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On the Assignment of Indices and  
Their Interpretation in Binding Theory

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This paper considers problems in the assignment of indices in the Binding Theory of current Government Binding Theory.\* The basics of this theory, as developed in Chomsky (1983), are given in (1)-(4). Note that I have made a change in terminology--instead of calling reflexives, reciprocals and NP-trace "anaphors", a term confusing to those familiar with its older sense, I have called them A-pronouns. And I have used B-pronouns instead of Chomsky's "pronominals" to refer to all non-A-pronouns and PRO.

- (1) Random indices assigned to all NPs
- (2) Binding Theory (revised terminology)
  - (A) An A-pronoun is bound in its governing category.  
(reflexives, reciprocals, NP-trace)
  - (B) A B-pronoun is free in its governing category.  
(all other pronouns and PRO)
  - (C) An R-expression is free.  
(non-pronominal NPs?)
- (3) binding:  $\alpha$  is (A)-bound by  $\beta$  iff  $\alpha$  and  $\beta$  are coindexed,  $\beta$  c-commands  $\alpha$ , and  $\beta$  is in an A-position.
- (4) Governing Category:  $\alpha$  is a governing category for  $\beta$  iff  $\alpha$  is the minimal category containing  $\beta$ , a governor of  $\beta$ , and a SUBJECT accessible to  $\beta$ .

A few of the problems which concern us are exemplified in (5)-(7):

- (5) Alan and Margaret ate their dinner.
- (6) Mary thought she had the mumps and Alice did too.
- (7) a) Only Reagan voted for himself.  
b) Only Reagan voted for Reagan.

Each case poses a problem for the interpretation generally assumed of the randomly assigned indices: that

coindexed NPs are coreferential, while non-coindexed NPs are not. In (5), due to Daniel Seely, the relation between the indices of each of the proper nouns and that of the conjoined NP they form (or of their) is a problem. Neither NP is coreferential with the whole or with their, so they must receive different indices. Yet, neither are they disjoint in reference. In (6) we see an example of Tanya Reinhart's (1983) sloppy identity cases--Alice may think that she herself has the mumps (the sloppy reading) or that Mary does (the non-sloppy reading). Given that she in the first sentence may refer to Mary on either reading, we must assign it an index that permits both readings of the second sentence after the VP has been copied. In the Evans-type cases in (7) (cf. Evans (1980)), the b) sentence seems acceptable with the two instances of Reagan coreferential despite violation of Principle C of the Binding Theory. Note that (a) has different truth conditions than (b), e.g. in a situation in which many people voted for Reagan, (a) may be true while (b) may not.

Another type of problem is posed by what Leslie Saxon (1984) calls "disjoint anaphors". These occur in Dogreb, an Athapaskan language spoken in northern Canada. They are pronouns with the distribution of Chomsky's anaphors (our A-pronouns), and hence they must be bound in their governing category. But, quite unlike English A-pronouns, they are obligatorily disjoint in reference from the NP which binds them. If English was like Dogreb, we might have such a pronoun, call it herother. Then Mary likes herother would be grammatical, with herother bound by Mary and meaning 'Mary likes some other person we've already mentioned'. The sentence \*Herother likes Mary would be ungrammatical because the pronoun is not bound in its governing category. This is obviously a problem for the assumption that bound NPs are coreferential.

I note that Higginbotham's Linking framework (1983) provides a solution for the problem in (5), since the conjoined NP may be referentially dependent on both the proper nouns at once. However, Higginbotham still has problems with the Evans-type cases, with sloppy identity and with the disjoint anaphors.

In developing a solution to these problems, I propose that we begin with the observation that pronouns are always referentially dependent, i.e. they must be bound, like variables in a predicate calculus.

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But binding in natural language is richer than in the classical predicate calculus in at least two respects: First, there are two kinds of structural relations which permit binding between an NP and a pronoun: one is intra-sentential and requires c-command of the pronoun by its antecedent, at least in configurational languages. We will call antecedent-anaphor relations licensed in this way c-command binding. The other type of structure is found in discourse. Neither pronouns nor definite expressions more generally can be linked to just any prior expression in the discourse in which they occur. Consider (9):<sup>1</sup>

- (9) a) If I had a garden, I'd plant an apple tree. It would bear fruit in a few years.  
 b) #If I had a garden, I'd plant an apple tree. It was damaged in the last snow storm.

The discourse in (9a) is felicitous with it referring back to an apple tree. But (b) is not. A theory of anaphora in discourse, then, does not simply reflect the order in which information is introduced in discourse, since in both (a) and (b) an apple tree occurs before it, but some other aspect of their relation. The closely related discourse theories of Irene Heim (1982) and Hans Kamp (1981) are both concerned, among other things, with how to constrain anaphora in discourse. They and others have shown that it is dependent on a hierarchical discourse structure. Although we cannot discuss details here, note that NPs that are possible antecedents for a pronoun must be accessible<sup>2</sup> to that pronoun in discourse. The accessibility of an NP to a pronoun depends on their relative positions in the structure of the whole discourse. We will call antecedent-anaphor relations licensed by this kind of binding discourse binding. As we will see in the sloppy identity cases, c-command binding and discourse binding are not in complementary distribution.

Besides the two kinds of binding, natural language also has two kinds of "variable", or pronoun: A-pronouns, including the Dogreb disjoint anaphors, must be c-command bound in their governing category, while B-pronouns may either be c-command bound outside their governing category or discourse bound.

My proposal attempts to retain the insights of both the sentential-level theories of anaphora, such as Government Binding theory, and the discourse theories,

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while providing solutions to problems in both.<sup>3</sup> I will use indices at S-Structure as diacritics to mark c-command binding. Here, as in Reinhart's insightful paper Coreference and bound anaphora (1983), assignment of indices is no longer random, and coindexation is restricted to pronouns and c-commanding NPs; but unlike Reinhart, I dissociate indices from any direct or uniform interpretation. It will no longer be the case that coindexed NPs must be coreferential nor that non-coindexed NPs cannot corefer. Instead, the indices, along with the lexical content of the NPs they mark, are used as guides in a mapping from S-Structure directly to a level of Discourse Representation. Each index induces the introduction of a discourse referent in the Discourse Representation, and discourse binding is explained in terms of which discourse referents for NPs are accessible to the discourse referent for a pronoun seeking an antecedent.

Indices are assigned as follows: Move-Alpha leaves the moved element and its trace coindexed. Then at S-Structure, a top-down procedure assigns to each NP which is not already marked a distinct index, with the possible exception of a pronoun and a NP which c-commands it. These may be optionally coindexed by a procedure which incorporates restrictions on A- and B-pronouns rather like conditions A and B of the Binding Theory. Reinhart proposed one such coindexation procedure. However, there is a problem with her procedure: it does not cover the cases usually treated via reconstruction, as exemplified in (11):

- (11) a) [Which picture of himself]<sub>i</sub> does John like t<sub>i</sub>

Reconstructed: John likes which picture of himself

- b) [Which picture of John]<sub>i</sub> does he like t<sub>i</sub>

Reconstructed: \*He likes which picture of John

- c) [Which picture of himself that Mary likes]<sub>i</sub> will [John give her]<sub>i</sub> t<sub>i</sub>

Reconstructed: \*John gave her that picture of himself that Mary likes

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The example in (11a) shows that in some cases reconstruction of a moved element into its base generated position seems necessary to account for the use of an A-pronoun. But (11b) shows that in other instances reconstruction would give infelicitous results from the point of view of Principle C. And David Pesetsky's example (11c) is a case where reconstruction is both obligatory, for the binding of himself by John, and infelicitous, since then she would c-command Mary. This example shows that we cannot simply make reconstruction optional. We seem to need to have our cake and eat it.

The crucial factor in these cases is the relation between the preposed element and its trace in the matrix clause. I propose that we use this relation without actual reconstruction. We define the coindexing procedure as in (12):

- (12) Coindexing Procedure for C-Command Binding with "Reconstruction":

Coindex a pronoun  $\alpha$  with an NP  $\beta$  such that  $\beta$  c-commands a node  $\gamma$  which contains  $\alpha$ .

Conditions:

- (A) If  $\alpha$  is an A-pronoun,  $\beta$  must be in its governing category.  
 (B) If  $\alpha$  is a B-pronoun,  $\beta$  must be outside its governing category.

A pronoun may be coindexed with an NP which c-commands it, with the conditions stipulating that an A-pronoun must be bound inside its governing category, while a B-pronoun must be bound outside its governing category. But the NP need not c-command the pronoun directly. Rather, in a case where the pronoun is in a constituent which has been wh-moved, its NP antecedent need only c-command the trace left behind after movement. This is achieved by the technical use<sup>5</sup> of the term contains which I have defined in (13):

- (13) A node  $\gamma$  contains a node  $\alpha$   $\equiv_{df}$ .

- (1)  $\gamma$  dominates  $\alpha$ , or  
 (2)  $\gamma$  dominates the case-marked trace of some node  $\delta$  which contains  $\alpha$ .

In a simple case, like John likes that picture of himself, himself can be coindexed with John, which c-commands it within its governing category. In the obligatory reconstruction case (11a), the A-pronoun

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himself may be bound by John. Here, John c-commands the trace of the wh-fronted constituent which contains himself.

In (11b), at no point does John c-command he; even our "pseudo-reconstruction" can't help because though he c-commands the trace of the phrase containing John, a proper name cannot be bound by procedure (12). How, then can John and he be coreferential? By discourse binding. Recall that two NPs need not be coindexed, i.e. c-command bound, to be coreferential. Here, John only needs to be accessible to he.

In the mapping from S-Structure to Discourse Representation, an NP indexed i will generally be assigned a discourse referent x with the same index i. The exception is in the case where a pronoun is coindexed with a c-commanding NP. Then, whether the two receive the same discourse referent, as with the English A-pronoun in (11a), or a different one, as would be the case with Dogreb disjoint anaphors, depends on the lexical content of the two NPs. Any pronoun which is not c-command bound, and hence coindexed with an antecedent, must find a discourse antecedent. We'll see an example of this below; for (11b) it suffices to note that John is entered in the Discourse Representation prior to he and is accessible to it. The same approach accounts for the coreference of Mary and she in (11c), also discourse bound, while John and he in that example are c-command bound.

Let us now examine how this proposal would handle the interpretive problems we outlined earlier. First, example (5), Alan and Margaret ate their dinner, is no longer a problem, since even though neither Alan nor Margaret can be coindexed with the NP which contains them, this does not mean they are disjoint from it in reference. Non-coindexation no longer implies non-coreference. Rather, the discourse referents for the proper names will stand in a constitution relation to the discourse referent for their whole subject NP. This is exemplified in the Discourse Representation in (14):

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(14) [Alan<sub>i</sub> and Margaret<sub>j</sub>]<sub>k</sub> ate [their<sub>k</sub> dinner]<sub>m</sub>

$x_i$	$x_j$	$X_k$	$x_m$
Alan ( $x_i$ )			
Margaret ( $x_j$ )			
$X_k = \{x_i, x_j\}$			
$X_k$ 's dinner ( $x_m$ )			
$X_k$ ate $x_m$			

Each of the proper names, as well as the full subject induces the introduction of a discourse referent, and the condition on the discourse referent for the full subject  $X_k$  specifies that its reference is the set of the entities referred to by the conjuncts.

In sloppy identity cases, as in (6), the two different readings for the second conjunct depend on whether the pronoun she in the first conjunct is c-command bound by Mary or only discourse bound by it. We construct Discourse Representations for the two readings as follows:

The mapping to a Discourse Representation is a top-down procedure reducing the original sentence to a structure with a discourse referent for each term and predicates over the discourse referents. (The variable-like discourse referents then get bound in interpretation depending on their structural position in the discourse representation.) We begin with the indexed S-Structure, and introduce a discourse referent for the first conjunct, placing on it the condition that it be Mary in any possible interpretation. The original sentence then becomes a condition on that discourse referent:

(15) a) Sloppy Reading: Mary<sub>i</sub> thinks she<sub>i</sub> has the mumps and Alice<sub>j</sub> does too.

$x_i$
Mary ( $x_i$ )
$x_i$ thinks she <sub>i</sub> has the mumps



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Now we need to reduce the condition further by finding a discourse referent for the pronoun she. But she is already indexed  $i$  and hence already has a discourse referent,  $x_i$ . We reduce the condition accordingly to  $x_i$  thinks  $x_i$  has the mumps. We then reduce the second conjunct, introducing the discourse referent  $x_j$  for the subject Alice. Since there is no VP, or predicate on that subject, we borrow one from the preceding conjunct, simply replacing all instances of  $x_i$ , the discourse referent for Mary, by  $x_j$ , the discourse referent for Alice:

(15) b)

$x_i$	$x_j$
Mary ( $x_i$ )	
$x_i$ thinks $x_i$ has the mumps	
Alice ( $x_j$ )	
$x_j$ thinks $x_j$ has the mumps	

In constructing the non-slopping reading, however, we begin from an S-Structure where Mary and she are not coindexed. When we reach the point in the construction where we need to reduce the VP in the first conjunct, we need to introduce a new discourse referent for the pronoun she. But since it is a pronoun which is not c-command bound, it must be discourse bound. We do this by equating it with an accessible discourse referent. Here, the discourse referent for Mary is one possible antecedent, so we equate them (though of course, there might be other readings where she refers to an even earlier discourse referent):

(16) a) Non-sloppy:  $Mary_i$  thinks  $she_k$  has the mumps and  $Alice_j$  does too.

$x_i$	$x_k$
Mary ( $x_i$ )	
$x_i$ thinks $she_k$ has the mumps	
$x_k = x_i$	
$x_i$ thinks $x_k$ has the mumps	

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If we assume a model-theoretic interpretation, the equation assures that the two terms will be coreferential. Now we treat the second conjunct as before, replacing all instances of  $x_i$  by  $x_j$ . But the result here differs because  $x_k$  is already bound to Mary, and so Alice thinks that Mary has the mumps:

(16) b)

$x_i$	$x_k$	$x_j$
Mary ( $x_i$ )		
$x_i$ thinks $x_k$ has the mumps		
$x_k = x_i$		
Alice ( $x_j$ )		
$x_j$ thinks $x_k$ has the mumps		

The problem with the Dogreb case is now overcome as well: the disjoint anaphors must be coindexed with a c-commanding NP in their governing category, just like English A-pronouns. But in the mapping from S-Structure to Discourse Representation, their lexical content, perhaps in the form of a feature [+disjoint] or the like, induces us to choose any accessible antecedent except the NP with which they are coindexed.

Before we turn to the Evans-type focus cases in (7), we will have to consider how to handle the disjoint reference facts given in (17):

- (17) a) \*Zelda saw Zelda.  
 b) \*Zelda saw her.  
 c) ?The flowers in Zelda's apartment pleased Zelda.

These include cases covered by Principle C of the Binding Theory, as in (a), cases like (b) where a B-pronoun is coreferential with an NP in its governing category, and cases like (c) where repetition of a proper name seems less than perfectly felicitous even though it doesn't violate Principle C.

Reinhart (1983) proposes a pragmatic strategy for disjoint reference. We will adopt this general approach, but note that with our distinctions among types of binding and types of pronouns, we can develop a finer scale of binding strength. Note that we have

three pragmatic grades of binding in (18), distinguished by the degree of ambiguity they permit:

(18) Three Pragmatic Grades of Binding:

- a) c-command binding of A-pronouns  
(strongest)  
ex: Zelda saw herself.
- b) c-command binding of B-pronouns  
(weaker than a)  
ex: Zelda thought she saw a mouse.
- c) discourse binding (of B-pronouns only)  
(weakest)  
ex: Annie told us about the surprise party. The flowers in Zelda's apartment pleased her.  
her = Annie? Zelda?

First, c-command binding of A-pronouns is the strongest, since it is least likely to be ambiguous, as in the example. With c-command binding of B-pronouns we may be less confident of the intended reference of the pronoun, as when the example in (b) is in a context following The cat crept silently toward the barn, where she might be taken to be discourse bound by the cat instead of c-command bound by Zelda. And discourse binding is notoriously full of potential for ambiguity, as illustrated in the example in (c).

One can define the binding potential of two NP positions in a given syntactic structure as the strongest kind of binding permitted there. Observance of the Gricean cooperative principle leads one to use the strongest means he has to make the identity of referents unambiguous. I offer, then, a revision of Reinhart's proposal, in (19):

(19) Pragmatic Disjoint Reference Strategy:

- a) Speaker's Strategy: Use the strongest type of binding permitted by the syntactic structure you are using, unless you have reason to avoid binding.
- b) Hearer's Strategy: If the speaker doesn't take advantage of the binding potential of the structure she is using, then, unless she has reasons to avoid binding, she doesn't intend her expressions to corefer.

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Further, the stronger the binding potential of a given structure, i.e. the greater the opportunity to avoid ambiguity, the more difficult it is to avoid binding without leading the hearer to assume disjoint reference, in line with (19). We see this in the differential acceptability of (17a) and (17c).

In a case like (7b), Only Reagan voted for Reagan, the speaker does in fact have reason to avoid bound anaphora, since here the truth conditions differ from the bound variant in (7a), Only Reagan voted for himself. In a discourse representation for (7b), each token of Reagan will receive a distinct discourse referent, since they are not coindexed by our procedure (12), and their discourse referents are not equated, since neither is a pronoun and hence they don't need antecedents. However, by virtue of being proper names and hence directly referring expressions, the two tokens will in fact refer to the same entity in the world when the discourse representation is interpreted.

Note that not only does this strategy provide an explanation for the disjoint reference cases, it also permits an explanation of the crossover phenomena which accounts for the interaction of crossover with focus.

Consider the classic crossover cases in (20) and (21):

## (20) Strong Crossover

- a) \*who<sub>i</sub> does he like t<sub>i</sub>
- b) \* he likes everyone
- c) \* he likes Jóhn
- d) \* he líkes John
- e) he likes JOHN

## (21) Weak Crossover

- a) \*who<sub>i</sub> does his mother like t<sub>i</sub>
- b) \* his mother likes everyone
- c) \* his mother likes Jóhn
- d) his mother líkes John
- e) his mother likes JOHN

Note that the two structures have different binding potentials. The strongest type of binding is possible in the strong crossover structure, as in John likes himself, but not in the weak: hence the unacceptability of \*John's mother likes himself.

The (a) and (b) examples for both structures are considered totally unacceptable. The reason for this

in the framework presented here is twofold. First, neither the trace nor the *wh*-element which binds it, nor the quantifier everyone is a pronoun; hence they cannot be coindexed with the *c*-commanding NP by (12). Second, discourse anaphora is impossible because who and everyone do not actually refer, as does, e.g., a proper name, and hence it is not possible that they refer to something already salient in the discussion which might then be accessible to he.

Now consider the cases with proper names in (c), (d) and (e). (20c) with non-contrastive stress on John is just plain bad. He and John cannot be coindexed in this or any of the remaining cases, since John is not a pronoun. We get the same unacceptable result in the weak crossover case in (21c), as noted by Chomsky in his discussions of the interaction of crossover with focus in "Conditions on Rules of Grammar" (1976) and Rules and Representations (1980). But the differential binding potential of the two structures explains the difference between the unacceptable (20d) and the acceptable (21d). In these cases, it is not that likes is focussed. Rather, John being already salient in the discourse, the proper name John is distressed, like a pronoun, and likes receives default stress. Hence, though he and John can't be coindexed, the discourse referent for he in (21d) can be equated with that of the previous occurrence of John. This suffices to overcome the disjoint reference strategy in the weak crossover construction, but not in the stronger case of (20d). It is only contrastive stress, requiring a particular type of preceding discourse, which overcomes the disjoint reference strategy in the strong crossover case (20e), as well as in the weak (21e). These are the types of cases Evans discussed. An appropriate discourse might be as in (22):

- (22) Speaker A: John doesn't like anyone.  
                   He doesn't like Al.  
                   He doesn't like Sam.  
                   He doesn't like Ginger.

Speaker B: But he likes JOHN.

In the Discourse Representation constructed for this discourse, successive occurrences of he are given individual discourse referents, each equated with that for the first occurrence of John. The parallelism of the structures and the related strength of contrastive focus overcomes the disjoint reference strategy.

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Hence, we see that this proposal is able to explain the facts about focus in an integral way, while the present Binding Theory must regard them as anomolous.

In summary, let me note that this specific proposal simply exemplifies a deeper point: there are two kinds of binding, constrained by relations on structures in distinct domains. Here we see a clear example of the virtues of modularity. Theories of anaphora in each domain will be simpler and more adequate as they recognize which cases of binding fall within their purview and which do not.

## FOOTNOTES

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<sup>1</sup>Here and below, underlining indicates intended coreference.

<sup>2</sup>This is Kamp's (1981) term, given a technical definition in his Discourse Representation Theory.

<sup>3</sup>I believe that the main point of this paper is valid in other frameworks as well. I chose the Binding Theory as the most fully worked-out sentential level theory of anaphora.

<sup>4</sup>The idea of discourse referents intermediate between syntactic NPs and their real world referents was originally introduced by Karttunen (1976). The term was taken up by Heim (1982), who implemented the idea in her File Change Semantics. Technically, discourse referents act as variables (cf. discussion in Chierchia and Rooth (1984)), though I don't think that the details of this are crucial to an intuitive understanding of their function in what follows. Kamp uses

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the term "reference markers" instead of discourse referents, but I have used the latter term for historical and theoretical continuity.

<sup>5</sup>Note that the term contains is already included in Chomsky's (1983) definition of governing category given in (4) above.

<sup>6</sup>See Ladd (1980) for extensive discussion of the phenomenon of default destressing.

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