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BINDING AND LOGICAL FORM

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It was suggested some time ago by Koster (1978), following work of Friedin (1978), that the cyclic transformations could be eliminated entirely, along with the principle of subjacency. In Koster's system traces, i.e., coindexed empty nodes, are generated directly in S-structure and the principle of subjacency is replaced with a set of conditions on the occurrence of empty nodes in S-structure, along with other independently needed principles such as binding conditions, performance constraints, and so forth. In this paper I would like to take Koster's argument one step further and show that the island constraints that originally motivated the principle of subjacency can be most economically stated as a single condition on the binding of variables in logical form, given a few minimal assumptions concerning the nature of representations in LF. Ultimately I think it can be shown that all the binding conditions are most appropriately stated as conditions on logical form (cf. Bowers (1983)), suggesting that there are no purely syntactic principles of universal grammar constraining the class of grammars that can be acquired. It is clear that the status of subjacency is of crucial importance in this connection, since it is the only principle of UG so far proposed that is unequivocally syntactic in character.

I shall assume that representations of LF are associated with the structures, or rules, of syntax[1] by a set of construal rules. The construal rules are of two kinds: (1) functional rules;

(2) extraction rules. Rules of the first type produce functional expressions of the general form $X'(A_1', \ldots, A_n')$, where X', A_i' represent the translation in LF of the syntactic categories X, A_i, respectively. Associated with the following syntactic structures, for example:

(1)a. $[_S$ NP VP]

b. $[_{VP}$ V NP]

we might have functional expressions of the following sort:

(2)a. VP'(NP'), S'

b. V'(NP'), VP'

(2a) indicates that the translation of an expression of category VP is a function whose argument is the translation of some expression of the category NP and that this function represents the meaning of some expression of the category S. I assume in addition that higher categories are projections of basic lexical categories, thus incorporating X-bar theory into representations in LF.

The second type of rule, the extraction rules, also produce functional representations. However, they also have the effect of binding a variable $x_{\alpha'}$, ranging over translations of expressions of the category α to the translation of some expression of that category. I assume that a variable is supplied automatically in representations of LF whenever the null element e is chosen to represent a category in a syntactic structure. In general, then, a syntactic structure of the form $[_\alpha$ e] is translated by a variable of the form $x_{\alpha'}$. I assume as a general principle of well-formedness governing representations of LF that all variables must be bound to some constant term. Variable binding is represented formally by coindexing of a variable with its antecedent. Coindexing is generally interpreted pragmatically as actual or intended coreference, but not necessarily (cf. Bach and Partee (1980), for discussion).

Given the sort of functional representations assumed above, there are at least two possible types of extraction rules that we might expect to find: (1) binding of an argument to an argument; (2) binding of an argument to a function. The operator that produces structures of the first type I shall call the Λ-operator; the operator that produces structures of the second type I shall call the Δ-operator. Structures containing these operators are represented formally in the following fashion:

(3)a. $(\Lambda x_{\alpha'}, [\beta'])(\alpha'), \gamma'$

b. $(\beta')(\Delta x_{\beta'}, [\alpha']), \gamma'$

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Application of the Λ-operator to an expression containing the variable $x_{NP'}$ will produce functional structures of the general form: $(...x_i...)(NP_i')$. Application of the Δ-operator to such an expression will produce structures of the form: $(NP_i')(...x_i...)$. Representations of this sort are associated with specific syntactic structures, just as simple functional representations are. For example, associated with the structure (4), representing topicalized constituents:

(4) $[_{\bar{S}}$ NP S]

is the LF representation (5):

(5) $(NP')(\Delta x_{NP'}, [S']) = NP_i'(...x_i...)$

I shall assume that true pronominal elements, whether phonologically realized or not, differ from variables in that they are not bound by operators, but instead are subject to a free indexing mechanism. Obviously, these principles of interpretation will produce a great many structures of LF that are not possible interpretations. It is the job of the binding conditions (among others) to filter out the impossible interpretations. Before starting these conditions, however, it is first necessary to define a number of terms.

Suppose we have a functional structure of the following form: $\beta'(...\alpha'...), \gamma'$. If α' is coindexed with β', and β' is the nearest such function, then we say that α' is (locally) <u>function-bound</u> (f-bound) by β' in γ'. Similarly, in a structure of the form: $(...\alpha'...)(\beta'), \gamma'$, where α' and β' are coindexed and β' is the nearest such argument, we say that α' is (locally) <u>argument-bound</u> (a-bound) by β' in γ'. If an argument is not f-bound in some domain, then it is <u>f-free</u>; if it is not a-bound, then it is <u>a-free</u>. Consider now a structure of the form: $\beta'(...\alpha'...), \gamma'$. If α' is an argument of β' and $\beta' = X^o$ (i.e., β' is a lexical category), then we say that β' <u>governs</u> α'. If $\beta' = X^n$ (i.e., β' is a maximal projection of X), then we say that β' <u>dominates</u> α'. We now define the notions governing and dominating category. The <u>governing category</u> of α' is the minimal $\bar{S}'$ or NP' containing both α' and a governor of α'. The <u>dominating category</u> of α' is the minimal $\bar{S}'$ or NP' containing both α' and a category that dominates it.

Equipped with these notions we can now state the binding conditions for variables, anaphors and pronouns in the following fashion:

(6) A. An anaphor is a-bound in its governing category.
B. A pronoun is free in its governing category.
C. A variable is f-bound in its dominating category.

The conditions for anaphors and pronouns are similar to those in

the recent literature and need not be discussed further.[2] The remainder of this paper will be devoted to showing how Condition C accounts for the island constraints. Crucial to my argument will be certain assumptions regarding the functional structure of various constructions in English. It is therefore useful to inquire whether there is any independent test for deciding if a given expression is an argument or a function in LF. In fact, it appears that the process known generally as Right Node Raising (RNR) provides such a diagnostic. It is well known of course that RNR provides a test for constituent-hood (cf. Abbott (1976), Gazdar (1981)), but it does not seem to have been widely noticed that it also distinguishes arguments from functions, only the former being possible in right node raised position. Thus compare examples such as the following:

(7)a. *John the beans and Mary the hot dogs ate.
b. *John at 3:00 and Mary at 4:00 went sailing.
c. *John bought a book __ Mary and Bill found a book __ Sue for.
d. *John is __ of Mary and Bill is __ of Sue fond.

with familiar examples such as these:

(8)a. John caught and Mary killed the rabid dog.
b. Tom said he would and Bill actually did eat a raw eggplant.
c. Harry claimed but I don't believe that Melvin is a communist.
d. I like, but Tom doesn't like, to visit new places.

Now notice that by the RNR test, the preposed wh-word in questions, WH-complements, and relatives must be a function, of which the associated S' is an argument:

(9)a. I can tell you when, but I can't tell you why, he left me.
b. I know which books, but I don't know how many books, John gave Mary.

(10)a. *I can tell you __ he left me, but I can't tell you __ he will come back, when.
b. *I don't know __ John gave Mary, nor do I know __ she returned to him, which books.

This suggests that the structure of WH-complements in LF are formed by the Δ-operator, resulting in structures such as the following:

(11)a. who John saw
b. $who'(\Delta x_{NP'}, [(see'(x_{NP'}))(John')]) = who'_i((see'(x_i))(John'))$

Example (11) meets Condition C since the variable is f-bound (to who') in its dominating category. Likewise, in a complement such as:

(12)a. (I wonder) who Bill thinks John saw
b. who'(Δx[Bill thinks(John saw x)]) = who'$_i$ (Bill thinks(John saw x_i))

Condition C is still met, since the variable is bound (to who') in its dominating category, in this case the higher $\bar{S}'$. Suppose, however, we produce a sentence such as the following:

(13)a. (I don't know) what Bill wonders who John gave to
b. what'(Δx[Bill wonders(who'(Δy[John gave x to y]))]) = what'$_i$(Bill wonders(who'$_j$(John gave x_i to y_j)))

This violates Condition C, since the variable x_i is not f-bound in its dominating category.[3]

It is easy to show that this same analysis will work in the case of that-less relatives and complex NPs as well. The RNR test shows that the functional structure of such complex NP's is NP'($\bar{S}'$):

(14)a. John knows the girl, and Bill knows the boy, (that) I used to be friends with in high school.
b. John doesn't acknowledge the fact, nor will he even consider the possibility, that the earth is flat.

(15)a. *John knows __ that has blond hair, and Harry knows __ that has black hair, the girl.
b. *John doesn't deny __ that the earth is flat, nor does he deny __ that the moon is flat, the claim.

It follows by Condition C that a variable contained in a complex NP can only be bound to the NP which is its head.

Consider next the Left Branch Condition. The RNR test demonstrates that the genitive NP in prenominal position is a function, not an argument. Contrary to certain versions of X-bar theory, then, genitive NP's are not functionally parallel to subjects of sentences:

(16)a. John likes Bill's, but Harry likes Sue's, portrait of Mary.
b. *John likes __ portrait of Mary, and Bill likes __ photograph of Jill, Sue's.

Notice, however, that if the structure of NP's with genitive modifiers in LF is of the form NP'($\bar{N}$'), then the Left Branch Condition follows automatically from the fact that the Δ-operator, by definition,[4] can only bind variables that are arguments in LF, not functions. For exactly the same reason, it is impossible to bind a wh-word in COMP position, since such a variable would be a function in LF and the Δ-operator only applies to arguments. This rules out structures of the form:

(17) $\text{who}_i(\text{do you wonder}(x_i(\text{John saw } y_i)))$

as well as structures of the form:

(18) $\text{whose}_i(\text{John bought}(x_i(\text{book})))$.

Consider next the SSC in NPs. Since genitive NPs are functions, it follows from Condition C that in such structures NP' will always be the dominating category. Hence a variable can only be bound to the genitive NP, if there is one, and can't be bound outside it. Structures of the first type are well-known, e.g., $\text{Mary}'_i(\text{photograph}'(\text{of}'(x_i)))$, $\text{John}'_i(\text{picture}'(\text{by}'(x_i)))$, etc., and structures of the latter type are of course impossible: *who did you buy John's picture of?, etc. On the other hand, there is nothing to prevent sentences such as who did you buy a picture of? Nor will Condition C prevent examples such as which pupil do you recognize the need for a talk with? (Koster (1978)). This conclusion seems to me correct, contrary to Chomsky (1973), as has been argued by Koster (1978). It is also consistent with Ross's Pied Piping data.

One virtue of Condition C is that it immediately generalizes to structures containing functions belonging to other categories besides NP'. In particular, it will prevent extraction from the sentential complement associated with adjectival degree modifiers:

(19)a. *I wonder who John is as pleased with Mary as he is angry at.
b. *the subject that Bill is even more disillusioned with economics than he is disenchanted with

If we assume that the functional structure of these AP expressions is of the form: AP'($\bar{S}$'), then these facts follow automatically from Condition C. Once again, the RNR test indicates that this is the correct functional structure in LF:

(20)a. Mary is more angry at Bill, and Sue is more angry at Harry, than either wants to admit.
b. *Mary is __ than she wants to admit, and Bill is __ than he wants to admit, more angry at Sue.

Similarly, consider the fact that extraction is in general

impossible out of adverbial clauses:

(21)a. *What did John go to the store because he needed to buy?
b. *I wonder which book John asked Mary before he borrowed.
c. *It was Sue that Mary got angry when she saw at the door.

Depending on whether we take these clauses to be restrictive or non-restrictive we might assign them either the structure VP'(P'(S')), or possibly $\bar{S}$'(P'(S')). If VP' is the maximal projection of V' and $\bar{S}$' is the maximal projection of S', then in either case Condition C will predict these results. Once again the RNR tests lends support to this analysis:

(22)a. John washed the dishes, and also took out the garbage, before Mary got home from work.
b. *John __ before Mary got home from work, and Bill __ before Sally got home, washed the dishes.

Consider finally the Sentential Subject Constraint. Suppose that sentential subjects have a functional structure of the form (23):

(23) $\underline{pro}_i(that_i(S'))$

with a phonetically null pronominal element belonging to the category NP' as head.[5] Then Condition C will immediately rule out structures of the following sort:

(24) $who_i'(upset'(Mary'))(\underline{pro}_j(that_j(Bill\ see\ x_i)))$

since the variable x_i will not be bound in its dominating category. No such problem arises in the case of sentential complements, on the other hand, since they are not complex NPs.

The result of Condition C, then, is to prevent a variable from being bound by an operator in logical form in all those cases that are covered by the principle of subjacency. At the same time it will also take care of a number of constraints that are not accounted for by subjacency. Essentially, what Condition C says is that a variable looks for the nearest function that can bind it. If it fails to find one in the lower NP or $\bar{S}$ containing it, then it is allowed to go up to the next NP or $\bar{S}$ to find a possible binder. It if fails to find one anywhere, then the sentence is uninterpretable. Notice that Condition C accounts for the unbounded character of WH-Movement, and related processes, without having to assume a successive cyclic derivation. This is clearly an advantage, since the existence of the intermediate

traces that are required under this approach is at best dubious.

If the theory proposed here is correct, then it seems reasonable to conclude that there are no cyclic transformations at all, and hence no level of D-structure. What we have instead is a theory in which surface structure is related directly to logical form. Furthermore, if, as seems likely, all the binding constraints can be stated at the level of LF, then it may be possible to conclude that there are few, if any, purely syntactic constraints on the class of possible grammars that human beings are capable of acquiring.

FOOTNOTES

[1] I believe that there are strong empirical reasons for preferring a rule-to-rule approach to semantic interpretation, as opposed to the structure-to-structure approach assumed in standard transformational grammar. The focus of this paper, however, is on the representations of LF themselves and it is irrelevant whether we think of these as being associated with rules or structures.

[2] See Bowers (1982, 1983) for further discussion, and also for arguments that the typology of anaphoric and pronominal elements proposed in Chomsky (1981, 1982) needs to be extended to accommodate parasitic gaps.

[3] I assume that each operator, except in conjoined structures, can bind one and only one variable. This has been termed the "Bijection Principle" by Koopman and Sportiche (1981).

[4] Note, however, that there is nothing wrong with an example such as the man$_1$ whose$_1$ book I reviewed, because whose is a pronoun, not a variable, and therefore is not subject to Condition C.

[5] See Bowers (1981) for arguments in support of this analysis.

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