NON-REDUNDANCY:

TOWARDS A SEMANTIC REINTERPRETATION OF BINDING THEORY

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Abstract: In Generative Grammar, Binding Theory has traditionally been considered a part of syntax, in the sense that some derivations that would otherwise be interpretable are ruled out by purely formal principles. Thus *He$_i$ likes him$_i$* would in standard semantic theories yield a perfectly acceptable interpretation; it is only because of Condition B that the sentence is deviant on its coreferential reading. We explore an alternative in which some binding-theoretic principles (esp. Condition C, Condition B, Condition A, a modified version of the Locality of Variable Binding argued for by A. Kehler and D. Fox, and Weak and Strong Crossover) follow from the interpretive procedure - albeit a somewhat non-standard one. In a nutshell, these principles are taken to reflect the way in which sequences of evaluation are constructed in the course of the interpretation of a sentence. The bulk of the work is done by a principle of *Non-Redundancy*, which prevents any given object from appearing twice in any sequence of evaluation. An account of split antecedents and non-overlapping-reference effects is included in the analysis, and a detailed implementation of a large part of the theory is given in an Appendix.

0 Overview

❑ *Syntactic Accounts of Binding Theory*

In Generative Grammar, Binding Theory has traditionally been considered a part of *syntax*, in the sense that certain structures that would otherwise be interpretable semantically are ruled out by purely *formal* constraints. In the account offered in Chomsky (1981), syntactic structures come equipped with indices whose intended semantics is to encode coreference. Certain configurations are then ruled out by formal constraints on *binding*. As in formal logic, the relation □ *binds* □ holds just in case (i) □ and □ bear the same index k, (ii) □ is in the scope of (=is c-commanded by) □, and (iii) there is no other element □' with index k such that (a) □' is in the scope of □, and (b) □ is in the scope of □' (for otherwise □' rather than □ would bind □). Binding is then subject to the following (simplified) constraints, where the 'local domain' of an element is -very roughly- its clause:

(1) *Condition A*: A reflexive pronoun *must* be bound in its local domain.
a. John$_1$ likes himself$_1$
b. *[John$_1$'s mother]$_2$ likes himself$_1$
c. *John$_1$ thinks that Mary$_2$ likes himself$_1$

(2) *Condition B*: A non-reflexive pronoun *cannot* be bound in its local domain.
a. *John$_1$ likes him$_1$
b. [John$_1$'s mother]$_2$ likes him$_1$
c. John$_1$ thinks that Mary$_2$ likes him$_1$

(3) *Condition C*: A proper name or a definite description *cannot* be bound (at all)
a. ??John$_1$ likes John$_1$
a'. *He$_1$ likes John$_1$
b. [John$_1$'s mother]$_2$ likes John$_1$
c. ??John$_1$ thinks that Mary$_2$ likes John$_1$

An additional principle constrains configurations in which a quantificational element can take scope over (or 'cross over') a pronoun. One possible statement is the following:

(4) *(Weak) Crossover Constraint*: A pronoun cannot be bound by an element that is in a non-argument position[1] (=an A'- position).
a. Who$_1$ [t$_1$ likes his$_1$ mother]?

b. ??Who$_1$ does his$_1$ mother like t_1?
c. [Every boy]$_1$ [t_1 likes [his$_1$ mother]] (pronounced as: *Every boy likes his mother*)
d. ?? [Every boy]$_1$ [[his$_1$ mother] likes t_1] (pronounced as: *His mother likes every boy*)

(The preceding representations are the syntactician's 'L(ogical) F(orms)', which are obtained from Surface Forms by moving quantificational elements covertly to their scope positions). Violations of the Weak Crossover Constraint yield relatively mild cases of ungrammaticality when the offending pronoun does not c-command the trace of its binder. When it does c-command it, as in **Who$_1$ does he$_1$ like t_1?*, the violation becomes much more severe and is for this reason called 'Strong Crossover'.

Accounts that followed Chomsky's groundbreaking work developed Binding Theory in several directions:
(i) Crosslinguistic studies refined the typology of elements subject to binding principles, and parametrized those principles to account for language variation.
(ii) The syntax and semantics of indices was clarified and systematized. Important work in this domain was done by semanticists, in particular by Heim (1993) and more recently Büring (2002a, b).
(iii) Reinhart (1983) sought to attain greater explanatory depth by deriving Condition C effects from a pragmatic principle that favors structures in which coreference is a result of syntactic binding rather than an 'accident' of the semantic interpretation. According to Reinhart, *John$_1$ thinks that Mary$_2$ likes John$_1$* is ruled out because *John$_1$ thinks that Mary$_2$ likes him$_1$*, which has the same truth-conditions but involves binding, is deemed preferable by her principle (Reinhart's analysis was refined in Heim (1993)). Whatever the merits of Reinhart's approach, it shares with other analyses a syntactic core, in the sense that the ungrammatical or dispreferred structures are assumed to be in principle interpretable by the semantic component.

❑ *A Semantic Alternative*

In this paper we explore a semantic alternative to these accounts (it is by no means the only one on the market: other semantic accounts of binding-theoretic constraints have been developed, in particular by E. Bach & B. Partee (1980), A. Branco (2001), C. Shan & C. Barker (2003), A. Butler (2003), and P. Jacobson (2000, 2004). A systematic comparison is left for future research). We concentrate on the most basic data, with the hope that refinements of the standard Binding Theory could in principle be incorporated into our framework (whether this is so will have to be determined on a case-by-case basis).

As in most other semantic theories, a sentence is interpreted by evaluating its components under certain modifications of an initial assignment function, or sequence of evaluation. We posit simple (but non-standard) constraints on the construction of sequences, and show that these suffice to derive Condition C, Condition B, and a version of the Locality of Variable Binding discussed in Kehler (1993) and Fox (2000). With one additional assumption, motivated on theory-internal grounds, we also derive Weak and Strong Crossover effects. While some of the predictions are different from those of existing theories (especially when it comes to the Locality of Variable Binding), we will mostly attempt to match our competitors' basic results within a system that is arguably simpler and has in any event a very different deductive structure. Finally, although Condition A does not *follow* from the rest of the system, an analysis of reflexives as arity-reducers can be made compatible with it, as is briefly discussed in Section 2.3.

The metaphor we pursue is that a sequence of evaluation represents a state of a *memory register,* which is constructed as a sentence is processed, top-down, in accordance with the following rules (the term *demonstrative pronoun* in (5)a refers to what is otherwise called *free pronouns*, with the exception of first and second person pronouns, which fall under the rule in (5)b, for reasons that are discussed in Section 2.1):

(5) a. **Treatment of R-Expressions (i.e. Proper Names, Demonstrative Pronouns and Definite Descriptions)**[2]

When an R-expression (proper name, definite description or demonstrative pronoun) is processed, its denotation is added at the end of the register (i.e. at the end of the sequence of evaluation).

b. **Treatment of Non-Demonstrative Pronouns (i.e. indexical and bound pronouns)**
When a non-demonstrative pronoun is processed, some element of the register is recovered and moved to the end of the register.

In order to specify which element is moved in this way, non-demonstrative pronouns are given *negative indices* such as -1, -2, etc, which indicate how far from the end of the register their denotation is to be found (by contrast, demonstrative pronouns are assumed to have positive indices; their interpretation is given by a separate 'demonstrative function', discussed below; they are then treated in the same way as proper names). Thus *he*$_{-1}$ evaluated under a sequence John^Max^Peter denotes Peter, *he*$_{-2}$ denotes Max, and *he*$_{-3}$ denotes John. This notation makes syntactic representations somewhat simpler than is commonly the case, since indices appear only on bindees and never on binders. Thus instead of writing *John*$_i$ *thinks that he*$_i$ *is clever* or *John λi i thinks that he*$_i$ *clever,* we will use the representation: *John thinks that he*$_{-1}$ *is clever*. This yields the desired dependency because when the sentence is evaluated under a sequence s, the denotation of *John* (call it j) is added at the end of s as soon as the subject is processed. As a result, *he*$_{-1}$ is evaluated under the extended sequence s^j. But by definition *he*$_{-1}$ denotes the last element of s^j, i.e. John, as is desired. Although there are important differences, our system shares this 'semi-variable-free' nature with the so-called 'De Bruijn notation' of the λ-calculus (see Barendregt (1984, pp. 579-581) for a very brief introduction to the De Bruijn notation; see also Ben-Shalom 1996, Dekker 1994 , van Eijck 2001, and Bittner 2001, 2003 for applications of related principles to the analysis of anaphora).

The values of individual-denoting terms are added to the sequence of evaluation in an order that mirrors their hierarchy in the syntactic structure. As a result, when an atomic predicate P has just been processed we can know for sure that (i) in case P is intransitive, the denotation of its subject is found in the last position of the sequence; (ii) in case P is transitive, the denotations of its subject and object are in positions -2 and -1 respectively (this is because the object is more embedded than the subject, and hence in a top-down procedure it is processed 'after' it). In this way the values of the arguments of the predicate P can be recovered from the sequence under which P is evaluated. It makes sense, then, to talk of the truth of P under a sequence s[3], which will yield rules of interpretation such as the following (for perspicuity I write sequences of evaluation in normal font rather than as superscripts; I identify 1-membered sequences with their only element, and I write s^s' for the concatenation of sequence s and sequence s'. In the meta-language, a proper name is abbreviated with its initial, j for John, b for Bill, etc.):

(6) a. John hates Bill
b. $[[a]]^s$=[[a]]s=1 iff
[Step 1: the subject has been processed] [[hates Bill]]s^j=1, iff
[Step 2: the object has been processed] [[hates]]s^j^b=1, iff
[Step 3: the predicate is evaluated] j^b∈I(hates)

The last major principle we will need rules out redundancy in registers, in the sense that it does not allow one and the same object to occur twice in any given register (see Higginbotham (1983, (26)) for a related principle):

(7) **Non-Redundancy**
No object may occur twice in the same sequence of evaluation

We speculate that Non-Redundancy is a general cognitive principle, which requires that a new cognitive file should not be created for an object that is already stored in memory. Be that as it may, it is important to note that Non-Redundancy is in a sense nothing new. A version of this principle is implicitly assumed in Chomsky and Lasnik's classic syntactic accounts of Binding Theory. To see this, consider the sentence *He hates him*. The empirical observation is that *he* and *him* cannot corefer. Condition B is stated to rule out the representation He_i *hates* him_i, where *he* and *him* bear the same index i. But this still fails to disallow He_i *hates* him_k, where i and k are different indices that both happen to refer to John. In simple cases, the necessary stipulation is that no two indices may refer to the same individual[4]. Restated in terms of sequences rather than assignment functions, this simply says that the same individual may not occur twice in any sequence, which is just our principle of Non-Redundancy. Our claim is that with the non-standard semantics we will develop shortly, Non-Redundancy can do almost all the work - no additional syntactic principles are required. This does not mean that no additional (semantic) stipulations will be needed, but in each case we will try to make clear what motivates the stipulation and what further results it derives 'for free'. Finally, it can also be checked that our principles are indeed semantic in nature, since all they do is specify (a) how sequences of evaluation are constructed, and (b) which sequences are admissible.

One proviso is in order. If our metaphor of the sequence of evaluation as a memory register is to be taken seriously, our technical apparatus must be reinterpreted, since it cannot be the object itself, but rather a standard name or description of the object which appears in a memory register (when I talk about George W. Bush, my memory register might contain a description of W., but certainly not W. himself, who wouldn't fit in there anyway). This move from objects to standard names or descriptions thereof is independently motivated on two grounds. First, as was shown in Reinhart (1983) and further elaborated in Heim (1993), there are various exceptions to Binding Theory that can only be handled by making semantic values more fine-grained, and thus by moving from objects to descriptions or 'guises'[5]. Second, a theory-internal problem that we will encounter in the analysis of quantification will again be solved by appealing to a kind of implicit descriptions. For simplicity, however, most of the theory is built as if sequences of evaluation contained objects; the same simplifying assumption has been made in Appendix IV, which provides a precise implementation of a large part of the theory.

- *Structure of the Theory*

The structure of the theory to be developed is as follows:

(Section 1) The Treatment of R-expressions and Non-Redundancy conspire to derive Condition C: as soon as a referring is processed (be it a proper name, a definite description or a pronoun of any sort), its value, for instance j, must appear at the end of the sequence of evaluation. When a coreferring proper name or definite description is processed lower down in the tree, another occurrence of j is added at the end of the same sequence, as is required by the Treatment of R-Expressions. As a result, the sequence of evaluation ends up having the same object (=j) in two different cells, and this violates Non-Redundancy. Here is a simple illustration:

(8) a. John [likes John]
b. Step 1: the subject has been processed => s^j
c. Step 2: the object has been processed => s^j^j (this violates Non-Redundancy)

We will show that with one small additional assumption the theory also explains why John talking to Mary may not normally say *John is happy* or *Mary is happy* - this observation will in fact serve to motivate Non-Redundancy.

(Section 2) The Treatment of R-expressions and Non-Redundancy taken together leave very little leeway for the analysis of pronouns - something like our Treatment of Non-Demonstrative Pronouns must be posited. The latter, together with Non-Redundancy and the rule of interpretation of atomic predicates, derives a version of Condition B. To take the example of a transitive verb, the idea is simply that after the subject is processed, its value, say j, must appear at the end of the sequence of evaluation. But then -by the Treatment of Non-Demonstrative Pronouns- all a coreferring pronoun can do is to recover this value, i.e. to move it to the end of the sequence, and crucially *not* to introduce a new occurrence of j in the sequence (note that in any event this would run afoul of Non-Redundancy). As a result, there is simply no way for a sentence such as *John likes him*$_{-1}$ to mean that John likes John, since this would require that *like* be evaluated under a sequence whose last two elements are jˆj. This mechanism is illustrated in the following simplified example, where I have assumed that when an object is recovered and moved to the end of the sequence, it leaves in its original position the element #, which indicates that this position is now empty[6].

(9) a. John likes him$_{-1}$ (evaluated under a sequence s)
b. Step 1: the subject is processed => j is added to the sequence: sˆj
c. Step 2: the object is processed => j is moved to the end, leaving #: sˆ#ˆj
d. Step 3: the predicate is evaluated, and recovers the last two elements of sˆ#ˆj, i.e. #ˆj.

Since one of the last two elements of the final sequence sˆ#ˆj contains #, the last step of the evaluation procedure will result in a failure, as is desired. Thus a version of Condition B follows from the present system (in fact this is to our knowledge the first theory to establish a logical connection between a non-local constraint, Principle C, and a local one, Principle B). Condition A doesn't follow in the same way, but it can be made compatible with the present theory if we adopt Bach & Partee's analysis of reflexives as 'arity-reducers' (Bach & Partee 1980).

(Section 3) The Treatment of Non-Demonstrative Pronouns and Non-Redundancy derive a principle of Locality of Variable Binding - one that I adopt from Kehler (1993) and Fox (2000) (though Fox has a slightly different version of the rule). Suppose that a pronoun □ appears in a structure [... A ... B... □...] where □ is in the scope of B, which is itself in the scope of A. Standard theories postulate that if A and B both refer to an object i, □ may come to denote i by being bound by A or by B, *and both options should be open*. Fox and Kehler argue that this is incorrect, and that in such cases if □ is to denote i it *must* be bound by the closest possible antecedent, namely B. In our framework this follows from the very architecture of the system because when □ is processed there is a single occurrence of i in the sequence of evaluation, with the result that a single indexing - the 'local' one- is possible.

(Section 4) We will see that the simplest version of our system encounters a problem in the analysis of quantified structures. A stipulation will be needed, to the effect that elements introduced by quantifiers appear in an independent sequence, which we call the 'quantificational sequence', and which is not subject to Non-Redundancy[7]. The advantage of this analysis is that it yields an immediate account of Weak and Strong Crossover effects, as well as an explanation of why the former are less severe than the latter.

Various refinements are considered at the end of the paper and in four Appendices. They show that (a) split antecedents and disjoint reference effects can be incorporated to an extension of the theory (**Section 5**); (b) the top-down interpretation of the theory, although natural enough, can be dispensed with (**Section 6**); (c) the device of 'empty cells' is eliminable when temporal anaphora is taken into account(**Appendix I**); (c) Refinements of Condition B and Condition A can be incorporated to the theory (**Appendix II**) ; (e) our version of the Locality of Variable Binding, which is also Kehler's, makes different and arguably better predictions from Fox's version of the same principle (**Appendix III**); (f) most of the theory can be implemented in a reasonably simple formal system (**Appendix IV**).

The following summarizes the deductive structure of the theory:

(10) Structure of the theory

Treatment of R-expressions + **Non-Redundancy**

Treatment of Non-Demonstrative Pronouns

-Condition C
-Condition on reference to speaker/hearer
-Condition B
-Locality of Variable Binding

+ Additional Assumption

-Solution of a problem in the analysis of quantification
-Weak and Strong Crossover

1 Non-Redundancy and Condition C

1.1 The Interpretation of R-expressions and Predicates

❑ *Sequences of Evaluation and Linguistic Context*

The general intuition we pursue is that a sequence of evaluation represents the *linguistic context* with respect to which a constituent is evaluated. The linguistic context has two components:
(a) first, it includes those objects that are given by the mere existence of the speech act, i.e. a speaker and an addressee. In a more sophisticated version of the system we would also include a time of utterance, as is done in Appendix I; but to keep things simple we start by omitting time altogether [8]. We further assume that the speaker and addressee are introduced with a role, respectively 'A' and 'H' (for 'author' and 'hearer), so that we may recover from a sequence of evaluation the identity of the speaker and hearer (to be concrete, the speaker is that object of the sequence which appears with the role 'A', while the addressee is the object that appears with the role 'H')
(b) second, the sequence of evaluation includes the objects that have been linguistically introduced, i.e. which are the denotations of terms that have been processed. Given a very simple set-up the sequence will also encode the order in which the terms are processed. In a top-down procedure, this order mirrors the scope (=c-command) relations that are found in the syntax. This will be the key to achieve a semantic reinterpretation of standard syntactic conditions on binding. It should be emphasized, however, that this result follows from entirely standard assumptions about the syntax/semantics interface: the semantic component simply interprets compositionally the sister-to-sister configurations that are found in the syntax. In the present theory, when an R-expression r is encountered, its sister s is evaluated under a modified sequence which ends with the value of r. Further R-expressions found within s will again add their value to the sequence, which will thus end up encoding the c-command relations that are found in the syntax[9].

Importantly, the denotation of demonstrative pronouns (i.e. free pronouns that are not indexical) is assumed *not* to be given directly by the sequence of evaluation, but through the intermediary a 'demonstrative function' D. Thus if D(1)=John, the speaker of s intended to refer to John by uttering the pronoun he_1. There is a weak conceptual argument and a strong empirical one for distinguishing the demonstrative function from the sequence of evaluation. The conceptual point is that demonstrative pronouns need extra-linguistic information to get a denotation - for instance they may be completed by a demonstrative gesture on the part of the speaker; in that sense their denotation cannot be recovered from the speech act in a narrow sense. The empirical argument is that in a sentence such as *His mother likes John*, where *his* denotes John, we do *not* want to say that John must already be found in the initial sequence to provide *his* with a referent, for this would incorrectly predict a violation of Non-Redundancy when *John* is processed (two occurrences of John would be found in the final sequence; see the discussion below). We thus follow Reinhart (1983) in claiming that there is no formal connection between the free pronoun *his* and what is intuitively its antecedent, namely *John;* accordingly, we treat *his* as being demonstrative in our sense. (For all intents and purposes, we will treat demonstrative pronouns in the same way as proper names, which will account for the fact that *He_1 likes John*, where D(1)=John, is ungrammatical, in the same way as *John likes John* (one may think of demonstrative pronouns as 'temporary proper names'.)

- *Basic Rules*

Let us now consider some basic examples. Suppose that John, talking to Mary, said: *Ann runs*. The initial sequence is simply $j^{A}\hat{}m^{H}$, where j^A and m^H can be seen respectively as the abbreviations of the pairs <j, A> and <m, H>, indicating that John (=j) is the speaker of the speech act, and that Mary (=m) is its addressee. By the Treatment of R-expressions, when *Ann* is processed, its value is added to the sequence, yielding a new sequence $j^{A}\hat{}m^{H}\hat{}a$. At that point all the arguments of the verb have been processed, and thus *runs* is evaluated under the sequence $j^{A}\hat{}m^{H}\hat{}a$. Since *run* is intransitive, it is true under the sequence $j^{A}\hat{}m^{H}\hat{}a$ just in case its last element, namely a, lies in the extension of the predicate at the world of evaluation w (=I_w(run)). We thus obtain the following interpretation, in which we have relativized truth and denotation to a sequence of evaluation and a world parameter:

(11) $[[\text{Ann run}]]^{w}\, j^{A}\hat{}m^{H} = 1$ iff $[[\text{run}]]^{w}\, j^{A}\hat{}m^{H}\hat{}a = 1$, iff $a \square I_w(\text{run})$

A transitive construction is interpreted in the same way, except that the verb ends up being true just in case the *pair* of the last two elements of the final sequence lies in its extension:

(12) $[[\text{Ann hate Bill}]]^{w}\, j^{A}\hat{}m^{H}=1$ iff $[[\text{hate Bill}]]^{w}\, j^{A}\hat{}m^{H}\hat{}a = 1$, iff $[[\text{hate}]]^{w}\, j^{A}\hat{}m^{H}\hat{}a\hat{}b=1$,
iff $a\hat{}b \square I_w(\text{hate})$ (since $a\hat{}b$ are the last two elements of $j^{A}\hat{}m^{H}\hat{}a\hat{}b$)

On a technical level, the definition in (13) gives a preliminary implementation of our Treatment of R-expressions:

(13) Treatment of R-expressions (preliminary version)
If $\square$ is a proper name, a definite description or a demonstrative pronoun (i.e. a pronoun with a positive subscript), $[[\,[\square\ \square]\,]]^{w} s = [[\,[\square\ \square]\,]]^{w} s = [[\square]]^{w} s\hat{}[[\square]]^{w} s$

The definition is straightforward, and simply formalizes the idea that the denotation of an R-expression is systematically added at the end of the sequence of evaluation; the sister to the R-expression is then evaluated under this new sequence. Obviously basic rules to determine the denotation of R-expressions and predicates must be added as well. For the former the definition in (14) will do, and for that latter that in (15):

(14) Denotation of R-expressions (preliminary)
a. If $\square$ is a proper name, $[[\square]]^{w}s=I_w(\square)$
b. If p is a pronoun and i is a non-negative integer, $[[p_i]]^{w}s=D(i)$.
c. $[[\,[\text{the } \square]\,]]^{w}s=\#$ iff there is 0 or more than one object d satisfying $[[\square]]^{w}s,d=1$.
Otherwise $[[\text{the } \square]]^{w}s=d$, where d satisfies $[[\square]]^{w}s\hat{}d=1$[10]

(15) Interpretation of Predicates (preliminary)
Let P be an n-place predicate.
$[[P]]^{w}s=\#$ iff one of the last n elements of s is # or s violates Non-Redundancy [the latter clause is justified in the next section]. Otherwise, $[[P]]^{w}s=1$ iff $s_n \square I_w(P^n)$, where s_n is the sequence of the last n elements of s.

(s_n must be defined carefully to take into account the case in which one of the last n elements is a pair of the form <d, A> or <d, H>, if d is the speaker or hearer. In such cases we want s_n to recover only the first coordinates of the relevant elements. The proper definitions are given in Appendix IV.)[11]

1.2 Non-Redundancy

- *Linguistic Motivation for Non-Redundancy: constraints on terms denoting the speaker and the hearer*

We now come to the motivation for our crucial Principle, Non-Redundancy. As was mentioned earlier, a version of this principle is implicitly assumed in most syntactic theories of binding, since without it there would be no way to rule out on syntactic grounds a sentence such as *He$_1$ likes him$_2$*, where both *he$_1$* and *he$_2$* refer to John. But there is also independent motivation for Non-Redundancy. Notice that John talking to Mary may not normally refer to himself or to her using a proper name such as *John* or *Mary*, or even a definite description, as is shown in the following paradigm:

(16) Context: John, who is the syntax professor, is speaking to Mary, who is the semantics professor.
a. #John is happy.
a'. I am happy.
b. #Mary is happy.
b'. You are happy.
c. #John's mother is happy.
c'. My mother is happy.
d. #Mary's mother is happy.
d'. Your mother is happy.
e. #The syntax professor is happy.
f. #The semantics professor is happy.

On the assumption that the speaker and hearer figure in the initial sequence of evaluation, these facts follow our principle. In (16)a we start out with a sequence $j^{A}\hat{}m^{H}$ (since John is the speaker and Mary is the addressee). When the subject *John* is processed, the Treatment of R-expressions requires that its denotation be added to the sequence of evaluation, which yields a new sequence $j^{A}\hat{}m^{H}\hat{}j$. But the latter violates Non-Redundancy, since John appears twice. The same effect is found in (16)b, where by the Treatment of R-expressions Mary is added to the initial sequence to yield a new sequence $j^{A}\hat{}m^{H}\hat{}m$, which again violates Non-Redundancy[12, 13].

- *Condition C: Basic Cases*

Let us now see how Condition C effects are derived. Consider the sentence *Bill likes Bill*. First, the subject is processed, and its denotation Bill (=b) is added to the initial sequence of evaluation $j^{A}\hat{}m^{H}$ to yield $j^{A}\hat{}m^{H}\hat{}b$. At this point no problem arises, since this new sequence does obey Non-Redundancy. But as soon as the object is processed, Non-Redundancy is violated because another occurrence of Bill is added to the sequence, yielding $j^{A}\hat{}m^{H}\hat{}b\hat{}b$, which is illicit:

(17) a. #Bill like Bill (said by John to Mary)
b. $[[\text{Bill like Bill}]]^{w}\, j^{A}\hat{}m^{H}=[[\text{like Bill}]]^{w}\, j^{A}\hat{}m^{H}\hat{}b=[[\text{like}]]^{w}\, j^{A}\hat{}m^{H}\hat{}b\hat{}b=\#$ because $j^{A}\hat{}m^{H}\hat{}b\hat{}b$ violates Non-Redundancy.

Exactly the same effect holds if the subject is replaced with a demonstrative pronoun *he$_1$* which denotes Bill. As soon as the subject is processed, the rest of the derivation becomes indistinguishable from that in (17), and Non-Redundancy ends up being violated once again:

(18) a. #He$_1$ likes Bill (said by John to Mary, where *he$_1$* is a demonstrative pronoun denoting Bill)
b. $[[\text{He}_1 \text{ like Bill}]]^w j^{A\wedge}m^H = [[\text{like Bill}]]^w j^{A\wedge}m^{H\wedge}D(\text{he}_1) = [[\text{like Bill}]]^w j^{A\wedge}m^{H\wedge}b = [[\text{like}]]^w j^{A\wedge}m^{H\wedge}b^\wedge b = \#$
because $j^{A\wedge}m^{H\wedge}b^\wedge b$ violates Non-Redundancy.

By contrast, no violation of Non-Redundancy occurs in *Bill's teacher likes Bill,* analyzed for simplicity as *The Bill teacher likes Bill* (where *teacher* is a 2-place predicate). The key is that the VP *hates Bill* is evaluated under a sequence that contains Bill's teacher but not Bill himself, with the result that Non-Redundancy is satisfied. This is illustrated in the following partial derivation (a full derivation of an analogous example is found in Appendix IV, (ix)):

(19) a. Bill's teacher likes Bill *(said by John to Mary, and analyzed as:)*
a'. The Bill teacher likes Bill
b. $[[(a')]]^w j^{A\wedge}m^H = [[\text{like Bill}]]^w j^{A\wedge}m^{H\wedge}t = [[\text{like}]]^w j^{A\wedge}m^{H\wedge}t^\wedge b$, with $t = [[\text{the Bill teacher}]]^w j^{A\wedge}m^H$

Exactly the same analysis applies to *His$_1$ teacher likes Bill,* where *his* is a demonstrative pronoun denoting Bill (so that D(1)=b) - unsurprisingly, since we have assumed that demonstrative pronouns are treated in the same way as proper names[14].

By contrast, *Bill likes Bill's teacher* (analyzed as *Bill likes the Bill teacher*) yields a violation of Non-Redundancy. This is because as soon as the subject is processed, its value Bill is entered in the sequence of evaluation, which now becomes $j^{A\wedge}m^{H\wedge}b$. All the elements that are in the scope of *Bill* are evaluated under extensions of this initial sequence. As a result, when the second occurrence of *Bill* is processed, it adds b to a sequence of the form $j^{A\wedge}m^{H\wedge}b^\wedge\ldots$, yielding a sequence $j^{A\wedge}m^{H\wedge}b^\wedge \ldots{}^\wedge b$, which violates Non-Redundancy. The same analysis applies to *His$_1$ teacher likes Bill*, where *his$_1$* is a demonstrative pronoun that denotes Bill. Once the denotation of *his$_1$* is added to the initial sequence, the derivation becomes indistinguishable from that of *Bill likes Bill's teacher,* and a semantic failure is correctly obtained.

One cautionary note is in order at this point. Binding conditions B and C have notorious counterexamples, such as the one in (20):

(20) (Who is this man over there?) He is Colonel Weisskopf (Reinhart & Grodzinsky (1993))

If Condition C were applied blindly, the sentence would be predicted to be ungrammatical, since *he* and *Colonel Weisskopf* denote the same person. One line of analysis, due to Heim (1993), is to make semantic values more fine-grained than is usual by introducing 'guises' or values of implicit descriptions ('individual concepts') under which various denotations are apprehended. In the case at hand the implicit descriptive content of *he* may be something like *the man you just pointed at*, which is probably different from the usual descriptive content associated with *Colonel Weisskopf.* For this reason the two expressions count as referentially distinct from the standpoint of the Binding Theory, and Reinhart's problem can be solved.

This strategy can be adapted to the present framework. In a more elaborate version of our system (one with a context parameter), we could include in the sequence of evaluation functions from contexts to objects, rather than simply objects. In other words, the sequence of evaluation would contain the values of (rigidified) descriptions rather than the described objects themselves[15] (note that if we wished to preserve the metaphor of the sequence-as-a-memory-register, we would have to say that the sequence contains the descriptions rather than their values, since a memory register can contain symbols but not what they denote). Of course once we make this move we open a Pandora's box - why couldn't we *always* introduce different implicit descriptions to refer to a given individual, thus circumventing any kind of binding-theoretic violation? To put it differently, why is *He likes John ever* unacceptable with coreference, since *he* and *John* could in principle introduce different guises that both denote John? Clearly the use of implicit descriptions must be constrained. We could posit tentatively that, in the unmarked case, there exists a canonical description which is the *only* one under which a given individual may be denoted. Interestingly, Corblin (2002) has suggested a similar constraint for *overt* descriptions[16]. His basic motivation can be illustrated by the following case. If you and I have both known John Smith since our days in graduate school, it will be odd to talk of *Ann Smith's husband* or of *the Harvard professor* even if John happens to be married to Ann or to be the only Harvard professor around. In most cases, *John* (or a pronoun) is the only term with which we may naturally refer to him[17]. The hope is that a constraint of this sort could be motivated for implicit descriptions as well[18]. This point, which will be set aside in what follows (except for a brief reappearance in Section 3), will have to be investigated further in future research.

- *Condition C: Adding* that-*clauses*[19]

As is well-known, Condition C effects also hold in sentences with embeddings, such as *#Bill claims that Bill runs*. In order to give an analysis of such examples, I need to say a bit more about the semantics of attitude verbs. To keep things simple, I stick to the traditional notion that the sentence *Bill claims that Ann runs* is true just in case Bill stands in the *claim* relation to the set of worlds in which Ann runs. In the technical implementation, the rule in (21), which is standard, specifies that a *that*-clause denotes a function from possible worlds to truth values; while (22) stipulates that *that*-clauses should be treated in the same way as R-expressions, in the sense that their denotations should be added at the end of the sequence of evaluation. This naturally leads to the rule of interpretation of attitude verbs given in (22), which states that an attitude verb such as *claim* is true under a sequence just in case its last two elements are an individual and a proposition which stand in the *claim* relation.

(21) Rule for *that*-clauses
$[[\text{that } \square]]^{w}s = \square w' \, [[\square]]^{w'}s$

(22) Treatment of R-expressions (revised): If □ is a proper name, a definite description, a demonstrative pronoun (i.e. a pronoun with a positive subscript), **or a *that*-clause**,
$[[\, [\square\ \square]\,]]^{w}s = [[\, [\square\ \square]\,]]^{w}s = [[\square]]^{w}s\hat{}[[\square]]^{w}s$

(23) Interpretation of attitude verbs
If A is an attitude verb, $[[A]]^{w}s = \#$ iff s violates Non-Redundancy or the last two elements of s are not an individual and a proposition respectively. Otherwise, $[[A]]^{w}s = 1$ iff $s_2 \square I_w(A)$, where s_2 is the pair of the last two elements of s.

To illustrate briefly, consider the derivation of *Bill claims that Ann runs* (for simplicity I omit failure conditions):

(24) a. Bill claims that Ann runs (said by John to Mary)
b. (It can be shown that $[[a]]^{w} j^{A}\hat{}m^{H} \neq \#$)
$[[a]]^{w} j^{A}\hat{}m^{H} = [[\text{claims that Ann runs}]]^{w} j^{A}\hat{}m^{H}\hat{}b = [[\text{claims}]]^{w} j^{A}\hat{}m^{H}\hat{}b\hat{}p$
with $p = [[\text{that Ann runs}]]^{w} j^{A}\hat{}m^{H}\hat{}b = \square w' \, [[\text{Ann runs}]]^{w'} j^{A}\hat{}m^{H}\hat{}b$
$= \square w' \, [[\text{runs}]]^{w'} \mathbf{j^{A}\hat{}m^{H}\hat{}b\hat{}a} = \square w' \, a \square I_{w'}(\text{runs})$
Hence $[[a]]^{w} j^{A}\hat{}m^{H} = 1$ iff $b\hat{}p \square I_w(\text{claims})$

When *Ann* is replaced with *Bill*, the final sequence (written in bold) becomes $j^{A}\hat{}m^{H}\hat{}b\hat{}b$, which of course violates Non-Redundancy, as is desired[20].

2 The Interpretation of Pronouns, Condition B and Condition A

2.1 The Interpretation of Pronouns

- *Anaphoric Pronouns*

Given Non-Redundancy and our rule of interpretation for atomic predicates, we don't have much leeway in the analysis of pronouns. Clearly, anaphoric pronouns cannot *add* a new element to a sequence of evaluation, as this would immediately yield a violation of Non-Redundancy in a sentence such as *Bill likes his mother*, where *his* denotes Bill. On the other hand it also won't do to posit that anaphoric pronouns simply leave a sequence of evaluation unchanged, for given our rule of interpretation for atomic predicates this would yield incorrect results for a sentence such as *Bill claims that Ann thinks that he runs*: if *run* were simply evaluated under the sequence obtained after *Ann* has been processed, we would obtain the value 'true' just in case *run* is satisfied by $j^{A\wedge}m^{H\wedge}b^\wedge a$; as a result, running would be attributed to the last member of that sequence, Ann, rather than to Bill - an undesirable result.

The only natural solution is to posit that an anaphoric pronoun *recovers an element that is already in a sequence of evaluation and puts it at the end of that sequence*. This can be implemented in two ways:

(i) We could posit that sequences are reordered, i.e. that an element of position -i is 'moved' to the end of the sequence. For instance when he_{-2} is processed under a sequence Mary^John^Ann, the new sequence of evaluation would be Mary^Ann^John, where John has been moved from position -2 to the last position.

(ii) Alternatively, we could stipulate that an element that is recovered leaves behind an empty cell. Under this view when he_{-2} is evaluated under a sequence Mary^John^Ann, the new sequence becomes Mary^#^Ann^John, where '#' indicates that the position that John used to occupy is now empty.

For reasons of simplicity, we adopt (ii) over (i) in the body of this paper, and we show in Appendix I that (a) in its simplest implementation, Solution (i) yields incorrect results but (b) it becomes a viable and arguably a more elegant option when temporal anaphora is taken into account. For the moment, we may make (i) precise through the following rule:

(25) Treatment of Non-Demonstrative Pronouns (preliminary)
If □ is a pronoun pro_{-i}, $[[\ [□\ □]\ ]]^w s = [[\ [□\ □]\ ]]^w s = \#$ iff s has fewer than i elements. Otherwise, for a possibly empty sequence s' and for some elements $d_1, ..., d_i$, $s = s'^\wedge d_i{}^\wedge ...^\wedge d_1$ and $[[\ [□\ □]\ ]]^w s = [[\ [□\ □]\ ]]^w s = [[□]]^w\ s'^\wedge \#^\wedge d_{i-1}{}^\wedge ...^\wedge d_1{}^\wedge d_i$

A simple grammatical example is given below (the example involves an embedding because otherwise the pronoun would be 'too close' to its antecedent, yielding a Condition B violation):

(26) a. Bill claims that he_{-1} runs
b. $[[(a)]]^w\ j^{A\wedge}m^H = [[\text{claims that } he_{-1} \text{ runs}]]^w\ j^{A\wedge}m^{H\wedge}b = [[\text{claims}]]^w\ j^{A\wedge}m^{H\wedge}b^\wedge p$
with $p = [[\text{ that } he_{-1} \text{ runs}]]^w\ j^{A\wedge}m^{H\wedge}b$
$= □w'\ [[he_{-1} \text{ runs}]]^{w'} j^{A\wedge}m^{H\wedge}b$
$= □w'\ [[\text{runs}]]^{w'} j^{A\wedge}m^{H\wedge}\#^\wedge b$
$= □w'\ b□I_{w'}(\text{runs})$

Since no referential expression was processed between *Bill* and he_{-1}, the effects of the rule are fairly uninteresting in this case: b (=the denotation of *Bill*) is found at the end of the sequence before he_{-1} is processed; the anaphoric pronoun has the effect of bringing to the final position something that was already there, and the effect is not particularly dramatic. Things become more interesting when an additional level of embedding is added, as in (27), where *Ann* has been 'sandwiched' between *Bill* and he_{-2}:

(27) a. Bill claims that Ann thinks that he_{-2} runs
b. $[[a]]^w\ j^{A\wedge}m^H = [[\text{claims that Ann runs}]]^w\ j^{A\wedge}m^{H\wedge}b = [[\text{claims}]]^w\ j^{A\wedge}m^{H\wedge}b^\wedge p$
with $p = [[\text{ that Ann thinks that } he_{-2} \text{ runs}]]^w\ j^{A\wedge}m^{H\wedge}b$
$= □w'\ [[\text{Ann thinks that } he_{-2} \text{ runs}]]^{w'} j^{A\wedge}m^{H\wedge}b$
$= □w'\ [[\text{thinks that } he_{-2} \text{ runs}]]^{w'} j^{A\wedge}m^{H\wedge}b^\wedge a$
$= □w'\ [[\text{thinks}]]^{w'} j^{A\wedge}m^{H\wedge}b^\wedge a^\wedge q_{w'}$
with (for each w') $q_{w'} = q = [[\text{that } he_{-2} \text{ runs}]]^{w'} j^{A\wedge}m^{H\wedge}b^\wedge a$
$= □w''[[he_{-2} \text{ runs}]]^{w''} j^{A\wedge}m^{H\wedge}b^\wedge a$

=□w" [[runs]] $^{w"}$ **j^{A}^m^{H}^#^a^b**

=□w" b□$I_{w"}$(runs)

=□w' a^q□$I_{w'}$(thinks)

It can be shown that [[a]] ^{w} j^{A}^m^{H}≠#, and [[a]] ^{w} j^{A}^m^{H}=1 iff b^p□I_{w}(claims)

While this may look a bit complex, all that really matters for binding-theoretic purposes is the nature of the sequences under which the various constituents are evaluated. The crucial step is indicated in bold. After the embedded subject *Ann* is processed, the sequence of evaluation is j^{A}^m^{H}^b^a. It is then turned into j^{A}^m^{H}^#^a^b when the pronoun *he*$_{-2}$ is processed, because it has the effect of moving the element that was in position -2 to the last position of the sequence, leaving behind #. This derives the intended truth-conditions, since the property of running is now attributed to Bill, and not to Ann, as would have been the case if b had not been moved in this way.

For future reference, I note that in the present system there is exactly one indexing that can make a pronoun □ coreferential with a c-commanding term □. This is because each constituent that is in the scope of □ is evaluated with respect to a sequence that contains a single occurrence of the denotation of □ - say, Peter. Non-Redundancy prevents the pronoun □ from introducing another occurrence of Peter in the sequence, and hence □ cannot bear a positive index (since pronouns with positive indices, like other R-expressions, add their denotation to the sequence of evaluation). Thus □ must bear a negative index, and can denote Peter only if it bears an index that references the position occupied by Peter in the sequence at the point where □ is processed - for instance the index -3 if at that point the sequence is j^{A}^m^{H}^p^e^a. By this reasoning, *he* can refer to Bill in *Bill thinks that he is clever only if* it bears the index -1. This might seem unfortunate in view of the notorious existence of an ambiguity in ellipsis resolution, for instance in *Bill thinks that he is clever* _*and Sam does too*_, which may mean that Sam thinks that Bill is clever or that Sam thinks that *Sam* is clever. Traditionally the ambiguity is blamed on the antecedent *Bill thinks that he is clever,* which is taken to have distinct but logically equivalent logical forms. In Section 3 we will see that the ambiguity is better analyzed in a purely semantic fashion.

- *Indexical Pronouns*

Indexical pronouns (*I, you*) can be incorporated into the present framework, with the provision that *I* may only recover from a sequence an element that bears a superscript *A*, indicating that it is the author of the speech act; and that similarly *you* may only recover an element that bears the superscript *H* (for 'hearer'). By contrast, other pronouns may not recover such elements. The necessary assumption has been stated explicitly in the Appendix IV (under 'Adequacy'); its content will be implicitly assumed in what follows. Apart from this, there is nothing special to say about indexical pronouns. In particular, they enter in the same kind of anaphoric relations as third person pronouns, except that due to the restriction we just discussed *I* and *you* may only recover from the sequence elements that denote the author and the hearer respectively. A consequence of this analysis is that, say, a first person pronoun p may be 'bound' by another first person pronoun p' that c-commands it - or to put it in the terms of the present theory, p may bear the index -i if p' is the i^{th} closest referring expression that c-commands p. For instance, in *I think that I am sick* the second *I* may bear the index -1 - in fact, by the Locality of Variable Binding, to be discussed in Section 3, it *must* bear the index -1.

The hypothesis that first and second person pronouns can be bound contradicts standard treatments of indexicality, which assume that *I* and *you* take their value from a context parameter rather than from an assignment function (Kaplan 1989). But the following facts, due (in a different form) to Heim (1991), show that the standard treatment is incorrect, since first and second person pronouns (unlike other indexicals) do give rise to bound variable readings in ellipsis:

(28) a. I did my homework. Sam did too.
Reading 1: Sam did Sam's homework.

Reading 2: Sam did my homework.
b. You did your homework. Sam did too.
Reading 1: Sam did Sam's homework.
Reading 2: Sam did your homework.
c. John did his homework. Sam did too.
Reading 1: Sam did Sam's homework.
Reading 2: Sam did John's homework.

While ellipsis resolution will be discussed in Section 3, we conclude for the moment that it *is* desirable to give first, second and third person pronouns a unified treatment, and thus to allow all of them to bear a negative indices.

2.2 The Derivation of Reinhart & Reuland's Version of Condition B

We are now in a position to derive a version of Condition B. The initial observation is that *Bill likes him* cannot normally mean that Bill likes Bill. In the present framework this follows because (a) by Non-Redundancy, there can be no more than one occurrence of Bill in the sequence of evaluation, but (b) the interpretive rule for *likes* requires that the last two positions of the sequence be occupied by Bill if the sentence is to have the intended interpretation. This tension is illustrated in (29) (*Bill likes him)*, which is evaluated under a sequence s. We may then reason as follows:
-*Bill* adds b to the sequence, yielding $s^\wedge b$. The pronoun *him* cannot refer deictically to Bill, as this would add another occurrence of Bill in the sequence, yielding $s^\wedge b^\wedge b$, which violates Non-Redundancy. Thus if *him* is to corefer with *Bill*, it must bear a negative index, in fact the index -1.
-But this does not give the intended truth-conditions, as shown in the following derivation:

(29) a. #Bill likes him_{-1} (evaluated under a sequence s)
b. $[[\text{Bill likes him}_{-1}]]^{w}\, s$
$=[[\text{likes him}_{-1}]]^{w}\, s^\wedge b$
$\mathbf{=[[like]]^{w}\, s^\wedge \#^\wedge b}$
=# since *like* is transitive and one of the last two elements of the sequence (namely element -2) is #.[21]

As expected, Condition B violations disappear when there is more 'distance' between the pronoun and its antecedent. The requirement is simply that these should never be coarguments of the same atomic predicate, a condition satisfied in (30):

(30) a. Bill claims that he_{-1} runs (said by John to Mary)
b. $[[(a)]]^{w}\, j^{A\wedge}m^{H}=[[\text{claims that he}_{-1}\text{ runs}]]^{w}\, j^{A\wedge}m^{H\wedge}b=1$
$=[[\text{claims}]]^{w}\, j^{A\wedge}m^{H\wedge}b^\wedge p$
with p $=[[\text{that he}_{-1}\text{ runs}]]^{w}\, j^{A\wedge}m^{H\wedge}b=\square w'\ [[\text{he}_{-1}\text{ runs}]]^{w'} j^{A\wedge}m^{H\wedge}b$
$=\square w'\ [[\text{runs}]]^{w'} j^{A\wedge}m^{H\wedge}\#^\wedge b=\square w'\ b\square I_{w'}(\text{runs})$
$=1$ iff $b^\wedge p\square I_{w}(\text{claims})$

One exception is worth pointing out, however. In 'exceptional case marking' (ECM), the subject of the embedded clause appears to be 'close enough' to the superordinate subject to create a Condition B effect:

(31) Bill_i believes himself_i/*him_i to be clever.

The same point applies to raising-to-subject, as with the verb *seem,* whose surface subject is often analyzed as originating in the embedded position and raising by A-movement:

(32) Bill_i seems to himself_i/*him_i to be clever.

For these and related constructions, we have no choice but to claim that either directly or through a rule of restructuring, the embedded subject is in fact an argument of the matrix verb. Different possible implementations discussed in Appendix II.

The present theory thus predicts that two arguments of the same predicate cannot denote the same object. This is in essence Reinhart & Reuland's version of Condition B, which states that 'a (semantically) reflexive predicate must be reflexive-marked', i.e. be either (a) lexically reflexive, or else (b) be followed by a *zelf*-element. This theory has serious problems, even with respect to Dutch-like languages (see for instance Bergeton (2003) for a recent critique of Reinhart & Reuland's theory, based in particular on Danish). Similar ideas have also been pursued by other researchers, who take Condition A and Condition B to be constraints on co-arguments. We inherit both the qualities and the deficiencies of these theories.

2.3 Condition A

The analysis developed so far explains why *John$_i$ likes him$_i$* is not grammatical; but it does not explain why *John$_i$ likes himself$_i$* is. Clearly, an assumption is needed about the behavior of reflexive pronouns, one that explains how they can yield local coreferential readings without violating Non-Redundancy. There is a long tradition of treating reflexives as operators that reduce the arity of the predicate they apply to (e.g. Quine 1960; the theory of Bach & Partee 1980 analyzes reflexives both in terms of operators and variables, as we also do in our final analysis). Let us first consider the case of reflexives that appear as the objects of transitive verbs (ditransitives are treated below). We could, as a first attempt, posit a rule that states that *self-hate* (=the operator *self* applied to the predicate *hate*) is true under a sequence s just in case the last member of s hates itself. Taking into account the necessary provisions for semantic failure, this would yield the following analysis:

(33) Treatment of reflexive pronouns (to be modified)
$[[\text{self-hate}]]^w s=\#$ iff $s_1=\#$ or s violates Non-Redundancy. Otherwise, $[[\text{self-hate}]]^w s=1$ iff
$s_1\hat{}s_1$□$I_w(\text{hate})$ [where s_1 is the last member of s]

To illustrate, let us consider the derivation of *Bill hates himself*. Bill is added to the sequence of evaluation, and then the rule we just stated kicks in to produce the desired truth conditions:

(34) a. Bill hates himself
a'. Bill self-hate
b. $[[(a')]]^w j^A\hat{}m^H=[[\text{self-hate}]]^w j^A\hat{}m^H\hat{}b=1$ iff $b\hat{}b$□$I_w(\text{hate})$.

This analysis won't quite suffice, however. There are three problems to solve.
(i) First, in complex cases a reflexive may have two local antecedents, as in the following example:

(35) a. ^{Ok} John$_i$ introduced Bill$_k$ to himself$_i$
b. ^{Ok} John$_i$ introduced Bill$_k$ to himself$_k$

In such cases one can't just say that the verb has been reflexivized, one must also specify *which position* has been reflexivized. This is a general problem for operator-based approaches, which forces one to posit different sorts of *self*-operators.
(ii) Second, as was already mentioned in the previous paragraph in the context of Condition B, in the analysis of *Bill believes himself to be clever* and *Bill seems to himself to be clever,* we must posit that *seem* and *believe* can take two individual arguments (and thus a total of three arguments). Possible analyses of these examples are discussed in Appendix II.
(ii) Third, and more importantly, the analysis of reflexives as arity reducers only takes care of half of the problem. To see this, consider the following paradigm:

(36) a. Peter$_i$ believes Ann to like him$_i$
b. *?Peter$_i$ believes Ann to like himself$_i$

c. $Peter_i$ believes $himself_i$ to like Ann
d. *$Peter_i$ believes $himself_i$ to like him_i
e. $Peter_i$ believes $himself_i$ to like $himself_i$

Reflexivizing the 3-place version of *believe* explains why (36)c is grammatical, but not why (36)d isn't. The latter fact can be accounted for only if the reflexive has the effect of making its antecedent unavailable for further anaphoric uptake (note that this is something that other pronouns systematically do in the present system). But by the foregoing considerations it also won't do to state that a reflexive simply behaves like an anaphoric pronoun, as this would immediately lead to uninterpretability (by the same reasoning that derived Condition B).

The most natural suggestion is that a reflexive such as *himself* is composed of two parts:
-*him* behaves like an anaphoric pronoun: it simply moves an element of the sequence to its final position, leaving behind an empty cell (which has the effect of making its antecedent unavailable for further anaphoric uptake, as is desired)
-*self* is an arity-reducing operator, which in effect turns an n-place predicate into an (n-1)-place predicate. In order to specify which position is reflexivized, we write $SELF_{i/k}$, with i<k, to indicate that the i^{th} and the k^{th} position of the predicate will end up coreferring.

Let us consider two examples (explicit rules and derivations are provided in Appendix IV). In our analysis of *Ann hates herself*, the *self*-part of the pronoun appears at Logical Form on the verb, while *her* behaves like a normal anaphoric pronoun, with index -1. *Ann* has the effect of turning an initial sequence $j^{A}\char`^m^{H}$ into $j^{A}\char`^m^{H}\char`^a$. $her_{-1}$ turns it into $j^{A}\char`^m^{H}\char`^\#\char`^a$, which still contains only one occurrence of a, as is required by Non-Redundancy. $SELF_{1/2}$, whose indices indicate that positions 1 and 2 of the predicate are coreferential, applies in the last step to ensure that the correct truth conditions are obtained.

(37) a. Ann hates herself
a'. [Ann [$SELF_{1/2}$-hate her_{-1}]]
b. $[[(a')]]^{w}\, j^{A}\char`^m^{H}=[[[SELF_{1/2}\text{-hate } her_{-1}]]]^{w}\, j^{A}\char`^m^{H}\char`^a=[[SELF_{1/2}\text{-hate}]]^{w}\, j^{A}\char`^m^{H}\char`^\#\char`^a =1$ iff
$a\char`^a \in I_w(\text{hate})$.

The same analysis applies to *Ann introduced Berenice to herself,* where *herself* and *Ann* corefer. This time we make use of the operator $SELF_{1/3}$ (since the first and the third position of the predicate are to be coreferential), but for the rest the derivation of the truth conditions proceeds as in the previous example.

(38) a. Ann introduced Berenice to herself, where *herself* and *Ann* corefer
a'. [Ann [Berenice [$SELF_{1/3}$-introduce her_{-2}]]]
b. $[[(a')]]^{w}\, j^{A}\char`^m^{H}=[[[\text{Berenice } [SELF_{1/3}\text{-introduce } her_{-2}]]]]^{w}\, j^{A}\char`^m^{H}\char`^a=[[[SELF_{1/3}\text{-introduce } her_{-2}]]]^{w}$
$j^{A}\char`^m^{H}\char`^a\char`^b= [[SELF_{1/3}\text{-introduce}]]^{w}\, j^{A}\char`^m^{H}\char`^\#\char`^b\char`^a =1$ iff $a\char`^b\char`^a \in I_w(\text{introduce})$.

This analysis is not entirely without problems, however. As is detailed in example (xxi) of Appendix IV, the theory as stated wrongly predicts that *Ann introduced Berenice to herself$_{-1}$*, where *herself* is intended to corefer with Berenice, should yield a semantic failure. But we also show in Appendix I that this is a relatively inessential artifact of the implementation based on empty cells. When the analysis is restated within a framework without empty cells but with temporal anaphora, as in Appendix I, the problem disappears.

3 The Locality of Variable Binding and Ellipsis Resolution

❑ *Denotational Economy and Truth-conditional Economy*

Any theory in which binding is a non-transitive relation between two expressions has to supplement the classic version of Condition B ('a pronoun may not be bound locally') with a principle that *requires* local binding in certain configurations. Otherwise *Bill claims that he hates him* would be predicted to have a grammatical reading on which *he* is bound *non*-locally by *Bill*, and thus denotes Bill as well. Thus although the binding pattern displayed in (39)a is correctly blocked by Condition B, we must still ensure that an additional principle (which we will call 'Locality of Variable Binding', following Fox (2000)) blocks (39)b as well:

(39) Bill claims that he hates him
a. (...ruled out by Condition B)
b. (...ruled out by the Locality of Variable Binding)

The intuition that has been pursued in the literature is that the binding pattern in (39)b is disallowed because *him* is bound non-locally by *Bill* even though local binding by *he* would yield the same semantic result (... if local binding were possible, that is; it is clear that the condition must be checked *before* Condition B has had a chance to rule out (39)a). The general idea, then, is that to achieve a given semantic effect local binding is more 'economical' than and hence preferable to non-local binding. However there are two ways to interpret the relevant notion of economy. *Truth-conditional economy* (Reinhart 1983, Heim 1993, Fox 2000, Büring 2002a) stipulates that local binding must be preferred unless non-local binding yields different *truth conditions*. By contrast, Kehler (1993) argues for a principle of *denotational economy,* which requires local binding unless non-local binding yields a different *denotation* for the bound pronoun. To put it loosely, truth-conditional economy is 'smart' and looks at the interpretation of an entire clause, whereas denotational economy is 'dumb' and considers only the interpretation of a referential expression:

(40) Truth-conditional vs. Denotational economy
a. Truth-conditional economy (modified from Büring 2002a)
For any two NPs □ and □, if □ could bind □ (i.e. if it c-commands □ and □ is not bound in □'s c-command domain already), □ must bind □, **unless this changes the truth conditions of the entire sentence.**
b. Denotational economy (cf. Kehler 1993[22])
For any two NPs □ and □, if □ could bind □ (i.e. if it c-commands □ and □ is not bound in □'s c-command domain already), □ must bind □, **unless this changes the denotation of □**

Although truth-conditional and denotational economy do not in general make the same predictions, they both rule out (39)b.

As it turns out, the present theory predicts that Denotational Economy should always be satisfied. Crucially, and unlike what is the case in other theories, Economy is not an autonomous principle; rather, it follows from the very architecture of the system - nothing needs to be added to obtain Kehler's prediction. Let us now see why. As was observed earlier, in the present framework there is at most one indexing that makes a pronoun coreferential with a given expression that c-commands it. Furthermore, if three coreferential expressions are in a c-command relation of the form [... A... $\square_1$... $\square_2$], where A c-commands $\square_1$, $\square_1$ c-commands $\square_2$, and both $\square_1$ and $\square_2$ are pronouns (the only grammatical possibility, by Non-Redundancy), $\square_2$ must bear the index -i if $\square_1$ is the i^{th} referential expression from $\square_2$. More concretely, (41)a can yield a reading on which *his* denotes John only if *his* bears the index -1:

(41) a. ^{Ok}John claims that he$_{-1}$ believes that he$_{-1}$ isn't good enough
b. *John claims that he$_{-1}$ believes that he$_{-2}$ isn't good enough

The indexing in (41)b would in fact result in ungrammaticality. An initial sequence of evaluation s will be turned into s^j after *John* has been processed, and then into s^#^j after *he$_{-1}$* has been processed.

At that point an attempt to interpret *he*$_{-2}$ yields a failure, since the element in position -2 is #. Going back to *John claims that he hates him*, we can now see that on any indexing for *him* the sentence results in a semantic failure:

(42) a. John claims that he$_{-1}$ hates him$_{-1}$ => uninterpretable (Condition B)
b. John claims that he$_{-1}$ hates him$_{-2}$ => uninterpretable (Denotational Economy)

Suppose the initial sequence of evaluation is s. Whether the indexing is as in (42)a or (42)b, the new sequence of evaluation after *John* has been processed must be s^j, which in turn is transformed into s^#^j after *he*$_{-1}$ has been processed. If *him* bears the index -1, ungrammaticality results because *hate* is evaluated under a sequence s^#^#^j, which has # in one of its last two positions. If on the other hand *him* bears the index -2, *hate* is evaluated under a sequence s^#^j^#, which again yields a semantic failure (here too # is found in one of the last two positions). This is precisely the result that we want.

❑ *Bound vs. Strict Readings in Ellipsis*

Since the empirical arguments in favor of the Locality of Variable Binding stem from an analysis of ellipsis resolution, we should consider briefly how the latter is handled in the present system.

It is often argued that a sentence such as *Peter claims that he runs* has two possible syntactic representations that both yield a coreferential reading. In one of them, *he* is a variable bound by *Peter* (or by a λ-abstractor that immediately follows *Peter*); in the other, *he* is a free variable that happens to denote Peter. This analysis is motivated by the observation that an ambiguity arises in some elided clauses: *Peter claims that he runs and Sam does too* may entail that Sam claims that Peter runs (strict reading), or that Sam claims that Sam runs (sloppy reading). On the ambiguity view, the elided conjunct is read as 'sloppy' if its antecedent has a Logical Form in which the pronoun is bound (e.g. by a λ-abstractor, as in (43)a); and it is read as 'strict' otherwise:

(43) a. Peter λx x claims that he$_x$ runs. Sam does too ~~λx x claims that he$_x$ runs.~~
$\Rightarrow$ Sam claims that Sam runs (=sloppy reading)
b. Peter λx x claims that he$_y$ runs. Sam does too ~~λx x claims that he$_y$ runs.~~,
where y denotes Peter
$\Rightarrow$ Sam claims that Peter runs (=strict reading)

In the present theory, by contrast, the strict/sloppy distinction *cannot be represented syntactically*, for the simple reason that for any coreferential reading involving c-command there is a single indexing that can represent it. Is this a problem? No, because in any event the ambiguity theory does not suffice to account for all the facts; and (a version of) the additional mechanism that is needed anyway turns out to be sufficient to derive the strict/sloppy distinction *without* a syntactic ambiguity in the first place.

The following examples, originally due to Dahl (1973), show that in a sequence of two elided VPs the first one may be read as sloppy even though the second is read as strict (as before I have followed Fox's convention of indicating in angle brackets the intended reading of the deleted material):

(44) a. Max thinks he is strong, Oscar does, too <think that Oscar is strong>, but his father doesn't <think that Oscar is strong>. (Fiengo & May 1994 p. 131)
b. Smithers thinks that his job sucks. Homer does, too <think that Homer's job sucks>. However, Homer's wife doesn't <think that Homer's job sucks> (Fox 2000 p. 117)
c. John revised his paper, and Bill did too <revise Bill's paper>, although the teacher didn't <revise Bill's paper> (Hardt 2003).

If the antecedent has a 'sloppy' *syntactic representation*, then both elided VPs should be sloppy as well; on the other hand if it has a 'strict' representation, both elided VPs should be strict. But in fact we observe a mixed situation, which is not predicted: the second clause is read as sloppy with respect to the first, and the third is read as strict with respect to the second. An additional stipulation is thus needed. Fox (2000), followed by Büring (2002a), postulates in essence that an elided element can bear a different index from its antecedent, as long as a condition of parallelism is respected. It is then decreed that an elided element may be parallel to its antecedent either by displaying the same anaphoric dependencies, or by having the same referential value. Thus the reading described in (44)c is presumably represented as in (45). The second conjunct is *syntactically* parallel to the first because the λ-abstract has been copied. The third conjunct is not syntactically parallel to the second, since the index of *his* has been changed from x to y. However if y denotes Bill, *his*$_y$ is in fact *semantically* parallel to *his*$_x$ because it has the same referential value.

(45) John λx x revised his$_x$ paper, and Bill did too ~~λx x revised his$_x$ paper~~,
although the teacher didn't ~~λx x revised his$_y$ paper~~.

Once 'referential values' are appealed to in this way, we might as well make them do all the work. Following this strategy, I will simply suggest that in the course of ellipsis resolution *an elided pronoun may optionally introduce in the sequence the value that its antecedent did*. To put it differently, an elided pronoun with index -i can optionally replace 'at the last minute' the element it is 'supposed' to bring to the last position of the sequence of evaluation with the element that its antecedent had recovered when the corresponding element of the unelided clause was processed. This is admittedly a stipulation, but as far as I can tell it is no worse than the stipulation that other theories need in any event to solve the problem of mixed readings. To illustrate the basic mechanism, consider the interpretation of *Bill claims that he runs,* followed by the two possible interpretations of *Sam does too* (again I omit failure conditions):

(46) a. Bill claims that he$_{-1}$ runs (said by John to Mary)
b. $[[a]]^{w}\ j^{A\hat{}}m^{H} = [[\text{claims that he}_{-1}\text{runs}]]^{w}\ j^{A\hat{}}m^{H\hat{}}b = 1$
$= [[\text{claims}]]^{w}\ j^{A\hat{}}m^{H\hat{}}b\hat{}p$
with p $= [[\text{that he}_{-1}\text{ runs}]]^{w}\ j^{A\hat{}}m^{H\hat{}}b = \lambda w'\ \mathbf{[[he_{-1}\ runs]]^{w'}j^{A\hat{}}m^{H\hat{}}b}$
$= \lambda w'\ [[\text{runs}]]^{w'}j^{A\hat{}}m^{H\hat{}}\#\hat{}b = \lambda w'\ b \in I_{w'}(\text{runs})$
$=1$ iff $b\hat{}p \in I_{w}(\text{claims})$

(47) Sam does too ~~claim that he$_{-1}$ runs~~ (said by John to Mary)
a. *Sloppy reading:* recover the syntactic form of the antecedent, and interpret it in the normal way. The interpretation is like (46)a, with *Sam* replacing *Bill* and s replacing b.
b. *Strict reading*: recover the syntactic form of the antecedent, and when *he*$_{-1}$ is processed add to the sequence the value that its antecedent had recovered from the sequence in the course of the interpretation of the antecedent clause.
$[[(a)]]_{strict}{}^{w}\ j^{A\hat{}}m^{H} = [[\cancel{\text{claim that he}_{-1}\text{ runs}}]]_{strict}{}^{w}\ j^{A\hat{}}m^{H\hat{}}s = 1$
$= [[\cancel{\text{claims}}]]_{strict}{}^{w}\ j^{A\hat{}}m^{H\hat{}}s\hat{}p$
with p $= [[\cancel{\text{that he}_{-1}\text{ runs}}]]_{strict}{}^{w}\ j^{A\hat{}}m^{H\hat{}}s = \lambda w'\ [[\cancel{\text{he}_{-1}\text{ runs}}]]_{strict}{}^{w'}j^{A\hat{}}m^{H\hat{}}s$
$= \mathbf{\lambda w'\ [[\cancel{runs}]]_{strict}{}^{w'}j^{A\hat{}}m^{H\hat{}}\#\hat{}b}$ (deleting s and introducing in the sequence b, which was in position -1 in the sequence $j^{A\hat{}}m^{H\hat{}}b$, i.e. in the sequence with respect to which the antecedent pronoun was evaluated)
$= \lambda w'\ b \in I_{w'}(\text{runs})$
$=1$ iff $s\hat{}p \in I_{w}(\text{claims})$

The crucial step is indicated in bold. In (47)b the pronoun *he*$_{-1}$ starts by deleting the element that was in position -1. But instead of adding that same element at the end of the sequence, it introduces the element that was so introduced in the corresponding step of the interpretation of the antecedent, shown in bold in (46)b. This derives the strict reading. While this sketch is by no means a full account of ellipsis, it should suffice to make the point we need concerning the Locality of Variable Binding.

- *Dahl's Puzzle [=Fiengo & May's 'Many Pronouns Puzzle']*

Fox (2000) introduces his principle of Locality of Variable Binding in order to account, among other things, for 'Dahl's puzzle' (also called the 'Many Pronouns Puzzle' by Fiengo & May 1994). The puzzle is this: *if an elided pronoun $□_1$ is resolved as strict, all the elided pronouns it c-commands must be read as strict too*. This is illustrated in the two pronoun case below:

(48) Max said he saw his mother, and Oscar did too. (Fiengo & May's (3) p. 130)
a. [Ok] sloppy - sloppy: Oscar said that Oscar saw Oscar's mother
b. [Ok] strict - strict: Oscar said that Max saw Max's mother
c. [Ok] sloppy - strict: Oscar said that Oscar saw Max's mother
d. *strict - sloppy: Oscar said that Max saw Oscar's mother

Fiengo & May (1993) claim that the generalization holds when there are more pronouns, and they give a procedure to construct all possible readings. Here are some examples, where □ indicates that a pronoun is read as strict while □ indicates that it is read as sloppy:

(49) Available readings in ellipsis (Fiengo & May pp. 134-135) (Left-to-right order represents c-command) □=pronouns read as strict; □=pronouns read as sloppy

2 pronouns	3 pronouns	4 pronouns
□ □	□ □ □	□ □ □ □
□ □	□ □ □	□ □ □ □
□ □	□ □ □	□ □ □ □
	□ □ □	□ □ □ □
		□ □ □ □

According to Fiengo & May, the generalization holds only when the strict pronoun *c-commands* the other pronouns. When there is no c-command relation, no readings are filtered out, as is illustrated below (*his* does not c-command *him*, and thus *him* can be read as sloppy even when *his* is read as strict):

(50) Max said his mother saw him, and Oscar did, too (Fiengo & May's (53) p. 156)
a. [Ok] sloppy - sloppy: Oscar said that Oscar's mother saw Oscar
b. [Ok] strict - strict: Oscar said that Max's mother saw Max
c. [Ok] sloppy - strict: Oscar said that Oscar's mother saw Max
d. [Ok] strict - sloppy: Oscar said that Max's mother saw Oscar

In essence, Fox 2000 derives the generalization by suggesting that the only binding relation authorized in the antecedent of (48) is the one given in (51), which involves local binding: non-local binding of *his* by *Max* would not modify the truth-conditions of this conjunct, and is thus blocked[23]:

(51) Max said that he saw his mother.

As a result, Fox's disjunctive definition of parallelism (an element may be parallel to its antecedent by displaying the same syntactic dependencies *or* by having the same referential value) authorizes the readings in (52)a-c, but crucially not that in (52)d:

(52) Oscar did too.
a. Oscar said that he saw his mother.

b. Oscar said that <Max> saw his mother

c. Oscar said that he saw <Max>'s mother.

d. *Oscar said that <Max> saw his mother.

(52)a is allowed by syntactic parallelism. (52)b is allowed because <*Max*> (or rather, a pronoun *he* with a new index, denoting Max) satisfies referential parallelism, while *his* satisfies syntactic parallelism (it displays the same dependency as its antecedent). (52)c is allowed because *he* is syntactically parallel to its antecedent, while <*John*> has the same denotation as its antecedent. On the other hand (52)d is correctly predicted to be ungrammatical: *his* isn't referentially parallel to its antecedent, since it denotes Oscar, not Max. And it isn't syntactically parallel to its antecedent either, since by economy the latter had to be bound locally.

This result can be replicated in the present framework. There is no choice as to the Logical Form of the elided part of (52), which is simply copied from the antecedent VP, yielding (53):

(53) Max said that he_{-1} saw his_{-1} mother. Oscar did too ~~say that he_{-1} saw his_{-1} mother~~.

The various interpretive possibilities arise when different choices are made in the interpretive component: for each elided pronoun either its 'normal' value or the value of its antecedent can be added to the sequence of evaluation. This yields the following possibilities, where for simplicity I have only represented the crucial sequences rather than the entire derivations:

(54) Oscar did too ~~say that he_{-1} saw his_{-1} mother~~.
a. Sloppy-sloppy reading: the normal interpretation process applies
s^o
s^#^o
s^#^#^o
b. Strict-strict reading: Max instead of Oscar is added to the sequence in the 2nd step.
s^o
s^#^m [*he_{-1}* deletes o; but instead of inserting it at the end of the sequence, it inserts the element that its unelided countepart had recovered in the interpretation of the antecedent, i.e. m]
c. Sloppy-strict reading: Max instead of Oscar is added to the sequence in the 3rd step
s^o
s^#^o
s^#^#^m [*his_{-1}* deletes o; but instead of inserting o at the end of the sequence, it inserts the element that its unelided countepart had recovered in the interpretation of the antecedent, i.e. m]
d. *Strict-sloppy: cannot be derived

As in Fox's and Kehler's systems, the unattested reading on which *he* is strict (=denotes Max) while *his* is sloppy (=denotes Oscar) simply cannot be derived. This is because the only way for *he_{-1}* to denote Max is to introduce the value of its antecedent rather than its 'normal' value in the sequence of evaluation. But then the rest of the sentence, ~~*saw his_{-1} mother*~~, is evaluated with respect to the new sequence s^#^m. There are then only two possibilities for the interpretation of *his_{-1}*, which both yield the same result:
(i) if nothing special is done, *his_{-1}* recovers the last element of s^#^m, and thus *his* denotes m.
(ii) alternatively, *his_{-1}* may recover the value of its unelided counterpart. But unelided *his_{-1}* denoted m as well, so this gives exactly the same result as (i).
Thus not matter which choice is made, we obtain an across-the-board strict reading, as in (54)b[24].

The result, then, is that the basic predictions of Fox's and Kehler's analyses are matched -and derived- by the present theory. A further enterprise would be to distinguish between the predictions of Truth-conditional Economy and Denotational Economy. This question is addressed in Appendix III, where we suggest that Denotational Economy (i.e. the version of the Locality of Variable Binding which is derived by the present theory) is arguably superior to Truth-conditional Economy.

4 Quantification and Crossover Constraints[25]

As it stands, our theory encounters a serious problem with quantification - it incorrectly predicts that a sentence such as *Ed thinks that every professor is underpaid* cannot attribute to Ed the thought that every professor *including Ed himself* is underpaid (D. Büring, p.c.). The problem is real, and a stipulation is needed to solve it; but this stipulation also yields a direct account of Weak and Strong Crossover, as well as of the difference between them.

To see what the issue is, let us see how quantification could be incorporated to the present framework. Assuming with several standard theories that quantifiers take scope by undergoing 'Quantifier Raising', we could posit the following rule for *every*, which is standard (again I omit failure conditions):

(55) $[[\,[[\text{every N'}]\ \text{I'}]]]^{w}\ s=1$ iff for each d satisfying $[[\,\text{N'}]]^{w}\ s\hat{}d=1$, $[[\,\text{I'}\,]]^{w}\ s\hat{}d=1$

Similarly we could decide to treat traces in exactly the same way as pronouns. If we followed this course we would obtain the following derivation for *Every professor is underpaid:*

(56) a.[[Every professor] [t_{-1} is underpaid]]
b. $[[a]]^{w}\ s=1$ iff for each d such $[[\text{professor}]]^{w}\ s\hat{}d=1$, $[[t_{-1}\ \text{is-underpaid}]]^{w}\ s\hat{}d=1$
iff for each d such $d \in I_w$(*professor*) , $[[\text{is-underpaid}]]^{w}\ s\hat{}\#\hat{}d=1$
iff for each d such $d \in I_w$(*professor*), $d \in I_w$(*is-underpaid*)

Unfortunately, if Non-Redundancy is checked with respect to each of the many sequences that enter in the truth-conditions of (56), we must predict that *Ed thinks that every professor is underpaid* cannot mean that Ed thinks that every professor *including himself* is underpaid. The reason is that once *Ed* has been processed, *every professor is underpaid* must be evaluated as in (56), but under an initial sequence of the form s=s'^e where e is Ed. As a result, for d=e Non-Redundancy is violated, contrary to what we want.

This problem suggests that the elements that are introduced by a quantifier *do not appear in the sequence of evaluation,* but in a different sequence, the 'quantificational sequence', which is not itself subject to Non-Redundancy (for otherwise the same problem could be recreated with more complex examples, e.g. *Everybody loves everybody*, which certainly requires that *love* be evaluated at some point with respect to a sequence that contains two instances of John[26]). Since the elements of the quantificational sequence must in the end play a role in the evaluation of predicates, the sequence of evaluation must have a way to cross-reference them. We assume that *traces of quantifiers perform this function*, by introducing in the sequence of evaluation indices that cross-reference cells of the quantificational sequence (thus traces play a role which is *very* different from that of pronouns). This mechanism solves the above problem, but it also explains why there are Crossover effects. The heart of the matter is that the effect of a quantifier is now decomposed into two separate steps, which are conflated in standard treatments:

-*Introduction step:* when a quantifier is evaluated with respect to a sequence of evaluation s and a quantificational sequence q, it leaves s unchanged but turns q into q^d for each object d that is quantified over.

-*Cross-reference step:* when a trace indexed with the quantifier is processed, an index i is introduced in the sequence of evaluation which indicates which cell of the quantificational sequence must be retrieved.

-If necessary, there can then be further *anaphoric steps,* with garden-variety pronouns. The index i is then treated as any other object found in the sequence of evaluation. If the trace is immediately followed by a pronoun with index -1, the sequence of evaluation is turned from s^i into s^#^i, as is required by the rule of interpretation of anaphoric pronouns. Crucially, if the anaphoric step precedes the cross-reference step, the pronoun will try to retrieve from the sequence of evaluation an object that is not there yet (since it is only after the trace has been processed that the index i is added to the sequence of evaluation). This, in a nutshell, is our account of Weak Crossover effects: pronouns can be affected by quantifiers only after a trace has introduced in the sequence of evaluation an index that cross-references the relevant cell of the quantificational sequence.

4.1 Separating Quantification from Anaphora: Weak Crossover Effects

- *Basic examples*

Let us make this analysis more precise. To start with an example, consider what happens in the new system when *Every man is mortal* is evaluated under a sequence of evaluation s and an empty quantificational sequence. We adopt the same notation as before to encode dependencies between traces and their antecedents: t_{-1} indicates that the trace is bound by the closest potential binder, i.e. by the closest quantifier, t_{-2} by the second closest, etc[27]. In addition, the empty sequence is written as ø. Thus [[(a)]] ^{w} s, ø indicates that (a) is evaluated with respect to the sequence of evaluation s and the empty quantificational sequence.

(57) a. [Every man] [t_{-1} is mortal]
b. [[(a)]] ^{w} s, ø=1 iff
[Step 1] for each d such [[man]] ^{w} s, d=1, [[t_{-1} is-mortal]] ^{w} s, d=1
iff [Step 2] for each d such d□I_w(*man*), [[is-mortal]] ^{w} s^1, d=1
iff [Step 3] for each d such d□I_w(*man*), d□I_w(*is-mortal*)=1

Consider the evaluation of the nuclear scope *t_{-1} is mortal*. In the first step, for each individual d that satisfies the restrictor (i.e. for each d that is a man), d is added to the quantificational sequence (if there were additional quantifiers, the values they introduce would be added at the end of the quantificational sequence, which could thus include simultaneously any number of elements). Then in the second step an index is added to the sequence of evaluation to cross-reference the corresponding element of the quantificational sequence (here the index is 1, because there is a single element in the quantificational sequence). Then this information is used to evaluate the atomic predicate *is-mortal*. Essentially the same thing happens for the restrictor, except that there is no need to indicate which element of the quantificational sequence must be retrieved, because a noun is always evaluated with respect to the element introduced by its determiner.

Before we get into further technicalities, let us see what goes wrong in an example that involves Weak Crossover. As before, the quantifier introduces an element in the quantificational sequence. But as long as the trace hasn't been processed, this element cannot be recovered by a pronoun, whose search domain is the sequence of evaluation, not the quantificational sequence. Thus we can only get as far as the interpretive step given in (58)b:

(58) a. ??His mother likes every man
a'. [Every man] [[the [he_{-i} mother]] [likes t_{-1}]]
b. [[(a')]] ^{w} s, ø=1 iff for each d such [[man]] ^{w} s, d=1, [[[the [he_{-i} mother]] likes t_{-1}]] ^{w} s, d=1

No matter what the index of *his_{-i}/he_{-i}* is, the pronoun will not be able to recover the object d, for the simple reason that d is not in the correct sequence. If on the other hand the trace *t_{-1}* had been processed 'before' *[his_{-i} mother],* i.e. in a position that c-commands it, there would have been no such problem - *his_{-i}* could have retrieved an index that cross-referenced the relevant element of the quantificational sequence, and the final truth-conditions would have been correct.

- *Rules*

I mention for completeness the rules that will be needed. I make the following assumptions about the syntax/semantics interface:
(a) An operation of 'Quantifier Raising' applies before semantic interpretation. It brings the quantifiers to their scope positions.

(b) The syntax is set up in such a way that the trace of a quantifier has the 'right' index, i.e. the index that will allow it to be dependent on the quantifier that originated in its position. For instance, in the structure [... Q ... Q'... t... t'...], where linear precedence represents c-command, I assume that if t is the trace of Q and t' is the trace of Q', t bears the index -2 and t' bears the index -1.
(c) For each pair of a sequence of evaluation s and a quantificational sequence q, an operation of *n-resolution* is defined which picks out the last n elements of s, properly resolved in case they cross-reference elements of the quantificational sequence q. The result is written as $s_n(q)$. The details of the definition are given in Appendix IV.

(59) [[[the n]]] ^{w} s, q=# iff there is 0 or strictly more than 1 element x of X satisfying [[n]] ^{w} s, q^x=1. Otherwise, [[[the n]]] ^{w} s, q=x for x satisfying [[n]] ^{w} s, q^x=1.

(60) If N is a noun taking n arguments, [[N]] ^{w}s, q=# iff s violates Non-Redundancy or $s_{n-1}(q)$ contains # or |q|=0. Otherwise, [[N]] ^{w} s, q=1 iff q_{-1}^$(s_{n-1}(q)) \in I_w(N)$

To see how the analysis of definite descriptions works, let us consider the sentence *The director smokes*.

(61) a. The director smokes
a'. [[the director] smoke]
b. [[a']] ^{w} s, q=[[smoke]] ^{w} s, q^[[the director]]^{w}s, q
[[the director]]^{w}s, q=# iff there is 0 or more than 1 object d satisfying [[director]] ^{w} s, q^d=1, i.e. $d \in I_w$(director). Otherwise, [[the director]] ^{w}s, q=d, where d satisfies [[director]] ^{w} s, q^d=1, i.e. $d \in I_w$(director). Hence:
[[a']] ^{w} s, q=# iff there is 0 or more than 1 object d satisfying $d \in I_w$(director) or there is exactly one object d satisfying $d \in I_w$(director) and that object d is a member of s.
Otherwise, [[a']] ^{w} s, q=1 iff $d \in I_w$(smoke) for $d \in I_w$(director)

The analysis of quantifiers is also straightforward: they simply manipulate elements that are added at the end of the quantificational sequence.

(62) [[[[every n] e]]] ^{w} s, q=# iff (i) for some x in X, [[n]] ^{w} s, q^x=#, or (ii) for some x in X satisfying [[n]] ^{w} s, q^x=1, [[e]] ^{w} s, q^x=#. Otherwise, [[[[every n] e]]] ^{w} s, q=1 iff for each x in X satisfying [[n]] ^{w} s, q^x=1, [[e]] ^{w} s, q^x=1.

(63) [[[t_{-i} □]]] ^{w}s, q= [[[□ t_{-i}]]] ^{w}s, q= [[□]] ^{w}s^(|q|+1-i), q

To illustrate briefly, suppose that a trace t_{-1} is evaluated with respect to a sequence of evaluation s and a quantificational sequence d^d'. d' is the element introduced by the last quantifier, hence we want t_{-1} to introduce in the sequence of evaluation an index that cross-references d'. For technical reasons, we need to count from the beginning rather than from the end of the quantificational sequence[28]. The index we need is thus 2 (=length(d^d')-1+1). Similarly if t_{-2} were interpreted with respect to a quantificational sequence d^d'^d"^d'", it would cross-reference d", and hence would introduce in the sequence of evaluation the index 3.
To be more concrete, here is a derivation of the truth conditions of *Every student smokes:*

(64) a. Every student smokes
a'. [[every student] [t_{-1} smoke]]
b. [[a']] ^{w} s, ø=# iff (for some $x \in X$, [[student]] ^{w} s, x=#) or (for some $x \in X$, [[student]] ^{w} s, x=1 and [[smoke]] ^{w} s, x=#). None of these cases ever arises, and hence:
[[a']] ^{w} s, ø=1 iff for each $x \in X$ satisfying [[student]] ^{w} s, x=1, [[t_{-1} smoke]] ^{w} s, x=1, iff
for each $x \in X$ satisfying $x \in I_w$(student), [[smoke]] ^{w} s^1 x=1, iff
for each $x \in X$ satisfying $x \in I_w$(student), $(s$^$1)_1(x) \in I_w$(smoke), iff
for each $x \in X$ satisfying $x \in I_w$(student), $x \in I_w$(smoke).

- *A different prediction: referential expressions in an A'-position (Lasnik & Stowell's Generalization)*

In the introduction we summarized the generalization concerning Weak Crossover by stating that a pronoun may not be bound from a non-argument (A') position. The present system makes a slightly different prediction, however, since it is the *nature* rather than the *position* of the binder that matters. This is because the elements that must be treated through quantificational sequences are exactly those that fail to yield violations of Non-Redundancy when one would otherwise expect them to. R-expressions are clearly not in that group. As a result, we predict that R-expressions that bind a pronoun from an A'-position should be perfectly acceptable. Lasnik & Stowell (1991) have argued that this is in fact the case. They give the following example, which displays *no* Weak Crossover effect in a sentence that clearly involves a pronoun bound by an R-expression (the availability of a sloppy reading for the elided conjunct testifies that binding is really involved):

(65) This book I would never ask its author to read __, but that book I would __ (Lasnik & Stowell 1991)

We further predict that in such cases the R-expression in the A'-position should trigger a Condition C effect if it c-commands a coreferring R-expression. This appears to be correct, although it is a bit unclear why (66)b isn't more degraded than it is (the examples in a'-d' involve Clitic Left Dislocation in French):

(66) a. John, his mother adores.
b. ?(?) John, John's mother adores.
c. *Him$_i$, John$_i$'s mother adores.
d. John's mother adores John.
a'. Jean, sa mère l'adore.
Jean, his mother him adores.
b'. ??Jean, la mère de Jean l'adore.
Jean, the mother of Jean him adores.
c'. *Lui$_i$, la mère de Jean$_i$ l$_i$'adore.
Him$_i$, the mother of Jean$_i$ him$_i$ adores
d'. La mère de Jean adore Jean.
The mother of Jean adores Jean

In sum, we agree with Lasnik & Stowell's characterization of (that part of) the problem:

> The only factor that correlates almost perfectly with the distribution of WCO effects is the intrinsic quantificational status of the local A'-binder of the pronoun. A WCO effect seems to occur just when the pronoun and trace are locally A'-bound by a true QP (or by a trace of a true QP). If the local A'-binder is either a referential NP (topicalization) or an operator bound by an external antecedent (appositive relatives, *tough*-movement constructions, and parasitic gap constructions), then there is no WCO effect. (Lasnik & Stowell 1991 pp. 704-705)

- *Adding Relative Clauses*

A word should be said about relative clauses, which interact with the analysis of Weak Crossover effects. The first of the following rules simply states that a relative clause is interpreted by intersective modification, while the second states that the *wh*-element is semantically vacuous:

(67) a. $[[N'\ RC]]^{w}s, q=1$ iff $[[N']]^{w}s, q=1$ and $[[RC]]^{w}s, q=1$
b. $[[\ [wh\_\ IP]]]^{w}s, q=[[\ IP]]^{w}s, q$

To illustrate, consider the interpretation of *Every man who runs is mortal.* The key is that the determiner *every* introduces an element x in the quantificational sequence (a different element x for each object in the domain). It is only when the trace is processed that an index is introduced in the sequence of evaluation to cross-reference x. With this procedure, the correct truth-conditions are easily derived:

(68) a. Every man who drinks smokes
a'. [Every [man who t_{-1} drink]] [t_{-1} smoke]
b. It can be shown that [[a']] ^{w} s, ø≠# . Thus:
[[a']] ^{w} s, ø=1 iff for each x such that [[[man [who [t_{-1} drink]]]]] ^{w} s, x=1, [[[t_{-1} smoke]]] ^{w} s, x=1
iff for each x such that [[man]] ^{w} s, x=[[[who [t_{-1} drink]]]] ^{w} s, x=1, [[smoke]] ^{w} s^1, x=1
iff for each x such that [[man]] ^{w} s, x=[[drink]] ^{w} s^1, x=1, [[smoke]] ^{w} s^1, x=1
iff for each x such that x□I_w(man) and $(s\hat{}1)_1$(x) □I_w(drink), $(s\hat{}1)_1$(x) □I_w(smoke),
iff for each d such that d□I_w(man) and d□I_w(drink), d□I_w(smoke)

Interestingly, we predict that restrictive relative clauses should give rise to Weak Crossover effects, since it is only when the trace is processed that the element which is in the quantificational sequence can be (indirectly) retrieved. Although the effects that are found are typically weaker than with quantifiers or interrogatives, several researchers claim that they are quite real. Thus Lasnik & Stowell write: "Like Higginbotham 1980 and Safir 1986, we disagree with Chomsky's claim that WCO effects are fully absent in restrictive relatives, even in examples like [(69)] [29]":

(69) a. the man_i [who_i [his_i mother loves t_i]]
b. the $book_i$ [$which_i$ [its_i author read t_i]]

Lasnik & Stowell immediately add: "However, with appositive relative clauses, we (and the literature) are in full agreement with Chomsky's judgment that there is no WCO effect":

(70) a. Gerald, who his mother loves, is a nice guy.
b. This book, which its author wrote last week, is a hit.

This further fact can be accommodated in the present analysis. Since an appositive relative clause always modifies a referring expression, the value of the latter, call it d, must be introduced in the sequence of evaluation, not in the quantificational sequence. As a result, (i) a pronoun can retrieve that value if it is contained in the relative clause, without triggering any Weak Crossover effect. Furthermore, (ii) no R-expression denoting d can be found in the relative clause, as this would violate Non-Redundancy. Although there are differences across speakers, the predictions appear to be borne out in English (similar judgments hold in French):

(71) a. John, who his mother adores, had a very happy childhood
b. ?? John, who John's mother adores, had a very happy childhood.

The desired results can (almost) be achieved by defining the following rule of interpretation for referential expressions modified by a relative clause. Let us assume for simplicity that the relative clause functions as a presupposition on the value of the referential expression (Potts 2003 argues that appositives contribute a conventional implicature rather than a presupposition, but the difference is immaterial for our purposes). As argued above, the relative clause itself is evaluated under a sequence of evaluation to which the value of the referential expression has been added.

(72) If r is a referential expression and RC is a (non-restrictive) relative clause,
[[[r, RC]]] ^{w}s, q=[[r]] ^{w}s, q iff [[RC]] ^{w}s^[[r]] ^{w}s, q=1. Otherwise [[[r, RC]]] ^{w}s, q=#

There is a difficulty, however. We must assume that in a non-restrictive relative clause (and only in a non-restrictive relative clause) the trace left by the *wh*-element behaves like a pronoun[30], since otherwise it would seek its value in the quantificational sequence rather than in the sequence of evaluation. Independent evidence would have to be found for this assumption.

4.2 Weak vs. Strong Crossover

Why is Weak Crossover a relatively mild violation? Presumably because it allows for a repair strategy. As a matter of fact, if the pronoun is interpreted *as if* it were a trace, the intended interpretation can be obtained without semantic failure. Whether the repair occurs in the syntax or in the semantics, its effect is to interpret (73)a as if it were (73)a", with the truth-conditions in (73)b (as usual I treat *his mother* as *the he mother*, where *mother* is a dyadic predicate):

(73) a. Surface Structure: His mother likes every man.
a'. Actual LF: [Every man] [[the [he$_{-2}$ mother]] likes t$_{-1}$]
a". Repair: [Every man] [[the [t$_{-2}$ mother]] [like t$_{-1}$]]
b. It can be shown that $[[a"]]^w$ s, ø=# iff (for some x∈X, x∈I_w(man) and there is is 0 or more than 1 x'∈X satisfying: x'^x∈I_w(mother)), or ((for every x∈X satisfying x∈I_w(man), there is exactly one x'∈X satisfying x'^x∈I_w(mother)) and (for some x∈X satisfying x∈I_w(man), there is exactly one x'∈X satisfying x'^x∈I_w(mother), and that x' also belongs to s)) [the latter condition, which is baroque, is discussed in the next subsection]. Otherwise,
$[[a"]]^w$ s, ø=1 iff for each x such that $[[man]]^w$ s, x=1, [[[[the [he$_{-2}$ mother]] like t$_{-1}$]]$]^w$ s, x=1
iff for each x∈X such that x∈I_w(man), for (the) x' satisfying [[t$_{-2}$ mother$]]^w$ s, x^x'=1, [[like t$_{-1}$]] s^x', x=1,
iff for each x∈X such that x∈I_w(man), for (the) x' satisfying $[[mother]]^w$ s^1, x^x'=1, [[like]] s^x'^1, x=1,
iff for each x∈X such that x∈I_w(man), for (the) x' satisfying x'^x∈I_w(mother), x'^x∈I_w(like)

Suppose now that instead of a Weak Crossover violation we were dealing with a Strong Crossover violation. We could attempt to apply the same repair strategy, thus turning (74)a into (74)a". But this time the repair will immediately trigger a violation of Non-Redundancy, since each trace will introduce the same index (here: 1) in the sequence of evaluation, as is illustrated below:

(74) a. Surface Structure: He likes every man.
a'. Actual LF: [Every man] [he likes t$_{-1}$]
a". Repair: [Every man] [t$_{-1}$ likes t$_{-1}$]
b. $[[a"]]^w$ s, ø=# iff for some x∈X such that $[[man]]^w$ s, x=1, [[t$_{-1}$ likes t$_{-1}$$]]^w$ s, x =#,
iff for some x∈X such that $[[man]]^w$ s, x=1, [[likes t$_{-1}$$]]^w$ s^1, x =#
iff for some x∈X such that $[[man]]^w$ s, x=1, $[[likes]]^w$ s^1^1, s=#.
The latter condition is always met because s^1^1 violates Non-Redundancy.

Thus we see that Strong Crossover effects can be analyzed as Weak Crossover effects that cannot be repaired, except by violating Non-Redundancy. We have thus derived a version of Chomsky's old insight that a Strong Crossover violation is worse than a Weak Crossover violation because it adds to it a violation of Principle C (in Chomsky's theory this was because traces were considered as R-expressions). In effect, we have followed the same intuition, since traces, like R-expressions, systematically introduce an element in the sequence of evaluation. The difference between traces and R-expressions is that the latter introduce 'normal' objects while the former introduce 'formal' objects, that is, indices.

4.3 A Problem Regained?

At this point the structure of our argument can be summarized as follows:
(i) In order to avoid predicting that *Ed thinks that every professor is underpaid* cannot attribute to Ed the thought that every professor *including himself* is underpaid, we must introduce quantified elements in a separate sequence, the quantificational sequence (and furthermore the latter should not be subject to Non-Redundancy).
(ii) The mechanism needed to cross-reference elements of the quantificational sequence accounts for Weak and Strong Crossover effects.
It would appear, however, that the solution we adopted to solve the problem in (i) has displaced but not eliminated the difficulty. To see this, consider the following examples:

(75) a. Every politician will say that his mother is wise.
a'. [Every politician] t_{-1} will say that [the [he_{-1} mother]] is wise.
b. Ann Smith knows that every politician will say that his mother is wise.
b'. Ann Smith knows that [every politician] t_{-1} will say that [the [he_{-1} mother]] is wise.

In both examples *his mother* is analyzed as a definite description *[the [he mother]]*, where *he* is bound by the quantifier *[every politician].* Now suppose that (75)a is uttered by Mary, whose son happens to be a politician. Intuitively *every politician* may range over all the politicians in the domain of discourse, including Mary's son. As a result, *his mother* may range over all the politicians' mothers, including Mary herself. But the final version of the Treatment of R-expressions, copied below, specifies that the denotation of a definite description is always added to the sequence of evaluation (the final version of the rule is identical to that in (22), except that the quantificational sequence has been added as a parameter):

(76) Treatment of R-expressions (final): If □ is a proper name, a definite description, a demonstrative pronoun (i.e. a pronoun with a positive subscript), or a *that*-clause,
$[\![[□ □]]\!]^{w}s, q = [\![[□ □]]\!]^{w}s, q = [\![□]\!]^{w}s\hat{}[\![□]\!]^{w}s, q$

As a result, at some point in the interpretation of *Every politician will say that his mother is wise,* we find a sequence of evaluation of the form m^{A}^ ...^m (since Mary is the speaker and *his mother* ranges over all the politicians' mothers, including Mary), which violates Non-Redundancy. The prediction is that the sentence should be deviant, contrary to fact. The same problem can be replicated in (75)b, independently of the identity of the speaker. If Ann Smith's son, Peter Smith, happens to be a politician, *his mother* should again range, among others, over Ann Smith herself, which should yield a violation of Non-Redundancy - again an incorrect result.

As it turns out, the problem can be solved by appealing to an extension of the notion of 'guises', whose nature we have left a bit vague. Viewed as model-theoretic objects, guises in Heim's sense should be viewed as functions from contexts to individuals. We can further define *extended guises*, which are functions from pairs of the form <context, quantificational sequence> to individuals. Thus an extended guise corresponding to the (rigidified) description *the (actual) President of the US* will introduce in the sequence the function *□c □q the x: x is the President of the US in the world of c*. Similarly the extended guise introduced by an index 1 will be of the form *□c □q the first coordinate of q*, etc. In this way, if the quantifier *every politician* in the above examples introduced an element in the first position of the quantificational sequence, *his mother* will introduce in the sequence of evaluation a guise of the form *□c □q the x: x is in the world of c the mother of the element found in the first position of q*. This description is certainly different from that corresponding to Mary in (75)a or that corresponding to Ann Smith in (75)b. As a result, Non-Redundancy will not, in the end, be violated.

5 Disjoint Reference Effects

So far, we have only discussed constraints on coreference between singular Noun Phrases. But the classic theories of Chomsky and Lasnik were designed to account as well for restrictions on *overlapping* reference when plural terms are involved. As it stands our theory cannot handle these, but as we will see shortly minor modifications of the analysis can accommodate them.

For Condition C the actual generalization is that the denotation of an R-expression may not overlap with the denotation of an expression that c-commands it, as is illustrated by the following examples from Lasnik (1989):

(77) a. *They told John to leave (* if *they* and *John* have overlapping reference)
b. *They told John to visit Susan (* if *they* and *John*/*Susan* have overlapping reference)

A similar generalization appears to hold in the case of Condition B (Lasnik 1989):

(78) a. *We like me.
b. We think that I will win.
a'. *They like him [* if *they* and *him* have overlapping reference]
b'. They think that he will win [no restriction]

In other words, it appears that a pronoun may not overlap in reference with an expression that c-commands it locally. Reinhart & Reuland (1993) challenged this claim, arguing that examples such as (78)a improve markedly when the predicate is turned from distributive to collective; for instance they give *We elected me* as acceptable (see also Safir 2004 for related remarks). But there is a confound. Independently of the issue of collectivity, Condition B effects tend to be weaker (for reasons unknown) with first person pronouns, so that *I like me* is for instance relatively acceptable. We may control for this factor by considering cases of disjoint reference that involve second person clitics in French (binding-theoretic violations are in general sharper with clitics). It is then relatively clear that these examples are still deviant (the last example is the collective one, which is relatively degraded):

(79) a. *Tu vous aimes
you-sg you-pl like
b. *Vous t'aimez
you-pl you-sg like
c. *Tu vous choisiras
you-sg you-pl will-choose
d. *Vous te choisirez
you-pl you-sg will-choose
e. *Vous t'élirez
you-pl you-sg will-elect

I conclude that Chomsky's and Lasnik's generalization still holds. But at this point we cannot account for it - in particular because we haven't said anything about the semantics of plural expressions.

We start by analyzing plural pronouns that are bound by several antecedents - a phenomenon we henceforth call 'partial binding', echoing the term 'partial control' in Landau 2000. The mechanism we introduce is then used to provide an account of Disjoint Reference effects.

5.1 Split Antecedents and Partial Binding

❑ *Third Person Plural Pronouns*

Any theory must make provisions for cases in which a plural pronoun has several antecedents, as is is illustrated in (80) (I have used a traditional indexing mechanism to indicate binding dependencies):

(80) a. [Talking about John] [Each of his$_k$ colleagues]$_i$ is so difficult that at some point or other they$_{i,k}$'ve had an argument.
b. [Every boy]$_i$ told [every girl]$_k$ that they$_{i,k}$ should have lunch together

Obviously the examples could be complicated still further to show that ambiguities arise when several antecedents are available (e.g. *Every professor suggested to every boy that he should suggest to every girl that they should have a serious conversation*). In other words, any standard theory must allow for a logical syntax in which pronouns are multiply indexed. We do so in the present framework by allowing a plural pronoun to have an arbitrary number of indices of any kind (positive or negative). We then refine our interpretation procedure by introducing into our semantics 'split cells'. The idea is that the denotations of indices that appear on the same plural pronoun should appear in different compartments of the same (split) cell. This will lead to sequences such as j^{A}^m^{H}^o˘a, where as before separations between cells are indicated by ^, while separations between compartments of the same cell are indicated by $\breve{\ }$. Except for the evaluation of atomic predicates, compartments behave exactly like full-fledged cells - in particular, when a pronoun with index -i is to retrieve the element of position -i in a sequence, the position in question is determined by counting both cells and compartments. For instance, in the sequence $j^{A\wedge}m^{H\wedge}o\breve{\ }a$, a occupies position -1, o occupies position -2, m^{H} occupies position -3, and j^{A} occupies position -4. For the evaluation of predicates, however, the elements that are found in different compartments of the same cell are merged. Thus *smoke* evaluated under the sequence $j^{A\wedge}m^{H\wedge}o\breve{\ }a$ is deemed true just in case the (mereological) sum of o and a, which we write as $o\oplus a$, lies in the extension of *smoke* (at the world of evaluation). In the following example we present a mixed case, in which the pronoun *they*$_{-1,2}$ has an anaphoric component, indicated by the negative index -2, and a demonstrative component, given by the positive index 1 (which in this case denotes Ann). I further assume that the clause is embedded, and that the last referential expression that was processed denoted Oscar:

(81) a. They$_{1,-2}$ are happy (where 1 denotes Ann)
a'. They$_{1,-2}$ be-happy
b. $[[a']]^{w}\, j^{A\wedge}m^{H\wedge}o,\ \emptyset$
$=[[they_{,-2}\text{ be-happy}]]^{w}\, j^{A\wedge}m^{H\wedge}o^{\wedge}a,\ \emptyset$ since D(1)=a
$=[[are\text{-}happy]]^{w}\, j^{A\wedge}m^{H\wedge}\#^{\wedge}a\breve{\ }o,\ \emptyset$
$=1$ iff $a\oplus o$□I_{w}(be-happy)

The same analysis can be extended to more complex cases, involving both quantification and split antecedents. For instance the sentence *[Every professor] t*$_{-1}$ *thinks that they*$_{-1,\,3}$ *should-talk* involves a pronoun *they*$_{-1,\,3}$ which has a demonstrative component (hence the positive index 3) and which is also partly bound by the trace of a quantifier (this accounts for the index -1). In a nutshell, the derivation proceeds as follows:

-First, the quantifier *every professor* is processed. It introduces the individual d in the quantificational sequence of the nuclear scope for each d which is a professor. This leads to a pair of sequences $j^{A\wedge}m^{H}$, d, where $j^{A\wedge}m^{H}$ is the sequence of evaluation and d is the new quantificational sequence.

-Second, the trace of the quantifier is processed. It introduces in the sequence of evaluation an index 1 which cross-references the first (and only) element of the quantificational sequence. This leads to a new pair of sequences $j^{A\wedge}m^{H\wedge}1$, d.

-Third, the embedded clause is evaluated - its value is necessary in order to evaluate the predicate *think*. The evaluation starts with the embedded pronoun *they*$_{-1,\,3}$.

(a) In the first step, the index -1 is processed, with the effect that the last element of the sequence $j^{A\wedge}m^{H\wedge}1$ is replaced with # and moved to the end of the new sequence. This yields a new pair of sequences $j^{A\wedge}m^{H\wedge}\#^{\wedge}1$, d.

(b) In the second step, the second index of *they*$_{-1,\,3}$, namely 3, is taken care of. This has the effect of adding to the last cell of the sequence $j^{A\wedge}m^{H\wedge}\#^{\wedge}1$ a second compartment, which contains the denotation of 3, which we take to be Oscar. The resulting pair of sequences is thus $j^{A\wedge}m^{H\wedge}\#^{\wedge}1\breve{\ }o$, d.

-Finally, the predicate *should-talk* is evaluated with respect to the pair of sequences $^{A\wedge}m^{H\wedge}\#^{\wedge}1\breve{\ }o$, d. Since the index 1 found in the last cell of the sequence of evaluation cross-references the only element of the quantificational sequence, d, the predicate is true under this pair of sequences just in case the mereological sum of d and o ($=d\oplus o$) lies in the interpretation of *should-talk* at the world of evaluation.

The derivation is given in more detail below:

(82) a. Every professor thinks that they (=the professor and Oscar) should talk
a'. LF: [Every professor] t_{-1} thinks that they$_{-1,\,3}$ should-talk (where $D_{s}(3)=o$)
b. $[[(a)]]^{w}\, j^{A\wedge}m^{H},\ \emptyset=1$ iff for each d such that $[[professor]]^{w}\, j^{A\wedge}m^{H}$, d=1,
$[[t_{-1}$ thinks that they$_{-1,\,3}$ should talk$]]^{w}\, j^{A\wedge}m^{H}$, d=1
iff for each d such that d□I_{w}(professor), $[[$thinks that they$_{-1,\,3}$ should-talk$]]^{w}\, j^{A\wedge}m^{H\wedge}1$, d=1

iff for each d such that d□I_w(professor), [[thinks]] ^{w} j^{A}^m^{H}^1^p, d =1
with p=□w' [[they$_{-1, 3}$ should-talk]] $^{w'}$ j^{A}^m^{H}^1, d
=□w' [[they$_{, 3}$ should-talk]] $^{w'}$ j^{A}^m^{H}^#^1, d
=□w' [[should-talk]] $^{w'}$ j^{A}^m^{H}^#^1˘o, d
=□w' d⊕o□$I_{w'}$(should-talk)
iff for each d such that d□I_w(professor), dˆp□I_w(thinks)

- *First and Second Person Plural Pronouns*

This analysis can be extended to first and second person plural pronouns, at least when there is exactly one speaker and exactly one hearer. First, plural indexical pronouns, just like third person pronouns, can have split antecedents. The point was made in Partee (1989), who gave the following example:

(83) John often comes over for Sunday brunch. Whenever someone else comes over too, we (all) end up playing trios. (Otherwise we play duets). (Partee 1989)

Intuitively it is clear that *we* means something like: *John, myself, and whoever else comes as well*. This example involves additional complexities, however - in particular the presence of a 'donkey' component, since the existential quantifier *someone else* appears to partly bind *we* even though it does not c-command it. Simpler examples can make the same point (again I adopt a standard notation to indicate the intended reading):

(84) a. [Each of my$_i$ colleagues]$_k$ is so difficult that at some point or other we$_{i, k}$'ve had an argument.
b. [Each of your$_i$ new colleagues]$_k$ is so difficult that at some point or other you$_{i, k}$'ll end up having an argument.

It would be easy to construct examples in which *we* or plural *you* are partly bound by several quantifiers; in fact (83) is of precisely this kind. The generalization, then, is that just like third person plural pronouns, *we* and plural *you* can have an arbitrary number of antecedents. This suggests the following analysis of first, second and third person pronouns (be they singular or plural):

(85) The cell introduced by a pronoun *pro* must:
-contain the speaker if *pro* is first person
-contain the addressee but not the speaker if *pro* is second person
-contain neither the addressee nor the speaker if *pro* is third person

The results are unsurprising for simple examples: *I_{-3} run* is semantically acceptable under a sequence j^{A}^m^{H}^o because the element in position -3 carries the diacritic A. The following example is more intricate, because *we* has both an indexical and a demonstrative component:

(86) a. We$_{-2,1}$ agree (where *we* denotes the speaker and Ann)
a'. we$_{-2,1}$ agree (where 1 denotes Ann)
b. [[a']] ^{w} j^{A}^m^{H}, ø=[[we$_{,1}$ agree]] ^{w} #^m^{H}^j^{A}, ø
=[[agree]] ^{w} #^m^{H}^j^{A}˘a, ø since 1 denotes Ann
=1 iff j⊕a□I_w(agree)

The condition imposed by the first person feature of *we* ends up being met, because when the pronoun is processed the split cell it gives rise to, namely j^{A}˘a, does contain an element that bears the diacritic A.

Let us turn to a more complex example, *[Each of you]$_i$ thinks that he$_i$ is/≠you$_i$ are the (one and only) winner*. This sentence has proven difficult to handle for presuppositional analyses of second person features (e.g. Schlenker (2003a, b); see also Rullmann (2004)). The presuppositional analysis would go like this: a variable with second person features carries a presupposition that it ranges over addressees - with fine results when the variable in question is free, as in demonstrative uses of *you* (e.g. *you$_i$* [pointing] *are clever, but you$_k$* [pointing again] *aren't*). But in the above sentence the theory makes incorrect predictions: as it turns out, the bound pronoun *he* does range over addressees, and according to the presuppositional theory it should thus be pronounced as *you,* contrary to fact (since no bound reading is available when the pronoun *you* is used)[31]. This problem does not arise in the present framework. The trace of *each of you* introduces in the sequence of evaluation a formal object, say the index 1, which is distinct from any addressee (although of course the index 1 does *cross-reference* an addressee). The constraints on person features that we just stated entail that the bound pronoun, which simply recovers the formal object 1, should be spelled out as third rather than as second person. This is a welcome result.

The analysis is slightly more complex when *we* is partly bound by a quantifier. The key steps are summarized in the following derivation:

(87) a. Every professor thinks that we should talk
a'. LF: [Every professor] [t_{-1} thinks that $we_{-1,-4}$ should-talk]
b. Initial sequences: $j^{A}{}^\wedge m^{H}$, ø
1st Step: *[Every professor]* is processed => $j^{A}{}^\wedge m^{H}$, d, for various values of d
2nd step: t_{-1} is processed => $j^{A}{}^\wedge m^{H}{}^\wedge 1$, d
3rd step: the 1st index of $we_{-1,-4}$ is processed => $j^{A}{}^\wedge m^{H}{}^\wedge\#{}^\wedge 1$, d
4tH step: the 2nd index of $we_{-1,-4}$ is processed => $\#{}^\wedge m^{H}{}^\wedge\#{}^\wedge 1\breve{}j^{A}$, d
5tH step: *should-talk* is evaluated (with respect to the 1-resolution of $\#{}^\wedge m^{H}{}^\wedge\#{}^\wedge 1\breve{}j^{A}$, d, i.e. $d\oplus j$)

And a full derivation is included in (88) (again, I omit failure conditions):

(88) a. Every professor thinks that we should talk
a'. LF: [Every professor] t_{-1} think that $we_{-1,-4}$ should-talk
b. $[[(a)]]^{w}\ j^{A}{}^\wedge m^{H}$, ø=1 iff for each d such that $[[professor]]^{w}\ j^{A}{}^\wedge m^{H}$, d=1,
$[[t_{-1}$ thinks that $we_{-1,-4}$ should-talk$]]^{w}\ j^{A}{}^\wedge m^{H}$, d=1
iff for each d such that d□I_w(professor), [[thinks that $we_{-1,-4}$ should-talk$]]^{w}\ j^{A}{}^\wedge m^{H}{}^\wedge 1$, d=1
iff for each d such that d□I_w(professor), $[[thinks]]^{w}\ j^{A}{}^\wedge m^{H}{}^\wedge 1{}^\wedge p$, d=1
with p=□w' [[$we_{-1,-4}$ should-talk$]]^{w'}\ j^{A}{}^\wedge m^{H}{}^\wedge 1$, d
=□w' [[$we_{,-4}$ should-talk$]]^{w'}\ j^{A}{}^\wedge m^{H}{}^\wedge\#{}^\wedge 1$, d
=□w' $[[should\text{-}talk]]^{w'}\ \#{}^\wedge m^{H}{}^\wedge\#{}^\wedge 1\breve{}j^{A}$, d
=□w' $j\oplus d$□I_w(should-talk)
iff for d such that d□I_w(professor), $d{}^\wedge p$□I_w(think)

5.2 Disjoint Reference

Presumably something like the mechanism introduced in 5.1 is needed in any theory. Unfortunately, it is not *quite* enough to handle the disjoint reference data. Translating into our framework some of the early generative analyses of disjoint reference effects (Lasnik 1989), we could posit that the *only* way for an expression to denote a plurality is to bear one index for each of the objects of the group. But this proposal is immediately absurd, as it entails that in the following discourse *they* bears infinitely many indices:

(89) There are infinitely many even numbers. They are all multiples of 2.

There is no way to avoid the conclusion that a plural pronoun may bear an index that denotes a plural object (see also Büring 2002b for a similar remark). But as soon as this mechanism is introduced, it allows for representations such as *They$_1$ told John to leave,* where the index 1 denotes, say, the group that includes John and Mary (i.e. $j\oplus m$). Although the sentence is deviant on this reading, it is not ruled out by Non-Redundancy as currently stated, since John is not identical to the group that includes John and Mary (i.e., $j\oplus m\neq j$). If the theory is to stand, Non-Redundancy must be refined.

In the singular case, Non-Redundancy required that no object appear twice in the same sequence of evaluation. The heuristic motivation (to which we return at the end of this paper) was one of cognitive efficiency - a cognitive agent should not create two files for the same individual.

Whatever its merits, the same motivation would seem to apply to the plural case, and to prohibit the agent from creating a new cognitive file for a group one of whose members has already been listed. This leads to a revised version of Non-Redundancy, one that is well-suited to the analysis of disjoint reference effects:

(90) Non-Redundancy (revised)
A given sequence of evaluation may not contain overlapping objects in different cells.

❑ *Condition C*

Suppose first that *they*$_1$ denotes a group that includes Oscar and Ann. Then the sentence *They*$_1$ *think that Oscar is nice* will be straightforwardly ruled out, because when *Oscar* is processed a violation of the revised version of Non-Redundancy will occur:

(91) a. *They$_1$ think that Oscar is nice, where 1 denotes $o\oplus a$
b. (a) [evaluated under $j^{A\wedge}m^{H}$, ø] is deviant because *is-nice* must be evaluated under a sequence $j^{A\wedge}m^{H\wedge}o\oplus a^{\wedge}o$, ø, which violates the revised version of Non-Redundancy.

Note that it won't help to give several indices to *they* -say, 2 and 3, where 2 denotes Oscar and 3 denotes Ann. This will have the effect of introducing a split cell when the matrix subject is processed, but Non-Redundancy (in fact, the 'old' version of it) will be violated when Oscar is added to the sequence of evaluation:

(92) a. *They$_{2,3}$ think that John is nice, where 2 denotes Oscar and 3 denotes Ann
b. (a) [evaluated under $j^{A\wedge}m^{H}$] is deviant because *is-nice* must be evaluated under a sequence $j^{A\wedge}m^{H\wedge}o\breve{}a^{\wedge}o$, ø, which violates Non-Redundancy.

On the other hand multiple indexing will correctly allow a sentence such as *Oscar thinks that they* (=Oscar and Ann) *are nice*:

(93) a. [Ok]Oscar thinks that they$_{-1,3}$ are nice, *where* 3 *denotes Ann.*
b. (a) [evaluated under $j^{A\wedge}m^{H}$, ø] is predicted to be grammatical:
Step 1: *Oscar* is processed => $j^{A\wedge}m^{H\wedge}o$, ø
Step 2: the first index of *they*$_{-1,3}$ is processed => $j^{A\wedge}m^{H\wedge}\#^{\wedge}o$, ø
Step 3: the second index of *they*$_{-1,3}$ is processed => $j^{A\wedge}m^{H\wedge}\#^{\wedge}o\breve{}a$, ø

Without multiple indexing, however, this sentence would have been ruled out. On the assumption that *they*$_1$ denotes Oscar and Ann, a violation of the revised version of Non-Redundancy would have occurred when the embedded subject was processed - *are-nice* would have been evaluated under a sequence $j^{A\wedge}m^{H\wedge}o^{\wedge}o\oplus a$, ø which violates the revised version of Non-Redundancy.

We also correctly predict that *They think that he is nice* should be grammatical, even when *they* and *he* overlap in reference. But given the system laid out at this point this is possible only because multiple indexing is allowed on *they*:

(94) a. They$_{2,3}$ think that he$_{-2}$ is nice, where 2 denotes Oscar and 3 denotes Ann
b. (a) [evaluated under $j^{A\wedge}m^{H}$, ø] is predicted to be grammatical:
Step 1: the first index of *they*$_{2,3}$ is processed => $j^{A\wedge}m^{H\wedge}o$, ø
Step 2: the second index of *they*$_{2,3}$ is processed => $j^{A\wedge}m^{H\wedge}o\breve{}a$, ø
Step 3: *he*$_{-2}$ is processed => $j^{A\wedge}m^{H\wedge}\#\breve{}a^{\wedge}o$, ø

At this point we encounter a difficulty, however. So far we have only allowed *pronouns* to carry several indices. Proper names don't carry indices at all, hence a fortiori they cannot carry several indices. But this would seem to predict that *Bill and Hillary think that she will become president* should end up being a violation of Non-Redundancy. For as soon as *Bill and Hillary* is processed, its denotation, namely $b\oplus h$, should be entered in the original sequence $j^{A\wedge}m^{H}$, yielding a new sequence $j^{A\wedge}m^{H\wedge}b\oplus h$. If *she* is used deictically, the revised version of Non-Redundancy will be violated because the embedded VP is evaluated under a sequence $j^{A\wedge}m^{H\wedge}b\oplus h{}^{\wedge}h$, which violates the revised version of Non-Redundancy. On the other hand if *she* carries a negative index, say -1, it can only recover the entire object b⊕h, rather than h alone, as is desired. Clearly we need to say that b and h have been entered in different compartments of the same cell, yielding for instance a sequence $j^{A\wedge}m^{H\wedge}b{}^{\smile}h$. When she_{-1} is evaluated under this sequence, it has the effect of bringing h to the end of a new sequence, namely $j^{A\wedge}m^{H\wedge}b{}^{\smile}\#{}^{\wedge}h$. This yields the correct result: the embedded VP is predicated of Hillary rather than of the sum of Bill and Hillary. But it is as yet unclear why conjunctions of proper names may introduce split cells in the sequence of evaluation. I leave this for future research.

❑ *Condition B*

With this framework in place for Condition C, disjoint reference effects that arise with respect to Condition B follow straightforwardly. As before, the effect is triggered when atomic predicates are evaluated. We noted above that the sentence *They*$_{2,3}$ *think that he*$_{-2}$ *is nice,* with the indexing as indicated, is correctly predicted to be grammatical. But if we consider a sentence in which there is less 'distance' between the two pronouns, for instance *They*$_{2,3}$ *like him*$_{-2}$, the result is correctly predicted to be uninterpretable. As before, the key is that the atomic predicate *like* has to be evaluated under a sequence of evaluation that 'contains' # in one of its last two cells. The only new element concerns the technical implementation of the notion of 'containment'. In our previous system a given cell contained exactly one element. Now, by contrast, a cell may contain several compartments; and of course it will be enough to trigger a failure that one of the compartments involved in the evaluation of an atomic predicate contain #. This is illustrated in the following derivation:

(95) a. They$_{2,3}$ like him$_{-2}$, where 2 denotes Oscar and 3 denotes Ann
b. $[[(a)]]^{w}\, j^{A\wedge}m^{H}, \emptyset$
$=[[\text{they}_{,3}\text{ like him}_{-2}]]^{w}\, j^{A\wedge}m^{H\wedge}o, \emptyset$ (since 2 denotes Oscar)
$=[[\text{like him}_{-2}]]^{w}\, j^{A\wedge}m^{H\wedge}o{}^{\smile}a, \emptyset$ (since 3 denotes Ann)
$=[[\text{like}]]^{w}\, j^{A\wedge}m^{H\wedge}\#{}^{\smile}a{}^{\wedge}o, \emptyset$
$=\#$ since $j^{A\wedge}m^{H\wedge}\#{}^{\smile}a{}^{\wedge}o$ contains # in one of its last two cells.

In fact, the sequence history of this example is the same as that in (94). The only difference is that in the latter the embedded predicate *is-nice*, which is intransitive, could without problem be evaluated with respect to the sequence $j^{A\wedge}m^{H\wedge}\#{}^{\smile}a{}^{\wedge}o$. Here, by contrast, *like* is transitive, and hence must have access to the last two cells of $j^{A\wedge}m^{H\wedge}\#{}^{\smile}a{}^{\wedge}o$. But the penultimate cell, $\#{}^{\smile}a$, contains #, which presumably makes it impossible to form the sum of # and a, let alone to evaluate whether that sum stands in the *like* relation to o. This explains why the sentence is deviant.

6 Speculations, Possible Extensions and Open Problems

To conclude this paper, we speculate on the possible origin of Non-Redundancy, we sketch some possible extensions of the framework and list some open problems.

6.1 Speculations on Non-Redundancy

Can one find a deeper motivation for the Principle of Non-Redundancy, which drives this entire system? Consider any cognitive agent -call him Joe- in a natural environment. Joe must keep track of the objects that he encounters, for instance to learn that they might pose a threat. Joe has a memory register (=the 'sequence of evaluation' of the present theory), in which he may decide to open new cognitive files (=the cells of the sequence, reinterpreted as containing standard names of individuals rather than the individuals themselves). Now contrast the following two strategies that Joe might follow :

Strategy 1. Whenever a creature c is encountered, create a new file and include in it all the information learned about c.

Strategy 2. Whenever a creature c is encountered: (a) check whether there already is a file for c; if so, add the new information about c to that file; (b) otherwise, create a new file and add to it all the information available about c.

It would seem that Strategy 2 is more effective than Strategy 1 if Joe, as the rest of us, occasionally suffers from partial memory loss. Suppose that on Occasion A Joe encountered a tall dark-haired man with a long knife, and created a file F with the relevant information. Suppose further that on Occasion B Joe encountered a tall dark-haired man who angrily shouted at him. Using *Strategy 2,* if the individual of Occasion B looked sufficiently like that of Occasion A, Joe will *not* create a new file but will simply add to file F the information that the very person who has serious means of destruction also happens to hold a grudge against him. The inference that on future occasions that same individual should be avoided at all costs is then easy to draw. By contrast, if Joe follows *Strategy 1* he will have created two files, one, say F_1, with the information that a tall dark-haired man owns a long knife, and the other, F_2, with the information that a tall dark-haired man holds a grudge against him. The crucial question for Joe's survival, however, is: are the individuals of F_1 and F_2 one and the same? On future encounters Joe may still look through all his files and try to determine whether F_1 and F_2 refer to one and the same individual. Apart from the fact that it might not be optimal to perform this computation online upon each new encounter, this strategy will be sub-optimal if Joe tends to forget information over time. On a later occasion all that might remain on file F_2 might be: 'is a tall man who holds a grudge against me', with the information missing that the very same man also has dark hair. This will make it difficult to infer that F_1 and F_2 refer to the same man, who should hence be avoided. By contrast, much more information would have been available if the decision whether the two men were one and the same had been made on Occasion B, when all the information about the angry tall dark-haired man was still vividly available. Of course Strategy 2, unlike Strategy 1, obeys the Principle of Non-Redundancy, applied to cognitive files rather than to discourse referents[32]. This might suggest that deeper cognitive roots can be found for the Principle of Non-Redundancy. Whether this is indeed so is left for future research.

6.2 *Reinterpretations and Extensions*

The present theory could be extended in several directions.

(i) *Functional Reinterpretation:* Although we have stated the theory in terms of top-down processing, the rules themselves are silent about the direction in which the interpretation proceeds. In fact, our analysis can be translated into a standard system in which each expression is given a semantic value, and values are then composed according to rules that can be applied top-down or bottom-up. Consider for instance the rule for R-expressions as we state it in Appendix IV:

(96) If n is an R-expression, $[\![[n\ e]]\!]^{w}\ s, q = [\![[e\ n]]\!]^{w}\ s, q = [\![e]\!]^{w}\ s\hat{}[\![n]\!]^{w}s, q$

(96) can be restated as a recipe to compute the value of a an expression [n e] or [e n], where n is an R-expression, from the values of its parts. In each case we take the semantic value of an expression to be a (curried) function from possible worlds, sequences of evaluation and quantificational sequences to truth values (including #) or objects (including #), as the case may be. The rule for R-expressions can then be restated as follows:

(97) If n is an R-expression, $[\![[n\ e]]\!] = [\![[e\ n]]\!] = \square w\ \square s\ \ \square q\ [\![e]\!]^{w}\ s\hat{}[\![n]\!]^{w}s, q$

The result can be applied top-down or bottom-up, as one wishes. Truth and falsity are then defined as:
If *p* is uttered by x to y in world w, *p* is true iff $[[p]]^{w}\ x^{A}\hat{}y^{H}=1$, *p* is false iff $[[p]]^{w}\ x^{A}\hat{}y^{H}=0$, and *p* is deviant otherwise.

(ii) *Time and Possible Worlds:* Temporal and modal anaphora could be integrated to the fragment we developed in this paper. To do this, we would need to allow sequences of evaluation (and quantificational sequences) to include moments and possible worlds. An extension to temporal anaphora is developed in Appendix I, with the surprising benefit that it allows us to get rid of the notion of 'empty cells' without losing the main benefits of the analysis. Another potential interest of this extension is that it would automatically predict the existence of binding-theoretic constraints in the temporal and modal domain, some of which have already been argued to exist (see Schlenker (to in press) for an argument that there are Condition C effects in the modal domain).

(iii) *Default Values:* Like Modal Logic, and unlike standard extensional systems, the 'de Bruijn' notation we have used throughout provides a natural notion of 'default parameter of evaluation'. One may use for this function the last member of any sequence, and decree that a predicative element that has no syntactic argument in the syntax is evaluated with respect to this default parameter. In fact, the formal system developed in Appendix IV makes use of this property in the analysis of nouns, which are treated as predicates but are not endowed with any individual arguments. The semantics (already stated in (62)) is set up in such a way that the noun *dog* in *every dog* is evaluated with respect to the last element of the quantificational sequence, which has been introduced by the quantifier *every*. This strategy could be generalized to temporal and modal anaphora, for which one needs the full power of an extensional system with time and world variables (Cresswell 1990), although one might still want to say in some cases that the relevant arguments are not explicitly represented in the syntax.

(iv) *Domain Restrictions:* So far we have blithely ignored implicit domain restrictions on quantifier domains. What determines these restrictions? Quite a few things. Consider the following example:

(98) Every Dean asked every part-time instructor not to give an A to a majority of the students.

What is the implicit domain restriction of *students?* One could try one of the analyses in (99):

(99) [every dean]$_x$ asked [every part-time instructor]$_y$ not to give an A to a majority...
a. of the students in D
b. of the students in D(y)
c .of the students in D(x, y)

(99)a is clearly incorrect, since the domains of students relevant for the various instructors may be disjoint. But (99)b won't do either: some part-time instructors may work in different colleges. In such cases, every Dean's request is only about the instructor's students *that are in the Dean's college*[33]. In the general case, it would appear that implicit domain restrictions may be determined by every operator or referential element in whose scope they are found. While the domain restriction can be explicitly represented in the object language, as is done in (99)c, there is a more elegant alternative, which is to make the domain restriction a function of an entire assignment function (a proposal along these lines is mentioned in Heim 1991). However when one uses assignment functions that are total (i.e. assign value to every variable), some counter-intuitive results are obtained, since in principle the value of variables that play no role whatsoever in the sentence uttered may still determine its domain restrictions. With the 'de Bruijn'-style system we are using, the problem disappears because the sequence of evaluation only includes the values of elements that have been processed. We may in this way introduce a kind of 'accessibility relation' (call it R) between sequences and objects, and re-define the rule of interpretation of quantifiers so that, say, *every dog* only quantifies over dogs *that are relevant given the sequence of evaluation and the quantificational sequence* (the accessibility relation appears in bold)*:*

(100) $[[\ [\ [\text{every } n]\ e]\ ]]^{w}$ s, q =1 iff for each x in X satisfying (i) $[[n]]^{w}$ s, q^x=1 and **(ii) <s, q> R x**, $[[e]]^{w}$ s, q^x=1.

The resulting system is a mix of a modal logic and an extensional system, whose logical properties remain to be investigated.

(v) *Sequences vs. Sets* (Sauerland 2004): If sequences of evaluation always obey Non-Redundancy, one could try to replace them with *sets* of evaluation (since each element occurs at most once, there is no need to distinguish in a sequence different occurrences of the same element). This enterprise is currently being developed by U. Sauerland (Sauerland 2004). It must address some non-trivial questions, in particular: (a) how quantification is performed (in the present system, only the sequence of evaluation is subject to Non-Redundancy, but the quantificational sequence isn't); (b) how a notion of 'semantic failure' could be derived.

6.3 Open Problems

Although I hope to have suggested that a semantic analysis of binding-theoretic effects based on Non-Redundancy has at least some initial plausibility, there remain many open problems. Here are the most pressing:
(i) It is unclear at this point how Condition A and Condition B should be analyzed in the context of ECM and raising constructions. A possible solution is sketched in Appendix II.
(ii) Condition A and Condition B appear to apply to possessives in some languages, e.g. Russian. Our analysis, based on coarguments of a given atomic predicate, seems to be ill-suited to deal with these data, which may in the end refute the present attempt.
(iii) We have not explained the difference in status between *John likes John* (deviant but not horrible) and *He likes John,* understood with coreference (impossible). Nor have we accounted for the fact - noted by Lasnik (1989) - that some languages allow an R-expression to be c-commanded by a coreferential R-expression, while no language allows an R-expression to be c-commanded by a coreferential pronoun. In fact, we have not given any account of cross-linguistic variation with respect to binding constraints.
Other questions should be further investigated, for instance the analysis of ellipsis (which has only been touched upon), or the semantic role played by intermediate traces in case of successive cyclic *wh*-movement. I leave all of these qfor future research. On the other hand a significant part of the theory has been implemented in Appendix IV, which gives an account of Condition C, Condition B, Condition A, Quantification and Weak and Strong Crossover (though the rules do not handle partial binding or disjoint reference effects).

Appendix I. Doing Away with Empty Cells

In this Appendix we discuss an alternative framework based on the same principles as in the rest of the paper, but without the device of empty cells. Thus in this system an anaphoric or indexical pronoun with index -i brings the element found in position -i to the end of the sequence, *but does not leave behind an empty cell.* We show (A) that the simplest version of this system makes absurd predictions for Condition B configurations, but (B) that the problem can be eliminated when temporal anaphora is taken into account, and that (C) the resulting system makes better predictions for Condition A.

A. A problem for a system without empty cells: Consider again our derivation of the Condition B effect found in *Bill likes him:*

(101) a. #Bill likes him_{-1} (evaluated under a sequence s)
b. $[[$Bill likes $him_{-1}]]^{w}$ s
$=[[$likes $him_{-1}]]^{w}$ s^b
$=[[$like$]]^{w}$ s^#^b
=# since *like* is transitive and one of the last two elements of the sequence (namely element -2) is #.

In order to trigger the failure, it is crucial that in the line represented in bold an empty cell appears in the penultimate position, thus yielding a semantic failure when *like* attempts is evaluated with respect to the last two positions of the sequence. Without empty cells no failure could be achieved; worse, some absurd results would sometimes be obtained. Suppose that *him* bears the index -1 and that Charles figures at the end of the original sequence (for instance because the entire sentence was *Charles believes that [Bill likes him_{-1}]*). As it turns out, the embedded clause *Bill likes him_{-1}* is now predicted to mean that... Charles likes Bill! This unfortunate result is illustrated in (102):

(102) An unfortunate result
a. #Bill likes him_{-1}
b. $[[$Bill likes $him_{-1}]]^{w}$...^c
$=[[$likes $him_{-1}]]^{w}$...^c^b
$=[[$like$]]^{w}$...^c^b
=1 iff c^b $\in$ I_w(likes)

Even when one has stopped laughing, it isn't obvious how the problem can be fixed given this very simple framework.

B. A solution: Surprisingly, as soon as temporal anaphora is taken into account the problem can be circumvented. Before we get into technicalities, let us consider the general idea. Suppose that every predicate takes a time argument, which comes before all individual arguments. Thus in the interpretation of *[T_1 [Bill [like Ann]]]*, where the tense T_1 denotes the moment t_1, the predicate *like* ends up being evaluated under a sequence that ends in ...^t_1^b^a, and therefore the sentence is true just in case t_1^b^c lies in the extension of *like* (since *like* is now a 3-place predicate, it is true under a sequence just in case it is satisfied by the last three elements of that sequence). In general, then, a tuple that is in the extension of *like* must be of the form <time of the liking, liker, likee>, with the time argument in the first position. But now suppose that we evaluate the sentence *[T_1 [Bill [like him_{-1}]]]* under a sequence which, as in the absurd derivation above, ends in c (for *Charles*). After *Bill* is processed, the sequence of evaluation ends in ...c^t_1^b. When *him_{-1}* is processed, it takes the last element of the sequence and moves it to the end - which amounts to doing nothing at all. Thus *like* is evaluated under a sequence that ends in ...c^t_1^b, and looks at the final triple, as before. But now the time argument is in the wrong position: it should appear in the first position of the triple, but appears in the second. This, we claim, is what triggers a semantic failure. This reasoning can be applied in full generality: whenever an individual argument of a predicate is anaphoric on another individual argument, it fails to introduce a new element in the sequence, and as a result the time argument of the predicate ends up in the wrong position, yielding a semantic failure.

Let us now develop this idea in greater detail. Following Partee (1973), we treat tense as a time-denoting pronoun, whose reference can be given deictically, for instance in the sentence *Bill liked Charles*. We assume that a time argument T_1, denoting a salient past moment t_1, appears in the Logical Form, and that the time of utterance is represented in the initial sequence of evaluation as t^U. This yields the derivation in (103):

(103) a. Bill liked Charles
a'. [T_1 [Bill [like Charles]]]
b. $[[\text{ a' }]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}$
$=[[\text{[Bill [like Charles]]}]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1$
$=[[\text{[like Charles]}]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}b$
$=[[\text{like}]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}b\hat{}c$
$=1$ iff $t_1\hat{}b\hat{}c$□$I_w(\text{like})$

So far, so good - as long as the denotation of *like* at a world w is a set of triples of the form $\text{time}\hat{}\text{individual}_1\hat{}\text{individual}_2$, the correct truth conditions are predicted. By contrast, in *Bill liked him*, where *him* is intended to be anaphoric on *Bill*, the same derivation forces us to evaluate *like* under a sequence that ends in $m^{H}\hat{}t_1\hat{}b$:

(104) a. #Bill liked him_{-1}
a'. [T_1 [Bill [like him_{-1}]]]
b. $[[\text{ a' }]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}$
$=[[\text{[Bill [like him}_{-1}]]]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1$
$\boldsymbol{=[[\text{[like him}_{-1}]]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}b}$
$=[[\text{like}]]^{w}\ t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}b$

In $m^{H}\hat{}t_1\hat{}b$ the time argument is in the 'wrong place', so to speak - it should be in position -3, but because the anaphoric pronoun he_{-1} failed to introduce a 'new' individual argument in the sequence, t' ends up being in position -2. In this way a failure is correctly derived without the device of empty cells.

This analysis can be extended to Condition B effects that apply within a Noun Phrase. As was noted by a number of researchers, nouns, just like verbs, appear to take a time argument (Enç 1987)[34]. Assuming further that this time argument appears in the highest position (i.e. in a position that c-commands the other arguments of the noun), we can account for the Condition B in a sentence such as *#John's worry about him$_{-1}$ is excessive*. A semantic failure is triggered because *worry* needs its time argument to come before its two individual arguments at the end of the sequence of evaluation. But when one of the individual arguments is anaphoric on the other, the time arguments ends up in the 'wrong' position, which yields a failure, as is desired.

C. Some improved predictions: Condition A. The new system makes better predictions than the one based on empty cells when it comes to Condition A. In (38) we gave a (correct) derivation of *Ann introduced Berenice to herself*, where *herself* and *Ann* corefer. But now consider the same sentence in which *herself* is taken to refer to Berenice. No matter what version of SELF we choose, we make the incorrect prediction that the sentence should be uninterpretable, as is laid out in (105) (also found as (xxi) in Appendix IV)

(105) a. Ann introduced Berenice to herself, where *herself* and *Berenice* corefer a'. [Ann [Berenice [$\text{SELF}_{i/k}$-introduce her_{-1}]]]
b. $[[\text{a'}]]^{w}\ j^{A}\hat{}m^{H}=[[\text{[Berenice [SELF}_{i/k}\text{-introduce her}_{-1}]]]]^{w}\ j^{A}\hat{}m^{H}\hat{}a=[[\text{[SELF}_{i/k}\text{-introduce her}_1]]]^{w}$

$j^{A}\hat{}m^{H}\hat{}a\hat{}b=[[\text{SELF}_{i/k}\text{-introduce}]]^{w}\, j^{A}\hat{}m^{H}\hat{}a\hat{}\#\hat{}b=\#$ since one of the last two positions of the sequence is #.

The problem is that any version of SELF has the effect of turning an n-place predicate into an n-place predicate into an (n-1) place predicate, which must thus 'look' at the last (n-1) elements of a sequence to obtain a truth value. In (105), this means that *$SELF_{i/k}$-introduce* depends on the last two elements of $j^{A}\hat{}m^{H}\hat{}a\hat{}\#\hat{}b$ to obtain a truth value. But one of these elements is #, which triggers a semantic failure - contrary to what we would like.

This problem does not arise in the new system, for the simple reason that there are no empty cells to cause it. Because *introduce* is now endowed with a time argument, it is a 4-place predicate. Using $\text{SELF}_{3/4}$ to reflexivize it yields the desired truth conditions (for a 4-place predicate P, $\text{SELF}_{3/4}$ P is true under a sequence that ends in ...a^b^c just in case a^b^c^c satisfies P).

(106) a. Ann introduced Berenice to herself, where *herself* and *Berenice* corefer
a'. $[T_1[\text{Ann [Berenice [SELF}_{3/4}\text{-introduce her}_{-1}]]]]$
b. $[[a']]^{w}\, t^{U}\hat{}j^{A}\hat{}m^{H} = [[\ [\text{Ann [Berenice [SELF}_{3/4}\text{-introduce her}_{-1}]]]]]^{w}\, t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1$
$=[[\ [\text{Berenice [SELF}_{3/4}\text{-introduce her}_{-1}]]]]^{w}\, t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}a=[[\ [\text{SELF}_{3/4}\text{-introduce her}_{1}]]]^{w}$
$t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}a\hat{}b=[[\text{SELF}_{3/4}\text{-introduce}]]^{w}\, t^{U}\hat{}j^{A}\hat{}m^{H}\hat{}t_1\hat{}a\hat{}b$ (since b was already in the last position)
$=1$ iff $t_1\hat{}a\hat{}b\hat{}b \in I_w$(introduce).

Appendix II. Condition A and Condition B Revisited

Our version of Condition A Condition B runs into problems with the following examples:

(107) a. *John_i believes [him_i to be smart].
a'. John_i believes [himself_i to be smart].
b. *John_i wants [him_i to be elected].
b'. John_i wants [himself_i to be elected]
c. *John_i seems to him_i to be smart.
c'. John_i seems to himself_i to be smart.

In all cases the difficulty is that standard syntactic analyses (esp. in the Government & Binding tradition) postulate that *him* is not an argument of the matrix verb (*believes, wants, seems)*, but rather that it belongs to the embedded clause, as is suggested by the bracketing. This certainly makes semantic sense, since it would seem that _ *believe*_, _*want*_ or *seem to*_ _ establish a relation between an individual (the attitude holder) and a proposition. This intuition is further strengthened by the observation that some quantifiers may (more or less easily) take scope under the attitude verb; on standard accounts this suggests that the semantic value of the object found under the verb is indeed a proposition, which entails that (108)a and b can have the Logical Forms in (108)a' and b' respectively (the latter is presumably obtained from (108)b by reconstructing the quantifier into its base position):

(108) a. Sam believes at least one person to be smart
a'. Sam believes [[at least one person]$_i$ t_i to be smart]
b. At least one person seems to Sam to be smart
b'. seems to Sam [at least one person]$_i$ [t_i to be smart]

On the other hand, these constructions also allow quantifiers such as *nobody* to take scope *over* the intensional verb. Thus (108)a and b have possible Logical Forms such as those in (109)a' and b' respectively. By contrast, the constructions involving *that*-clauses in (109)c-d do not have an analogous reading - the quantifier remains trapped in the *that*-clause:

(109) a. Sam believes no one (in particular) to be smart
a'. [no one]$_i$ Sam t_i believes [t_i to be smart]

b. No one (in particular) seems to Sam to be smart
b'. [no one (in particular)]$_i$ seems to Sam [t$_i$ to be smart]
c. Sam believes that no one (in particular) is smart
cannot mean: There is no one (in particular) that Sam believes is smart
d. It seems to Sam that no one (in particular) is smart
cannot mean: There is no one (in particular) that seems to Sam to be smart.

Independently of the present analysis, these observations can be derived from the following assumptions:
A1. In the derivational history of (108)a-b and (109)a-b, at some point the embedded subject raises out of the embedded clause to a position which we will call the 'high' position. For *seem* the process is overt, since the semantic subject of the embedded clause is pronounced in the matrix clause. For *believe* the process may or may not be overt, depending on whether Postal's 'raising to object' analysis is correct (see Postal (2003) for a recent discussion). In any event it is standardly assumed that the embedded subject may at some point reach a position in the matrix clause, maybe Chomsky's 'AgrO' position, from which it may move higher to adjoin to the matrix IP if it is a quantifier. This accounts for the data in (109).
A2. After it has moved to the 'high' position, the embedded subject may still reconstruct to a low position. Only this hypothesis can account for the data in (108) (if there were no possibility of reconstruction there would be no ambiguity).
This cannot be the end of the story, however. Unless the assumptions **A1** and **A2** are further constrained, we are bound to make incorrect predictions for (110)a:

(110) a. *He$_i$ seems to [Sam$_i$'s mother] to be clever
b. seems to [Sam$_i$'s mother] he$_i$ to be clever
c. he$_i$ seems to [Sam$_i$'s mother] t$_i$ to be clever

If, following **A2**, reconstruction is always possible, the Logical Form in (110)b should be available, and thus (110)a should have a reading that does not violate Condition C, contrary to fact. What is needed is a condition such as **A3**, for which Fox (2000) provides independent evidence:
A3. Reconstruction is possible only if affects the truth conditions.
Fox (2000) argues that, quite generally, Quantifier Raising and Quantifier Lowering are licensed only if they have an effect on the truth conditions[35]. Since *he* is a rigid designator, reconstructing it to its base position as in (110)b would not lead to different truth conditions from (110)c, and as a result (110)b is blocked**.** (110)c, on the other hand, is ruled out by Condition C.

How can this analysis be incorporated to our account of Condition B and Condition A? There are at least two solutions, both imperfect. For ease of exposition I discuss the case of *believe* (these remarks can be extended to *seem).*
B1. We may assume that *believe* is ambiguous: 'standard' *believe* takes two arguments, an individual and a proposition, while its variant *believe** takes three arguments, two individuals and a property. Furthermore *believe** is related to *believe* by the following rule:

(111) For all individuals a, b , for each property π, and for each possible word w,
$a\hat{}b\hat{}\pi \square I_w$(believes*) iff $a\hat{}\pi(b) \square I_w$(believes)

We need to further assume that the appearance of the star on *believe** is triggered by the presence of an argument in the 'high' position (without this stipulation *believe* and *believe** would appear in syntactic derivations that could not be compared by Fox's economy condition); and that unless there is reconstruction the semantic value of the embedded clause is a property, i.e. a member of $(\{0, 1\}^W)^X$, where W is the set of possible worlds and X the set of individuals. With these assumptions, (107)a receives the following analysis:

(112) a. #Sam believes him to be smart (with coreference)
a'. Sam him$_{-1}$ believes* to be smart (reconstruction of *him$_{-1}$* to the lower position is prohibited

by Fox's economy condition; the appearance of * on *believe* is triggered by the presence of an argument in the 'high' position)
b. [[a]] ^{w} j$^{A\wedge}^{m}^{H}$, ø=[[him$_{-1}$ believes to be smart]] ^{w} j$^{A\wedge}^{m}^{H\wedge}$^s, ø=[[believes* to be smart]]j$^{A\wedge}^{m}^{H\wedge}$^#^s, ø =[[believes*]]j$^{A\wedge}^{m}^{H\wedge}$^#^s^π, ø,with π=[[to be smart]]j$^{A\wedge}^{m}^{H\wedge}$^#^s, ø (which we assume is a property) =# since *believe** is a 3-place predicate and one of the last three elements of j$^{A\wedge}^{m}^{H\wedge}$^#^s^π is #.

By the same reasoning, *Sam believes himself to be smart* yields the right truth conditions if the operator SELF$_{1/2}$ appears in the Logical Form[36]. The derivation is identical to that in (112)b, except for the last step, which is as in (113):

(113) [[SELF$_{1/2}$-believes*]]j$^{A\wedge}^{m}^{H\wedge}$^#^s^π, ø≠# since # is found in none of the last two positions of j$^{A\wedge}^{m}^{H\wedge}$^#^s^π. Furthermore, [[SELF$_{1/2}$-believes*]]j$^{A\wedge}^{m}^{H\wedge}$^#^s^π, ø=1 iff s^s^π□I$_{w}$(believes*), iff s^π(s)□I$_{w}$(believes) [by the lexical rule in (111)]

B2. An alternative is to assume that *believe* is lexically ambiguous, but that the third argument of *believe** is a proposition rather than a property. The rule relating *believe** to *believe* is then much more trivial:

(114) For all individuals a, b, for each proposition p, and for each world w,
a^b^p□I$_{w}$(believes*) iff a^p□I$_{w}$(believes)

In order to ensure that the embedded clause is always interpreted as a proposition (even when there is no reconstruction), we may either stipulate that the trace left by A-movement behaves like a pronoun (rather than as a □-abstractor, as must be assumed in **B1**), or alternatively that the trace is not interpreted at all - as long as no other referential element intervenes between the 'high' position and the VP the latter will be predicated of the moved element, as is desired. The derivation in (112) is then modified to become (115):

(115) a. #Sam believes him to be smart (with coreference)
a'. Sam him$_{-1}$ believes* (pro$_{-1}$) to be smart (reconstruction of *him*$_{-1}$ to the lower position is prohibited by Fox's economy condition; the appearance of * on *believe* is triggered bby the presence of an argument in the high position; and the trace left behind by *him*$_{-1}$ behaves like a pronoun, or alternatively is not interpreted at all)
b. [[a]] ^{w} j$^{A\wedge}^{m}^{H}$, ø=[[him$_{-1}$ believes pro$_{-1}$ to be-smart]] ^{w} j$^{A\wedge}^{m}^{H\wedge}$^s, ø =[[believes* pro$_{-1}$ to be smart]]^{w}j$^{A\wedge}^{m}^{H\wedge}$^#^s, ø=[[believes*]]^{w}j$^{A\wedge}^{m}^{H\wedge}$^#^s^p, ø
with p=[[pro$_{-1}$ to be-smart]]^{w}j$^{A\wedge}^{m}^{H\wedge}$^#^s, ø =□w' s□I$_{w'}$(be-smart)
=# since *believe** is a 3-place predicate and one of the last three elements of j$^{A\wedge}^{m}^{H\wedge}$^#^s^p is #.

By the same reasoning, *Sam believes himself to be smart* yields the desired truth conditions if the operator SELF$_{1/2}$ appears in the Logical Form. The derivation is identical to that in (115)b, except for the last step:

(116) [[SELF$_{1/2}$-believes*]]j$^{A\wedge}^{m}^{H\wedge}$^#^s^p, ø ≠# since # is found in none of the last two positions of j$^{A\wedge}^{m}^{H\wedge}$^#^s^p. Furthermore, [[SELF$_{1/2}$-believes*]]j$^{A\wedge}^{m}^{H\wedge}$^#^s^p, ø=1 iff s^s^p□I$_{w}$(believes*), iff s^p(s)□I$_{w}$(believes) [by the lexical rule in (114)]

Appendix III. Distinguishing Denotational from Truth-conditional Economy

In Section 3 we showed that in our system the Locality of Variable Binding is 'built in'. Specifically, we derived a notion of Denotational Economy similar to Kehler's (Kehler 1993). By contrast, Fox 2000 argues for a rule of Truth-conditional Economy. We discuss below some predictions that distinguish between the two analyses.

Fox cites the following as evidence for Truth-conditional Economy (and against a potential alternative based on Denotational Economy):

(117) a. Everybody hates Lucifer. In fact, Lucifer knows very well that only he (himself) pities him.
b. Everybody hates every devil. In fact, every devil knows very well that only he (himself) pities him. (Fox's (34) p. 124)

Fox's argument can be reconstructed as follows: In *Lucifer knows very well that only he (himself) pities him*, the presence of *only* yields a truth-conditional difference between a representation in which *him* is bound locally and one in which it is bound by *Lucifer:*

(118) a. Lucifer λx x knows very well that [only he_x] λy y pities him_y.
$\Rightarrow$ Lucifer knows that Lucifer is the only person that has the property of pitying oneself.
b. Lucifer λx x knows very well that [only he_x] λy y pities him_x
$\Rightarrow$ Lucifer knows that Lucifer is the only person that has the property of pitying Lucifer

Since the interpretation obtained in (118)b is not equivalent to that in (118)a, Truth-conditional Economy does allow for non-local binding. By contrast, Denotational Economy predicts that Condition B should be violated.

While Fox's analysis is appealing, there are two problems with it.
(i) First, many examples that Fox predicts to be good are in fact rather degraded. This is particularly clear in French, where the clitics appear to make various binding-theoretic effects much sharper (for instance internal to French there is a contrast between **Tu vous aimes* [you-sg you-pl. like] and *?Tu aimes VOUS* [you-sg. like YOU-pl], where the object in the latter example is not cliticized). In English (117)b is not clearly acceptable. But its French counterpart is rather clearly ungrammatical, as shown in (119)a:

(119) a. *?Tout le monde déteste les diablotins. Chacun des diablotins sait d'ailleurs
**?Everyone hates the little-devils. Each of the little-devils knows in-fact*
pertinemment que lui seul l'aime.
very-well that he alone him likes
b. Ok ... que lui seul s'aime
Ok... that he alone himself likes

(Interestingly, and contrary to the predictions of every theory I know [including this one] (119)b allows both for a strict and for a sloppy reading[37]).
(ii) Second, the examples that *are* good can be accounted for by appealing to a more fine-grained semantics, in which not just the denotations but also the senses (the implicit descriptions under which the objects are referred to) are included in the sequences of evaluation.

(120) a. (Who is this man over there?) He is Colonel Weisskopf (Reinhart & Grodzinsky 1993)
b. A: Is this speaker Zelda?
B: How can you doubt it? She praises her to the sky. No competing candidate would do that. (Heim 1993)

As was mentioned earlier, the natural suggestion is that the same individual, say Weisskopf, is denoted under different 'guises' - once as the person who is over there, and a second time as a well-known colonel. Non-Redundancy is then violated just in case the same guise occurs in different cells of the same sequence, which is not the case in (120).

Once this mechanism is in place, it is tempting to use it to account for Fox's data as well. The idea is that *Lucifer knows very well that only he (himself) pities him* is good to the extent that *he* and *him* refer to Lucifer under different guises. Two arguments suggest that this line of explanation might be correct.
1. First, to the extent that Fox's *only* examples are acceptable, they can often be followed by sentences *without only* that also obviate Condition B. To my ear the following have the same status as Fox's original examples:

(121) Presque tout le monde déteste Lucifer. En fait, Lucifer sait fort bien que lui seul l'aime.
Almost everybody hates Lucifer. In fact, Lucifer knows perfectly well that only he likes him
'Aimer' est d'ailleurs un terme qui est trop faible: **il l'adore.**
'like' is in fact a term which is too weak: ***he adores him***

In each case the last sentence (printed in bold) appears to be as acceptable as the sentences that precede it. But since the last sentence does not include *only*, there is no way non-local binding could make any difference to its interpretation. Since the last sentence is acceptable, one is presumably forced to posit that the two pronouns refer to the same individual under different guises, so that Condition B is not violated in the end. But if such an assumption is needed for the last sentence, why could it not also explain the acceptability of the preceding sentences? It seems that 'guises' are all we need to account for Fox's data.

2. Additional evidence is provided by the behavior of plural pronouns. Note that whenever a single individual is presented under different guises, a plural expression may be used to assert that these guises pick out the same object. If I see someone in a mirror, and then see the same person standing in the distance, I may say: *They are one and the same!* With this observation in mind, it is interesting to consider the tentative generalization in (122), which is illustrated in (123):

(122) Whenever two singular coreferential expressions E_1 and E_2 are in a configuration that should trigger a Binding Theory violation but doesn't, E_1 and E_2 can be followed (often with an ironic overtone) by a *plural* pronoun P that refers to the (unique) denotation of E_1 and E_2. In other words, for purposes of computing plurality, E_1 and E_2 count as distinct.

(123) a. ?Pierre déteste Anne, Jean déteste Anne, François déteste Anne également - mais bien entendu Anne ne déteste pas Anne (il faut dire qu'elles ont beaucoup de choses en commun).
P. hates A., J. hates A., F. hates A. too - but of course A. doesn't hate A (unsurprisingly, since they have a lot in common)
b. Pierre déteste Anne, Jean déteste Anne, François la déteste aussi - seule Anne ne la déteste pas (il faut dire qu'elles ont beaucoup de choses en commun)
P. hates A., J. hates A., F. hates her too - only A. doesn't hate her (which is unsurprising, since they have a lot in common)
c. ... Anne ne se déteste pas (#il faut dire qu'elles ont beaucoup de choses en commun).
... A. doesn't hate herself (#which is unsurprising, since they have a lot in common)

(124) a. Tout le monde déteste Lucifer. Même Lucifer déteste Lucifer. (Il faut dire qu'ils ont déjà eu maille à partir.)
Everybody hates Lucifer. Even Lucifer hates Lucifer. (It should be added that they have already had problems (=with each other))
b. Tout le monde déteste Lucifer. Même Lucifer le déteste. (Il faut dire qu'ils ont déjà eu maille à partir.)
Everybody hates Lucifer. Even Lucifer hates him. (It should be added that they have already had problems (=with each other))
c. Tout le monde déteste Lucifer. Même Lucifer se déteste. (#Il faut dire qu'ils ont déjà eu maille à partir.)
Everybody hates Lucifer. Even Lucifer hates himself. (#It should be added that they have already had problems (=with each other))

In (123) and (124) a. obviates Condition C, b. obviates Condition B violation, while c. satisfies Condition A and thus includes a reflexive pronoun. To the extent that a. and b. are acceptable, they can relatively easily (though with a somewhat ironic overtone) be followed by a plural pronoun which in fact refers to a single individual, presumably under two guises. This is entirely impossible in c. The natural explanation is that the sentences in a. and b. are in fact acceptable *because* the same individual is denoted under different guises, which (i) obviates Conditions B and C, and (ii) makes it possible to use a plural pronoun to refer to a single individual[38]. However if this explanation is on the right track, an analysis based on guises suffices to account for the data, and there is no need for a rule of Truth-conditional Economy .

Preliminary evidence (based on three American speakers) suggests that (122) might to some extent hold for English as well. As for (121), judgments differ, and some speakers find that similar sentences tend to become worse when the sentence in bold is added, as Fox would predict. If so the facts in (122) would favor the present theory, and those in (121) Fox's[39]. Needless to say, more empirical work is needed to settle the issue.[40,41]

Appendix IV. Semantic Binding Theory: Rules and Derivations

- *Syntax*

We omit the syntax for the sake of brevity. Any set of rules that yield the Logical Forms we give below will do. The only difficulty is to insure that traces of quantifiers get the correct index, i.e. that they bear a negative index that corresponds to the LF position of the quantifier that is supposed to bind them. How this is best achieved is left open here. (As mentioned in endnote 27, we could have adopted a more conservative treatment of quantifiers and traces, in which (a) a quantifier Q_i manipulates i-variants of the quantificational sequence, and (b) a trace t_i introduces the index i in the sequence of evaluation. This would have gotten rid of the syntactic difficulty we just noted, but it would also have made our treatment of determiners and nouns more complicated, since we could not have relied on the fact that a determiner systematically introduces an element at the *end* of the sequence of evaluation. Obviously alternative options should be explored in future work).

- *Semantics*

• Models

A model for our Semantic Binding Theory is a quadruple <X, W, I, D>
where
-X is a set of individuals
-W is a set of possible worlds (disjoint from X)
-I is an interpretation function, which for each world w of W assigns:
(i) to each proper name PN an element I_w(PN) of X.
We further stipulate that for each proper name PN, for all w, w' of W, $I_w(PN)=I_{w'}(PN)$
(ii) to each element i-place verb or noun p, a subset $I_w(p)$ of X^i
(iii) to each attitude verb a, a subset $I_w(a)$ of $X \times \{0, 1\}^W$ (note that $\{0, 1\}^W$ is the set of <u>total</u> functions W to {0, 1})
-For each positive integer i, D assigns to i an element D(i) of X.

• Sequences of evaluation

A sequence of evaluation is a sequence of objects of $X \cup (X \times \{A, H\}) \cup \mathbb{N} \cup \{\#\}$, where A and H are two roles (author and hearer, respectively) and # is the undefined object (we take $X \times \{A, H\}$ to be a set of 2-membered sequences). We further stipulate that any sequence of evaluation contains exactly one member which is itself a sequence of the form x^A and exactly one sequence of the form x'^H, for x, x' in X.

Auxiliary conventions:
- If d is an element of X, we write d^A for d^A and d^H for d^H
-We identify throughout a 1-membered sequence with its only element.
-If s and s' are two sequences, s^s' is their concatenation

-If s is a sequence, $|s|$ is the length of s.
-If s is sequence, $i(s)$ denotes its i^{th} coordinate if it has one, and * otherwise.
-If s is a sequence that has at least n elements, s_{-n} is the element found in the n^{th} position, counting from the end of the sequence.
-If s is a sequence of evaluation and q is a quantificational sequence, we define the sequence of the last n individuals of s given q, written $s_n(q)$. $s_n(q)$ is defined so as *not* to include any roles:
If $n>|s|$, $s_n(q)=*$
If $n\leq|s|$: $(d_m\hat{}\ ...\hat{}d_n\hat{}\ ...\hat{}d_1)_n(q)= d_n[q]\hat{}\ ...\hat{}d_1[q]$
where for each $i \in [[1, n]]$
$d_i[q]=1(d_i)$ if $d_i \notin \mathbb{N}$ [e.g. if $d_i=j^A=<j, A>$, $d_i[q]=1(<j, A>)=j$. This rule is intended to get rid of the roles A and H].
$d_i[q]= d_i(q)$ if $d_i \in \mathbb{N}$ [e.g. if $d_i=2$ and $q=a\hat{}b\hat{}c$, $d_i[q]=2(a\hat{}b\hat{}c)=b$. 2 cross-references the 2^{nd} element of the quantificational sequence $a\hat{}b\hat{}c$, and $d_i[q]$ retrieves the element in question].

Adequacy: We say that d is <u>adequate</u> for a pronoun pro if
pro=I and $2(d)=A$
pro=you and $2(d)=H$
pro=he, she and $2(d) \notin \{A, H\}$

Non-Redundancy: A sequence of evaluation s satisfies Non-Redundancy iff for all positive integers m, n,
$((m\leq|s|\ \&\ n\leq|s|) \Rightarrow (1(s_{-m})\neq 1(s_{-n})\ v\ 1(s_{-m})=\#))$.

- **Satisfaction and Denotation**

—If pro_i is a pronoun with a positive index (pro≠*I*, *you*), $[[pro_i]]^w$ s, q=D(i).

—If PN is a proper name, $[[PN]]^w$ s, q=I_w(PN)

— $[[$ [the n] $]]^w$ s, q=# iff there is 0 or strictly more than 1 element x of X satisfying $[[n]]^w$ s, $q\hat{}x=1$. Otherwise, $[[$[the n]$]]^w$ s, q=x for x satisfying $[[n]]^w$ s, $q\hat{}x=1$.

—If N is a noun taking n arguments, $[[N]]^w$s, q=# iff s violates Non-Redundancy or $|q|=0$ or $q_{-1}\hat{}(s_{n-1}(q)) \notin X^n$. Otherwise, $[[N]]^w$ s, q=1 iff $q_{-1}\hat{}(s_{n-1}(q)) \in I_w(N)$

—If V is a verb taking n arguments, other than an attitude verb, $[[V]]^w$s, q=# iff s violates Non-Redundancy or $s_n(q) \notin X^n$. Otherwise, $[[V]]^w$ s, q=1 iff $s_n(q) \in I_w(V)$

—If A is an attitude verb, $[[A]]^w$ s, q=# iff s violates Non-Redundancy or $s_2(q) \notin X \times \{0, 1\}^W$. Otherwise, $[[A]]^w$ s, q=1 iff $s_2(q) \in I_w(A)$

—If pro_{-i} is a pronoun with a negative index -i, for any expression e,
$[[$ [pro_{-i} e]$]]^w$ s, q=$[[$ [e pro_{-i}]$]]^w$ s, q=# iff $|s|<i$ or s_{-i} is not adequate for pro. Otherwise, if $s=d_m...\hat{}d_{i+1}\hat{}d_i\hat{}d_{i-1}\hat{}\ ...\hat{}d_1$, $[[$[pro_{-i} e]$]]^w$ s, q=$[[$ [e pro_{-i}]$]]^w$ s, q=$[[e]]^w$ $d_m\hat{}\ ...\hat{}d_{i+1}\hat{}\#\hat{}d_{i-1}\hat{}\ ...\hat{}d_1\hat{}d_i$, q

—If n is an R-expression (i.e. a definite description, a proper name, a pronoun with a positive index, or a *that*-clause), $[[$ [n e] $]]^w$ s, q=$[[$[e n]$]]^w$ s, q=$[[e]]^w$ $s\hat{}[[n]]^w$s, q

— $[[$ [that p] $]]^w$ s, q=# iff for some w' in W, $[[p]]^w$ s, q=#. Otherwise, $[[$ [that p] $]]^w$ s, q=λw': w'$\in$W. $[[p]]^{w'}$ s, q

Treatment of SELF

—Let V be a verb taking n individual arguments, and let i<k<n. Then: $[[SELF_{i/k}\text{-}V]]^{w}s, q=\#$ iff s violates Non-Redundancy or $s_{n-1}(q)\notin X^{n-1}$. Otherwise, $[[SELF_{i/k}\text{-}V]]^{w}s, q=1$ iff $r\in I_w(V)$, where r is the n-ary sequence obtained from $s_{n-1}(q)$ by copying the k^{th} element into the i^{th} position, i.e.
$r=1(s_{n-1}(q))\hat{}\ldots\hat{}(i-1)(s_{n-1}(q))\hat{}k(s_{n-1}(q))\hat{}i(s_{n-1}(q))\hat{}\ldots\hat{}k(s_{n-1}(q))\hat{}\ldots\hat{}(n-1)(s_{n-1}(q))$

Treatment of Quantification

— $[[\,[\,[\text{every } n]\ e]\,]]^{w}s, q=\#$ iff (i) for some x in X, $[[n]]^{w}s, q\hat{}x=\#$, or (ii) for some x in X satisfying $[[n]]^{w}s, q\hat{}x=1$, $[[e]]^{w}s, q\hat{}x=\#$. Otherwise, $[[\,[\,[\text{every } n]\ e]\,]]^{w}s, q=1$ iff for each x in X satisfying $[[n]]^{w}s, q\hat{}x=1$, $[[e]]^{w}s, q\hat{}x=1$.

— $[[\,[t_{-i}\ \alpha]\,]]^{w}s, q=[[\,[\alpha\ t_{-i}]\,]]^{w}s, q=[[\alpha]]^{w}s\hat{}(|q|+1-i), q$

Examples

In the following examples, I assume that the speaker is John and that the addressee is Mary. The first letter of an individual's proper name is used in the meta-language to refer to that individual. When only one sequence appears, it is the sequence of evaluation, and the quantificational sequence is taken to be empty (when we need to refer to the empty sequence, we write it as ø). In each example a. is the English sentence whose simplified Logical Form is given in a'. b. provides a derivation of truth- and failure-conditions.

A. Examples Without Quantifiers

(i) a. Ann smokes *(is unproblematic)*
a'. [Ann smoke]
b. $[[a']]^{w}j^{A}\hat{}m^{H}=[[smoke]]^{w}j^{A}\hat{}m^{H}\hat{}a$. Hence
$[[a']]^{w}j^{A}\hat{}m^{H}=1$ iff $(j^{A}\hat{}m^{H}\hat{}a)_1\in I_w(smoke)$, iff $a\in I_w(smoke)$
Otherwise, $[[a']]^{w}j^{A}\hat{}m^{H}=0$.

(ii) a. I smoke *(is correctly interpreted if I bears the 'right' index)*
a'. $[I_{-2}$ smoke]
b. $[[[I_{-2}\ smoke]]]^{w}j^{A}\hat{}m^{H}=\#$ iff $2((j^{A}\hat{}m^{H})_{-2})\neq A$. But $(j^{A}\hat{}m^{H})_{-2}=j^{A}$ and $2(j^{A})=A$, hence this case does not arise. Thus
$[[a']]^{w}j^{A}\hat{}m^{H}=[[smoke]]^{w}\#\hat{}m^{H}\hat{}j^{A}$ and
$[[a']]^{w}j^{A}\hat{}m^{H}=1$ iff $(\#\hat{}m^{H}\hat{}j^{A})_{-1}\in I_w(smoke)$, iff $j\in I_w(smoke)$
Otherwise, $[[a']]^{w}j^{A}\hat{}m^{H}=0$

Note: (i) $[_{v}I_1$ smoke] is not generated by the syntax (first and second person pronouns are assumed to always be indexical and never demonstrative; this is obviously incorrect for second person pronouns).
(ii) A failure would have resulted if the index of *I* had been *-1* instead of *-2*:

(iii) a. I smoke *(yields a failure if* I *bears the 'wrong' index)*
a'. $[I_{-1}$ smoke]
b. $[[a']]^{w}j^{A}\hat{}m^{H}=\#$ because $2((j^{A}\hat{}m^{H})_{-1})=2(m^{H})=H$ and $H\neq A$.

(iv) a. #John smokes *(yields a failure because it is said by John)*
a'. [John smoke]
b. $[[[\text{John smoke}]]^{w} j^{A\wedge}m^{H}=[[\text{smoke}]]^{w} j^{A\wedge}m^{H\wedge}j=\#$ because $j^{A\wedge}m^{H\wedge}j$ violates Non Redundancy.

(v) a. #Mary smokes *(yields a failure because it is said to Mary)*
a'. [Mary smoke]
b. $[[[\text{Mary smoke}]]^{w} j^{A\wedge}m^{H}= [[\text{smoke}]]^{w} j^{A\wedge}m^{H\wedge}m=\#$ since $j^{A\wedge}m^{H\wedge}m$ violates Non-Redundancy.

(vi) a. Ann hates Bill *(is unproblematic)*
a'. [Ann [hates Bill]]
b. $[[a']]^{w} j^{A\wedge}m^{H}= [[\,[\text{hates Bill}]]]^{w} j^{A\wedge}m^{H\wedge}a= [[\,\text{hates}\,]]^{w} j^{A\wedge}m^{H\wedge}a^\wedge b$. Hence
$[[a']]^{w} j^{A\wedge}m^{H}=1$ iff $(j^{A\wedge}m^{H\wedge}a^\wedge b)_2 \in I_w(\text{hate})$, iff $a^\wedge b \in I_w(\text{hate})$,
Otherwise, $[[a']]^{w} j^{A\wedge}m^{H}=0$

(vii) a. #Ann hates Ann *(violates Non-Redundancy)*
a'. [Ann [hate Ann]]
b. $[[a']]^{w} j^{A\wedge}m^{H}= [[\,[\text{hate Ann}]]]^{w} j^{A\wedge}m^{H\wedge}a= [[\,\text{hate}]]^{w} j^{A\wedge}m^{H\wedge}a^\wedge a=\#$ since $j^{A\wedge}m^{H\wedge}a^\wedge a$ violates Non Redundancy

(viii) a. #She hates Ann *(violates Non-Redundancy if interpreted with coreference)*
a'. [she_1 [hate Ann]], assuming that D(1)=a
b. $[[a']]^{w} j^{A\wedge}m^{H}= [[\,[\text{hate Ann}]]]^{w} j^{A\wedge}m^{H\wedge}a$ since D(1)=a
$= [[\text{hate}]]^{w} j^{A\wedge}m^{H\wedge}a^\wedge a=\#$ since $j^{A\wedge}m^{H\wedge}a^\wedge a$ violates Non Redundancy

(ix) a. Ann's teacher hates Ann *(never violates Non-Redundancy)*
a'. [[the [Ann teacher]] [hate Ann]]
b. $[[a']]^{w} j^{A\wedge}m^{H}= [[[\text{hate Ann}]]]^{w} j^{A\wedge}m^{H\wedge}t$ with $t=[[[\text{the [Ann teacher]}]]]^{w} j^{A\wedge}m^{H}$.

Side computation
t=# iff there is 0 or more than 1 element x in X satisfying
$[[[\text{Ann teacher}]]]^{w} j^{A\wedge}m^{H}$, $x=[[\text{teacher}]]^{w} j^{A\wedge}m^{H\wedge}a$, x=1, iff there is 0 or more than 1 element x in X satisfying $x^\wedge a \in I_w(\text{teacher})$. Otherwise, t=x, where x satisfies $x^\wedge a \in I_w(\text{teacher})$.

Hence:

If there is 0 or more than 1 element x in X satisfying $x^\wedge a \in I_w(\text{teacher})$,
$[[a']]^{w} j^{A\wedge}m^{H}= [[[\text{hate Ann}]]]^{w} j^{A\wedge}m^{H\wedge}\#= [[\text{hate}]]^{w} j^{A\wedge}m^{H\wedge}\#^\wedge a=\#$ since $(j^{A\wedge}m^{H\wedge}\#^\wedge a)_2(\varnothing)=\#^\wedge a$, which contains #. Otherwise, for x satisfying $t^\wedge a \in I_w(\text{teacher})$, $[[a']]^{w} j^{A\wedge}m^{H}=[[[\text{hate Ann}]]]^{w} j^{A\wedge}m^{H\wedge}x= [[\text{hate}]]^{w} j^{A\wedge}m^{H\wedge}x^\wedge a=1$ iff $x^\wedge a \in I_w(\text{hate})$.

(x) a. Ann's teacher hates her *(never violates Non-Redundancy)*
a'. [[the [Ann teacher]] [hate her_1], with the assumption that D(1)=a
b. Same as the preceding example

(xi) a. #Ann hates her *(is uninterpretable if intended with coreference)*
a'. [Ann [hate her_{-1}]]
b. $[[(a')]]^{w} j^{A\wedge}m^{H}=[[[\text{hate her}_{-1}]]]^{w} j^{A\wedge}m^{H\wedge}a=[[\text{hate}]]^{w} j^{A\wedge}m^{H\wedge}\#^\wedge a=\#$ since $(j^{A\wedge}m^{H\wedge}\#^\wedge a)_2=\#^\wedge a \notin X^2$.

Note: If *her* had been given a positive index, e.g. 1 with the assumption that D(1)=a, a violation of Non Redundancy would have resulted.

(xii) a. Ann hates herself *(is interpretable when the right version of the SELF operator is used)*
a'. [Ann [$\text{SELF}_{1/2}$-hate her_{-1}]]
b. $[[(a')]]^{w}\, j^{A\wedge}m^{H}=[[[\text{SELF}_{1/2}\text{-hate her}_{-1}]]]^{w}\, j^{A\wedge}m^{H\wedge}a=[[\text{SELF}_{1/2}\text{-hate}]]^{w}\, j^{A\wedge}m^{H\wedge}\#^\wedge a$. Hence $[[(a')]]^{w}\, j^{A\wedge}m^{H}\neq\#$. Furthermore, $[[(a')]]^{w}\, j^{A\wedge}m^{H}=1$ iff $a^\wedge a \in I_{w}(\text{hate})$.

(xiii) a. #Ann hates Ann's teacher *(violates Non-Redundancy)*
a'. [Ann [hate [the [Ann teacher]]]]
b. $[[a']]^{w}\, j^{A\wedge}m^{H}=[[[\text{hate [the [Ann teacher]]]]]}^{w}\, j^{A\wedge}m^{H\wedge}a=[[\text{hate}]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge t$
with $t=[[[\text{the [Ann teacher]]]]}^{w}\, j^{A\wedge}m^{H\wedge}a$

Side computation t=# iff there is 0 or more than 1 element x in X satisfying $[[[\text{Ann teacher}]]]^{w}\, j^{A\wedge}m^{H\wedge}a$, x=1. But for every x in X $[[[\text{Ann teacher}]]]^{w}\, j^{A\wedge}m^{H\wedge}a$, $x=[[\text{teacher}]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge a$, x=# since $j^{A\wedge}m^{H\wedge}a^\wedge$ a violates Non-Redundancy. Hence there is 0 element x in X satisfying $[[[\text{Ann teacher}]]]^{w}\, j^{A\wedge}m^{H\wedge}a$, x=1, and t=#.

Thus $[[a']]^{w}\, j^{A\wedge}m^{H}=[[\text{hate}]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge\#=\#$ since $(j^{A\wedge}m^{H\wedge}a^\wedge\#)_{2}=a^\wedge\#\in X^{2}$

(xiv) a. Ann hates her teacher *(does not violate Non-Redundancy)*
a'. [Ann [hate [the [she_{-1} teacher]]]]
b. $[[a']]^{w}\, j^{A\wedge}m^{H}=[[[\text{hate [the [she}_{-1}\text{ teacher]]]]]}^{w}\, j^{A\wedge}m^{H\wedge}a=[[\text{hate}]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge t$
with $t=[[[\text{the [she}_{-1}\text{ teacher]]]]}^{w}\, j^{A\wedge}m^{H\wedge}a$

Side computation t=# iff there is 0 or more than 1 element x in X satisfying $[[[\text{she}_{-1}\text{ teacher}]]]^{w}\, j^{A\wedge}m^{H\wedge}a$, x=1, iff there is 0 or more than 1 element x in X satisfying $[[\text{teacher}]]^{w}\, j^{A\wedge}m^{H\wedge}\#^\wedge a$, x=1, iff there is 0 or more than 1 element x in X such that $x^\wedge a\in I_{w}(\text{teacher})$. Otherwise, t=x, where x satisfies $x^\wedge a\in I_{w}(\text{teacher})$

Thus $[[a']]^{w}\, j^{A\wedge}m^{H}=\#$ iff (a) there is 0 or more than 1 element x in X satisfying $x^\wedge a\in I_{w}(\text{teacher})$, or else (b) there is exactly one element x in X satisfying $x^\wedge a\in I_{w}(\text{teacher})$, and Non-Redundancy is violated in $j^{A\wedge}m^{H\wedge}a^\wedge x$, i.e. $x\in\{j, m, a\}$. Otherwise, $[[a']]^{w}\, j^{A\wedge}m^{H}=1$ iff $a^\wedge x\in I_{w}(\text{hate})$, where x satisfies $x^\wedge a\in I_{w}(\text{teacher})$

(xv) a. Ann introduced Berenice to Cassandra *(can be interpreted provided a Larsonian LF is posited)*
a'. [Ann [Berenice [introduce Cassandra]]]
b. $[[a']]^{w}\, j^{A\wedge}m^{H}=[[[\text{Berenice [introduce Cassandra]]]]}^{w}\, j^{A\wedge}m^{H\wedge}a=[[[\text{introduce Cassandra}]]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge b=[[\text{introduce}]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge b^\wedge c$. Hence $[[a']]^{w}\, j^{A\wedge}m^{H}=1$ iff $a^\wedge b^\wedge c\in I_{w}(\text{introduce})$. Otherwise, $[[a']]^{w}\, j^{A\wedge}m^{H}=0$

(xvi) a. #Ann introduced Berenice to her, where *her* and *Ann* corefer *(is uninterpretable)*
a'. [Ann [Berenice [introduce her_{-2}]]]
b. $[[(a')]]^{w}\, j^{A\wedge}m^{H}=[[[\text{Berenice [introduce her}_{-2}]]]]^{w}\, j^{A\wedge}m^{H\wedge}a=[[[\text{introduce her}_{-2}]]]^{w}\, j^{A\wedge}m^{H\wedge}a^\wedge b=[[\text{introduce}]]^{w}\, j^{A\wedge}m^{H\wedge}\#^\wedge b^\wedge a=\#$ since $\#^\wedge b^\wedge a\in X^{3}$

Note: If *her* carried a positive index that denoted Ann, the sentence would still end up being uinterpretable because Non-Redundancy would be violated.

(xvii) a. Ann introduced Berenice to herself, where *herself* and *Ann* corefer *(can be interpreted provided the right version of SELF is used)*
a'. [Ann [Berenice [$SELF_{1/3}$-introduce her_{-2}]]]
b. $[[(a')]]^{w}\, j^{A\hat{}}m^{H}$=[[[Berenice [$SELF_{1/3}$-introduce her_{-2}]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[[$SELF_{1/3}$-introduce her_{-2}]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}b$= [[$SELF_{1/3}$-introduce]]$^{w}\, j^{A\hat{}}m^{H\hat{}}\#\hat{}b\hat{}a$. Hence $[[(a')]]^{w}\, j^{A\hat{}}m^{H}\neq\#$. Furthermore, $[[(a')]]^{w}\, j^{A\hat{}}m^{H}$=1 iff $a\hat{}b\hat{}a$□I_{w}(introduce).

(xviii) a. #Ann introduced her to Cassandra, where *her* and *Ann* corefer *(is uninterpretable)*
a'. [Ann [her_{-1} [introduce Cassandra]]]
b. $[[a']]^{w}\, j^{A\hat{}}m^{H}$=[[[$her_{-1}$ [introduce Cassandra]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[[introduce Cassandra]]^{w} $j^{A\hat{}}m^{H\hat{}}\#\hat{}a$=[[introduce]]$^{w}\, j^{A\hat{}}m^{H\hat{}}\#\hat{}a\hat{}c$=# since $\#\hat{}a\hat{}c$□X^{3}

Note: If *her* carried a positive index that denoted Ann, the sentence would still end up being uinterpretable because Non-Redundancy would be violated.

(xix) a. Ann introduced herself to Cassandra, where *herself* and *Ann* corefer *(can be interpreted provided the right version of SELF is used)*
a'. [Ann [her_{-1} [$SELF_{1/2}$-introduce Cassandra]]]
b. $[[(a')]]^{w}\, j^{A\hat{}}m^{H}$=[[[$her_{-1}$ [$SELF_{1/2}$-introduce Cassandra]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[[$SELF_{1/2}$-introduce Cassandra]]$^{w}\, j^{A\hat{}}m^{H\hat{}}\#\hat{}a$=[[$SELF_{1/2}$-introduce]]$^{w}\, j^{A\hat{}}m^{H\hat{}}\#\hat{}a\hat{}c\neq\#$. Furthermore, $[[(a')]]^{w}$ $j^{A\hat{}}m^{H}$=1 iff $a\hat{}a\hat{}c$□I_{w}(introduce).

(xx) a. #Ann introduced Berenice to her, where *her* and *Berenice* corefer *(is uninterpretable)*
a'. [Ann [Berenice [introduce her_{-1}]]]
b. $[[a']]^{w}\, j^{A\hat{}}m^{H}$=[[[Berenice [introduce her_{-1}]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[[introduce her_{-1}]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}b$=[[introduce]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}\#\hat{}b$=# since $a\hat{}\#\hat{}b$□X^{3}

Note: If *her* carried a positive index that denoted Berenice, the sentence would still end up being uinterpretable because Non-Redundancy would be violated.

(xxi) a. Ann introduced Berenice to herself, where *herself* and *Berenice* corefer *(is wrongly predicted to be uninterpretable)*
a'. [Ann [Berenice [$SELF_{i/k}$-introduce her_{-1}]]]
b. $[[a']]^{w}\, j^{A\hat{}}m^{H}$=[[[Berenice [$SELF_{i/k}$-introduce her_{-1}]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[[$SELF_{i/k}$-introduce her_{1}]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}b$=[[$SELF_{i/k}$-introduce]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}\#\hat{}b$=# since $\#\hat{}b$□X^{2}.

Note: (i) A semantic failure is (wrongly) predicted no matter which indices i and k appear on SELF.
(ii) In the variant of the theory in which no empty cells can be used but temporal anaphora is taken into account, this sentence can be analyzed properly, as is outlined at the end of Appendix I.

(xxii) a. Ann claims that Bill smokes *(is easily interpreted)*
a'. [Ann [claim [that [Bill smoke]]]]
b. $[[a']]^{w}\, j^{A\hat{}}m^{H}$=[[[claim [that [Bill smoke]]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=[[claim]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a\hat{}p$
with p= [[[that [Bill smoke]]]]$^{w}\, j^{A\hat{}}m^{H\hat{}}a$=□w': w'□W. [[[Bill smoke]]]$^{w'}j^{A\hat{}}m^{H\hat{}}a$=□w': w'□W. [[smoke]]$^{w'}j^{A\hat{}}m^{H\hat{}}a\hat{}b$=□w': w'□W. b smokes in w'
(with the standard convention that *b smokes in w'* is used in the metalanguage to denote 1

if b smokes in w' and 0 otherwise).
Hence $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=1$ iff $a^\wedge p$□I_w(claim). Otherwise $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=0$.

(xxiii) Ann claims that she smokes, with coreference *(is easily interpreted)*
a'. [Ann [claim [that [she_{-1} smoke]]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=[[[\text{claim [that [she}_{-1}\text{ smoke]]]]]}^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a=[[\text{claim}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a^\wedge p$
with p= $[[\ [\text{that [she}_{-1}\text{ smoke]]}\ ]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a=$□w': w'□W. $[[[\text{she}_{-1}\text{ smoke}]\ ]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge a=$□w': w'□W. $[[\text{smoke}]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge a=$□w': w'□W. a smokes in w'
Hence $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=1$ iff $a^\wedge p$□I_w(claim). Otherwise $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=0$.

(xxiv) a. I claim that I smoke *(is easily interpreted if both occurrences of* I *carry the 'right' index)*
a'. [I_{-2} [claim [that [I_{-1} smoke]]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=[[[\text{claim [that [I}_{-1}\text{ smoke]]]]]}^{w}\, \#^\wedge m^{H}{}^\wedge j^{A}=[[\text{claim}]]^{w}\, \#^\wedge m^{H}{}^\wedge j^{A}{}^\wedge p$
with p= $[[\ [\text{that [I}_{-1}\text{ smoke]]}\ ]]^{w}\, \#^\wedge m^{H}{}^\wedge j=$□w': w'□W. $[[[\text{I}_{-1}\text{ smoke}]\ ]]^{w}\#^\wedge m^{H}{}^\wedge j^{A}=$□w': w'□W. $[[\text{smoke}]]^{w'}\#^\wedge m^{H}{}^\wedge\#^\wedge j^{A}=$□w': w'□W. j smokes in w'
Hence $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=1$ iff $a^\wedge p$□I_w(claim). Otherwise $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=0$.

(xxv) a. #Ann claims that she hates her, where *her* is anaphoric on *she (is uninterpretable)*
a'. [Ann [claim [that [she_{-1} [hate her_{-1}]]]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=[[[\text{claim [that [she}_{-1}\text{ [hate her}_{-1}\text{]]]]]]}^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a=[[\text{claim}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a^\wedge p$
with p= $[[\ [\text{that [she}_{-1}\text{ [hate her}_{-1}\text{]]}\ ]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a=$□w': w'□W. $[[[\text{she}_{-1}\text{ [hate her}_{-1}]]\ ]]^{w}$ $j^{A}{}^\wedge m^{H}{}^\wedge a=$□w': w'□W. $[[[\text{hate her}_{-1}]]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge a=$□w': w'□W. $[[\text{hate}]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge\#^\wedge a=$□w': w'□W. #, since $(j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge\#^\wedge a)_2=\#^\wedge a$□$X^2$. As a result, p=□w': w'□W. # is not in $\{0, 1\}^{W}$, and by the rule of interpretation of attitude verbs $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=\#$.

Note: (i) If *her* carried a positive index that denoted Ann, the sentence would still end up being uninterpretable because Non-Redundancy would be violated.
(ii) It won't help to link *her* to *Ann* rather than to *she*:

(xxvi) a. #Ann claims that she hates her, where *her* is anaphoric on *Ann (is uninterpretable)*
a'. [Ann [claim [that [she_{-1} [hate her_{-2}]]]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=[[\text{claim}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge a^\wedge p$ (as in (xxv))
with p=□w': w'□W. $[[[\text{hate her}_{-2}]]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge a$ (as in (xxv))
=□w': w'□W. $[[\text{hate}]]^{w'} j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge a^\wedge\#=$□w': w'□W. #, since $(j^{A}{}^\wedge m^{H}{}^\wedge\#^\wedge a^\wedge\#)_2=a^\wedge\#$□$X^2$. As in (xxv), we obtain the result that $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=\#$.

B. Examples With Quantifiers

(xxvii) a. Every man is mortal.
a'. [Every man [t_{-1} is-mortal]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}=\#$ iff (i) for some x in X, $[[\text{man}]]^{w}\, j^{A}{}^\wedge m^{H}$, x=#, or (ii) for some x in X satisfying $[[\text{man}]]^{w}\, j^{A}{}^\wedge m^{H}$, x=1, $[[[t_{-1}\text{ is-mortal}]]]^{w}\, j^{A}{}^\wedge m^{H}$, x=#. This case never arises.
$[[a']]^{w}\, j^{A}{}^\wedge m^{H}=1$ iff for each x in X satisfying $[[\text{man}]]^{w}\, j^{A}{}^\wedge m^{H}$, x=1, $[[[t_{-1}\text{ is-mortal}]]]^{w}\, j^{A}{}^\wedge m^{H}$, x=1,
iff for each x in X satisfying x□I_w(man), $[[\text{is-mortal}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge(1+1\text{-}1)$, x=1,
iff for each x in X satisfying x□I_w(man), $(j^{A}{}^\wedge m^{H}{}^\wedge 1)_1$(x)□$I_w$(is-mortal)=1,
iff for each x in X satisfying x□I_w(man), x□I_w(is-mortal)=1

(xxviii) a. Every man respects his mother
a'. [[every man][t_{-1} [respect [the [he_{-1} mother]]]]]
b. It can be shown that $[[a']]^{w}\ j^{A\hat{}}\hat{}m^{H}=\#$ iff
(i) for some x in X satisfying $x□I_w$(man),
there is 0 or more than 1 x' in X satisfying $x\hat{}x'□I_w$(mother), or
(ii) for some x in X satisfying $x□I_w$(man), thise exactly 1 x' in X satisfying
$x\hat{}x'□I_w$(mother), and that x' is j or m [for in that case Non-Redundancy gets violated when we evalulated $[[respect]]^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1\hat{}t$, x; this problem is discussed in the Note below.]

Otherwise, $[[a']]^{w}\ j^{A\hat{}}\hat{}m^{H}=1$ iff for each x in X satisfying $[[man]]^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=1, [[[$t_{-1}$[respect [the [$he_{-1}$ mother]]]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=1,
iff for each x in X satisfying $x□I_w$(man), [[[respect [the [he_{-1} mother]]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1$, x=1,
iff for each x in X satisfying $x□I_w$(man), $[[respect]]^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1\hat{}t$, x=1, with
t=[[[the [he_{-1} mother]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1$, x

Side computation
Since for each x in X satisfying $x□I_w$(man), there is exactly one x' in X satisfying
$x\hat{}x'□I_w$(mother),
t=x', where x' satisfies [[[he_{-1} mother]]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1$, $x\hat{}x'$=1, i.e. [[mother]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}\#\hat{}1$, $x\hat{}x'$,
i.e. $x'\hat{}x□I_w$(mother).

Thus $[[a']]^{w}\ j^{A\hat{}}\hat{}m^{H}=1$ iff for each x in X satisfying $x□I_w$(man), $x\hat{}x'□I_w$(respect), where x' satisfies $x'\hat{}x□I_w$(mother)

Note: A violation of Non-Redundancy is predicted if one of the men's mother is the speaker or the addressee. This prediction is probably incorrect. However as soon as the system is implemented using implicit descriptions (i.e. functions from pairs of the form <context, quantificational sequence> to individuals) rather than individuals, this problem disappears. This is because in $[[respect]]^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}1\hat{}t$, x, t will now be a function assigning to each pair <context, quantificational sequence> the 1st element of the quantificational sequence. Clearly such a function will be different from the implicit description corresponding to the speaker or hearer, and hence Non-Redundancy will be satisfied.

(xxix) a. His mother respects every man *(yields a Weak Crossover violation if* his *is bound by* every man*)*
a'. [[every man][[the [he_{-1} mother]] [respect t_{-1}]]]
b. $[[a']]^{w}\ j^{A\hat{}}\hat{}m^{H}=\#$ iff for some x in X satisfying $[[man]]^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=1, [[[[the [$he_{-1}$ mother]] [respect t_{-1}]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=#,
iff for some x in X satisfying $x□I_w$(man), [[[[respect t_{-1}]]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}t$, x=#, with
t=[[[the [he_{-1} mother]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, x,
iff for some x in X satisfying $x□I_w$(man), [[respect]]$^{w}\ j^{A\hat{}}\hat{}m^{H\hat{}}t\hat{}1$, x=#

Side computation
[[[the [he_{-1} mother]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=# iff there is 0 or more than 1 x' in X satisfying [[[he_{-1} mother]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, $x\hat{}x'$=1. But $(j^{A\hat{}}\hat{}m^{H})_{-1}$ is not adequate for *he*$_{-1}$, since $(j^{A\hat{}}\hat{}m^{H})_{-1}=m^{H}$ and $2(m^{H})$=H. Hence for each x' in X [[[he_{-1} mother]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, $x\hat{}x'$=#, and thus there is 0 x' in X satisfying [[[he_{-1} mother]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, $x\hat{}x'$=1. Therefore it is always the case that t=[[[the [he_{-1} mother]]]]$^{w}\ j^{A\hat{}}\hat{}m^{H}$, x=#.

Thus it is the case that for some x in X satisfying x□I_w(man), $[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge t^\wedge 1$, x=#, since for all x in X $[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge t^\wedge 1$, x=$[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge \#^\wedge 1$, x=# because $(j^{A}{}^\wedge m^{H}{}^\wedge \#^\wedge 1)_2(x)=\#^\wedge x$□$X^2$. Hence $[[a']]^{w}\, j^{A}{}^\wedge m^{H}$=#.

Note 1: We obtain a semantic failure because, for various values of x, the quantifier introduces x in the quantificational sequence rather than in the sequence of evaluation. As a result, the pronoun *he*$_{-1}$ must recover m^H, which is the last element of the sequence of evaluation. Since a 3rd person pronoun cannot access an object with the H diacritic, a failure occurs when *[he*$_{-1}$ *mother]* is interpreted. Note that even if this problem did not arise (because the last element of the sequence of evaluation did not contain an object with a diacritic), we would still *not* obtain a reading where *he*$_{-1}$ covaries with the quantifier. (In fact it would not help to change the index -1 to any other index either; as long as a trace has not been processed, no pronoun may access an element of the quantificational sequence).

Note 2: In the following example we consider what happens if the pronoun *he*$_{-1}$ is replaced with a trace *t*$_{-2}$ (the index has to be -2 rather than -1 because the determiner *the* introduces an element in the quantificational sequence). This is a kind of 'repair strategy'. The fact that it leads to an interpretable result explains that Weak Crossover violations yield relatively mild cases of ungrammaticality.

(xxx) a. His mother respects every man *(is interpretable on a bound reading if* her *is treated as if it were a trace with index -2)*
a'. [[every man][[the [t_{-2} mother]] [respect t_{-1}]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}$=# iff for some x in X satisfying $[[\text{man}]]^{w}\, j^{A}{}^\wedge m^{H}$, x=1, [[[[the [$t_{-2}$ mother]] [respect t_{-1}]]]]$^{w}\, j^{A}{}^\wedge m^{H}$, x=#,
iff for some x in X satisfying x□I_w(man), [[[[respect t_{-1}]]]$^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge t$, x=#, with t=[[[the [$t_{-2}$ mother]]]]$^{w}\, j^{A}{}^\wedge m^{H}$, x,
iff for some x in X satisfying x□I_w(man), $[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge t^\wedge 1$, x=#

Side computation
[[[the [t_{-2} mother]]]]$^{w}\, j^{A}{}^\wedge m^{H}$, x=# iff there is 0 or more than 1 x' in X satisfying [[[t_{-2} mother]]]$^{w}\, j^{A}{}^\wedge m^{H}$, x^x'=1, iff there is 0 or more than 1 x' in X satisfying x'^x□I_w(mother).
Otherwise, [[[the [t_{-2} mother]]]]$^{w}\, j^{A}{}^\wedge m^{H}$, x=x', where x' satisfies x'^x□I_w(mother).

Thus $[[a']]^{w}\, j^{A}{}^\wedge m^{H}$=# iff for some x in X satisfying x□I_w(man), $[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge t^\wedge 1$, x=#,
iff (i) for some x in X satisfying x□I_w(man), there is 0 or more than 1 x' in X satisfying x'^x□I_w(mother), or
(ii) for some x in X satisfying x□I_w(man), there is exactly one x' in X satisfying x'^x□I_w(mother), and that x' is j or m [for in this case Non-Redundancy is violated; see the Note following (xxviii) above].

Otherwise, $[[a']]^{w}\, j^{A}{}^\wedge m^{H}$=1 iff for each x in X satisfying x□I_w(man), $[[\text{respect}]]^{w}\, j^{A}{}^\wedge m^{H}{}^\wedge x'^\wedge 1$, x=1, where x' satisfies x'^x□I_w(mother),
iff for each x in X satisfying x□I_w(man), x'^x□I_w(respect), where x' satisfies x'^x□I_w(mother)

(xxxi) a. He respects every man *(yields a Strong Crossover violation if* he *is bound by* every man, *i.e. if the intended reading is Every man respects himself)*
a'. [[every man][he$_{-1}$ [respect t_{-1}]]]
b. $[[a']]^{w}\, j^{A}{}^\wedge m^{H}$=# iff for some x in X satisfying $[[\text{man}]]^{w}\, j^{A}{}^\wedge m^{H}$, x=1, [[[he$_{-1}$ [respect t_{-1}]]]]^{w}

$j^{A}{}^\wedge m^{H}$, x=#. This condition is always met because $(j^{A}{}^\wedge m^{H})_{-1}= m^{H}$ is not adequate for the pronoun *he*.

Note: Contrary to what was the case for the Weak Crossover violation in (xxix), it won't help to interpret the pronoun as if it were a trace, for this will immediately give rise to a violation of Non-Redundancy, as is illustrated in the following derivation (to be compared with (xxx)).

(xxxii) a. He respects every man *(yields a violation of Non-Redundancy if* he *is reanalyzed as a trace bound by* every man*)*

a'. [[every man][t_{-1} [respect t_{-1}]]]

b. [[a']] ^{w} $j^{A}{}^\wedge m^{H}$=# iff for some x in X satisfying [[man]] ^{w} $j^{A}{}^\wedge m^{H}$, x=1, [[[t_{-1} [respect t_{-1}]]]] ^{w} $j^{A}{}^\wedge m^{H}$, x=#,

iff for some x in X satisfying x□I_{w}(student), x=1, [[[respect t_{-1}]]] ^{w} $j^{A}{}^\wedge m^{H}{}^\wedge 1$, x=#,

iff for some x in X satisfying x□I_{w}(student), x=1, [[respect]] ^{w} $j^{A}{}^\wedge m^{H}{}^\wedge 1{}^\wedge 1$, x=#.

This condition is always met because $j^{A}{}^\wedge m^{H}{}^\wedge 1{}^\wedge 1$ violates Non-Redundancy.

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[1]This is by no means an unexceptionable generalization. There are at least two kinds of problems with it:
(i) It appears that a pronoun can be bound from a non-argument position, as long as the binder is non-quantificational, for instance in *John, his mother likes*. This refinement is predicted by our final account, as discussed in Section 4.2.
(ii) There are cases in which a pronoun is bound by a quantifier which is in a non-argument position, as in *Every boy's mother likes him,* whose Logical Form must be something like *[Every boy]$_i$ [[t$_i$'s mother] likes him$_i$]*. For these cases, Büring (2003) has proposed an E-type analysis in which *him* goes proxy for a definite description such as *the boy in s,* where s is a situation variable bound by a quantifier introduced by *every boy*. If such an analysis is feasible, it can be adapted to the present framework.
(iii) Postal (1993) and Spector (2004) analyze in detail exceptions to the standard statement of Weak Crossover in French. Although we entirely agree with their data, the present theory does not predict them.

[2] In the following I call 'referring expressions' those expressions whose value in an individual. The R-expressions are a proper subset of those (since anaphoric pronouns are referring expressions, but are not R-expressions).

[3] In some respects, the present system is similar to a modal logic whose primitive entities are sequences of individuals. In our system, predicates are true *at a sequence* in the same way that in propositional modal logic a proposition is true *at a world*. See Ben-Shalom (1996) for a system that is in part similar to the one developed here.

[4] As C. Potts (p.c.) observes, this stipulation would need to be refined to handle quantified examples, for precisely the reasons that raise difficulties for our own approach in Section 4.

[5] Heim (1993) identifies guises with *semantic values* of descriptions, i.e. individual concepts; on the other hand the metaphor of the 'memory register' would require that we use descriptions rather than their values, since what is contained in a memory register is a symbol rather than its denotation; we will largely disregard this distinction in what follows.

[6] A more sophisticated version of the theory can dispense with empty cells, as is discussed in Appendix I.

[7] Butler's recent work also relies on different sequences for quantificational and non-quantificational elements.
[8] We will relativize truth and denotation to a sequence of evaluation *and to a world parameter* because we need some account of attitude reports, which provide one of the simplest examples of syntactic recursion. In a more elaborate version of the system, the world parameter would appear in the sequence of evaluation (since in any event the equivalent of world variables are needed to handle the full expressive power of modal talk in natural language, as shown in Cresswell 1990). Given the present framework, this extension would lead one to predict that modal anaphora should be subject to binding-theoretic constraints. An argument that some Condition C effects can indeed be found with modal anaphora is given in Schlenker (in press).
[9] The present analysis is similar to other semantic theories in deriving the role of c-command from semantic rules whose inputs are sister-to-sister configurations. Quite generally, an operator (broadly construed) may affect the sequence with respect to which its sister is evaluated. As a result, the interpretation of any element contained within the sister can in principle be affected by the operator. This derives the semantic role of c-command, since 'to be contained within the sister of' simply means: 'to be c-commanded by'. The present framework differs from other theories in ensuring that the sequence of evaluation actually represents the c-command relations found in the syntax, and in making full use of this fact (which is for instance used in defining a notion of *truth of a predicate under a sequence*; in standard semantic accounts this notion would be meaningless).
[10] This definition will be modified when we analyze quantificational expressions. On a correct analysis the determiner *the* must manipulate a sequence, which for theory-internal reasons cannot be the sequence of evaluation but what we will call the 'quantificational sequence'. The rule in (14)c is provided only to give a preliminary idea of the semantics we will posit. The 'official' system is found in Appendix IV.
[11] It should be noted that the rules in (14) and (15) taken together force the syntax of 3-place predicates to be somewhat abstract. This is because a predicate can be interpreted only after all its arguments have been entered in the sequence of evaluation, in an order that mirrors c-command. Thus *Bill introduced Ann to Sam* must be given a syntax in which the verb is interpreted in a position c-commanded by each of its arguments. While I will not discuss the syntax of ditransitive verbs in greater detail, I should point out that the required structures are essentially Larsonian 'shells' (Larson 1988), as in the following simplified representation:

(i) a. Bill introduced Ann to Sam
b. [Bill [Ann [introduced to Sam]]

In this structure the verb originates in a position which is a sister to the Prepositional Phrase, and moves to its surface position by head-movement, an operation that does not affect interpretation (so that despite the movement the verb is interpreted in its base position). With this structure the interpretation of (ia) is unproblematic: the arguments are entered in the sequence before the verb is evaluated, as is desired and as is illustrated below (I assume, as is common, that *to* is semantically vacuous).

(ii) $[\![$[Bill [Sam [introduced (to) Ann]]]$]\!]^{w}$ j^{A}^m^{H}
=$[\![$[Sam [introduced (to) Ann]]$]\!]^{w}$ j^{A}^m^{H}^b
=$[\![$introduced (to) Ann$]\!]^{w}$ j^{A}^m^{H}^b^s
=$[\![$introduced (to) Ann$]\!]^{w}$ j^{A}^m^{H}^b^s^a
=1 iff b^s^a $\in$ I_w(introduce)

As suggested by B. Spector (p.c.), we could also dispense with this abstract syntax if we were willing to posit a special rule of interpretation for ditransitive verbs - we could stipulate that, say, *Sam to Ann* is interpreted in one fell swoop, whereby s and a are introduced 'at the same time' in the sequence of evaluation.
[12] Although it might not be immediately apparent, this part of our analysis is closely related to the theory of first person pronouns sketched in Heim (1991).
A. Heim observed that first person pronouns may sometimes function as bound variables, as in (ia), under the reading represented in (ib):

(i) a. Only I did my homework (therefore John didn't do this)
b. [only I]$_x$ x did my$_x$ homework

In order to achieve a uniform treatment, Heim suggested that first person pronouns should *always* be represented as bound variables, even on their indexical uses. The key was to re-analyze indexical uses as instances of binding by a λ-operator, as shown in (ii):

(ii) a. I smoke.
b. λx I$_x$ smoke

According to the Logical Form in (iib), the sentence in (ia) denotes a property rather than a proposition - a result that Heim welcomed because, as Lewis (1979) argued, propositional attitudes should be analyzed as relations to properties rather than to propositions ('De Se' analysis).
B. With respect to indexical pronouns, the present theory can be seen as a semantic reinterpretation of Heim's proposal. Instead of positing that first person pronouns are literally bound by a λ-operator, we simply include their denotation in the initial sequence of evaluation. We then treat first person pronouns in the same way as anaphoric pronouns, so that

they too recover their denotation from some position of the sequence of evaluation (in order to obtain a Lewisian property one would have to abstract over the coordinate that bears the role 'author').
C. Although to my knowledge Heim did not discuss restrictions on expressions denoting the speaker and the hearer, her analysis combined with Reinhart's version of Condition C could yield the same predictions as the present theory. The analysis would go like this:
Consider a Common Ground CG in which it is presupposed that the speaker is John. To make things concrete, consider CG as a set of centered worlds, i.e. as a set of pairs of the form <individual, world> (where intuitively the first coordinate represents the speaker). Since it is presupposed that John is the speaker, in each of these pairs the first coordinate must be John. With respect to CG, the assertion of λx *John smokes* has exactly the same effect as the assertion of λx *x smokes,* i.e. it removes from CG those pairs <John, w> for which John does not smoke in w. Reinhart's pragmatic rule requires that the Logical Form that involves binding be preferred over that which involves coreference. This explains why *I smoke* is preferred to *John smokes* when uttered by John in that Common Ground.

[13] Non-Redundancy does not just apply to individual-denoting terms, but also to time expressions, as is illustrated in (i):
(i) [Uttered at 6:50pm]
a. Peter is at home
b. Peter is at home now
c. #Peter is at home at 6:50pm
In (i)a-b, indexical reference to the time of utterance is acceptable. By contrast, non-indexical reference as in (i)c is deviant. These facts follow from a version of the theory that takes into account temporal anaphora, as is outlined in Appendix I.
C. Potts (p.c.) observes that variants of (i)c can be made good, as in (ii):
(ii) 6:50: the suspect leaves his house and boards his helicopter.
I believe that this example should be analyzed in terms of guises, i.e. implicit descriptions under which the relevant elements are denoted. To my ear, (ii) could be acceptable if a detective were taping a report, and was thus in a situation in which it is not presupposed that the denotation of *now* and the denotation of *6:50* are identical (so that different cognitive results are achieved whether one refers to the time of utterance under the guise *now* or under the guise *6:50*). Similar cases can be found with individual-denoting expressions. In fact, Potts's example may be prefixed with *This is Detective Smith,* which clearly has a different informational content from *This is me*.
An anonymous reviewer points out that the data in (i) can be replicated with locatives. *It is raining in Paris* is a weird thing to say in Paris, unless one is speaking to someone who does not know where the speaker is located; by contrast, *It is raining* or *It is raining here* are both acceptable. These facts can be captured straightforwardly if, as is natural, a location coordinate is added to the initial sequence of evaluation.

[14] It should be emphasized that in the present theory *His teacher likes Bill* is treated very differently from *Bill likes his teacher*. In the former sentence the pronoun is demonstrative, whereas in the second it is anaphoric. This may be counter-intuitive, but it is by no means a peculiarity of the present approach: in Reinhart's theory of anaphora (formalized and extended in (Heim 1993)), the first sentence involves 'accidential coreference' whereas the second involves binding.

[15] The descriptions must be rigidified so as to denote the same individual in every possible world. If we used non-rigidified descriptions we would predict that, say, a demonstrative pronoun embedded under a modal operator could denote non-rigidly (i.e. that it could denote different individuals in different possible worlds), which does not appear to be the case.

[16] Thanks to L. Danlos for pointing out the relevance of Corblin's work for this discussion.

[17] Corblin's constraint is stated as follows:
(i) If a and b belong to EC_{NP}, NP is the only designator authorized for its denotation.
EC_{NP} is the 'epistemic community' of people who know that NP denotes what it in fact denotes. Thus Corblin's constraint (which might well be too strong as it stands) is relativized to a speaker and addressee that share assumptions about the denotation of referential terms.

[18] Interestingly, the result we need can be obtained by appealing to Maria Aloni's notion of a 'conceptual cover', which was designed to solve entirely different problems (such as: quantification across attitudes, or the semantics of interrogatives). A conceptual cover is a set of individual concepts such that, 'in each world, each individual constitutes the instantiation of one and only one concept' (Aloni 2001 p. 64). Formally (Aloni 1999:
(i) If D is a domain of individuals and W is a domain of possible worlds, and M=<D, W>:
A *Conceptual Cover CC* over M is a set of individual concepts such that: $\forall w \in W\ \forall d \in D\ \exists! c \in CC\ c(w)=d$
We need to stipulate that, in the default case (though not, say, when someone's identity is under discussion), objects are referred to through individual concepts that belong to the same conceptual cover, so that for each individual there is one - and no more than one- 'canonical description' of it. The interaction between Aloni's work and the present theory is left for future research.

[19] For simplicity I only discuss *that*-clauses. As far as I can tell standard approaches to *if*- and *when*-clauses (e.g. in terms of general quantification over worlds and times) could be translated into the present framework.

[20] I note in passing that this analysis predicts that propositions could be the object of anaphora, and that in such cases they should be subject to Condition C. The first prediction is clearly correct, as shown by sentences such as *Bush claims that the war is imminent, but I don't believe it*. The second prediction is harder to test because it is not easy to make a *that*-clause appear in the scope of a coreferring pronoun. French clitics make things a bit easier, because they appear in a position that c-commands the entire IP they are adjoined to. The following paradigm, modeled after examples in Wasow (1972), suggests that the prediction might indeed be correct:

(i) a. Parce que Marie l'a écrit, je crois moi aussi que la guerre est imminente.
Because that Marie it has written, I believe me too that war is imminent
b. ?Parce que Marie a écrit que la guerre est imminente, je le crois moi aussi
Because that Marie has written that the war is imminent, I it believe me too
c. Je crois que la guerre est imminente parce que Marie l'a écrit.
I believe that war is imminent because that Marie it has written
d. *?Je le crois parce que Marie a écrit que la guerre est imminente
I it believe because that Marie has written that the war is imminent.

[21] Note that under this analysis Condition B effects are correctly predicted for 3-place predicates. Consider what happens in the evaluation of *Bill introduced Peter to him*$_{-i}$ under an initial sequence s. As above I posit a Larsonian-like structure at Logical Form, as in (i)a', which gives rise to the truth-conditions in (i)b.

(i) a. Bill introduced Peter to him$_{-i}$
a'. [Bill [Peter [introduced (to) him$_{-i}$]]]
b. $[[\text{a'}]]^w s = [[[\text{Peter [introduced (to) him}_{-i}]]]]^w s\hat{}b$
$=[[\text{introduced (to) him}_{-i}]]^w s\hat{}b\hat{}p$

If i=1, the final sequence is s^b^#^p, which yields a failure when the 3-place predicate *introduce* is evaluated with respect to it; and similarly if i=2, since in that case the final sequence is s^#^p^b, which also contains # in one of its last three positions. Coreference between *him* and Peter or Bill is thus correctly blocked.

[22] Kehler (1993) gives the following principle (his (26):
A referential element is linked to the most immediate coreferential element that c-commands it in the syntax.

[23] As Fox points out, it is crucial for him that economy be computed separately in each conjunct, for otherwise non-local binding in the second conjunct would make available for the entire conjunction the reading represented in (48)d.

[24] How can we extend this analysis of the strict/sloppy distinction to other constructions that display a similar ambiguity? Consider for instance *Only John likes his mother,* which may mean that only John is an individual x such that x likes x's mother, or that only John is an individual x such that x likes John's mother. The simplest solution would be to reduce this case to ellipsis, by analyzing this sentence as: *John likes his mother*. *Nobody else does ~~like his mother~~*, where the VP of the second sentence has been elided. This could be implemented within a focus-based semantics for *only,* along the following lines: *only* DP_F *VP* is felicitous iff *DP VP* is true. If so, *only* DP_F *VP* is true iff no salient alternative d to DP is such that *d does too ~~VP~~* is true. It is as yet unclear whether there is independent evidence for such an analysis.

[25] See Butler (2003) for another account of Crossover effects that relies on a distinction between two sequences of evaluation. See Shan & Barker (2003) for a detailed semantic account of Weak Crossover, based on entirely different principles.

[26] Thanks to G. Chierchia and B. Spector for suggesting that this point be clarified.

[27] An alternative would be to claim that the trace and its antecedent simply carry the same index, as on standard accounts. The role of the trace would then be to introduce in the quantificational sequence that very same index. This mechanism is simpler than the one we adopt in two respects:
(i) it obviates the need for a syntactic mechanism that ensures that the trace gets the 'right' negative index (the difficulty is that the value of the index depends on how many quantifiers intervene between the trace and its antecedent; it is unclear how the syntactic rule should best be stated);
(ii) it allows for a simpler semantics for traces, since we may simply decide that a trace t_i has the effect of introducing the index i in the quantificational sequence.
On the other hand, the system we decided upon allows for a slightly more elegant semantics for determiners and nouns. The choice between these two systems is left for future research.

[28] The reasons is this. Consider a configuration such as *Q ...* t_{-1} *Q'... pro*$_{-1}$*,* where *pro*$_{-1}$ is to retrieve the index introduced by t_{-1} (which is itself bound by Q). If t_{-1} were, say, to introduce in the sequence of evaluation an index -1 to indicate that the last element of the quantificational sequence is to be retrieved, we would obtain the wrong result when *pro*$_{-1}$ is processed. For *pro*$_{-1}$ would have the effect of turning the sequence s^-1 into the sequence s^#^-1. On the other hand because Q' was processed between the moment t_{-1} was interpreted and that at which *pro*$_{-1}$ was interpreted, the relevant quantificational sequence will be of the form d^d' rather than simply d, as was the case before *Q*' was processed; this has the undesirable result that *pro*$_{-1}$ will in the end cross-reference d' rather than d. To avoid this problem we count elements of the quantificational sequence 'from the beginning', in such a way that the same element is cross-referenced by any

pronoun anaphoric on a trace, no matter how many quantifiers have been processed between the trace and the pronoun. This is the motivation for the somewhat complicated definition in (63). This difficulty would be circumvented if we adopted the alternative treatment of traces and quantifiers sketched in the preceding footnote.

[29] On the other hand we do agree with the observations made in Postal 1993 about the lack of Weak Crossover effects in some French relative clauses. We have nothing to say about these facts, which do not follow from the present theory. See Spector 2004 for extremely interesting work on Weak Crossover effects in French relative clauses.

[30] See Safir 1996 for related ideas.

[31] For simplicity I assume that the embedded pronoun is given a De Re analysis. The discussion would be more complex if the availability of De Se readings were taken into account.

[32] The rationale for Strategy 2 can presumably be extended plural objects as well. Suppose that on Occasion A Joe encountered a tall dark-haired man with a long knife, and that on Occasion B Joe encountered two people angry at him, one tall and dark-haired, the other tall and blond. Again it would be highly ineffective to create a new file for the group of people encountered on Occasion B without first checking whether one member of the group hadn't already been seen on Occasion A. This strategy suggests that no new file should be created if the (singular or plural) object it refers to overlaps with another object already listed in an existing file. This can be seen as a cognitive motivation for the revised Principle of Non-Redundancy.

[33] This shows that the analysis offered in Stanley & Szabo 2000 is insufficiently general, since according to them the domain restriction is a function of the context and a *single* argument. But in fact, an arbitrary number of arguments may be needed.

[34] Enç (1987) discusses the sentence *The fugitives are now in jail*, and observers that if *fugitive* were evaluated with respect to the same time as the predicate *be in jail,* a contradiction would be obtained (since a a person cannot both be a fugitive at t and be in jail at t), contrary to fact. Enç's suggestion was that *fugitive* has a concealed time variable, which in this case is interpreted deictically, so that the sentence means something like: *the people who were fugitive at t are now in jail*.

[35] It will not have escaped the reader's attention that Fox's account of reconstruction is based on a truth-conditional notion of economy. Although we claimed earlier that with respect to the analysis of binding Denotational Economy is superior to Truth-conditional economy, we had not quarrel with Fox's analysis of quantifier movement.

[36] The semantic rule for SELF must be slightly different from that given in Appendix IV, which is only stated for verbs taking n individual arguments. By contrast, *believe** takes 2 individual arguments and 1 property argument. The correct rule must state that a semantic failure arises when $SELF_{i/k}$- *believe** is evaluated under a sequence s just in case s violates Non-Redundancy or one of the last two cells of s contains #.

[37] This is particularly surprising because in ellipsis the reflexive clitic 'se' only allows for sloppy readings:

(i) Jean s'aime. Pierre aussi.
Jean SE likes. Peter too
^{Ok} *Meaning 1:* Pierre likes Pierre.
**Meaning 2:* Pierre likes Jean

[38] It should be explained *why* focus-sensitive constructions (e.g. constructions with *only* or *even*) facilitate the introduction of different guises to refer to the same individual. This is left for future research.

[39] I include below the relevant test sentences for English. As mentioned there are important disagreements across speakers:

(i) a. Everybody hates Lucifer. In fact, Lucifer knows very well that only he (himself) pities him. [**For that reason he feels sorry for him]**

b. Everybody hates every devil. In fact, every devil knows very well that only he (himself) pities him[**, and for this reason he admires him.]**

(ii) a. Peter hates Ann, John hates Ann, Franck hates Ann too - but of course Ann doesn't hate Ann **[which is unsurprising, since they have so much in common...]**

b. Peter hates Ann, John hates Ann, Franck hates her too - only Ann doesn't hate her **[which is unsurprising, since they have so much in common...]**

c. Peter hates Ann, John hates Ann, Franck hates her too - only Ann doesn't hate herself [which is unsurprising, since they have so much in common...]

[40] There might be an additional problem with a truth-conditional version of the Locality of Variable Binding. Consider the following configuration, in which *Bill* c-commands *John* and *Bill* and *John* c-command *he*:

(i) Bill_i ... John_k ... [everyone bought the same book as him]

Now observe that if the domain of quantification includes both John and Bill, *Everyone bought the same book as John* is true if and only if *Everyone bought the same book as Bill* is true. Thus the truth conditions of the embedded clause should be the same whether *he* is coindexed with *John* or with *Bill*. As a result, truth-conditional economy should prevent *he* from denoting *John*. This is a very dubious result, though a longer discussion would be needed to establish this (in particular we would also have investigate what happens when meanings-as-truth-conditions are replaced with structured meanings). I leave this question for future research.

41 As a finale note to this section, it should be observed that the predictions made by the present system for the analysis of ellipsis have not yet been investigated systematically, and could turn out to be deeply flawed. In particular, we predict that an elided anaphoric pronoun could be bound by an element which is *not* in the elided part of the sentence - a prediction which does not hold in simple accounts based on λ-abstraction. An example is given below (the indexing for *his* is the one required by the 'official' version of the system, given in Appendix III):

(i) Bush decided that the White house would announce that Laura had invited his$_{-3}$ brother. Clinton decided that his office would announce that Hillary had too ~~invited his$_{-3}$ brother.~~

In standard accounts it is predicted that a sloppy reading can be obtained for *his brother* only if *his* is bound within the elided site. This is not the case in the present theory. On the other hand we predict that a failure should result if *his office* is replaced with *he*$_{-1}$, as this would have the effect of forcing the pronoun *his*$_{-3}$ to access an empty cell. I doubt that this prediction is borne out:

(ii) Bush decided that the White house would announce that Laura had invited his$_{-3}$ brother. Clinton decided that he$_{-1}$ would announce that Hillary had too ~~invited his$_{-3}$ brother.~~