.

Higginbotham, J.: 1989, 'Elucidations of Meaning', *Linguistics and Philosophy* **12**, this issue, 465–517.

Higginbotham, J. and R. May: 1981, 'Questions, Quantifiers and Crossing', *The Linguistic Review* **1**, 41–79.

Hintikka, J.: 1974, 'Quantifiers vs. Quantification Theory', *Linguistic Inquiry* **5**, 154–77.

Keenan, E.: 1987, 'Unreducible n-ary Quantifiers in Natural Language', in P. Gärdenfors (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*, Reidel, Dordrecht, The Netherlands.

Keenan, E. and J. Stavi: 1986, 'A Semantic Characterization of Natural Language Determiners', *Linguistics and Philosophy* **9**, 253–326.

Lindström, P.: 1966, 'First Order Predicate Logic with Generalized Quantifiers', *Theoria* **30–32**, 186–95.

Link, G.: 1983, 'The Logical Analysis of Plurals and Mass Terms: A Lattice-Theoretical

Approach', in R. Bauerle et al. (eds.), *Meaning, Use and Interpretation of Language*, de Gruyter, Berlin.
Link, G.: 1987, 'Generalized Quantifiers and Plurals', in P. Gärdenfors (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*, Reidel, Dordrecht, The Netherlands.
May, R.: 1977, *The Grammar of Quantification*, Doctoral dissertation, MIT, Cambridge, Massachusetts. (Distributed by Indiana University Linguistics Club.)
May, R.: 1985, *Logical Form: Its Structure and Derivation*, MIT Press, Cambridge, Mass.
May, R.: 1988, 'Ambiguities of Quantification and WH: A Reply to Williams', *Linguistic Inquiry* **19**, 118–35.
May, S. de: 1987, 'Transitive Sentences and the Property of Logicality', in I. Rusza and A. Szabolcsi (eds.), *Proceedings of the '87 Debrecen Symposium on Logic and Language*, Akademiai Kiado, Budapest.
Mostowski, A.: 1957, 'On a Generalization of Quantifiers', *Fundamenta Mathematica* **44**, 12–36.
Reinhart, T.: 1976, *The Syntactic Domain of Anaphora*, Doctoral dissertation, MIT, Cambridge, Massachusetts.
Reinhart, T.: 1983, *Anaphora and Semantic Interpretation*, Croon Helm, London.
Rooth, M.: 1987, 'NP Interpretation in Montague Grammar, File Change Semantics, and Situation Semantics', in P. Gärdenfors (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*, Reidel, Dordrecht, The Netherlands.
Schein, B.: 1986, *Event Logic and the Interpretation of Plurals*, Doctoral dissertation, MIT, Cambridge, Massachusetts.
Sher, G.: 1989a, *Generalized Logic*, Doctoral dissertation, Columbia University, New York, NY.
Sher, G.: 1989b, 'Ways of Branching Quantifiers', ms., Columbia University, New York, N.Y. To appear in *Linguistics and Philosophy*.
Thomason, R.: 1977, 'Multiple Quantification, Questions, and Bach–Peters Sentences: Some Preliminary Notes', ms., University of Pittsburgh.
Westerståhl, D.: 1987, 'Branching Generalized Quantifiers and Natural Language', in P. Gärdenfors (ed.), *Generalized Quantifiers: Linguistic and Logical Approaches*, Reidel, Dordrecht, The Netherlands.

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