LOGICALITY AND THE DETERMINATION OF SYNTACTIC CATEGORIES IN NATURAL LANGUAGE[1]

Shalom Lappin
School of Oriental and African Studies
University of London

1. INTRODUCTION

It is possible to distinguish two main approaches to the syntax and semantics of noun phrases. On the Fregean view, the class of NPs is partitioned into two distinct categories. Proper names correspond to constants which are arguments of predicates. Quantified NPs are treated as expressions in which the determiner denotes a unary quantifier and its N' is a predicate restricting the domain of the quantifier.

Higginbotham and May (1981), Higginbotham (1985), and May (1985), (1989), and (1991), have developed the Fregean view within the framework of Chomsky's Principles and Parameters model of grammar.[2] They propose a rule of quantifier raising (QR) which adjoins quantified NPs to VP or IP. This rule creates an abstract (non-overt) level of syntactic structure, logical form (LF), in which a quantified NP is an operator binding a syntactic variable (an A'-bound trace) in its original argument position. These structures provide the input to rules of semantic interpretation which take quantified NPs to be restricted quantifiers and the traces which they bind to be bound variables. Names are not within the domain of QR, and so they remain *in situ* at LF, where they are interpreted as referring expressions. 2a,b are the LF's of 1a,b respectively.

1a. John sings.
 b. Every student sings.

2a. $[_{IP}\ [_{NP}\ \text{John}][_{VP}\ \text{sings}]]$
 b. $[_{IP'}\ [_{NP}\ \text{every student}]_1[_{IP}\ t_1\ \text{sings}]]$

3b and 3c are the two possible LF representations of 3a.

3a. Most students completed a paper.
 b. $[_{IP'}\ [_{NP}\ \text{most students}]_1[t_1\ [_{VP'}\ [_{NP}\ \text{a paper}]_2[_{VP}\ \text{completed}\ t_2]]]]$
 c. $[_{NP'}\ [_{NP}\ \text{a paper}]_2[_{NP}\ \text{most students}]_1][_{IP}\ t_1\ \text{completed}\ t_2]$

3b corresponds to the reading of 4a on which *most students* receives wide scope, by virtue of the fact that *most students* asymmetrically c-commands *a paper* in this structure. In 3c *most students* and *a paper* c-command each other, and so either NP can be interpreted as having scope over the other. Therefore, 3c does not uniquely determine the scope interpretation of the quantified NPs in 3a and can feed a wide scope reading of either NP.[3]

May (1991) suggests that the property of logicality is the criterion for distinguishing between quantified and non-quantified NPs. Those NPs which correspond to restricted (unary) quantifiers are constructed by the application of a logical determiner (determiners which denote logical quantifiers) to an N'. In a sense which will be made precise in Section 2, such NPs can themselves be regarded as logical terms (more precisely, as corresponding to logical functions). Non-quantified NPs, on the other hand, are non-logical expressions. May (1991) makes logicality a necessary condition for the application of QR to an NP. He states that one of the central properties of LF is that it represents the syntactic structure of logical terms, particularly quantified expressions. The assertion that the distinction between logical and non-logical NPs corresponds to a difference in syntactic category and semantic type is an interesting empirical claim concerning the organization of categories and types in the grammar of natural language. I will refer to this assertion as the *Logicality Thesis.*

Generalized quantifier (GQ) theory provides an alternative to the Fregean analysis of noun phrases.[4] On the GQ view, NPs constitute a unified syntactic category and semantic type. Names and quantified NPs are not factored into distinct types. Every NP denotes a set of sets (or a set of properties), while a determiner denotes a function from a set to a set of sets (alternatively, a determiner denotes a relation between sets). 4a-c illustrate the way in which names and quantified NPs receive interpretations of the same type within the framework of GQ.

4a. $\|\text{John}\| = \{X \subseteq E: j \in X\}$
b. $\|\text{every student}\| = \{X \subseteq E: \text{Students} \subseteq X\}$
c. $\|\text{most students}\| = \{X \subseteq E: |\text{Students} \cap X| > |\text{Students} - \text{Sings}|\}$

5a-c indicate the truth conditions for 1a, 2a, and *Most students sing*, respectively, given the interpretations of their subject NPs specified in 5.

5a. $\|\text{John sings}\| = t$ iff $\text{Sings} \in \{X \subseteq E: j \in X\}$ *iff* $j \in \text{Sings}$
b. $\|\text{every student sings}\| = t$ iff $\text{Students} \subseteq \text{Sings}$
c. $\|\text{most students sing}\| = t$ *iff* $|\text{Students} \cap \text{Sings}| > |\text{Students} - \text{Sings}|$

In contrast to the Fregean view, the GQ account takes logicality to be orthogonal to the category of NPs and the semantic type with which it is associated.

In this paper I consider the interpretation of exception phrase NPs, like the subject of 6a and 6b, in the context of the debate between the Fregean and the GQ approaches to the representation of NPs.

6a. Every student except John arrived.
b. No student except John arrived.

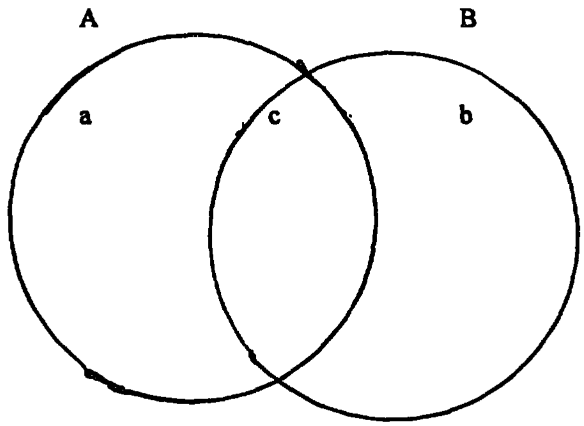
I argue that these NPs provide an important set of counter-examples to the Logicality Thesis that NPs are sorted according to logicality at the level of syntactic structure which provides the interface to semantic interpretation. Specifically, exception phrase NPs are heterogeneous with respect to logicality, but all members of this subcategory exhibit semantic and syntactic properties typical of other quantified NPs. This distribution of features within a subclass of quantified NPs is incompatible with the Logicality Thesis version of the Fregean approach, but it is entirely natural on the GQ account.

2. LOGICALITY

Mostowski (1957) characterizes a unary quantifier as a logical constant iff its interpretation remains constant under all permutations of the elements of the domain E, where a permutation is an automorphism of E which respects the cardinality of the subsets of E. Lindstrom (1966), van Benthem (1986) and (1989), and Sher (1991) and (forthcoming) progressively generalize this notion of logicality across syntactic categories to define a logical constant as a term whose interpretation is invariant under isomorphic structures defined on E.

If we apply this characterization of logicality to determiners, we can specify the set of logical determiners as the set which includes all and only those determiners denoting relations that depend solely upon the cardinality of the sets among which they hold and the cardinality of the intersections of these sets.[5] It is possible, then, to give the interpretation of a logical determiner as the cardinality values which apply to these sets if the relation denoted by the determiner holds. For the sets in 7 let $a = |A - B|$, $b = |B - A|$, and $c = |A \cap B|$. Examples of cardinality definitions for logical two-place determiners are given in 8.

7.



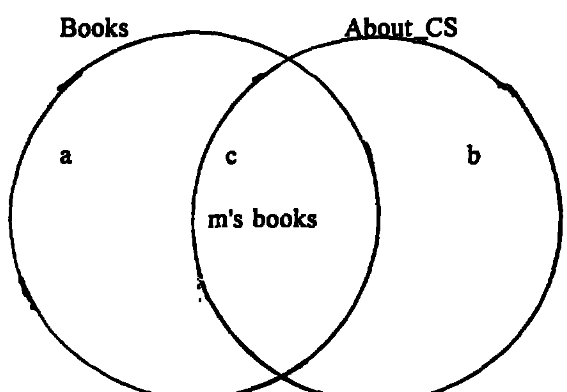
8a. every: $a = 0$
b. no: $c = 0$
c. some: $c \geq 1$
d. at least five: $c \geq 5$
e. most: $c > a$

Following van Benthem (1986) and (1989), we can characterize the set of logical NPs as in 10.

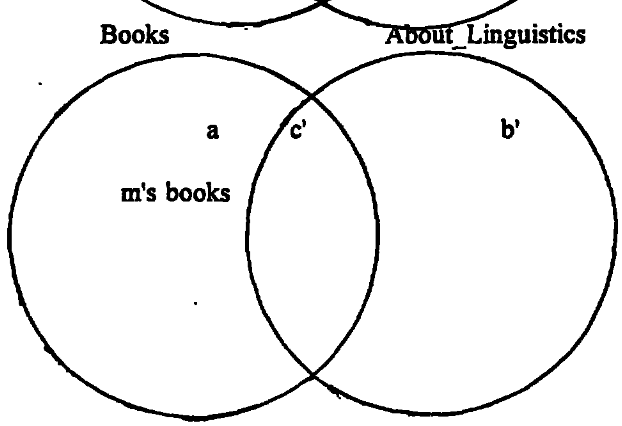
9. NP is a logical GQ iff, for every permutation π of E, $P \in ||NP||$ iff $\pi[P] \in ||NP||$.

Clearly, proper names do not satisfy 9. John may be a singer but not a dancer, even if the set of singers and the set of dancers have the same cardinality. For the case of NPs obtained by applying a determiner to an N', the contrast between logical and non-logical NPs is illustrated in 10 and 11.

10a.



b.



11a. c = c' & b = b'
b. Every/no/some/at least five/most books are about computer science. <=>
c. Every/no/some/at least five/most books are about linguistics
d. Mary's books are about computer science. <≠>
e. Mary's books are about linguistics

When we keep the N' set Books constant and take the cardinalities of the relevant sets in 10a and 10b to be as indicated in 11a, the equivalences between 11b and 11c hold by virtue of the fact that the NPs in the subject position of these sentences satisfy the condition in 9. However, assuming that all of Mary's books are about computer science but none of them are about linguistics, 11d and 11e are not equivalent. Therefore, *Mary's books* is not a logical NP.

The Logicality Thesis can be formulated as the claim that, at the level of syntactic representation which constitutes the interface to semantic interpretation, logical NPs are expressed as operator-variable chains while non-logical NPs appear in argument position.

3. THE INTERPRETATION OF EXCEPTION PHRASE NP's

It seems reasonable to require that any adequate account of exception phrase NPs should provide a compositional representation of the way in which the exception phrase (and its argument NP) contribute to the NP in which it appears. Moreover, there are at least three characteristic semantic properties of exception phrases which such an account should capture.[6]

First, the argument of the exception phrase falls under the N' restriction of the NP in which the exception phrase appears. Therefore, both 7a and 7b imply that John is a student.

6a. Every student except John arrived.
b. No student except John arrived.

Second, 6a implies that John did not arrive while 6b implies that he did. Finally, as 12 illustrates, exception phrases can only be applied to NPs with universal determiners.

12a.*Five students except John arrived.
b.*Most MP's except the Tories supported the bill.
c.*Mary spoke to many people except John.
d.*Not many students except five law students participated.

In Lappin (forthcoming) I discuss the analyses of exception phrases given in K&S, Hoeksema (1991), von Fintel (1993), and Moltmann (1993a) and (1993b). I argue that each of these theories suffers from a difficulty which prevents it from providing a fully adequate explanation of either the compositional interpretation of exception phrases, or one of the three characteristic semantic properties which theses phrases exhibit. I will limit myself here to presenting an alternative theory of exception phrase NP's. The account which I propose is in the spirit of the analyses suggested in Hoeksema (1991) and Moltmann, but it differs significantly from these treatments in the details of implementation. I follow Hoeksema and Moltmann in taking exception phrases to be modifiers of NP. I adopt Hoeksema's general strategy of characterizing the denotation of an exception phrase NP in terms of a remnant set A^{rem} obtained by subtracting a set associated with the NP argument of *except* from the restriction set A of the NP to which the exception phrase applies.

I use Moltmann's concept of a witness set to specify the set which is subtracted from A.

13. Moltmann (modifying B&C):
If A is the smallest set for which $||NP||$ is conservative, then W is a witness set for $||NP||$ iff $W \subseteq A$ and $W \in ||NP||$.

Any set of five students is a witness set for ||five students||, {john} is the only witness set for ||John||, and any set whose elements are John and three physics students is a witness set for ||John and three physics students||. For any generalized quantifier $||NP||$, let $w(||NP||)$ = the set of witness sets for $||NP||$.

I define a *total relation* R between two sets as in 13.

14. R is total iff (i) $R = \subseteq$, or (ii) for any two sets A, B, R(A,B) iff $A \cap B = \emptyset$.

According to 14, R is total iff it imposes a condition of inclusion or exclusion between two sets, and nothing more.

Let NP_2 be the NP to which the exception phrase *except*(NP_1) applies, and assume that $||NP_2|| = \{X \subseteq E: R(A,X)\}$. I restrict the domain of the function which an exception phrase denotes by requiring that it apply only to NP arguments for which R is total in every model M such that the value of the NP is defined in M. For any set X, let X' be the complement of X. We can specify the interpretation of exception phrase NPs by the rule given in 15.

15. $(||except||(||NP_1||))(||NP_2||) = \{X \subseteq E: R(A^{rem},X)\}$, where $||NP_2|| = \{X \subseteq E: R(A,X)\}$, R is total, and $\exists S(S \in w(||NP_1||)\ \&\ S \subseteq A\ \&\ A^{rem} = A - S\ \&\ R(S,X'))$.

If we apply 15 to *every student except five law students*, we obtain 16a. The interpretation of *every student except five law students participated* is given in 16b.

16a. $(||except||(\{X \subseteq E: |Law\_students \cap X| \geq 5\}))(\{X \subseteq E: Students \subseteq X\}) =$
$\{X \subseteq E: Students^{rem} \subseteq X\}$, where $\exists S(S \in w(\{X \subseteq E: |Law\_students \cap X| \geq 5\})\ \&$
$S \subseteq Students\ \&\ Students^{rem} = Students - S\ \&\ S \subseteq X'))$.

b. ||every student except five law students participated|| = t iff
$Students^{rem} \subseteq \{a: a \text{ participated}\}$, where
$\exists S(S \in w(\{X \subseteq E: |Law\_Students \cap X| \geq 5\})\ \&\ S \subseteq Students\ \&$
$Students^{rem} = Students - S\ \&\ S \subseteq \{a: a \text{ participated}\}'\ ))$.

15 provides a unified compositional representation of exception phrase NPs. It also captures the three central semantic properties of these NPs. First, given this definition, both 6a and 6b imply that John is a student. This implication holds by virtue of the fact that the witness sets for $||NP_1||$, the argument of the exception phrase, which render the existential assertion in 15 true are subsets of the N' set of the NP to which the exception phrase applies.

Second, it sustains the inference from 6a to the assertion that John did arrive, and the inference from 6b to the statement that John did not arrive. These inferences hold because of the requirement that the same total relation R which holds between the remnant set A^{rem} and the VP set, also hold for the witness set S for $||NP_1||$ in terms of which A^{rem} is defined and the complement of the VP set.

Finally, in 15 the domain of exception phrase functions is restricted to generalized quantifiers whose determiners denote total relations between their N' sets and the VP sets of the predicate. Therefore, 15 correctly excludes the application of exception phrases to NPs whose determiners are not universal, like those in 12.

12a.*Five students except John arrived.
b.*Most MP's except the Tories supported the bill.
c.*Mary spoke to many people except John.
d.*Not many students except five law students participated.

Moltmann (1993b) points out that exception phrases can also apply to certain coordinate NPs. In 17, for example, *except the teachers* can be understood as modifying the conjoined NP *every mother and every father.*

17. Every mother and every father except the teachers joined the PTA.

It seems that when exception phrases modify coordinate NPs, they are restricted to uniform conjunctions of positive or negative universally quantified NPs.

18a.*Every mother and no/several/most fathers except the teachers joined the PTA.
b.*Every mother or every father except the teachers joined the PTA.
c. No mother and no father except the teachers attended the meeting.
d.*No mother and every/several/most fathers except the teachers attended the meeting.
e.*No mother or no father except the teachers attended the meeting.

The denotation of an NP of the form *every*(A_1),..., *and every*(A_k) $(1 \leq k)$ is $\cap^k_{i=1}\|every(A_i)\|$ (the intersection of the denotations of each of the NP conjuncts). Similarly, the denotation of an NP of the form *no*(A_1),..., *and no*(A_k) $(1 \leq k)$ is $\cap^k_{i=1}\|no(A_i)\|$. For example, ||*every mother and every father*|| is the intersection of the set of sets containing all mothers and the set of sets containing all fathers. But this set is identical to the set of all sets containing the union of the set of mothers and the set of fathers. Similarly, the denotation of *no mother and no father* is the set of all sets whose intersection with the union of the set of mothers and the set of fathers is empty. Therefore, the identities in 18 hold.

19a. $\|\text{every}(A_1),\ldots,\text{ and every}(A_k)\| = \{X \subseteq E: (A_1 \cup \ldots \cup A_k) \subseteq X\}$
b. $\|\text{no}(A_1),\ldots,\text{ and no}(A_k)\| = \{X \subseteq E: (A_1 \cup \ldots \cup A_k) \cap X = \emptyset\}$

Given 19, the interpretation of exception phrases specified in 15 covers 17 and 18c, while excluding the ill formed cases of 18 .

It is important to note that the fact that exception phrases can apply to conjoined NPs provides strong motivation for treating them as modifiers of NP rather than as constituents of complex determiners.

Moltmann (1993a) and (1993b) also observes that exception phrases can modify uniform sequences of universally quantified NPs which are interpreted as resumptive quantifiers, as in 20.[7]

20. Every boy danced with every girl, except John with Mary.

20 asserts that for every ordered pair $<a,b>$ in which a is boy, b is a girl, and $<a,b> \neq <j,m>$, a danced with b, and j did not dance with m.

The resumptive GQ which corresponds to *<every boy, every girl>* in 19 is ||*every*||(Boys x Girls), which receives the interpretation given in 21.

21. $\|\text{every}\|(\text{Boys x Girls}) = \{R \subseteq E \times E: (\text{Boys x Girls}) \subseteq R\}$

The interpretation of the polyadic generalized quantifier associated with *<John,Mary>* is specified in 22.

22. $\|\langle\text{John,Mary}\rangle\| = \{R \subseteq E \times E: \|\text{John}\|(\{x: \|\text{Mary}\|(\{y: R(x,y)\}) = t\}) = t\}$

The witness set for the polyadic quantifier defined in 22 is $\{\langle j,m\rangle\}$. If we apply the exception phrase function $\|except\|(\{R \subseteq E \times E: (\text{Boys x Girls}) \subseteq R\})$ to the resumptive quantifier defined in 21, then, by 15, we obtain 23.

23. $(\|\text{except}\|(\{R \subseteq E \times E: \|\text{John}\|(\{x: \|\text{Mary}\|(\{y: R(x,y)\}) = t\}) = t\}))$
$(\{R \subseteq E \times E: (\text{Boys x Girls}) \subseteq R\}) = \{R \subseteq E \times E: (\text{Boys x Girls})^{rem} \subseteq R\}$, where
$\exists S(S \in w(\{R \subseteq E \times E: \|\text{John}\|(\{x: \|\text{Mary}\|(\{y: R(x,y)\}) = t\}) = t\})\ \&$
$S \subseteq (\text{Boys x Girls})\ \&\ (\text{Boys x Girls})^{rem} = (\text{Boys x Girls}) - S\ \&\ S \subseteq R'))$.

23 produces the interpretation of 20 given in 24, which represents the desired reading.

24. $\|\text{every boy danced with every girl, except John with Mary}\| = t$ iff
$(\text{Boys x Girls})^{rem} \subseteq \{\langle a,b\rangle: \text{danced\_with}(a,b\}$, where
$\exists S(S \in w(\{R \subseteq E \times E: \|\text{John}\|(\{x: \|\text{Mary}\|(\{y: R(x,y)\})\} = t)\} = t)\ \&$
$S \subseteq (\text{Boys x Girls})\ \&\ (\text{Boys x Girls})^{rem} = (\text{Boys x Girls}) - S\ \&$
$S \subseteq \{\langle a,b\rangle: \text{danced\_with}(a,b)\}'))$.

4. EXCEPTION PHRASES AND LOGICALITY

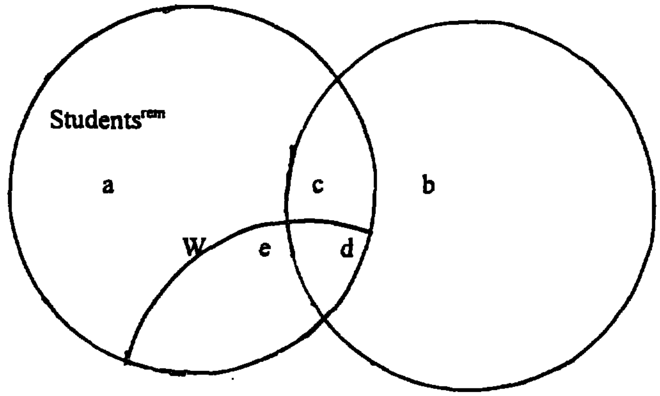
4.1. The Logically Heterogenous Character of Exception NPs

Let us return to the question of whether logicality provides a criterion for distinguishing different categories and types of NPs in natural language. Exception phrase NPs are heterogeneous with respect to logicality. An exception phrase NP is a logical GQ iff it is of the form *every A except det A*, and *det* is a logical determiner. This is not, the case for other exception NPs. Consider the contrast between 25a, on one hand, and 25b,c on the other.

25a. Every student except five (students) participated.
b. Every student except five law students participated.
c. Every student except John participated.

Let W in 26 be a witness set S for the argument of *except* which satisfies the condition for S specified in the existential clause of 15.

26. Students Participated



As 27a indicates, it is possible to characterize the interpretation of *every student except five* (*students*) solely in terms of the cardinality values a, d, and e, where, crucially, W can be any subset of Students with a cardinality of (at least) 5. Therefore, the truth-value of 25a remains constant for any permutation of the elements of the predicate set Participated with the elements of another set which respects the cardinality of Participated and its intersection with the set of Students. This is not the case for *every student except five law students* or *every student except John.*

27a. ||every student except five (students) participated|| = t iff a = 0, d = 0, & e$\geq$ 5
 (W any subset of Students^{-} with a cardinality of 5)
 b. ||every student except five law students) participated|| = t iff a = 0, d = 0, & e$\geq$ 5
 (W a set of law students with a cardinality of 5)
 c. ||every student except John participated|| = t iff a = 0 & W - Participated = {j}.

Given 27, if we substitute a set B for Participated which preserves the cardinal values a, b, c, d, and e but permutes elements of Students^{rem} $\cap$ Participated not contained in the set of law students with elements of W (so that the permutation verifies *Every student except five physics students B,* for example), then the truth-value of 25b changes. Similarly, if we substitute a set B for Participated which preserves the cardinal values a, b, c, d, and e but permutes john in W - Participated with bill in Students^{rem} $\cap$ Participated, the truth-value of 25c is altered.

However, both logical and non-logical exception phrase NPs display the same properties which May and Higginbotham initially cited as motivation for representing quantified NPs as operator-variable structures at LF. Specifically, both variants of exception phrases NPs exhibit the same relational scope properties as the logical GQ's from which they are derived. Thus, for example, the wide scope reading of the PP complement relative to *a representative* is preferred in each of the sentences in 28.

28a. A representative of every city attended the meeting.
 b. A representative of every city except two (cities) attended the meeting.
 c. A representative of every city except Migdal HaEmek attended the meeting.

Similarly, scope ambiguity is present in all of the sentences in 29.

29a. No student attended a logic course.
 b. No student except five (students) attended a logic course.
 c. No student except two computer science students attended a logic course.

Moreover, as the cases in 30 and 31 show, both logical and non-logical exception phrases impose a bound variable reading on the pronouns which they bind.

30a. Every student except one (student) submitted his paper.
b. Every student except John submitted his paper.

31a. No journalist except one checked his facts.
b. No journalist except Mary checked her facts.

The defining syntactic and semantic properties of exception phrase NPs do not appear to be sensitive to logicality. This provides motivation for the claim that these NPs form a unified syntactic sub-category of the category NP and a single semantic sub-type of the type GQ. As the property of logicality is orthogonal to this type, it does not provide the basis for distinguishing among different semantic types of NPs. This conclusion is incompatible with the Logicality Thesis, given the logically heterogenous character of exception phrase NPs. It is, however, a consequence of the generalized quantifier view on which NPs in general constitute a unified syntactic category and corresponding semantic type.

4.2. Exception Phrase NPs and the Deductive Treatment of Natural Language Quantifiers

Recently, several proof theoretic systems have been proposed for characterizing the meanings of natural language expressions through deductive procedures rather than model theoretic interpretation.[8] In general, these systems specify the contribution of an expression to the meaning of a sentence in terms of the set of inferences which the expression licenses. Van Benthem (1991) suggests that a proof-theoretic account of generalized quantifiers should satisfy the general constraint that the notion of entailment which it specifies is invariant under permutation in the sense defined in 32.

32. $X_1,\ldots,X_n \vdash A$ iff $\pi[X_1],\ldots,\pi[X_n] \vdash \pi[A]$ for each permutation π of the underlying universe of models or states.

This constraint effectively imposes the requirement of logicality on the generalized quantifiers whose interpretations are given proof-theoretically.

As we have seen, the set of generalized quantifiers which are generated by the application of exception phrase functions to universal NPs is not uniform with respect to logicality. Certain inference patterns will hold under all permutations for some exception NPs but not for others. Thus, for example, logical exception NPs will support inferences of the form given in 33, which is illustrated in 34.

33. Every/no A except n A's B.
The number of A's which B is equal to the number of A's which C. =>
Every/no A except n A's C.

34. Every/no student except five (students) sings.
The number of students who sing is equal to the number of students who dance. =>
Every/no student except five (students) dances.

Comparable inferences do not go through with non-logical exception NPs, like *every student except five law students*.

35. Every/no student except five law students sings.
The number of students who sing is equal to the number of students who dance. ≠>
Every/no student except five law students dances.

It follows that the GQ's denoted by exception phrase NPs cannot be uniformly modelled by a proof-theoretic system which satisfies the condition of invariance under permutation.To the extent, then, that a proof-theoretic representation of GQ's is a logical system (in the sense of this notion captured by 32), it will not be able to accommodate the full set of quantified NPs which occur in natural language. Exception phrase NPs indicate at least one of the limitations involved in using a proof-theoretic approach to represent generalized quantifiers corresponding to quantified NPs in natural language.

5. CONCLUSION

I have considered the debate between the Fregean and generalized quantifier approaches to NPs in light of the properties of exception phrase NPs, which constitute a subset of the set of quantified NPs. On May's version of the Fregean view, logicality is the basis for partitioning NPs into two distinct syntactic categories and associated semantic types. At the level of syntactic structure which determines the category-type correspondence, logical NPs are represented as operator-variable chains while non-logical NPs appear *in situ* in argument position. On the GQ view, logical and non-logical NPs are elements of a unified syntactic category and correspond to a single semantic type. The distinction between logical and non-logical NPs (as well as the difference between quantified and non-quantified NPs) is orthogonal to this category and its associated type.

I have proposed an account of exception phrase NP's which provides a compositional semantics for these terms and captures their characterisitic semantic properties. On this account, exception NPs are heterogeneous with respect to logicality. However, both logical and non-logical elements of this subset exhibit the scope and semantic binding properties of other quantified NPs. May and Higginbotham invoke these properties as an important part of their case for representing quantified NPs as operator-variable structures at LF. The fact that exception phrase NPs are non-uniform for logicality but behave like other quantified NPs in connection with scope and semantic binding provides motivation for the generalized quantifier approach to the syntax and semantics of NPs in natural language.

NOTES

1. I would like to thanks Ruth Kempson, and Friederike Moltmann for helpful discussion of some of the ideas contained in this paper. I am particularly grateful to Jaap van der Does for extensive comments on an earlier version of this paper.

2. See Chomsky (1981), (1986), (1993), and (1995) for this model of syntax.

3. See May (1985) and (1989) for a discussion of the relation between the syntactic scope of an NP at LF and the set of possible scope interpretations which its syntactic scope allows.

4. See, for example, Montague (1974), Barwise and Cooper (1981) (B&C), Cooper (1983), Keenan and Stavi (1986) (K&S), and van Benthem (1986) for different versions of the GQ approach.

May and Higginbotham provide independent syntactic and semantic arguments for incorporating QR and the level of representation which it defines into the grammar. See Lappin (1991) for a critical discussion of some of these arguments and a defence of the GQ account of the semantics of NPs. See May (1991) for a response to some of the points raised in Lappin (1991).

5. Westerstahl (1989) specifies that in addition to permutation invariance for isomorphic structures defined on E (his condition of Quantity), logical determiner functions must also satisfy Conservativity and Extension, where the definitions of these conditions for k-place ($1 \leq k$) determiner functions are given in (i) and (ii), respectively (see B&C, van Benthem, Keenan and Moss (1985), and K&S for discussions of conservativity).

(i) A k-place determiner function det is conservative iff
$B \in det\ (A_1,\ldots,A_k) <=> (A_1 \cup \ldots \cup A_k) \cap B \in det\ (A_1,\ldots,A_k)$.

(ii) A k-place determiner function det satisfies Extension iff
for any two models M and M', if $A_1,\ldots,A_k \subseteq M \subseteq M'$, then
$det_M\ (A_1,\ldots,A_k) = det_{M'}\ (A_1,\ldots,A_k)$.

I will follow B&C, K&S, and Westerstahl in assuming that all natural language determiners denote conservative functions. I will also adopt Westerstahl's suggestion that natural language determiner functions satisfy the Extension condition. Given these assumptions, the distinction between logical and non-logical natural language determiner functions depends upon the property of invariance under isomorphic structures defined on E.

6. See Hoeksema (1991), von Fintel (1993), and Moltmann (1993a) and (1993b) for discussions of these properties. Moltmann (1993a) provides detailed criticisms of the theories proposed in Hoeksema (1987), Hoeksema (1989), and von Fintel.

7. See May (1989) for a discussion of resumptive quantifiers. See Keenan (1987) and van Benthem (1989) for discussions of polyadic quantifiers.

8. See, for example, Kempson and Gabbay (1993), and Kempson (forthcoming) for outlines of a general framework for interpretation by natural deduction. Van Lambalgen (1991) suggests rules of natural deduction for several unary generalized quantifiers. Van Benthem (1991) discusses some of the issues involved in developing a proof-theoretic account of generalized quantifiers. Dalrymple et al. (1994) present a set of deductive procedures for representing quantifier scope relations within the framework of LFG. The system makes use of Girard's (1987) linear logic. However, unlike van Lambalgen's rules, it does not attempt to express the semantic content of quantified NPs in proof-theoretic terms. Instead it offers a deductive alternative to interpretation through compositional function-argument application in a higher-order type system.

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