

# Semantic vs. Syntactic Reconstruction

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## 1 Introduction

The term *syntactic reconstruction* refers to the process of moving a constituent back into the position of its trace. As movement before SPELL-OUT always goes upwards, and since reconstruction is a downward operation, syntactic reconstruction can only apply at LF. Accordingly, the purpose of reconstruction is to invert scope relations. Referring to the structure at SPELL-OUT as S-structure, we can say that  $\beta$  in (1-a) would have narrow scope with respect to  $\alpha$  at S-structure, whereas the converse is true at the reconstructed LF (1-b):

- (1) a.  $\alpha_i \dots [ \beta \dots t_i \dots ] \dots$  (S-Structure)  
b.  $\dots [ \beta \dots \alpha \dots ] \dots$  (LF)

An illustration is topicalization in German, which often creates scope ambiguity between a reconstructed and a non-reconstructed reading; cf. (2), in which the object moves into SpecC, and the verb moves into C:

- (2) [CP [DP Ein Haus ]<sub>i</sub> besitzt<sub>j</sub> [IP jeder t<sub>i</sub> t<sub>j</sub> ]]  
a house owns everyone

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\*To a large extent this paper summarizes Sternefeld (1997) and Sternefeld (1998a), which in turn elaborate on an idea sketched in Heim (1994, pp. 24-25). I also discuss some of the papers collected in Katz, Kim & Winhart (1998), as well as an anonymous reviewer's claim that the system developed in Sternefeld (1997) is identical to the approach to dynamic semantics in Chierchia (1995), which at the time of writing Sternefeld (1997) was unknown to me. The paper has profited immensely from numerous discussions with Cécile Meier; without her it could not have been written. Thanks also to Kirsten Brock, Graham Katz, Winnie Lechner, Uli Sauerland and Arnim von Stechow for helpful discussion.

The preferred reading here is the one with wide scope of *jeder*.<sup>1</sup>

The term *semantic reconstruction* refers to the interpretation of scope inversion by semantic methods, based on the mechanism of lambda abstraction and lambda conversion. Given a structure like (3-a) (same as (1-a)), semantic reconstruction is represented by the interpretation (3-b): Assuming that the variable  $x_i$  has the same logical type as  $\alpha$ , the lambda term can be applied to  $\alpha$  from right to left (as will be assumed throughout this paper), so that, due to lambda conversion, (3-b) is logically equivalent to (3-c):

- (3) a.  $\alpha_i \dots [ \beta \dots t_i \dots ] \dots$  (S-Structure, LF)  
 b.  $\alpha \lambda x_i \dots [ \beta \dots x_i \dots ] \dots$  (semantic interpretation of (3-a))  
 c.  $\dots [ \beta \dots \alpha \dots ] \dots$  (lambda conversion)

The identity between (3-c) and (1-b) suggests that the two methods are indistinguishable from each other. However, it has frequently been argued that syntactic and semantic reconstruction differ empirically. The purpose of this article is to review and evaluate the most relevant arguments and to show that the difference between the two methods is smaller than has been claimed in the literature.

## 2 Semantic Reconstruction of Binding

A major argument in favor of syntactic reconstruction is based on the well-known fact that reconstruction by lambda conversion is possible only if  $\alpha$  does not contain a variable that would become bound by  $\beta$  as a result of reconstruction. However, this is the standard situation with pronominal binding in examples parallel to (2); cf.:

- (4) [<sub>DP</sub> *sein<sub>i</sub>* *Haus* ]<sub>j</sub> putzt<sub>k</sub> jeder<sub>i</sub> t<sub>j</sub> t<sub>k</sub>  
       his house cleans everyone

Due to the presence of the syntactically free pronoun *sein<sub>i</sub>* (= his), lambda conversion of *sein<sub>i</sub>* *Haus* into the scope of the coindexed binder *jeder<sub>i</sub>* (= ev-

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<sup>1</sup>Reconstruction of a quantifier with a scope dependent interpretation can be obligatory, optional, or unacceptable, depending on phonology (intonation), syntax (topicalization vs. scrambling; movement across objects vs. subjects), and semantics (*most* cannot reconstruct, weak quantifiers reconstruct more easily than strong ones). The precise conditions on reconstruction will not be addressed here, but cf. e.g. Jacobs (1982), Liu (1990), Pafel (1991), Buring (1996), Jacobs (1997), and Lechner (1998).

everyone) is not allowed here; thus it would seem that semantic reconstruction is entirely useless, since one would in any case have to appeal to syntactic reconstruction in order to (re-)place the bound variable pronoun into the scope of its binder.

However, it has been observed by several linguists (notably by Irene Heim in unpublished work, cf. Heim (1994)) that this problem is contingent on the way one standardly interprets predicate logic. In traditional logic, value assignments to variables (assignment functions) do not form part of the interpretation of sentences, but serve as a means to arrive at the correct truth conditions. Such a semantics is non-compositional. Alternatively, however, when looking at the denotation of a clause  $\phi$  as the set of value assignments that satisfy  $\phi$ , the semantics of quantification becomes compositional again. This forms the basis for an algebraic treatment of quantification, as has been well known since Tarski & Vaught (1957); cf. also Hodges (1998) for an overview. Adopting such a view makes it possible to interpret sentences like (4) without having to resort to syntactic reconstruction.

To see how this works, let us look at the standard interpretation of predicate logic for clauses like (5-a), given in (5-b).

$$(5) \quad \begin{array}{l} \text{a.} \quad (\forall x_1)(P(x_1) \rightarrow R(x_1, x_1)) \\ \text{b.} \quad (\forall a \in D)(\forall g' \in G)(g'[a/1]g \rightarrow (I_P(g'(1)) \rightarrow I_R(g'(1), g'(1)))) \end{array}$$

Here,  $D$  is the domain of discourse,  $g$  and  $g'$  are assignment functions,  $I_P$  and  $I_R$  are the interpretations of  $P$  and  $R$  respectively, and  $g'[a/i]g$  means that  $g'$  differs from  $g$  at most in assigning  $a$  to be the variable  $x_i$ . Suppose next that we replace the last occurrence of  $g'(1)$  in (5-b) with  $\lambda g.g(1)(g')$ , as shown in (6):

$$(6) \quad (\forall a \in D)(\forall g' \in G)(g'[a/1]g \rightarrow (I_P(g'(1)) \rightarrow I_R(g'(1), \lambda g.g(1)(g'))))$$

By lambda conversion, (6) and (5-b) are equivalent. Next we apply lambda exportation to  $\lambda g.g(1)$ : First we replace  $\lambda g.g(1)$  with a variable, say  $Y$  as in (7-a), then we apply lambda abstraction with respect to  $Y$  as shown in (7-b), and finally we reintroduce  $\lambda g.g(1)$  as the argument of the entire expression, as in (7-c):

$$(7) \quad \begin{array}{l} \text{a.} \quad (\forall a \in D)(\forall g' \in G)(g'[a/1]g \rightarrow (I_P(g'(1)) \rightarrow I_R(g'(1), Y(g')))) \\ \text{b.} \quad \lambda Y(\forall a \in D)(\forall g' \in G)(g'[a/1]g \rightarrow (I_P(g'(1)) \rightarrow \\ \quad I_R(g'(1), Y(g')))) \end{array}$$

$$c. \quad (\lambda g.g(1))\lambda Y(\forall a \in D)(\forall g' \in G)(g'[a/1]g \rightarrow (I_P(g'(1)) \rightarrow I_R(g'(1), Y(g'))))$$

Again, by lambda conversion, (7-c) is equivalent to (6) and (5). But now think of (7-c) as the semantic representation of (8):

$$(8) \quad [\text{Himself}_1]_j \text{ every man}_1 \text{ loves } t_j$$

By comparison with (7) we find that *himself*<sub>1</sub> corresponds to  $\lambda g.g(1)$ , and *every man*<sub>1</sub> *loves* *t*<sub>j</sub> corresponds to (7-b), with  $P=man$  and  $R=loves$ . We have thus shown that we can get an *in situ* semantics for dislocated bound variables not c-commanded by their binder, provided that we allow for variables like  $Y$  above to range over (characteristic functions of) sets of value assignments. This works because the translation of a bound variable pronoun *himself*<sub>i</sub>, namely  $\lambda g.g(i)$ , is no longer a variable, but a function from assignments to individuals. Therefore lambda conversion does not cause any problem: There is no variable here that would get into the scope of a binder as a result of conversion; the material to be converted contains no variable whatsoever. For ease of reference, we will call expressions like  $\lambda g.g(i)$  **pseudo variables**, because they play the same role as variables in the traditional framework, except that they do not act like variables with respect to conversion, as shown above.

The above analysis can be couched in the general framework developed by Bennett (1979). Within his extension of Montague's (1973) Proper Treatment of Quantification (PTQ) all expressions of natural language are translated as functions of the form  $\lambda g.\alpha$ , where  $g$  is an assignment function, i.e. a function from integers to individuals of type  $e$ . This means that part of the meta-language that is normally used to interpret quantification has been translated into the object language. Although Bennett employs this system for somewhat different purposes, it is easy to see that the phenomena described here can directly be expressed within his system, an extensional variant of which is described in section 10. Within his framework, the translation of (8) into the language of quantificational logic would look like (9-a) (where  $g$  is a variable over assignment functions and  $\lambda Y$  applies from right to left), which is logically equivalent to (9-b):

$$(9) \quad \begin{array}{ll} a. & \lambda g[(\lambda g'.g'(1))\lambda Y(\forall x)(\mathbf{man}(x) \rightarrow \mathbf{loves}(x, Y(g[x/1])))]] \\ b. & \lambda g(\forall x)(\mathbf{man}(x) \rightarrow \mathbf{loves}(x,x)) \end{array}$$

Moreover, it is easy to see how (9-a) can be arrived at by a PTQ-like translation procedure. Starting with  $\lambda g \lambda x \lambda y. \mathbf{loves}(y, x)$  as the translation of *loves*, and assuming as above that  $Y_j$  is the translation of the trace  $t_j$ , we combine these two according to the general rule

$$(10) \quad F_1(\alpha, \beta) = \lambda g. \alpha(g)(\beta(g))$$

with appropriate logical types for  $\alpha$  and  $\beta$  being presupposed. This yields  $\lambda g \lambda y. \mathbf{loves}(y, Y_j(g))$  as the translation of *loves*  $t_1$ . Next, we have to look at the subject expression *every man*, which is translated as usual, namely as  $\lambda g \lambda P(\forall x)(\mathbf{man}(x) \rightarrow P(x))$ . We know that this expression cannot directly combine with *loves*  $t_1$  because if it did we could not get the effect of variable binding. As is clear from Montague's PTQ, variable binding requires some mechanism of quantifying in. We therefore first have to combine  $\lambda g \lambda y. \mathbf{loves}(y, Y_j(g))$  with a pseudo variable that becomes bound by quantifying in. This variable is  $\lambda g. g(1)$ , which combines with  $\lambda g \lambda y. \mathbf{loves}(y, Y_j(g))$  and yields  $\lambda g. \mathbf{loves}(g(1), Y_j(g))$  by  $F_1$ . The next step is to apply Bennett's rule of quantifying in stated in (11):

$$(11) \quad F_{2,n}(\alpha, \beta) = \lambda g. \alpha(g)(\lambda y. \beta(g[y/n]))$$

As a result of applying  $F_2$  with  $n = 1$  to *every man* and *he<sub>1</sub> loves*  $t_j$  we get:

$$(12) \quad \begin{aligned} & \lambda g \lambda P(\forall x)(\mathbf{man}(x) \rightarrow P(x))(\lambda y \lambda g'. \mathbf{loves}(g'(1), Y_j(g'))(g[y/1])) = \\ & \lambda g \lambda P(\forall x)(\mathbf{man}(x) \rightarrow P(x))(\lambda y. \mathbf{loves}(g[y/1](1), Y_j(g[y/1]))) = \\ & \lambda g \lambda P(\forall x)(\mathbf{man}(x) \rightarrow P(x))(\lambda y. \mathbf{loves}(y, Y_j(g[y/1]))) = \\ & \lambda g(\forall x)(\mathbf{man}(x) \rightarrow \lambda y. \mathbf{loves}(y, Y_j(g[y/1]))(x))) = \\ & \lambda g(\forall x)(\mathbf{man}(x) \rightarrow \mathbf{loves}(x, Y_j(g[x/1]))) \end{aligned}$$

Finally, we have to interpret movement by using a variant of quantifying in that applies to the "real" variable  $Y_j$  (we will dismiss with real variables later but retain them here for ease of exposition). This can be achieved by a new rule of composition which lambda abstracts over the variable  $Y_j$  and applies the resulting function to the moved argument  $\beta$ :

$$(13) \quad F_{3,n}(\alpha, \beta) = \lambda g[\lambda Y_n \alpha(g)(\beta)]$$

By applying  $F_{3,j}$  to (12) and the translation of *himself*, we finally arrive at (9).

It is clear that this method is consistent with the usual interpretation mechanism of PTQ. It thus follows that the restriction against lambda conversion is an artefact of the standard translation procedure, so that this particular argument against semantic reconstruction can, from a linguistic point of view, be ignored.

### 3 Semantic Reconstruction of Traces

Having shown that bound variable pronouns need not have a c-commanding antecedent to be interpreted as “bound”, I now suggest that the same holds for unbound traces generated by remnant movement. As has been shown by Gereon Müller in a number of publications (cf. Müller (1996*a*), Müller (1996*b*), Müller (1997), or Müller (1998)), remnant movement plays an important role in the grammar of German and has also become an important device in other languages, in particular due to the influence of Kayne (1998). As a simple and straightforward example, consider predicate fronting and the VP-internal subject hypothesis. Given that intermediate projections are “invisible” for movement (cf. Epstein (1998) for a recent minimalist explanation), only maximal projections can move, so that the remnant movement situation arises in predicate fronting cases like (14):

- (14) a.  $[_{VP} t_i \text{ criticize his boss } ]_j \text{ Bill}_i \text{ never did } t_j$   
 b.  $[_{AP} t_i \text{ proud of himself } ]_j \text{ nobody}_i \text{ was } t_j$

Comparison of (14) with our previous example (9) reveals that the only difference is the logical type of the fronted material. The above discussion implies that the trace of *Bill<sub>i</sub>* or *nobody<sub>i</sub>* can be interpreted as a pseudo variable; the interpretation of the subject expressions themselves requires a rule of quantifying in, as usual. Fronting of VP/AP leaves a variable *Y* of the type  $\langle\langle n, e \rangle, t \rangle$ , with *n* being the type of integers, *e* the type of individuals, and *t* the type of truth values. Reconstruction then proceeds by lambda conversion as above, the only difference being the type of *Y*, which is  $\langle\langle n, e \rangle, t \rangle$  but is  $\langle\langle n, e \rangle, e \rangle$  in example (9).

Everything else being equal, we conclude that remnant movement poses no particular problem for semantic interpretation, because the enhanced method of binding pseudo variables makes it possible to maintain surface compositionality without syntactic reconstruction.

Bennett’s system is somewhat limited, though, because it only works for remnant traces that would have the type  $e$  in the traditional translation. This is because it allows for assignment functions  $g$  that map integers into individuals of type  $e$  only. However, in more complex cases, this is not sufficient. In order to see this, let us discuss a case of remnant movement in German. (15-a) exhibits German’s basic verb final SOV word order before any dislocation; this sentence can of course be interpreted *in situ*:

- (15) a. daß er [VP [VP [VP jedem nur ein einziges Buch geben ]  
that he to-everyone only a single book give  
müssen ] wird ]  
have-to will  
‘that he will have to give to everyone only a single book’  
b. daß er [DP nur ein einziges Buch ]<sub>1</sub> [VP [VP [VP jedem t<sub>1</sub> geben ]  
müssen ] wird ]

In (15-b), the existentially quantified DP<sub>1</sub> is scrambled out of its VP. This transformation can (but need not) preserve scopal relations, so that the scrambled phrase can still be interpreted as being in the scope of the universal quantifier *to-everyone*. Assuming this, (15-b) involves semantic reconstruction that interprets the trace as a DP-variable. This can still be handled in the traditional way by the usual kind of lambda conversion. But now consider verb-second main-clause order. The finite verb moves to the C-position (this is to be reconstructed as well, but for ease of exposition, head movement will be ignored here), and some maximal projection, e.g. a VP, undergoes topicalization into SpecC, as shown in (16):

- (16) [CP [VP [VP jedem t<sub>1</sub> geben ] müssen ]<sub>2</sub> [C’ wird<sub>3</sub> [IP er [DP nur ein einziges Buch ]<sub>1</sub> [VP t<sub>2</sub> t<sub>3</sub> ]]]]

Given that topicalization preserves truth conditions, the existentially quantified phrase remains in the scope of the universal quantifier. Accordingly, topicalization of the remnant VP has to be reconstructed. This time, however, semantic reconstruction encounters a problem, because the topicalized item contains a trace  $t_1$  corresponding to a “free variable” of the DP-type  $Q$ . By analogy to the simple cases of reconstruction considered previously, it is clear that interpreting the trace inside the remnant VP as a bound variable pronoun of a DP-type does the job. But as mentioned above, Bennett’s system only contains assignment functions for entities of type  $e$ . Semantic

reconstruction of unbound material of higher types requires a generalization; what we need as assignments in the object language are functions  $g$  that map integers *and* types into entities of corresponding types. Extending Bennett's system in such a way is a technical matter, whose execution can be found in section 10. Without going into the details, we will now sketch the analysis of (16) on a semi-formal level.

First assume that assignments are mappings from types and integers into ordinary denotations. The logical type of a quantifier like *nur ein Buch* is then  $\langle g, \langle \langle e, t \rangle, t \rangle \rangle$  (abbreviated as  $Q$  in what follows), where  $g$  is the type of a generalized assignment (a function that maps a type  $a$  and an integer  $n$  into a denotation of type  $a$ ). A first approximation of (16) is (17):

$$(17) \quad [_{VP} \lambda g [_{VP} \text{jedem } g(Q,1) \text{ geben } ] \text{ m\u00fcssen } ] \lambda Y_2 \text{ er } [_{VP} [_{DP} \text{nur ein einziges Buch } ]_1 [_{VP} Y_2 \text{ wird } ]]$$

Leaving aside details of the interpretation of auxiliaries and modals, I assume that the innermost VP is translated as  $\lambda g.[Y_2 \text{ wird}] (= \beta$  in (18)). We then have to quantify in  $DP_1 (= \alpha$  in (18)), which is an expression of type  $Q$ . The required operation is:

$$(18) \quad F_{4,n}(\alpha, \beta) = \lambda g.\beta(g[\alpha/n]).$$

This yields  $\lambda g[Y_2(g[\text{nur ein einziges Buch}/1]) \text{ wird}]$  as the meaning of the *in situ* VP. We then add the subject and lambda convert with respect to  $Y_2$ . This gives us

$$(19) \quad [_{VP} \lambda g' [_{VP} \text{jedem } g'(Q,1) \text{ geben } ] \text{ m\u00fcssen } ] \lambda Y_2 \lambda g. \text{ er } [ Y_2(g[\text{nur ein einziges Buch}/1]) \text{ wird } ] = \\ \lambda g. \text{ er } [[_{VP} \lambda g' [_{VP} \text{jedem } g'(Q,1) \text{ geben } ] \text{ m\u00fcssen } ](g[\text{nur ein einziges Buch}/1]) \text{ wird } ] = \\ \lambda g. \text{ er } [[[_{VP} \text{jedem } g[\text{nur ein einziges Buch}/1](Q,1) \text{ geben } ] \text{ m\u00fcssen } ] \text{ wird } ] = \\ \lambda g. \text{ er } [[[_{VP} \text{jedem nur ein einziges Buch geben } ] \text{ m\u00fcssen } ] \text{ wird } ]$$

This correctly represents the intuitive meaning of (17).

For the remainder of this paper we will assume that there is no problem with reconstructing material of any type whatsoever.



## 4 Dynamic Binding

Before discussing the empirical issue of semantic versus syntactic binding, it should be noted that the system sketched above is strong enough to express dynamic binding in a straightforward way. The problem with sentences like (20) is that they contain a syntactically free variable that should become bound by a quantifier:

(20) A man<sub>*i*</sub> entered. He<sub>*i*</sub> was whistling

Given the general “dynamic” way of interpreting discourse as functions from sentences into possible continuations (cf. Smaby (1979) for one of the first fully elaborated systems), the first sentence in (20) would be represented as

(21)  $\lambda p[(\exists x_i)(\mathbf{man}(x_i) \ \& \ \mathbf{enter}(x_i)) \ \& \ p]$

The problem of binding now comes in when trying to apply this function to the second sentence in (20). Here, lambda conversion would bring a formerly free variable into the scope of a binder, something which was impossible in previous systems, but is no problem in our account of reconstruction.

This shows that the system proposed above is at least as strong as dynamic binding. An anonymous review claims that it in fact **is** dynamic binding and therefore it does not come as a surprise that reconstruction works the way it does in our system. This is not quite correct, however, since the system proposed here is much more general and much stronger than dynamic binding. Although dynamic logic is similar to the present system in making crucial use of assignment functions (beyond what is classically assumed in standard logic), the systems are different in that dynamic logic has to define something like dynamic conjunction and other kinds of dynamic operators, whereas these definitions do not have any formal counterparts in our system. Moreover, such dynamic operators would not help in analyzing the reconstruction effects described above. The reason is that the reconstruction effect arises from having variables in the object language that range over sets of assignments; assignments, however, are still part of the meta-language in dynamic logic. We would, therefore, need some dynamic counterpart of lambda abstraction, which to my knowledge has not yet been defined in dynamic logic.<sup>2</sup>

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<sup>2</sup>The same remark applies to what has been called “dynamic binding” in Chierchia (1995). Here Chierchia assumes, as we do, that sentence denotations are represented as

## 5 Binding Theory

Let us now turn to more empirical arguments against semantic reconstruction. Consider the contrasts in (22) and (23) (from Heycock (1995) and Fox (1998)):

- (22) a. (i) \*[ How many stories about Diana's<sub>i</sub> brother ]<sub>j</sub> is she<sub>i</sub> likely to invent t<sub>j</sub>?  
(ii) [ How many stories about Diana's<sub>i</sub> brother ]<sub>j</sub> is she<sub>i</sub> likely to re-invent t<sub>j</sub>?  
b. (i) [ How many lies aimed at exonerating Clifford<sub>i</sub> ]<sub>j</sub> did he<sub>i</sub> claim that he<sub>i</sub> had no knowledge of t<sub>j</sub>?  
(ii) \*[ How many lies aimed at exonerating Clifford<sub>i</sub> ]<sub>j</sub> is he<sub>i</sub> planning to come up with t<sub>j</sub>?

With *invent* and *plan*, reconstruction is semantically preferred, because it is normally understood that one does not invent something that already exists; we do not expect a *de dicto* reading here. With *re-invent* and *claim* the opposite holds: reconstruction is not necessary because the existence of the stories or lies is presupposed. The ungrammaticality of the above examples, in which reconstruction is semantically enforced, shows that condition (C) must be a reconstruction sensitive principle of LF.

The question then arises as to how this should be formally captured in Binding Theory. One approach consistent with semantic reconstruction would be to extend Barss's (1986) dissertation, which contains an explicit account of binding that is sensitive to movement chains. In order to capture the data in (22) it would of course be necessary to differentiate between traces that are reconstruction sites, and traces which are not; but otherwise there is no great technical difficulty in modifying his theory so as to properly account for the data (cf. Sternefeld (1998a)).

Romero (1998), on the other hand, correctly argues that taking movement chains into account is still a considerable additional complication that can be dispensed with entirely if one assumes that syntactic reconstruction is the correct option.<sup>3</sup> However, the semantic theory sketched above offers a new

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sets of assignments. He then develops a logical system that is a variant of Groenendijk & Stokhof's (1990) dynamic logic. Again it seems to us that the system is much less general and less powerful than the system developed in Sternefeld (1997).

<sup>3</sup>Actually, Romero's conclusion is stronger, namely that a Barssian type of theory could not handle the data correctly. This is true for the theory as formulated in Barss (1986),

explanation in terms of another traditional account of condition (C), namely the one proposed by Reinhart (1983). According to Reinhart, condition (C) is violated if the R-expression can be replaced by a pronoun that is interpreted as bound by the antecedent (a bound variable pronoun), so that the truth condition of the original sentence and the modified sentence coincide. In the traditional semantic treatment of binding, Reinhart’s proposal cannot describe the facts without syntactic reconstruction, because after replacing a name or R-expression with a pronoun, the bound variable reading still cannot be captured without reconstruction. Within the new account for dislocated bound variables, however, the bound variable reading is available via semantic reconstruction, so that whenever semantic reconstruction is involved, the bound reading becomes available as well. This means that the interaction between reconstruction and principle (C) can be explained along Reinhart’s lines so that arguments in favor of syntactic reconstruction cannot be based on principle (C) effects alone.

As far as principle (A) and (B) are concerned, there seems to be no interaction between reconstruction and binding. This can be seen by comparing (22) with (23) and (24):

- (23) a. How many stories about herself<sub>i</sub> is Diana<sub>i</sub> likely to invent t?
- b. How many stories about herself<sub>i</sub> is Diana<sub>i</sub> likely to re-invent t?
- (24) a. Noone<sub>i</sub> knows how many pictures of himself<sub>i</sub> Diana wants to sell
- b. Noone<sub>i</sub> knows how many stories about himself<sub>i</sub> Diana is likely to invent

For semantic reasons, the *picture*-phrase in (24) has to reconstruct into the scope of the modals so that, given a movement approach to reconstruction, the closest antecedent of *himself* at LF would be *Diana*. Nonetheless, binding by *noone* is admissible, contrary to what one would expect from Binding Theory at LF. Similarly, if reconstruction were relevant in (23), we would expect (23-b) to be ungrammatical, which is not what we find. However, assuming, as semantic reconstruction does, that the LFs of the above sentences coincides with their SPELL-OUT structure and assuming that condition (A) can be checked derivationally (cf. Belletti & Rizzi (1988), Uriagereka (1988), Lebeaux (1991), Sabel (1995), Kim (1996); or perhaps as conditions on the mapping between syntax and argument structure, cf. Reinhart & Reuland

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but does not take into account possible modifications of this theory, as formulated in Sternefeld (1997) or Sternefeld (1998*a*).

(1993)), the above data can be accounted for, so that reconstruction is in fact irrelevant for the binding of anaphors.

However, although Lebeaux (1991) argues that principle (A) of Binding Theory should be checked during the derivation, Lebeaux (1994) discusses the following data, arguing that such a theory would not predict the non-ambiguity of (25-b):

- (25) a. Two women<sub>i</sub> seem t<sub>i</sub> to be expected t<sub>i</sub> to dance with every senator  
(ambiguous)
- b. Two women<sub>i</sub> seem to each other<sub>i</sub> t<sub>i</sub> to be expected t<sub>i</sub> to dance with every senator  
(unambiguous)<sup>4</sup>

Whereas reconstruction (combined with clause bounded QR<sup>5</sup>) is optional in (25-a), (25-b) exhibits what Lebeaux calls the “Trapping Effect:” Due to the presence of the reciprocal in the matrix clause, the quantifier is trapped there and cannot reconstruct into the embedded clause. But given that principle (A) is checked in the course of the derivation, this is unexpected; as argued by Lebeaux there must be, in addition to derivational checking, a so-called “coherence condition” which states that “LF must be a coherent representation, in the sense that an element occupies a particular position at LF (rather than occupying several positions at once, in the sense of chain-binding (Barss, 1986)).” Since the scope of the binder *two women* is read at LF, binding of the anaphor must also be checked *there*, in contrast to other cases of binding that do not involve scope-inducing quantifiers.

Although Lebeaux is certainly right in arguing for a single level that *interprets* bound pronouns and scope, his conclusion that we need some special coherence condition seems to be on the wrong track. The need for such a condition only evolves if we completely disregard that indices also have a semantic interpretation. But given that indices are interpreted semantically, there is no need to state anything special in the syntactic part concerned

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<sup>4</sup>Some native speakers of (American) English question the grammaticality of this sentence. According to my intuitions, its analogue in German would be ungrammatical as well.

<sup>5</sup>An argument that the lower quantifier is not scoped upward is provided by the following example.

- (i) Mary seems to two women to be expected to dance with every senator (unambiguous)

Upward scoping would yield a second reading which is factually inaccessible.

with Binding Theory. As an illustration, consider (26):

(26)  $\text{His}_i$  mother whispered that Bill loves everyone $_i$

Given that QR is clause bound, the pronoun cannot receive an interpretation as a bound variable, hence coindexation in (26) is not interpretable. But this does not have to be captured by any syntactic principle of grammar. If we interpret  $\text{his}_i$  as a referential variable, it is translated as  $\lambda g.x_i$ , which means that it is a referential free variable. In that case, (26) is well-formed, but the “intended meaning” (which is a pre-theoretic notion) of the coindexation is not expressed by the actual translation of (26). Alternatively we could interpret  $\text{his}_i$  as a pseudo variable  $\lambda g.g(1)$ , but again this variable cannot become bound. Such unbound variables can be considered as semantically ill-formed: Expressions that depend on specific assignments must become bound in the course of a derivation; there are no such “free pseudo variables” in natural language.

Pursuing the same argument, reconstruction in (25-b) does not yield any violation of principle (A) of BT, but leads to a semantically uninterpretable structure: Assuming that the reciprocal must be interpreted as a bound variable (cf. Sternefeld (1998*b*)) and given that anaphors in general are to be interpreted as pseudo variables (with the notable exception of logophoric anaphors) it follows that by semantic reconstruction the indefinite DP ends up inside the scope of the universal quantifier (modulo QR). But for the anaphor to be interpretable (as suggested by our pre-theoretic expectations about the indexing), it would be necessary to reconstruct the anaphor as well, which is impossible in (25): There is no place left to reconstruct the anaphor into the scope of the quantifier. It follows again that reconstruction would enforce an unbound pseudo variable so that the non-ambiguity of (25-b) can be explained semantically, without invoking principles of BT.

## 6 Specificational Pseudo Clefts

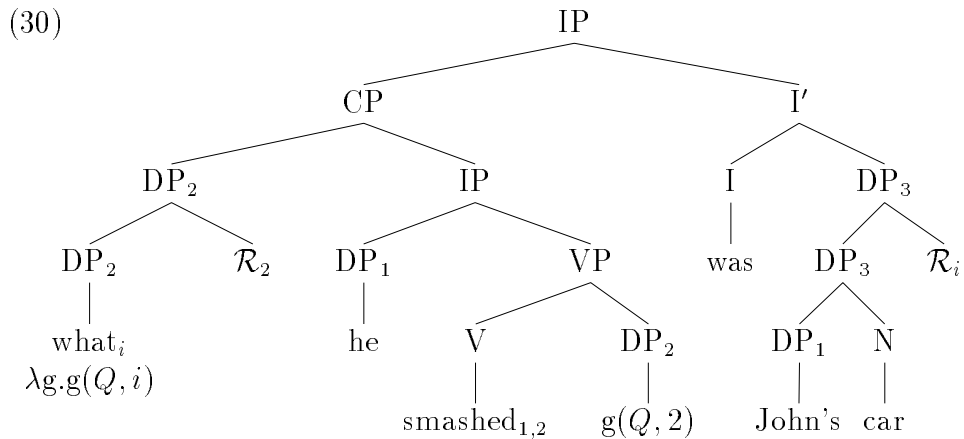
One type of phenomenon Barss’s theory is explicitly designed for is specificational pseudo clefts.

- (27) a. What nobody $_i$  did was buy a picture of himself $_i$   
b. Buy a picture of himself $_i$  was what nobody $_i$  did

These also show reconstruction effects with principle (C), so that obligatory reconstruction seems to be called for (the examples in (28) are from Bach (1969) and Higgins (1973), Higgins (1979)):

- (28) a. \*What  $he_i$  smashed was John's $_i$  car  
 b. \*What  $he_i$  discovered was a proof of Descartes' $_i$  existence  
 (okay only with predicational reading)  
 c. \*What the man who lived next door to him $_i$  also discovered was a proof that Descartes $_i$  existed
- (29) a. \*John's $_i$  car was what  $he_i$  smashed  
 b. \*Shave John's $_i$  beard was what  $he_i$  forced Mary to do

Syntactic reconstruction (as proposed by Heycock & Kroch (1998)) is somewhat unlikely here, since it would have to involve the deletion of a syntactic predicate (the copula) and of a syntactic operator (namely *what*). No such problems arise in a semantic treatment. Corresponding to the syntactic deletion of the copula, we assume that it has no meaning (or only a trivial meaning, basically the identity function  $\lambda x.x$ ). Instead of deleting the syntactic operator *what*, we assume that  $what_i$  translates as a pseudo variable  $\lambda g.g(Q,i)$  with  $Q$  being the semantic type of a DP; this pseudo variable must be reconstructed into the position of its trace (the trace of *what*) by an operator  $\mathcal{R}$ . The logical structure of (29-a) can then be represented as in (30):



$\mathcal{R}$  is a reconstruction operator which is a compositional counterpart of lambda abstraction;  $\mathcal{R}_i$  is defined in section 10 in such a way that the following holds:

$$(31) \quad \mathcal{R}(i)(\alpha)(\dots g(Q, i)\dots) = \lambda x_i(\dots x_i\dots)(\alpha) = (\dots \alpha \dots)$$

Accordingly,  $\mathcal{R}_i$  reconstructs *John's car* into the position of *what*, which in turn is reconstructed into the position of the trace by  $\mathcal{R}_2$ . Accordingly, *John* is in the semantic scope of *he* so that coindexation is ruled out by Reinhart's Condition (C).

Besides variable binding, negative polarity also seems to imply reconstruction:

$$(32) \quad [ \text{What John}_1 \text{ didn't do} ] \text{ was buy any picture of himself}_1$$

According to the standard view, the licensing condition of negative and positive polarity items is a matter of LF. Evidence for this is presented by Linebarger (1987), who observes that the local licensing of negative polarity items (NPIs) is sensitive to the scope of quantifiers at LF. She gives the following examples:

- (33) a. \*John didn't give a red cent to every charity  
 b. \*She didn't wear any earrings to every party  
 (Available reading: Wide scope of *any* over *every*;  
 NOT available: It wasn't to every party that she wore any earrings.)

At S-structure the NPI is as close to the negation as can be; nonetheless, the reading with *every* having wide scope over the NPI is impossible. This can be explained by looking at LF, where the quantifier is closer to the negation than the NPI. This produces an intervention effect: There is an intervening operator between the NPI and its licenser which blocks the strictly local licensing requirement of the NPI. Accordingly, switching from the negative to the corresponding positive polarity item *rules in* the previously unavailable reading. For example, compare (33-b) with (34), which seems fairly acceptable in the intended reading:

$$(34) \quad ?\text{She didn't wear some earrings to every party}$$

The Positive PI *some* is grammatical in (34) because at LF an operator intervenes. We conclude that PPIs too must be checked at LF.

Given all this, consider next (35):

(35) What John (also) didn't do was drink any/some wine

The grammaticality of both *some* and *any* in this context is unexpected if the LF of the sentence involves (obligatory) reconstruction:

(36) \*John didn't drink some wine

Likewise, obligatory reconstruction seems to be necessary in order to account for the ungrammaticality of (37):

(37) \*What he<sub>i</sub> didn't do was drink any/some wine from John's<sub>i</sub> cellar

The ungrammaticality of (37) can be accounted for on the surface, by way of semantic reconstruction, as a condition (C) violation; likewise, it seems that the grammaticality of *some* in (36) can also only be accounted for on the surface, because it is not in the syntactic scope of negation. Together with our previous conclusion this suggests that surface structure and LF must coincide, but that the licensing of *any* is a matter of downward entailment.

This conclusion is confirmed by the observation that the behavior of *any* is exceptional in that other NPIs are ungrammatical in contexts where *any* is okay; cf.

- (38) a. John didn't give a talk until he was 25  
b. \*John gave a talk until he was 25  
c. \*What John didn't do was give a talk until he was 25

Here again it is the surface structure that counts. Marcel den Dikken (p.c.) has pointed out to me that the same might be true for idioms. For example, the idiomatic interpretation is lost in (39):

(39) What Mary didn't lift was a finger

These findings seem to militate against an LF-reconstruction account of negative polarity in these cases. Likewise, the fact that NPIs must precede their trigger, as in (40), also indicates that surface conditions may play a role here:

(40) a. \*Any picture of Fred was what John didn't buy



- b. \*Steal anything was what nobody did
- c. \*Pictures of anyone John didn't buy
- d. \*It was pictures of anyone that John didn't buy
- e. \*Pictures of anyone are easy to ignore
- f. \*... but steal anything, nobody did

These data vary in acceptability (thanks to Chris Wilder and Sam Featherstone for discussion), showing, if anything, that their status is sensitive to a structural level that must be different from a syntactically reconstructed linguistic form.

The above data suggest that the *truth conditions* can be captured correctly by semantic as well as syntactic reconstruction, but that there are other *licensing conditions* that depend on surface structure. This seems inconsistent with the minimalist view that all conditions must be stated at interface levels. It seems, then, that the only way to stay consistent with these requirements is to identify S-structure with LF. This is exactly what semantic reconstruction does.

Cleft constructions are the paradigm cases for *structured meanings*; if we adhere to the tradition of Lewis (1972), Stechow (1982), Stechow (1984), Cresswell (1985), and others, this implies that any part of a structured meaning must be a meaningful expression on its own. This is also assumed when the clefted part is described as having an *independent meaning* such that the speaker assumes that the hearer is thinking about it; cf. Prince (1978). This requires that the parts of a structure can be put together in a compositional way, so as to yield the meaning of the whole. This is guaranteed in the semantic theory of pseudo variables, but fails in the traditional theory as soon as one part contains a “free variable” that is bound by a quantifier that is contained in another part.<sup>6</sup> Accordingly, if cleft constructions directly display the structure of a structured meaning, they directly support the use of pseudo variables and the method of semantic reconstruction; only these seem to automatically guarantee compositionality, which seems unattainable by the standard method of treating bound variable pronouns.

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<sup>6</sup>note that free pseudo variables were excluded above as ill-formed. This statement is in need of qualification: they are ill-formed not as proper parts of a structured meaning, but only as parts of a “complete” utterance in a context. In contrast, real variables as translations of non-referential pronouns in parts of a structured proposition always yield the wrong meaning.

## 7 Ellipsis and Accidental Coindexing

Romero (1998) attempts to show that semantic reconstruction cannot cope with data on VP ellipsis and VP reduction. Discussing elliptical degree questions, as in (41), she notes that *himself* in (41) has a strict reading referring to *John*, the subject of the antecedent VP, as in (41-a), and a sloppy reading referring to *Peter*, the subject of the elided VP, as in (41-b).

- (41) How many pictures of himself did John manage to sell per month before Peter did [<sub>VP</sub>  $\emptyset$  ]?
- a. “For which n: John managed to sell (the amount of) n-many pictures of John per month before Peter managed to sell n-many pictures of **John** per month.”
  - b. “For which n: John managed to sell (the amount of) n-many pictures of John per month before Peter managed to sell n-many pictures of **Peter** per month.”

Romero claims that a strict compositional surface semantics for the sloppy reading of (41) is available only if both sloppy subjects *John* and *Peter* and the anaphor *himself* are coindexed at the level of LF, as in (42).

- (42) [<sub>CP</sub> how<sub>6</sub> [<sub>CP</sub> [<sub>DP</sub> t<sub>6</sub> many pictures of himself<sub>1</sub> ]<sub>5</sub> [<sub>IP</sub> [<sub>IP</sub> John<sub>1</sub> [<sub>VP</sub> t<sub>1</sub> managed PRO per month T<sub>5</sub> to sell ] ] [<sub>CP</sub> before [<sub>IP</sub> Peter<sub>1</sub> [<sub>VP</sub> t<sub>1</sub> managed PRO per month T<sub>5</sub> to sell ]]]]]]]

Here, both occurrences of T<sub>5</sub> are semantic reconstruction sites for *n-many pictures of himself*. The basic assumption is that *himself* is translated as a pseudo variable that may be bound in the process of semantic composition by a binder with the same index. Accordingly, the semantically most crucial part of (42) is (43) (where all lambdas apply from right to left):

- (43) [ ... x<sub>1</sub> ... ] λT<sub>2</sub> [ ... [ John λx<sub>1</sub> ... T<sub>2</sub> ... ] before [ Peter λx<sub>1</sub> ... T<sub>2</sub> ... ] ]

For this to work properly we must assume that John and Peter have the same binding index, because there is only one occurrence of *himself* in (42). However, Romero argues that this “accidental coindexing” is problematic for Rooth’s conditions on VP ellipsis and VP reduction. Basically, she adopts the view of Rooth (1992) and Rooth (1995) that VP ellipsis and VP reduction must fulfill the two recoverability conditions stated in (44) and (45).

(44) **The LF-Identity Condition**

The antecedent VP and the elided VP must be identical at LF, except maybe for indices.

(45) **The Focus Condition**

There must be LF-constituents  $\alpha$  and  $\beta$  dominating the antecedent VP and the elided VP respectively such that the ordinary semantic value of  $\alpha$  ( $= \llbracket \alpha \rrbracket^{F, g^o}$ ) belongs to (or implies a proposition that belongs to) the focus semantic value of  $\beta$  ( $= \llbracket \beta \rrbracket^{F, g^f}$ ).

The dynamic approach to reconstruction is now argued by Romero to be incompatible with Rooth's theory of ellipsis. Her argumentation proceeds in a very indirect way, but we can use a shortcut by looking again at (45). Rooth's Focus Condition would require us to compare the underlined constituents in (46):

- (46) [ ...  $x_1$  ... ]  $\lambda T_2$  [ ... [ John  $\lambda x_1$  ...  $T_2$  ... ] before  
[ PETER  $\lambda x_1$  ...  $T_2$  ... ] ]

However, looking at a sentence like (47-a) and its schematic representation in (47-b), the focus condition would also be satisfied.

- (47) a. How many pictures of himself<sub>1</sub> did John<sub>1</sub> manage to sell before Bill<sub>1</sub> said that PETER did [<sub>VP</sub>  $\emptyset$  ]?  
b. [ ...  $x_1$  ... ]  $\lambda T_2$  [ ... [ John  $\lambda x_1$  ...  $T_2$  ... ] before Bill  $\lambda x_1$  said that [ PETER  $\lambda x_2$  ...  $T_2$  ... ] ]

This reading, saying that Peter managed to sell n-many pictures of Bill, is not available, although it cannot be excluded by Rooth's condition.

Romero concludes that we must not allow for accidental coindexation and that we therefore have to give up the idea of semantic reconstruction.

What she proposes instead is the following. First, we have to assume that there is no accidental coindexation. We thus have to presuppose an indexation as in (48-a), schematically represented as in (48-b):

- (48) a. [<sub>CP</sub> how<sub>6</sub> [<sub>CP</sub> [<sub>DP</sub>  $t_6$  many pictures of himself<sub>1</sub> ]<sub>5</sub> [<sub>IP</sub> [<sub>IP</sub> John<sub>1</sub> [<sub>VP</sub>  $t_1$  managed PRO per month  $T_5$  to sell ] ] [<sub>CP</sub> before [<sub>IP</sub> Peter<sub>2</sub> [<sub>VP</sub>  $t_2$  managed PRO per month  $\emptyset$  to sell ]]]]]]]  
b. [ ...  $x_1$  ... ] [ ... [ John  $\lambda x_1$  ...  $T_2$  ... ] before [ Peter  $\lambda x_2$  ...  $\emptyset$  ... ] ]

Second, we have to reconstruct syntactically, as shown in (49):

(49) [ ... [ John  $\lambda x_1$  ... [ ...  $x_1$  ... ] ... ] before [ Peter  $\lambda x_2$  ...  $\emptyset$  ... ]]

Third, we have to reconstruct the ellipsis, thereby allowing for reindexing in order to get the sloppy reading:

(50) [ ... [ John  $\lambda x_1$  ... [ ...  $x_1$  ... ] ... ] before [ Peter  $\lambda x_2$  ... [ ...  $x_2$  ... ] ... ]]

Fourth, we have to check the Focus Condition, which is satisfied, because it allows for reindexing (i.e. alphabetic variants).

Although this procedure seems more complex than ours, it convincingly shows that we have to take measures against this kind of offending coindexation. However, it is not entirely clear whether Romero's global restriction against coindexation should not be replaced by a more local one, so that arbitrary coindexation would still be permitted in the sloppy identity cases. This would re-allow semantic reconstruction so that we could dispense with the complexity of the above derivation. Instead, the restriction against coindexation would be more complex than the one assumed by Romero: Given that the antecedent and the gap are constituents of the focus constituents  $F_a$  and  $F_g$  respectively (which in the example above are underlined), the relevant condition on coindexation could then be stated as in (51):

- (51) a. If  $\alpha_i$  c-commands  $F_g$  but not  $F_a$ , and if  $\beta_j$  c-commands  $g$ , then  $i \neq j$ .  
 b. If  $\alpha_i$  c-commands  $F_a$  but not  $F_g$ , and if  $\beta_j$  c-commands  $a$ , then  $i \neq j$ .

(51-a) excludes the coindexation in (47), but permits local coindexation within  $F_a$  and  $F_g$ , which is what we need to express the sloppy reading in a semantic theory of reconstruction. Moreover, assuming that the sloppy reading requires coindexation, we also exclude the sloppy reading of (52):

(52) John<sub>*i*</sub> wants Susan to water his<sub>*i*</sub> plants and my father said nobody<sub>*j*</sub> believed Mary would  $\emptyset$  (= ... water his<sub>*\*j*</sub> plants)

Above, we followed Romero in presupposing that Rooth's theory of ellipsis is basically correct. This, however, might not be the case; as has been pointed out by Cécile Meier (p.c.), there are examples that are parallel to

the structure of Romero’s crucial examples (and to our example (47)), which nevertheless admit a sloppy reading. No matter if we assume a dynamic framework of interpretation or a classic one, and no matter if we do or do not allow accidental coindexation, we cannot predict the sloppy reading of (53) if we maintain the ellipsis theory of Rooth.

- (53) Every spy<sub>1</sub> hid his<sub>1</sub> files in TIME. And [ the head of the CIA ]<sub>2</sub> hoped  
 [F his SEcretary ] did [VP  $\emptyset$  ]

This sentence may mean that the head of the CIA hoped that the head’s secretary hid the head’s files. Note that this sentence has no strict reading and that the sloppy reading could be accounted for semantically by allowing arbitrary coindexation of *every spy* and *the head of the CIA*. However, in order to satisfy Rooth’s Focus Condition we have to find a constituent dominating the antecedent VP whose denotation belongs to the focus semantic value of a constituent dominating the elided VP and containing the focus of the ellipsis. This seems impossible, as shown in (54) and (55).

- (54) a.  $\llbracket$  Every spy<sub>1</sub> hid his<sub>1</sub> files in time  $\rrbracket^{\text{F.g}^\circ} \notin$   
 b.  $\llbracket$  [F his<sub>2</sub> secretary] hid his<sub>2</sub> files in time  $\rrbracket^{\text{F.g}^f}$
- (55) a.  $\llbracket$  Every spy<sub>1</sub> hid his<sub>1</sub> files in time  $\rrbracket^{\text{F.g}^\circ} \notin$   
 b.  $\llbracket$  The head<sub>2</sub> hoped [F his<sub>2</sub> secretary] hid his<sub>2</sub> files in time  $\rrbracket^{\text{F.g}^f}$

These data lead us to the conclusion that it is Rooth’s theory of ellipsis that is in need of revision, and that it cannot be used as it stands as an argument against semantic reconstruction.

## 8 Scope versus Binding

In all our previous cases, scope reconstruction and reconstruction of bound pronouns go hand in hand. However, this might be accidental; it might be possible that these cases differ in grammaticality. Of course, there are configurations in which reconstruction of variable binding is possible, while reconstruction of scope is not: Topicalization of *most* in German seems to be a case in point:

- (56) Die meisten Bücher haben nur zwei Autoren geschrieben  
 the most books have only two authors written

It seems to me that *most* cannot receive a scope dependent reading, i.e. cannot reconstruct, so that both *most* and *two* must be given a scope independent interpretation (cf. Sternefeld (1998b)). The interesting case, however, is one in which scope reconstruction is possible, but the reconstruction of variable binding is not. Schematically this situation can be depicted as in (57) (with Q being a scope dependent quantifier):

(57) Before Reconstruction:

[ Q ... pronoun ... ]<sub>i</sub> ... [  $\forall x_j$  ... t<sub>i</sub> ... ]

Semantic Interpretations:

a. ... [  $\forall x_j$  ... [ Q ... pronoun<sub>k</sub> ... ]<sub>i</sub> ... ]

b. \*... [  $\forall x_j$  ... [ Q ... pronoun<sub>j</sub> ... ]<sub>i</sub> ... ]

Such data would be crucial, because we would then have an argument in favor of a certain division of labor between syntactic and semantic reconstruction, in which both would be independently needed. To see this, let us develop the argument more slowly.

Suppose that pseudo variables are available. We would then expect both (a) and (b) to be grammatical. If pseudo variables are unavailable, however, then semantic reconstruction cannot generate the (b)-reading, which is as desired, because (b) is assumed not to be a possible reading. In order to exclude this reading, we must also block syntactic reconstruction here; hence, the only way to get (a) without also getting (b) is semantic reconstruction. As argued by Lechner (1998), semantic reconstruction is needed for scope reconstruction, but syntactic reconstruction is still needed for the reconstruction of binding. The relevant data he presents are the following cases of “short scrambling” in German:

(58) a. weil der Quizmaster [<sub>AGR</sub>IOP [ keinem Kandidaten ]<sub>i</sub> [<sub>AGR</sub>OP [ ein Bild von seinem<sub>i</sub> Auftritt ] überreichen wollte ]]

‘since the talk show host didn’t want to give any candidate a picture of his appearance’

b. \*weil der Quizmaster [<sub>AGR</sub>IOP [ ein Bild von seinem<sub>i</sub> Auftritt ]<sub>DO</sub> [<sub>AGR</sub>IOP [ keinem Kandidaten ]<sub>i</sub> [<sub>AGR</sub>OP t<sub>DO</sub> überreichen wollte]]]

(59) a. \*weil ich [ einige Freunde von einander<sub>i</sub> ]<sub>DO</sub> den Gästen<sub>i</sub> t<sub>DO</sub> vorgestellt habe

‘since I have introduced some friends of each other to the guests’

b. weil sie<sub>i</sub> [ einige Freunde von einander<sub>i</sub> ]<sub>DO</sub> den Gästen t<sub>DO</sub>

vorgestellt haben  
 ‘since they have introduced some friends of each other to the  
 guests’

Note that scrambling across a subject allows reconstruction of binding; cf.:

(60) weil [IP [ seine<sub>i</sub> Mutter ]<sub>j</sub> [IP jeder<sub>i</sub> t<sub>j</sub> liebt ]]  
 because his mother everyone loves

This means that we need an extra stipulation to the effect that syntactic reconstruction should be blocked only in the case of what Lechner calls *short* scrambling.

The fact that this extra stipulation does not follow from anything else in the grammar seems to indicate, however, that one of the basic assumptions concerning clausal structure is also problematic: First, there is no empirical evidence in favor of an agreement object position in German; second, it has been argued that in double object constructions there is no evidence for any type of movement whatsoever. This view has been defended by Steinbach & Vogel (1998), who assume that the dative object can be freely adjoined either above or below the accusative object. Following this analysis, we are led to conclude that the explanation for the lack of the (b)-reading in (57) is simply that the presupposed structure is not available, because there is no trace and therefore no reconstruction site available. Scope ambiguity as observed in the (a) case would then be a matter of quantifier raising, which is still blocked in the (b) case by the usual restriction against cross-over at LF (cf. Lasnik & Stowell (1991), Postal (1993)).

To summarize, there is no convincing argument for a division of labor between syntactic and semantic reconstruction: both go *in tandem*. This means that the data above do not refute the theory based on pseudo variables, but they also do not show that semantic reconstruction is needed here (or that it would crucially differ from syntactic reconstruction).

## 9 PUB Violations

Another argument against semantic reconstruction (and in favor of syntactic reconstruction) can be gained from the discussion of the copy theory of movement in Kang & Müller (1994), Kim (1996), and Beck & Kim (1997). It is argued that in degree or amount questions like (61),

- (61) *Wieviele Hunde hat Karl nicht t gefüttert*  
 how many dogs did Carl not feed

reconstruction is necessary for semantic reasons (cf. the paraphrase in (62-a)), but cannot go into the position of the trace (cf. the paraphrase in (62-b)):

- (62) a. for which  $n$  is it true that there are  $n$  dogs Carl didn't feed  
 b. \*for which  $n$  is it false that there are  $n$  dogs Carl fed

The problem with (62-a) as an LF-like representation is that there is no position in (61) into which *n dogs* could be reconstructed. Therefore, neither the copy theory of movement nor semantic reconstruction could work here; only syntactic lowering can solve the problem.

Of course, one could stipulate an intermediate trace as Cresti (1995) does, generating an S-structure like (63-a) and an LF as in (63-b,c):

- (63) a. [*Wieviele Hunde*]<sub>*i*</sub> hat *t'*<sub>*i*</sub> Karl nicht *t*<sub>*i*</sub> gefüttert  
 b. Before reconstruction:  
*Wieviele*<sub>*j*</sub> [*t*<sub>*j*</sub> *Hunde*]<sub>*i*</sub> hat *t'*<sub>*i*</sub> Karl nicht *t*<sub>*i*</sub> gefüttert  
 c. After reconstruction:  
*Wieviele*<sub>*j*</sub> hat [*t*<sub>*j*</sub> *Hunde*]<sub>*i*</sub> Karl nicht *t*<sub>*i*</sub> gefüttert

However, the intermediate trace *t'* would violate the Principle of Unambiguous Binding (PUB) defended in Müller (1992), Müller & Sternefeld (1993), Müller (1995), Müller & Sternefeld (1996) and elsewhere.

Here again the problem can be solved by rejecting one of its premisses, namely that the semantics of questions makes it necessary to reconstruct. This is usually taken for granted on the basis of Karttunen's (1977) standard semantics for data like (64):

- (64) a. Whose mother was coming?  
 b. How old are you?  
 c. Which mountain in which country did you climb?

However, one can argue that the need for reconstruction here only results from the particular encoding of types standardly used. Within Karttunen's theory it is necessary that all *wh*-phrases must be moved into a sentence initial position in order to get scope over Karttunen's type shifting operator in the C-position of the question. It has been argued by Reinhart (1992), however, that such a theory cannot correctly handle *wh-in-situ* phrases; rather,



such phrases can only be interpreted by leaving them *in situ* and interpreting them by using choice functions (cf. also Stechow (2000)).  $f$  is a choice function iff for any  $P$ ,  $f(P) \in P$ . We may then interpret an *in situ* question like (65-a) as indicated in (65-b):

- (65) a. Wenn welcher Mann kommt, wird welche Frau gehen?  
 if which man comes will which woman go?  
 b.  $\lambda p(\exists f)(\exists g)(p = \text{wenn } f(\text{Mann}) \text{ kommt wird } f(\text{Frau}) \text{ gehen})$

In effect, then, semantic question formation involves quantification over choice functions only. Since this operation can affect more than one choice function, it has been equated in the literature with an “unselective” binder. This is misleading because such an operation is sensitive to the scope of the *in situ* phrases that are coindexed with the existential binder. Assuming that such a binder is represented by  $Q$ , and indexing  $Q$  with the indices of the choice functions it has to bind existentially, Baker’s (1970) ambiguity of (66) can be resolved as in (66-a) and (66-b):

- (66) Who knows where we bought what  
 a.  $Q_i f_i(\text{person}) \text{ knows } Q_{j,k} f_j(\text{place}) \text{ we bought } f_k(\text{thing})$   
 b.  $Q_{i,k} f_i(\text{person}) \text{ knows } Q_j f_j(\text{place}) \text{ we bought } f_k(\text{thing})$

( $Q_j$  cannot bind “unselectively” because it must not bind  $f_k$ . in (66-b)). It is clear that this works independently of whether or not there is *wh*-movement (in the case of a subject question in English, there is probably none). And conversely, even in cases where there is movement into SpecC, we should not stipulate that this movement goes *across* some kind of Karttunian type shifting operator. As illustrated in (66), if  $f_j(\text{place}) (= \textit{where})$  is in SpecC, the relevant question operator  $Q$  is adjoined to CP! It then follows that reconstruction is not called for with respect to the requirements of question formation, although there might, of course, be independent reasons for why the material in SpecC needs to be reconstructed, e.g. because it has to go into an intensional context.<sup>7</sup>

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<sup>7</sup>Alternatively, we could assume a question operator in C, which takes both the material in IP and the *wh*-phrase in SpecC as an argument, interpreting it in such a way that (i-b) is logically true:

- (i) a.  $[_{CP} \alpha Q_x [_{IP} \beta ]]$   
 b.  $(\exists Q')(Q_x (\beta) (\alpha) \leftrightarrow Q'_x (\beta(\alpha)))$

Coming back to (61), I assume that its LF is something like (67):

(67)  $[_{CP} \lambda p \exists f \ \& \ [_{CP} p = \exists X \text{Hunde}(X) \ \& \ f(\text{number})(X) \ \& \ [_{C'} \text{NEG Karl füttert } X \ ]]]$

As before, no reconstruction of any kind is called for.

## 10 An Extension of Bennett's System

As mentioned above, the first system that contains assignments in its object language is Bennett's (1979) extension of Montague's (1973) PTQ. Since the paper has never been published in a journal, I will, for the benefit of the reader, restate some of Bennett's definitions. The formal system itself is a rather conservative extension of the intensional logic Montague defined in PTQ. For the present purpose, it will suffice to focus on the extensional subsystem; I have therefore removed the intensional part, which could easily be reintroduced by adding possible worlds and intensional operators.

Formally, Bennett's only addition to PTQ is the inclusion of natural numbers as a new type of denotation. Since variable assignments are functions from numbers (the index  $i$  of the variable  $x_i$ ) into individuals, numbers are needed in order to define denotations for assignment functions in the object language.

(68) **Bennett's Extension:**

- a. a set  $D_n$  of non-negative integers which is added to the set of possible denotations,
- b. a corresponding type  $n$ , and
- c. appropriate constants and variables of type  $n$  that denote non-negative integers.

Apart from this, the language and its interpretation are identical to the standard system of type theory. Accordingly, the set of types is defined as in (69), and the set of possible denotations as in (70):

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This presupposes that the logical type of  $\beta$  is such that  $\beta$  can be applied to  $\alpha$ . Whether or not  $\beta$  reconstructs is a matter of the logical type of  $\beta$  itself. A theory like this can be made precise only in a fully compositional theory like that developed in section 10.

(69) **Types:**

The set *Type* of types is the smallest set  $Y$  such that

- a.  $e, n$  and  $t$  are in  $Y$ ,
- b. whenever  $a$  and  $b$  are in  $Y$ ,  $\langle a, b \rangle$  is in  $Y$ .

(70) **Possible Denotations:**

$D_a$  is understood to be the set of *possible denotations*, characterized by the following recursive definition:

- a.  $D_e = I$ , the set of individuals
- b.  $D_n = \mathbb{N}$ , the set of natural numbers
- c.  $D_t = \{0,1\}$ , the set of truth values
- d.  $D_{\langle a,b \rangle} = D_b^{D_a}$ , the set of functions from  $D_a$  into  $D_b$ .

The set of expressions is standard, containing the symbols  $v_{n,a}$  and  $c_{n,a}$  for each non-negative integer  $n$  and each type  $a$ . In order to ensure that the  $n$ -th constant of type  $n$  denotes the number  $n$ , we define interpretations as in (71):

(71) **Interpretation of Constants:**

Assuming that  $Con_a$  denotes the set of expressions  $c_{n,a}$  for each non-negative integer  $n$  and each type  $a \in Type$ , an *interpretation* is a function  $F$  having as its domain the set  $\bigcup_{a \in Type} Con_a$ , such that

- a.  $F(c_{n,n}) = n$  for any non-negative integer in  $\mathbb{N}$ , and
- b. if  $\alpha \in Con_a$  for any type  $a$  other than  $n$ ,  $F(\alpha) \in D_a$ .

The logical language, its meaningful expressions, and its truth conditions are defined exactly as in the standard system.<sup>8</sup>

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<sup>8</sup>That is, we assume a set of *letters* of predicate logic (i.e. the set  $\{(, ), \neg, \&, \leftrightarrow, =, \exists, \forall, \lambda, \iota, \dots\}$ ) and a set  $ME_a$  of *meaningful expressions* for any type  $a$ , which are defined as usual. In particular,  $Var_a$  denotes the set of expressions  $v_{n,a}$  for each non-negative integer  $n$  and each type  $a \in Type$ . Furthermore, the meaning of  $ME_a$  is defined relative to an interpretation and an assignment of variables, which is a function  $g$  with domain  $\bigcup_{a \in Type} Var_a$ , such that for any type  $a$ , if  $u \in Var_a$ , then  $g(u) \in D_a$ . For any  $\alpha \in ME_a$ , we define its *meaning*  $\llbracket \alpha \rrbracket^{F,g}$  as in (i), with (i-a,b) as the basis of the recursion:

(i) **Interpretation of  $ME_a$**

- a. If  $\alpha \in Con_a$ , then  $\llbracket \alpha \rrbracket^{F,g}$  is  $F(\alpha)$ .
- b. If  $\alpha \in Var_a$ , then  $\llbracket \alpha \rrbracket^{F,g}$  is  $g(\alpha)$ .
- c. If  $\varphi \in ME_t$ , then  $\llbracket \neg\varphi \rrbracket^{F,g}$  is 1 iff  $\llbracket \varphi \rrbracket^{F,g}$  is 0, and similarly for  $\&$ , etc.
- d. If  $\varphi \in ME_t$  and  $u \in Var_a$ , then  $\llbracket \exists u\varphi \rrbracket^{F,g}$  is 1 iff there exists  $x \in D_a$  such that

As noted in section 3, this system is not general enough to interpret syntactically unbound material whose logical type differs from  $e$ . This can be achieved by an extension of Bennett's system. Suppose we replace expressions like  $\lambda g.P(g(1),g(2))$  with  $g \in Var_{\langle n,e \rangle}$  with expressions of the form  $\lambda g.P(g(e, 1), g(e, 2))$ , where  $g$  takes two arguments: a type and an integer. By analogy to Bennett's own extension, both components of ordinary variables become semantic entities of the model. As with  $n$  for integers, we now have to add new objects to the ontology, namely types. Furthermore, we need a new type  $g$  for generalized value assignments. Since types will occur only as arguments of assignments, it is not necessary to combine them systematically with any other objects in the ontology. We may thus define the enlarged set of types and possible denotations as follows:

- (72) **Types:** The set  $Type^+$  of extended types is the smallest set such that
- a.  $Type \subset Type^+$ ,  $g \in Type^+$ , and  $type \in Type^+$ ;
  - b. whenever  $a \in Type$ , then  $\langle g, a \rangle \in Type^+$ .
- (73) **Added Denotations:**
- a.  $D_{type} = Type$  (= the set of types defined in (69)).
  - b.  $D_g = \{f: f(a,n) \in D_a \text{ for all } a \in D_{type} \text{ and } n \in D_n\}$  (= the set of assignments).
  - c. Whenever  $\langle a, b \rangle$  is in  $Type^+$ ,  $D_{\langle a, b \rangle} = D_b^{D_a}$ .

Observe that assignments are defined in (73-b) only with respect to the original set  $Type$  rather than  $Type^+$ .

The next step is to extend the language. We assume that the extended language contains constants and variables for the denotations defined above, except for the case of assignments for which we do not need constants.

Concerning the interpretation of the new symbols, we assume that a type

- 
- $\llbracket \varphi \rrbracket^{F, g'}$  is 1 where  $g'$  is an assignment like  $g$  with the possible difference that  $g'(u) = x$ ; and similarly for  $\forall u \varphi$ .
- e. If  $\alpha \in ME_a$  and  $u \in Var_b$ , then  $\llbracket \lambda u \alpha \rrbracket^{F, g}$  is that function  $h$  with domain  $D_b$  such that whenever  $x$  is in that domain,  $h(x)$  is  $\llbracket \alpha \rrbracket^{F, g'}$ , where  $g'$  is as in (i-d).
  - f. If  $\alpha \in ME_{\langle a, b \rangle}$  and  $\beta \in ME_b$ , then  $\llbracket \alpha(\beta) \rrbracket^{F, g}$  is the value of the function  $\llbracket \alpha \rrbracket^{F, g}$  for the argument  $\llbracket \beta \rrbracket^{F, g}$ .
  - g. If  $\varphi \in ME_t$  and  $u \in Var_a$ , then if there exists a unique  $x \in D_a$  such that  $\llbracket \iota u \varphi \rrbracket^{F, g'}$  is 1 where  $g'$  is as in (i-d), then  $\llbracket \iota u \varphi \rrbracket^{F, g}$  is  $x$ ; otherwise,  $\llbracket \iota u \varphi \rrbracket^{F, g}$  is an arbitrary object fixed by the interpretation.

is interpreted as a name of itself, so that  $Con_{type} = D_{type}$  and  $F(\alpha) = \alpha$  for all  $\alpha \in Type$ . In addition, we have to include a new one place operation **type** into the formal language; its semantics is defined by  $F(\mathbf{type}(\alpha)) = a$  iff  $a$  is the type of  $\alpha$ . Accordingly,  $\mathbf{type}(\alpha)$  is a Meaningful Expression of type  $type$ . Meaningful expressions and Truth Conditions are defined as usual, but with the addition of the following clause:

- (74) If  $n \in ME_n$ ,  $\tau \in ME_{type}$ , and  $h \in Var_g$ , then
- a.  $h(\tau, n) \in ME_\alpha$ , where  $\alpha = \llbracket \tau \rrbracket^{F,g}$  and
  - b.  $\llbracket h(\tau, n) \rrbracket^{F,g}$  is  $\llbracket h \rrbracket^{F,g}(\llbracket \tau \rrbracket^{F,g}, \llbracket n \rrbracket^{F,g})$ .

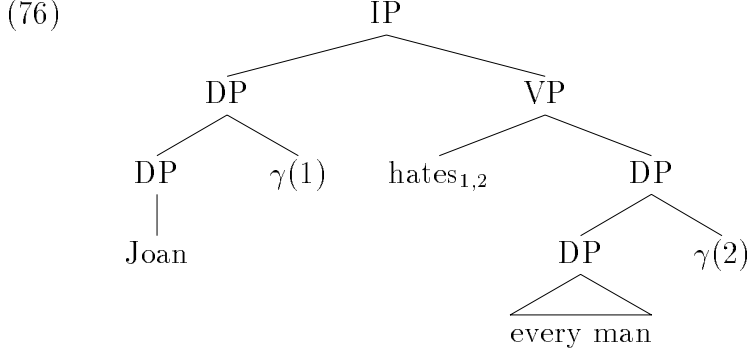
The notion of a *modified assignment*, which is essential in the formulas (5-a), (6), and (7), is defined as in (75):

- (75) **Modified Assignment:** If  $\alpha \in Var_g$ ;  $\beta \in ME_g$ ;  $u \in ME_a$  for any  $a \in Type$ ;  $n \in Var_n$ ;  $i \in ME_n$ ; and  $t \in Var_{type}$ , then
- $$\beta[u/i] := \iota\alpha((\alpha(\mathbf{type}(u), i) = u) \ \& \ \forall n \forall t (\neg(n = i) \vee \neg(\mathbf{type}(u) = t)) \rightarrow (\alpha(t, n) = \beta(t, n)))$$

As a result, we are in a position to express all kinds of semantic reconstruction in a fairly compositional way.

However, in all applications considered above we have still presupposed a mechanism which is not fully compositional, namely reconstruction by lambda conversion. As is well known, quantification in predicate logic is not compositional. Likewise, neither lambda abstraction nor PTQ's rule of quantifying in are compositional. However, given the system developed above, we have a chance to regain compositionality by replacing all real variables that occur as the translation of parts of natural language with pseudo variables.

As an illustration, consider the sentence *Joan<sub>1</sub> hates every man<sub>2</sub>*, whose logical form is assumed to be something like (76):



Our aim is to show that (76) can be interpreted without using syncategorematic rules of quantification, thus restricting the interpretation of branchings in a tree to functional application. In order to do this, we assume the following translations of the terminal nodes in (76):

- (77) Let  $g$  be the type  $\langle n, e \rangle$  and  $g$  the variable  $v_{0,g}$ . (sequences or “assignments”)  
 Let  $p$  be the type  $\langle g, t \rangle$  and  $p$  the variable  $v_{0,p}$ . (propositions)  
 Let  $P$  be the type  $\langle e, t \rangle$  and  $P$  the variable  $v_{0,P}$ . (properties)  
 Let  $Q$  be the type  $\langle g, \langle P, t \rangle \rangle$  and  $Q$  be the variable  $v_{0,Q}$ . (DPs)
- Then the terminal nodes in (76) translate as follows:
- Joan  $\implies \lambda g \lambda P. P(j)$   
 $\text{hates}_{n,m} \implies \lambda g. \mathbf{hates}(g(n), g(m))$   
 $\text{every man} \implies \lambda g \lambda P. (\forall y)(\mathbf{man}(y) \rightarrow P(y))$   
 $\gamma(n) \implies \lambda Q \lambda p[\lambda g. Q(g)(\lambda x. p(g[x/n]))]$

Note that we use Bennett’s simple system here which does not use assignment functions for types other than  $e$ ; accordingly, we write  $g(n)$  rather than  $g(e, n)$ . It is then mere routine to calculate the designations of the non-terminal nodes of (76):

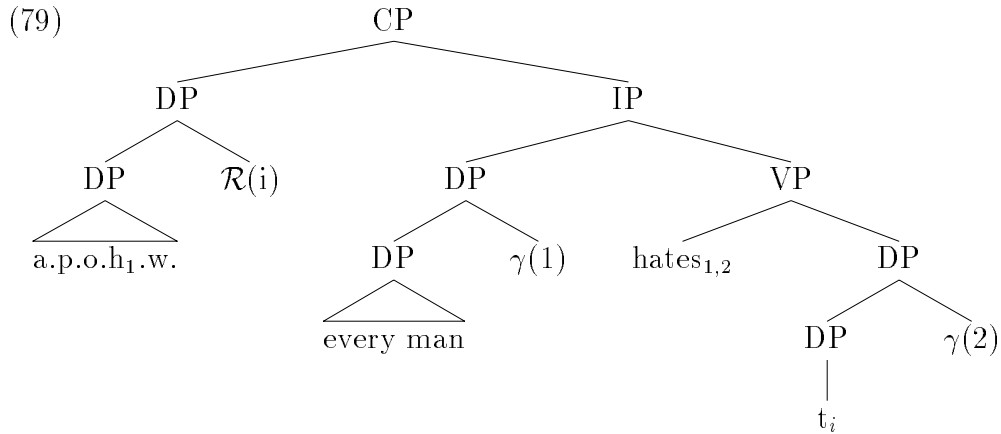
$$\begin{aligned}
 \text{VP} &= \\
 \gamma(2)(\lambda g \lambda P. (\forall y)(\mathbf{man}(y) \rightarrow P(y)))(\lambda g. \mathbf{hates}(g(1), g(2))) &= \\
 \lambda g. \lambda g \lambda P. (\forall y)(\mathbf{man}(y) \rightarrow P(y))(g)(\lambda x \lambda g. \mathbf{hates}(g(1), g(2))(g[x/2])) &= \\
 \lambda g. \lambda P. (\forall y)(\mathbf{man}(y) \rightarrow P(y))(\lambda x. \mathbf{hates}(g[x/2](1), g[x/2](2))) &= \\
 \lambda g. \lambda P. (\forall y)(\mathbf{man}(y) \rightarrow P(y))(\lambda x. \mathbf{hates}(g(1), x)) &= \\
 \lambda g. (\forall y)(\mathbf{man}(y) \rightarrow (\lambda x. \mathbf{hates}(g(1), x))(y)) &= \\
 \lambda g. (\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(g(1), y)) &=
 \end{aligned}$$

$$\begin{aligned}
\text{IP} &= \\
\gamma(1)(\lambda g \lambda P.P(j))(VP) &= \\
\gamma(1)(\lambda g \lambda P.P(j))(\lambda g.(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(g(1), y))) &= \\
\lambda g.\lambda P.P(j)(\lambda x \lambda g.(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(g(1), y)))(g[x/1]) &= \\
\lambda g.\lambda P.P(j)(\lambda x(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(g[x/1](1), y))) &= \\
\lambda g.\lambda P.P(j)(\lambda x(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(x, y))) &= \\
\lambda g.\lambda x \lambda g.(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(x, y))(j) &= \\
\lambda g(\forall y)(\mathbf{man}(y) \rightarrow \mathbf{hates}(j, y)) &
\end{aligned}$$

Next we consider reconstruction in cases like (78):

$$(78) \quad [{}_{\text{CP}} \text{A portrait of his}_1 \text{ wife}]_2 [{}_{\text{IP}} \text{every man}_1 [{}_{\text{VP}} \text{has } t_2 \text{ on his}_1 \text{ desk}]]$$

To simplify the exposition, we will assume a somewhat less complex syntactic structure (and the lexeme *hates* instead of the discontinuous constituent *has t on his desk*), without going into the semantic details of the VP and the DPs:



The translations of *every man*,  $\gamma$ , and *hates* are exactly as before. The translation of *a portrait of his<sub>1</sub> wife* is also exactly as one would expect, namely:

$$(80) \quad \lambda g \lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \ \& \ P(x))$$

It remains to interpret the the trace  $t_i$  and the reconstruction operator  $\mathcal{R}$ . Consider first  $t_i$ , which represents the reconstruction site for topicalization. Previously this trace has been translated as a free variable that needs lambda abstraction somewhere else in the tree. This is precisely the point where the

system is not completely compositional. Assume now that  $t_i$  is translated as the pseudo variable  $\lambda g[g(Q,i)(g)]$ , where  $Q$  is the logical type of the expression in (80), so that an assignment  $g$  when applied to a  $Q$  and  $i$  yield an entity of type  $Q$ . Let us first show that this yields the right result: Combining the trace with  $p = \mathit{hates}_{1,2}$  by  $\gamma(2)$  gives us (81):

$$(81) \quad \begin{aligned} & \lambda g[g(Q,i)(g)\lambda x\lambda g'.\mathit{hates}(g'(1),g'(2))(g[x,2])] = \\ & \lambda g[g(Q,i)(g)\lambda x.\mathit{hates}(g[x,2](1),g[x,2](2))] = \\ & \lambda g[g(Q,i)(g)\lambda x.\mathit{hates}(g(1),x)] \end{aligned}$$

(Here again we omit type  $e$ .) Next, by adding *every man*<sub>1</sub> we get the following:

$$(82) \quad \begin{aligned} & \lambda g\forall y[\mathbf{man}(y) \rightarrow g[y/1](Q,i)(g[y/1])\lambda x.\mathit{hates}(g[y/1](1),x)] = \\ & \lambda g\forall y[\mathbf{man}(y) \rightarrow g(Q,i)(g[y/1])\lambda x.\mathit{hates}(y,x)] \end{aligned}$$

Finally, we have to reconstruct the fronted material in a compositional way, which is done by a compositional counterpart of the lambda operator as defined in (83):

$$(83) \quad \begin{aligned} & \mathbf{The Reconstruction Operator} \text{ (cf. (18):} \\ & \text{If } n \in ME_n, \alpha \in ME_\tau \text{ and } p \in ME_{\langle g,t \rangle}, \text{ then} \\ & \mathcal{R}(n)(\alpha)(p) := \lambda g.p(g[\alpha/n]) \end{aligned}$$

Applying this to (82) and (80) yields:

$$(84) \quad \begin{aligned} & \mathcal{R}(i)(\lambda g\lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \ \& \ P(x))) \\ & (\lambda g\forall y[\mathbf{man}(y) \rightarrow g(Q,i)(g[y/1])\lambda x.\mathit{hates}(y, x)]) = \\ & \lambda g\lambda g'\forall y[\mathbf{man}(y) \rightarrow g'(Q,i)(g'[y/1])\lambda x.\mathit{hates}(y, x)] \\ & (g[\lambda g\lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \ \& \ P(x))/i]) = \\ & \lambda g\forall y[\mathbf{man}(y) \rightarrow g[\lambda g\lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \\ & \ \& \ P(x))/i](Q,i)(g[\lambda g\lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \ \& \\ & \ P(x))/i][y/1])\lambda x.\mathit{hates}(y, x)] = \\ & \lambda g\forall y[\mathbf{man}(y) \rightarrow \lambda g\lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g(1)) \ \& \\ & \ P(x))(g[y/1])\lambda x.\mathit{hates}(y, x)] = \\ & \lambda g\forall y[\mathbf{man}(y) \rightarrow \lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, g[y/1](1)) \\ & \ \& \ P(x))\lambda x.\mathit{hates}(y, x)] = \\ & \lambda g\forall y[\mathbf{man}(y) \rightarrow \lambda P(\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, y) \ \& \\ & \ P(x))\lambda x.\mathit{hates}(y, x)] = \end{aligned}$$



$$\begin{aligned} & \lambda g \forall y [\mathbf{man}(y) \rightarrow (\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, y) \ \& \\ & \lambda x. \mathbf{hates}(y, x)(x))] = \\ & \lambda g \forall y [\mathbf{man}(y) \rightarrow (\exists x, z)(\mathbf{portrait-of}(x, z) \ \& \ \mathbf{wife-of}(z, y) \ \& \\ & \mathbf{hates}(y, x))] \end{aligned}$$

This is obviously what we wanted to get. Observe, however, that this result cannot yet be achieved by the formal system defined above. This is because the derivation shown above involves expressions of the form  $g(Q, i)$ , where  $g$  is an assignment and  $Q$  is the logical type of a DP, which is itself a function from assignments into ordinary denotations. In definition (73-b), however, we assumed that  $Q$  must be an ordinary type, i.e. an element of *Type* rather than of *Type*<sup>+</sup>. We therefore have to revise the definition  $D_g$ . The new set of assignment functions needed to do away with real variables is defined as  $D_g^+$  in (85):

$$(85) \quad D_g^+ = D_g \cup \{f: f(\langle g, a \rangle, n) \in D_a^{D_g} \text{ for all } a \in D_{type} \text{ and } n \in D_n\}$$

That is, we take the old assignments  $D_g$  and add the new ones for the types  $\langle g, a \rangle$  in *Type*<sup>+</sup>. This concludes the formal development of the system.

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