Binding without Command

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Abstract

Building on Thomason's idea of representing open propositions as functions from sequences of individuals to ordinary propositions and adopting Belnap's proposal that all expressions of natural language should be translated into logical representations that denote functions from sequences of individuals to their usual denotations, I will demonstrate that there is a compositional way of dealing with bound variable pronouns that are not c-commanded by their antecedents. In particular, it can be shown that *reconstruction* phenomena can be accounted for by an entirely compositional way of interpreting surface structures.

1 Overview

This paper focusses on a compositional *in situ* semantics for sentence (1-a) which also lays the ground for dealing with further cases of "extended binding" illustrated in (1-b) to (1-e):

(1) a. Pictures of himself$_j$ Mary thinks that nobody$_j$ likes t.
b. What everyone$_i$ saw was a picture of himself$_i$.
c. A man$_k$ came in. He$_k$ whistled.
d. Somebody from every city$_n$ despises it$_n$.
e. John talks with Mary$_i$ about herself$_i$.

These sentences have in common that the antecedent does not c-command the pronoun, hence no formal binding relation can be established between the anaphor and its binder. As for (1-a), it has been argued that any adequate compositional semantic interpretation enforces *syntactic reconstruction* of the *picture*-phrase into the position of its trace, since only there can the pronoun *himself* be interpreted as a bound variable. The usual account of doing *semantic* reconstruction via lambda conversion fails, because the lambda calculus does not permit conversion of an element α, if

*Thanks to . . .

the result of conversion would bring a free variable contained in α (namely: the translation of *himself* in *pictures of himself*) into the syntactic scope of a binder of that variable (namely: *nobody*).

I will argue that, contrary to what seems to be dictated by purely logical considerations, a compositional surface semantics for (1-a) is nonetheless feasible. Reformulating ideas of Heim (1994) within the formal apparatus of Bennett (1979), it can be shown that due to a slightly different encoding of open propositions, being represented as sets of sequences of individuals, and due to a corresponding encoding of pronouns as functions from sequences of individuals to individuals, no translation of any natural language expression will contain any free variable, so that the restriction against lambda conversion is irrelevant with respect to the semantic representation of (1-a).

A general issue addressed within this framework is compositionality in and by itself. In fact, our point of departure will be that the semantics of quantification and lambda abstraction is not compositional. However, as soon as we shift from traditional semantic denotations, in particular those with free variables, to the more complex denotations without them, it can be shown that the mechanism of *binding*—traditionally implemented by modified assignments in the meta-language—can be expressed in the object-language in a completely compositional way, with sequences of individuals in the object-language playing the same role as the traditional variable assignments of the meta-language. Due to this additional degree of compositionality it will become possible to state surface compositional truth conditions for (1-a) without the use of any syncategorematic devices.

The system developed to account for (1-a) will then be shown to cover other cases of binding without c-command. In particular, it also extends to cases like (1-b) and similar ones that cannot involve a syntactic mechanism of reconstruction. This shows that the interpretative mechanism designed for (1-a) is independently motivated. Moreover, we conjecture that syntactic reconstruction can be dispensed with entirely. Arguments in favor of syntactic reconstruction were typically derived from the semantics of questions. I will show that—again due to Bennett's variable-free encoding of open propositions—there is a compositional *in situ* semantics for these cases as well.

Moreover, the way binding is treated in this system automatically explains other cases where c-command fails; *eg.*, it predicts the effects of dynamic binding illustrated in (1-c). Combining semantic reconstruction with dynamic conjunction will also provide for a way of dealing with May's (1985:68) example of inversed linking (1-d). I conjecture that almost all cases of purported quantifier raising can be reanalyzed as cases of "dynamic reconstruction."

Finally, I discuss and reject Pesetsky's (1995) treatment of "binding out of PPs." As will be shown in the next section, the index of an argument-NP will be compositionally interpreted as identifying the slot of a predicate to be "bound" by the argument-NP. Presupposing a Davidsonian semantics of events and an event-related semantics for prepositions, it follows that the argument of a preposition must at the same time be an argument of the predicate, so that the index needed for binding of slots must be attached to the entire PP *with Mary* in (1-e) rather than to the

NP within the PP. In consequence, NPs and PPs must have the same logical type. Given that syntactic rules for anaphors are stated in terms of the semantic objects that actually perform the binding (*ie.*, the index attached to the PP), we arrive at a straightforward explanation for (1-e): Although it appears as if the anaphor is "bound but not c-commanded" by *Mary*, the real binding relation holds between the index of the entire PP and the anaphor, and no violation of c-command is actually involved.

2 Compositionality and the Semantics of Indices

In section 2.1 I will explain in more detail the problem of compositionality, showing that binding requires a syncategorematic treatment which is not fully compositional. In section 2.2 I will sketch a more compositional alternative treatment of binding in natural language, which at the same time renders possible an *in situ* semantics for dislocated constituents that contain a syntactically unbound anaphor. Section 2.3 contains a formal elaboration of the proposal, which proves that semantic reconstruction via lambda conversion correctly accounts for unbound anaphors. However, this treatment is not yet fully compositional, which necessitates a further extension of the system carried out in section 2.4. Further applications of the theory will then be discussed in the remaining sections 3 to 6.

2.1 Problems with Strict Compositionality

It is well-known that Montague's (1974) "Proper Treatment of Quantification" (PTQ) provides for a strictly compositional way of dealing with sentences like *every man loves a woman*. This compositional treatment presupposes a type shifting operation to the effect that the predicate that translates the verb *love* does not denote a two place relation among individuals, but rather a relation between individuals and NP-meanings, *ie.*, generalized quantifiers. Without such a type shift there would be no way to express relational predication in a compositional way. However, even within the framework of PTQ, there is no compositional way of interpreting binding. Recall the mechanism that deals with interpreting bound pronouns in PTQ, schematically illustrated in (2):

(2)

- IP $= \forall x(\mathbf{man}(x) \rightarrow \mathbf{shave}(x,x))$
  - $\lambda P \forall x(\mathbf{man}(x) \rightarrow P(x))$ every man
  - IP $= \lambda x_1.\mathbf{shave}(x_1,x_1)$
    - λx_1 quantifying-in$_1$
    - IP $= \mathbf{shave}(x_1,x_1)$
      - x_1 he$_1$
      - VP $= \lambda y.\mathbf{shave}(y,x_1)$
        - $\lambda x \lambda y.\mathbf{shave}(y,x)$ shaves
        - x_1 him$_1$

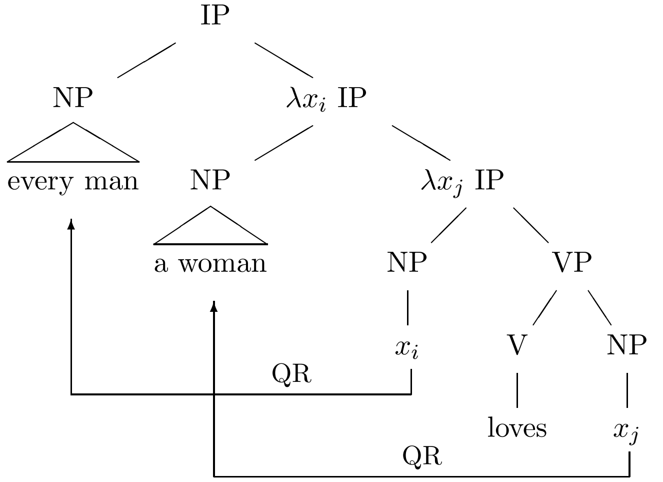
First, one has to form the expression he_1 *shaves* him_1, which translates as an open proposition. Second, there is a syntactic rule that substitutes the first occurrence of he_1 by *every man* and eventually changes him_1 into *himself*, which yields the surface expression *every man shaves himself*. This syntactic rule is accompanied by the semantic rule of quantifying-in which involves two operations: lambda abstraction and functional application. Both the syntactic and the semantic rule have to keep track of an index which serves to identify (a) the pronoun to be substituted by the full NP, and (b) the variable to be abstracted. But like quantification in ordinary predicate logic this last step is of course not entirely compositional, *ie.*, it is not a truth functional operation, because the denotation of the open proposition denoted by the lowest IP in (2) is a truth value, but the result of lambda abstraction does in no way depend on this denotation.

The problem of capturing binding in natural language can also be illustrated in terms of a failure of lambda conversion. Given that pronouns translate as variables, the simplest way of representing reflexivization would be to identify the subject variable with the argument of the object position, *ie.*, we would like to perform lambda conversion in $\lambda y \lambda x.\mathbf{shave}(x, y)(x)$, which should yield $\lambda x(\mathbf{shave}(x, x))$. But as is well-known, lambda conversion is illegitimate in this context: it is blocked if the replacement puts the argument of λy (here: (x)) into a position where it becomes bound by an operator (here: λx).

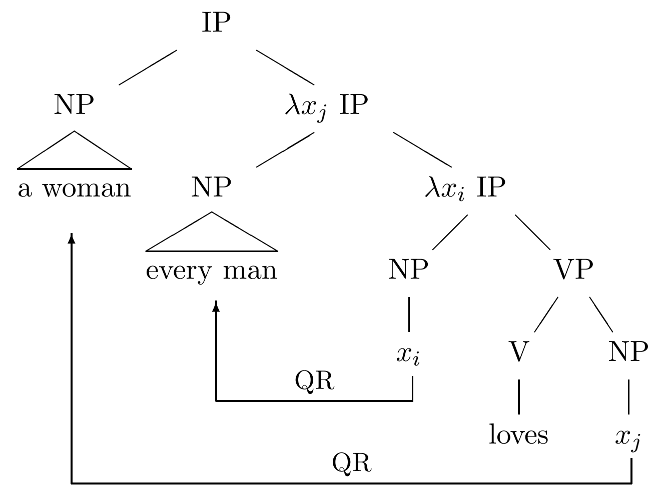
Note that this problem is independent of the encoding of the predicate, *ie.* of whether the verb denotes a relation between individuals or generalized quantifiers. Assuming (as seems standard practice in work not too closely related to Montague's PTQ) that the verb expresses a relation between individuals, even sentences like *every man loves a woman* cannot adequately be treated in a purely compositional way. This has given birth to the widespread dogma that quantifiers induce obligatory raising—a syntactic device whose semantics is exactly parallel to Montague's rule of quantifying-in:

(3) Every man loves a woman.

a.



b.



In both readings there is non-compositional material stuffed in at the IP-nodes, namely binding by lambda abstraction. It thus follows that even relational predication cannot be captured in a strictly compositional way.

The above considerations suggest that we can distinguish between different grades of compositionality; the question then arises how compositional natural language is in general, and which kinds of constructions should be described in which way. We may thus consider the following global theories:

(4) **Degrees of Compositionality**

A. Weak Compositionality:

a. Given certain natural assumptions about the logical types of natural language expressions, various constructions, in particular anaphoric binding, cannot adequately be handled in a strictly compositional way; this necessitates "stuffed-in" material not present in the meaning of lexemes.

b. The way this additional semantic glue is interpreted is essentially non-truth functional; *ie.*, semantic interpretation can proceed in a *syncategorematic* way.

B. Strong Compositionality:

agrees with (a.), but rejects (b.) by interpreting additional glue compositionally.

C. Strict Compositionality:

rejects both (a.) and (b.), so that composition reduces to functional application among lexical items.

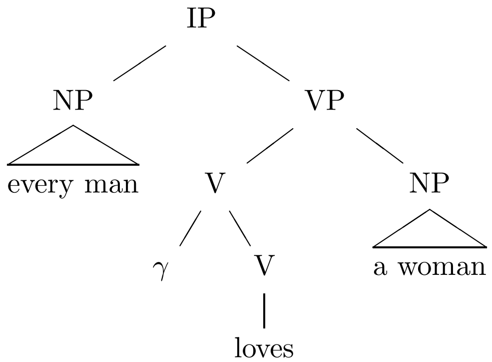
With regard to the two sentences discussed above one could, of course, maintain strict compositionality by modifying the translation of lexical items, for instance by translating the anaphoric pronoun as $\lambda R \lambda x.R(x)(x)$. And one could distinguish between the translation of nominative determiners and that of accusative determiners, so that the latter yields an encoding of accusative NPs as $\lambda R \lambda x \forall y(\mathbf{man}(y) \rightarrow R(x,y))$. In both cases, however, there is good reason to reject such translations as being too construction specific: they both work only in one specific syntactic configuration, namely [$_{\mathrm{VP}}$ V NP]. For example, translating accusative NPs as above would not work with bitransitive verbs or in cases of Exceptional Case Marking, nor would reflexivization.

As far as explanatory adequacy is concerned, it seems that the goal of strict compositionality seems unattainable, even if we allow for various sorts of type lifting that have been proposed in the literature, *cf.* Hendriks (1993) for a representative example. In fact there are a number of "strictly compositional" treatments of scope ambiguities which all rely on complex type shifting operations, and imply that a natural language expression is assigned infinitely many different types. In a certain sense, however, these methods still stuff in additional semantic glue, namely the (lexical) type lifting operation in and by itself. Moreover, I am not aware of any account of binding within a type lifting framework. And finally it has been shown by Keenan (1992) that a wide range of natural language constructions involve non-Fregean quantification, which is analysed by Keenan as a simultaneous quantification over more than one variable that cannot be expressed as a compositional iteration of unitary quantifiers. In consequence, it seems to be agreed upon that natural language goes beyond strict compositionality.

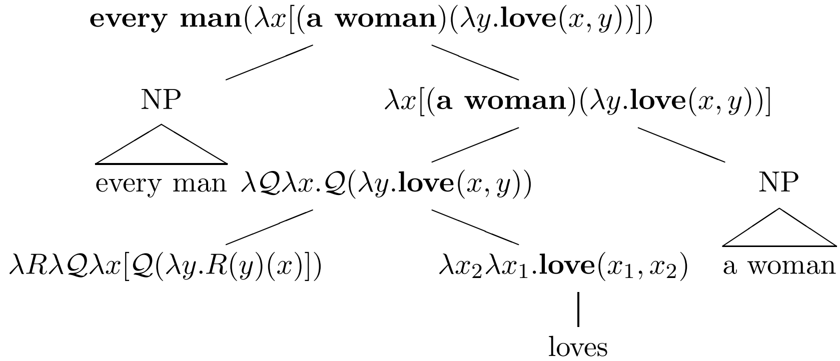
Since strong compositionality is logically weaker than strict compositionality, the former should be easier to achieve, although it is by far not clear how this goal could be reached in an explanatory way.[1] To illustrate, one might easily conceive of an operator γ with an independent "lexical" denotation that combines a predicate and its object as follows:

(5) *Ad-hoc rule for interpreting* [$_{\mathrm{VP}}$ V NP]:
Let R range over two place relations, and $\mathcal{Q}$ over NP-meanings (*ie.*, generalized quantifiers). Then (5-a) can be interpreted as shown in (5-b):

a.



[1]For example there is considerable disagreement on how the cases presented by Keenan (1992) should be dealt with in an explanatory way; compare *eg.* Keenan's account of the distributive reading of certain plural sentences with an alternative treatment of such constructions in Sternefeld (forthcomming).

b. 

Here again the question arises whether or not this explanatory. By and large, it seems that the same objection raised against the strictly compositional translation would also carry over to the interpretation of γ; here again the additional glue is still too construction specific.[2]

Nonetheless, the still interesting property of the above analysis is its compositionality: Unlike lambda abstraction in (3), the semantic glue that is needed to express relational predication can, at least in principle, be given a meaning of its own.[3] Since any kind of additional compositionality should be considered a virtue, it might still be promising to look for glue that is not construction specific, eventually reducing the number of elements needed to combine constituents to a minimum. In fact, it is my aim in this paper to outline a semantic system that does away with syncategorematic rules, but supplies only two different operators instead; one that encodes "ordinary predication" (which is Bennett's term for his analogue of quantifying-in), and a second one that is needed for describing reconstruction. Apart from these two operators, everything else is lexical. Moreover, the modifications required to reach this aim will at the same time offer a new perspective on the issue of binding in natural language and the problem illustrated in (1), *ie.*, the problem of binding without command.

Independent motivation for seeking an alternative to the standard way of removing type mismatch by envoking QR is its being syntactically unmotivated. It always struck me as strange that QR obeys different constraints than other LF-movement operations, and that there should'nt be any *in situ* interpretation of simple transi-

[2]The idea of using lambda categorial glue can be found explicitly in Ballmer's theory of punctuation; cf. Ballmer (1975). Ballmer uses glue mainly to overcome syntactic problems posed by word order (*eg.* discontinuous constituency). His glue is syntactically located in punctation signs which reflect the traditional idea of different underlying "*Satzbaupläne*." In our view, this is explanatorily inadequate again, because it only captures construction specific syntactic properties. In contrast, as has been illustrated in (1), our use of glue is semantically motivated and goes far beyond the range of phenomena that could be treated in a framework like Ballmer's.

[3]Once this glue can be lexicalized it is tempting to think of it as the meaning of a morphological transitivity marker, or some kind of object agreement (*ie.*, the head of some AGR$_O$ projection). For various reasons I will not pursue this line of reasoning: First, γ in (5) does not head a functional projection; second, if we would adjust the structure as required, this projection would be "interpretable"—contrary to what has been assumed for AGR$_O$ in Chomsky (1995); and third, in chapter 4 of Chomsky (1995), AGR-Projections are in any case dismissed with. This does not imply that Chomsky is necessarily correct, nonetheless I will be leaving the matter to the imagination of the reader.

tive constructions. A related and equally puzzling feature of QR is this: How come that movement of an NP leaves a trace to be interpreted by something of a totally different semantic type? As far as I can see, this mechanism is exceptional in lacking a counterpart in other categories. Either movement leaves a trace of the same logical type as the constituent being moved, or the trace is not interpretable at all. There are also additional questions concerning word order: in many languages surface order strictly determines scope in terms of S-structural command relations; but once type driven QR comes into play, one would have to explain why this order must apparently be preserved at LF.[4] In any case it seems to make more sense to restrict QR to cases where it has an effect on scope, which is obviously not the case in type driven QR.

2.2 Compositionality Regained

In this section I will try to sketch more or less informally the theory to be developed more precisely in section 2.3. The basic idea is this. Due to a minimal extension of the object-language it will become possible to mimic the meta-linguistic treatment of lambda abstraction and quantification in the object-language itself. As it turns out, this rephrasing of the meta-linguistic truth conditions is entirely compositional.

Within the meta-language the usual way of dealing with quantification and abstraction is by means of variable assignments. These will play a key role in the present proposal, which consists of integrating sequences of individuals into the object-language. For example, one might recast existential quantification or lambda abstraction in compositional terms, if only one interprets their arguments as functions from assignments into truth values, as expressed in a somewhat sloppy way in (6):

(6) *Compositional rephrasings of* $\exists x_i(\ldots)$ *and* $\lambda x_i(\ldots)$*:*
Assume that g ranges over variable assignments and α over the characteristic function of a set of such assignments. Then

$$(\exists x_i) := \lambda\alpha\lambda g\exists x.\alpha(g[i/x])$$
$$(\lambda x_i) := \lambda\alpha\lambda g\lambda x.\alpha(g[i/x])$$

where $g[i/x]$ is the value assignment that possibly differs from g in that $g(x_i) = x$.

The reason for sloppyness is in improper merge of object-language and meta-language. At the present stage of formalization, assignments in (6) still belong to the meta-language; hence, our main task is to remove this conflation, by defining formal objects that can do the job of meta-linguistic assignments within the object-language itself.

As a first step towards that end note that the operations defined above are not general enough, since they only express lambda abstraction and quantification over a particular variable x_i. What we really would like to say is (7):

[4] See Müller (1986) for a recent discussion of the issue and an attempt to solve the problem.

(7) $\exists := \lambda n\lambda\alpha\lambda g\exists x.\alpha(g[n/x])$
$\lambda := \lambda n\alpha\lambda g\lambda x.\alpha(g[n/x])$

In order to express this we have to include *numbers* into the ontology of the object-language. But by doing so, type theory will provide us also with *assignments*, namely functions from numbers (the index of a variable) to individuals. Accordingly, (7) will become an expression of our object-language if only open propositions be represented in the correct way, namely as illustrated in (8-b):

(8) *Open propositions:*
a. Traditional implementation: $\mathbf{love}(x_1, x_2)$
b. Bennett's implementation: $\lambda g.\mathbf{love}(g(1), g(2))$

Numbers here serve as place holders or *slots*, much like the indexed free variables in the traditional implementation. Given this particular way of encoding propositions, abstraction and quantification are illustrated in (9):

(9) a. *Existential quantification wrt. slot 1:*
$\exists(1)(\lambda g.\mathbf{love}(g(1), g(2))) =$
$\lambda n\lambda\alpha\lambda g\exists x\alpha(g[n/x])(1)(\lambda g.\mathbf{love}(g(1), g(2))) =$
$\lambda\text{g}\ \exists\text{x}\ \lambda\text{g}.\mathbf{love}(\text{g}(1),\text{g}(2))(\text{g}[1/\text{x}]) =$
$\lambda\text{g}\ \exists\text{x}\ (\mathbf{love}(\text{g}[1/\text{x}](1),\text{g}[1/\text{x}](2))) =$
$\lambda g\exists x\mathbf{love}(x, g(2))$
b. *Lambda abstraction wrt. slot 2:*
$\lambda(2)(\lambda g.\mathbf{love}(g(1), g(2))) =$
$\lambda n\lambda\alpha\lambda g\lambda x.\alpha(g[n/x])(2)(\lambda g.\mathbf{love}(g(1), g(2))) =$
$\lambda g\lambda x.\mathbf{love}(g(1), x)$

Now, it is clear that quantification works exactly as one would expect; the only remaining task is to define modified assignments in the object language. This will be done in a straightforward way in the next subsection.

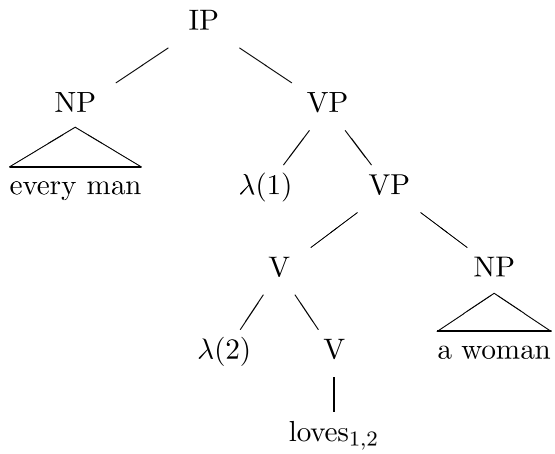
It emerges, then, that the reading (3-a) can be analyzed in a more compositional way. For suppose a two place relation R, which is to be used in a predicative construction, is taken from the lexicon and inserted into a syntactic (and semantic) derivation. This is done by an operation SELECT which adds indices to the syntactic and semantic representations.[5] The semantics of SELECT can be described as in (10):

(10) $\mathit{SELECT}(R)(i)(j) := \lambda g.R(g(j))(g(i))$

We restrict indices of predicates to the first positive integers, so that SELECT indexes R with 1 and 2. The indexed predicate can now enter into the syntactic and semantic analysis as illustrated in (11):

[5]Note that this is the analogue of the lexical type shifting operation in theories with flexible types; *cf.* Hendriks (1993) or Partee and Rooth (1983).

(11)



The interpretation of this tree is almost straightforward; we only have to settle a minor problem concerning a still existing type mismatch between the translation of the predicate and that of the NPs. Looking back to (7), note that the result of applying lambda abstraction (or quantification) to an integer and a proposition is a function with the domain of assignments again, which must now be combined with an NP-meaning. As will become important immediately, NPs (and in fact all translations of natural language expressions) must be functions of assignments as well, though with different semantic values. For example, the NP *every man* is, for systematic reasons, translated as in (12):

(12) every man $\rightsquigarrow \lambda g \lambda P \forall x(\mathbf{man}(x) \to P(x))$

This much said it is clear that the problem of type mismatch can now be solved by redefining functional application between the constituents in (11) as follows:

(13) *Modified version of functional application* (will become obsolete later):
Assume binary branching. Given that
a. X and Y translate as α and β,
b. $\alpha(g)(\beta(g))$ is wellformed, and
c. Z immediately dominates X and Y,
then Z is interpreted as $\lambda g.\alpha(g)(\beta(g))$.

By analogy to the usual semantics of quantifying-in it now follows from the above definitions that (11) correctly represents (3-a).[6]

For the remainder of this subsection I will demonstrate how such a system can handle dislocated anaphors, beginning with a discussion of the meaning of the VP *shaves himself*. The ideal discussed above would be that the translation of the

[6] It still remains to analyze (3-b) which can be accounted for immediately by simply QRing the indefinite NP:

(i) a woman (λ(2)(every man(λ(1)(loves$_{1,2}$))))

Semantic interpretation, however, crucially differs from the traditional one in that the trace does not receive any semantic representation. I will return to the analysis of scope reversal and wide scope semantics of indefinites further below.

anaphor is identical to the variable in subject position. We have seen, however, that due to the failure of lambda conversion in this context, this did not work. But now observe that the transition from (14-a) to (14-b) is a completely legitimate operation.

(14) a. $\lambda x.\mathbf{shave}(g(1), x)(g(1))$
b. $\mathbf{shave}(g(1), g(1))$

This works because the entities figuring previously as variables are now translated as constant functions; in fact, given the redefinition of functional application in (13), (14) suggests that the pronoun *himself*$_n$ is translated as that function which assigns to each sequence its n-th element:

(15) *Translation of indexed pronouns:*
a. Traditional translation: x_n (or rather $\lambda P.P(x_n)$) ???????
b. Bennett's translation: $\lambda g.g(n)$ (or rather $\lambda g\lambda P.P(g(n))$)[7].

We then get the derivation shown in (16):

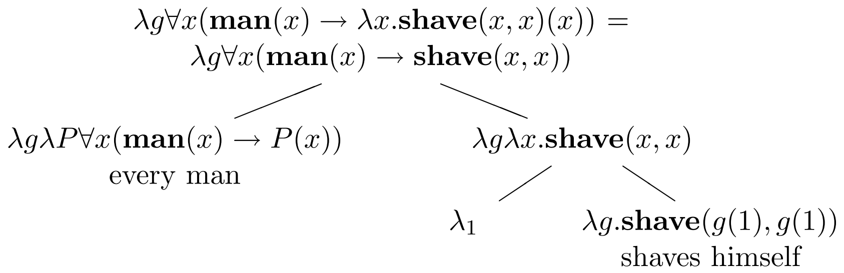
(16)
- $\lambda g[\lambda x.\mathbf{shave}(g(1), x)(g(1))] =$ $\lambda g.\mathbf{shave}(g(1), g(1))$
  - $\lambda g\lambda x.\mathbf{shave}(g(1), x)$
    - λ_2
    - $\lambda g.\mathbf{shave}(g(1), g(2))$
      - shaves
  - $\lambda g.g(1)$
    - himself$_1$

Now, reinterpreting this as an open proposition (in the traditional sense of the term), it is clear that we obtained exactly the result we were unable to derive by lambda conversion when trying to use identical variables as translations for the object pronoun and the subject position. Nonetheless, this is, in a certain sense, exactly what has been done in the above (slightly type-shifted) analysis. The basic point of the procedure is that the translation of the pronoun does not contain any free variable whatsoever, so that the usual restriction against lambda conversion does not apply.

To terminate the derivation we continue with lambda abstraction over slot 1, followed by universal quantification as shown in (17):

[7] The analyses as a generalized quantifiers will be adopted below for reasons of uniformity, but would not work in the present somewhat simplifying context.

(17)

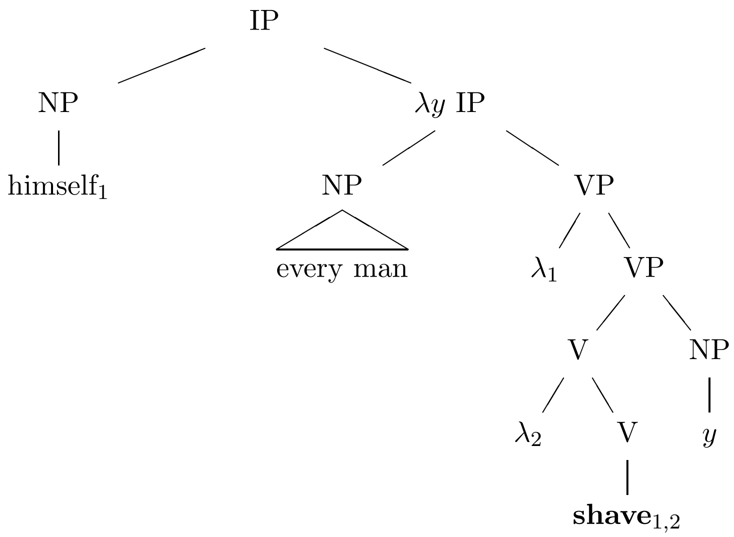


In order to see more perspicuously the theoretical impact of this method, let us now sketch the semantic interpretation of the topicalized structure (18):

(18) Himself every man shaves

The traditional problem with (18) is that the derivation cannot proceed as one would expect, *ie.*, by first forming something like *every man shaves him*$_2$, because subsequent quantifying-in of *himself* cannot put the anaphor into the scope of the quantifier. However, adopting the idea illustrated above reveals that no such problem arises when interpreting the anaphor as a complex constant function. This can be seen as follows.

(19)



Given that y has the same logical type as *himself*, and assuming that the lambda expression λy.IP applies to *himself* in the usual way (*ie.*, not as described in (13)), it can be seen that the (still weakly) compositional interpretation of this tree is no problem. This is demonstrated in the following derivation:

(20)
$$\begin{aligned}&\lambda g\forall x(\mathbf{man}(x) \to \mathbf{shave}(g[1/x](1), (\lambda g.g(1)(g[1/x])))) =\\ &\lambda g\forall x(\mathbf{man}(x) \to \mathbf{shave}(g[1/x](1), g[1/x](1))) =\\ &\lambda g\forall x(\mathbf{man}(x) \to \mathbf{shave}(x, x))\end{aligned}$$

$$\Tree [.{\lambda g\forall x(\mathbf{man}(x) \to \mathbf{shave}(x, x))} [.{\lambda g.g(1)} \text{himself}_1] [.{\lambda y\ \lambda g\forall x(\mathbf{man}(x) \to \mathbf{shave}(g[1/x](1), (y(g[1/x]))))} [.NP \text{every man}] [.{\lambda g\lambda x.\mathbf{shave}(g[1/x](1), (y(g[1/x])))} \lambda_1 [.{\lambda g.\mathbf{shave}(g(1), (y(g)))} [.{\lambda g\lambda x.\mathbf{shave}(g(1), x)} \lambda_2 [.V {\lambda \mathrm{g}.\mathbf{shave}(\mathrm{g}(1),\mathrm{g}(2))}]] [.NP y]]]]]$$

The above analysis is a first approximation only, since abstraction on y is still non-compositional. I will remedy this defect later; what counts is that the derivation in (20) interprets the anaphor *in situ*, albeit it is not in the scope of its binder. We expect, then, that this method will work for more complicated cases as well.

Summarizing so far, the basic feature of the system, which enables us to interpret anaphors *in situ*, is this:

(21) *Guarantee of Success:*
No translation of any natural language expression may contain free variables.

This principle guarantees unrestricted lambda conversion, and it therefore accounts for dislocated variable pronouns in a straightforward way. The basic method is that of type lifting again. But there is a clear and straightforward difference to any of the traditional lifting operations: First, the operation is a systematic one that preserves the correspondence between categories and types; in particular, each expression belongs to exactly one type. And second, nothing really new comes into play that would not already have been there in the meta-language, when looking at denotations that depend on variale assignment. All that we have done is making this dependence explicit.

2.3 Bennett's Innovation

As mentioned above, the first treatment of open propositions in terms of sequences of individuals can be found in Bennett's (1979) paper, which attributes the basic ideas to Belnap and Thomason. Since the paper has never been published in a journal and might thus be inaccessible for the reader, I will in this section simply restate some of Bennett's definitions. As will be seen, the formal system itself is a rather conservative extension of the intensional logic Montague defined in PTQ. For the present purpose, however, it will suffice to focus on the extensional subsystem. I will therefore strip off the intensional part, which could be reintroduced in the usual manner by adding possible world and intensional operators.

Bennett's innovation lies less in the formal language as such than in the translation procedure, to which we will turn later in this subsection. As regards the former, Bennett's only innovation is the inclusion of natural numbers and appropriate types.

(22) *Bennett's Extension:*

a. A set D_n of nonnegative 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 nonnegative integers.

Apart from that, the language and its interpretation are identical with the standard system of typed predicate logic. Accordingly, the set of types is defined in (23), and the set of possible denotations in (24):

(23) **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.

(24) **Possible Denotations:**
By D_a is understood the set of *possible denotations*, which is characterized by the following recursive definition:

a. $\mathrm{D}_e = \mathrm{I}$, the set of individuals

b. $\mathrm{D}_n = \mathrm{N}$, the set of natural numbers

c. $\mathrm{D}_t = \{0,1\}$, the set of truth values

d. $\mathrm{D}_{\langle a,b\rangle} = {\mathrm{D}_b}^{\mathrm{D}_a}$, the set of functions from D_a into D_b.

The set of expressions is just the usual one, except that it has constants of type n, which denote numbers. Accordingly, the formal language contains the symbols $v_{\mathrm{n},a}$ and $c_{\mathrm{n},a}$ 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, one has to define interpretations as in (25) and (26):

(25) **Constants and Variables:**

a. By Con_a is understood the set of expressions $c_{\mathrm{n},a}$ for each nonnegative integer n and each type $a \in \mathit{Type}$.

b. By Var_a is understood the set of expressions $v_{\mathrm{n},a}$ for each nonnegative integer n and each type $a \in \mathit{Type}$.

(26) **Interpretation of Constants:**
An *interpretation* is a function F having as its domain the set $\bigcup_{a\in \mathit{Type}} Con_a$, such that

a. $\mathrm{F}(c_{\mathrm{n},n}) = \mathrm{n}$ for any nonnegative integer in N, and

b. if $\alpha \in Con_a$ for any type a other than n, $\mathrm{F}(\alpha) \in \mathrm{D}_a$.

Now, as regards the logical system and its meaningful expressions, all the rest is completely standard.[8]

Our next task is to bring together the meaning of a generalized quantifier and that of the predicate, as for example in *every man snores*. Recall that predicates are indexed (by some function SELECT that inserts a lexical item into a syntactic and semantic derivation) and enter the computational system as "open propositions." For example, the predicate that enters the semantic computation is the expression λs.**snore**(s(1)), where s is a variable of type $\langle n, e\rangle$, *ie.*, the formal analogue of the meta-linguistic assignment function. (I will adopt Bennett's notation "s" for variable assignments, rather than using "g" which serves as a variable for the "real" assignment in the meta-language.) Although expressions of this type are not open formulas in a technical sense, I will continue to refer to them as "open propositions." The fact that these "open propositions" do not contain any free variables will of course become highly relevant in further applications of the theory.

What we need next in order to express "binding" of the argument position of *snore* is the notion of a modified assignment. The following definition is of course the standard meta-linguistic one; its only unusual feature is its being expressed in the formal object-language itself:

(27) **Modified Assignments** (taken from Bennett (1979, p. 8)):
If $\alpha \in Var_{\langle n,e\rangle}$, $\beta \in ME_{\langle n,e\rangle}$, $\mathrm{u} \in Var_e$, $\mathrm{n} \in Var_n$, and $\gamma \in ME_n$, then $\beta[\mathrm{u}/\gamma]$ is to be the expression

$$\iota\alpha((\alpha(\gamma) = \mathrm{u}) \wedge \forall \mathrm{n}(\neg(\mathrm{n} = \gamma) \rightarrow (\alpha(\mathrm{n}) = \beta(\mathrm{n}))))$$

[8]For example, given the *letters* of predicate logic (*ie.*, the set {(,), ¬, ∧, ↔, =, ∃, ∀, λ, ι, ...}), the set ME_a of *meaningful expressions* for any type a is defined as usual. Furthermore, the meaning of a 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 $\mathrm{u} \in Var_a$, then $\mathrm{g(u)} \in \mathrm{D}_a$. For any $\alpha \in ME_a$ we define its *meaning* $[\![\alpha]\!]^{\mathrm{F,g}}$ as usual, with (27-a,b) as the basis of the recursion, and the remaining expressions being defined recursively in the standard way:

(i) **Interpretation of ME_a**

a. If $\alpha \in Con_a$, then $[\![\alpha]\!]^{\mathrm{F,g}}$ is $\mathrm{F}(\alpha)$.

b. If $\alpha \in Var_a$, then $[\![\alpha]\!]^{\mathrm{F,g}}$ is $\mathrm{g}(\alpha)$.

c. If $\varphi \in ME_t$, then $[\![\neg\varphi]\!]^{\mathrm{F,g}}$ is 1 iff $[\![\varphi]\!]^{\mathrm{F,g}}$ is 0, and similarly for $\wedge$, etc.

d. If $\varphi \in ME_t$ and $\mathrm{u} \in Var_a$, then $[\![\exists \mathrm{u}\varphi]\!]^{\mathrm{F,g}}$ is 1 iff there exists $\mathrm{x} \in \mathrm{D}_a$ such that $[\![\varphi]\!]^{\mathrm{F,g'}}$ is 1 where g′ is an assignment like g with the possible difference that $\mathrm{g'(u) = x}$; and similarly for $\forall u\varphi$.

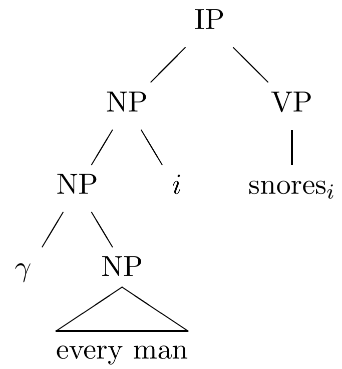
e. If $\alpha \in ME_a$ and $\mathrm{u} \in Var_b$, then $[\![\lambda u\alpha]\!]^{\mathrm{F,g}}$ is that function h with domain D_b such that whenever x is in that domain, h(x) is $[\![\alpha]\!]^{\mathrm{F,g'}}$, where g′ is as in (4).

f. If $\alpha \in ME_{\langle a,b\rangle}$ and $\beta \in ME_b$, then $[\![\alpha(\beta)]\!]^{\mathrm{F,g}}$ is the value of the function $[\![\alpha]\!]^{\mathrm{F,g}}$ for the argument $[\![\beta]\!]^{\mathrm{F,g}}$.

g. If $\varphi \in ME_t$ and $\mathrm{u} \in Var_a$, then if there exists a unique $\mathrm{x} \in \mathrm{D}_a$ such that $[\![\iota u\varphi]\!]^{\mathrm{F,g'}}$ is 1 where g′ is as in (i-b), then $[\![\iota \mathrm{u}\varphi]\!]^{\mathrm{F,g}}$ is x; otherwise, $[\![\iota \mathrm{u}\varphi]\!]^{\mathrm{F,g}}$ is an arbitrary object fixed by the interpretation.

We are now in a position to express “quantifying-in” in compositional terms, which removes the type mismatch between the quantifier NP and an “open proposition” $\lambda s.\mathbf{snore}(s(1))$. It is at this point where the interpretation of indices of NPs comes into play. Following Heim (1993) and Sternefeld (forthcomming), I distinguish between the index of a binder and the index of a bindee, which is traditionally interpreted as the index of a bound variable (a bound pronoun). The former can be interpreted as semantic glue which combines the meaning of an NP with the meaning of a verbal projection. Given that each such projection is an open proposition containing a slot that will be bound by the index of an NP, the meaning of such an index can be described as a variant of lambda abstraction defined above in section 2.2. Whereas Heim (1994) defines a family of such operators by taking numbers as names for each operator (so that, *eg.*, i is a function taking an NP such that the resulting NP_i operates on an open proposition), the present system allows the definition of one single operator γ that mediates between the NP, the index of the NP and the open proposition. For example, given that *every man snores* has the transparent LF in (28-a), and given the meaning of γ as defined in (28-b) (which corresponds to Bennett’s rule of *Ordinary Quantification*.[9], and abbreviating s(i) as s_i we can now analyze (28-a) as (28-c):

(28) a.



b. **Binding of Slots** (cf. Bennett (1979, p. 11)):
Let s be the type $\langle n, e\rangle$ and s the variable $v_{0,s}$. (assignments)
Let p be the type $\langle s, t\rangle$ 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 $\langle s, \langle P, t\rangle\rangle$ and $\mathcal{Q}$ be the variable $v_{0,Q}$. (NPs)
Then the meaning of γ is

$$\lambda\mathcal{Q}\lambda\text{n}\lambda\text{p}[\lambda\text{s}.\mathcal{Q}(\text{s})(\lambda x.\text{p}(\text{s}[x/\text{n}]))].$$

[9]I would like to stress that the system presented here is nothing really new; all I have done is to translate Bennett’s rules into current notation.

c.

- $\lambda s \forall x(\mathbf{man}(x) \rightarrow \lambda s.\mathbf{snore}(s_i)(s[x/i])) =$ $\lambda s \forall x(\mathbf{man}(x) \rightarrow \mathbf{snore}(s[x/i](i))) =$ $\lambda s.\forall x(\mathbf{man}(x) \rightarrow \mathbf{snore}(x))$
  - $\lambda p \lambda s \forall x(\mathbf{man}(x) \rightarrow p(s[x/i]))$
    - $\lambda n \lambda p[\lambda s \lambda P.\forall x(\mathbf{man}(x) \rightarrow P(x))(\lambda x.p(s[x/n]))]$
      - γ
      - $\lambda s \lambda P.\forall x(\mathbf{man}(x) \rightarrow P(x))$
        - every man
    - i
  - $\lambda s.\mathbf{snore}(s_i)$
    - snores$_i$

This is, of course, exactly what one would expect to get. Observe also that functional application works as usual, *ie.* as in (29):

(29) **Functional Application:**
Assume binary branching. Suppose Z immediately dominates X and Y. If X translates as an expression α of type $\langle b, a\rangle$, and Y translates as β of type b, then Z translates as $\alpha(\beta)$ of type a.

For reasons of uniformity of types I will furthermore adopt the standard assumption that pronouns and names are translated as generalized quantifiers. Hence, an indexed pronoun he_i or him_i is translated as $\lambda s \lambda P.P(s)$. Accordingly, our final analysis of *every man shaves himself* is this:

(30)

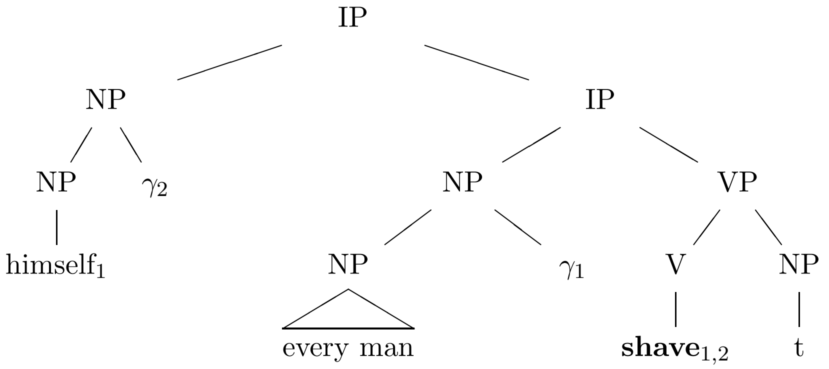
- $\lambda s.\forall x(\mathbf{man}(x) \rightarrow \mathbf{shave}(x, x))$
  - $\lambda p \lambda s \forall x(\mathbf{man}(x) \rightarrow p(s[x/1]))$
    - $\lambda n \lambda p[\lambda s \lambda P.\forall x(\mathbf{man}(x) \rightarrow P(x))(\lambda x.p(s[x/n]))]$
      - γ
      - $\lambda s \lambda P.\forall x(\mathbf{man}(x) \rightarrow P(x))$
        - every man
    - 1
  - $\lambda s.\mathbf{shave}(s(1),s(1))$
    - $\lambda s.\mathbf{shave}(s(1),s(2))$
      - shaves$_{1,2}$
    - $\lambda p \lambda s.p(s[s(1)/2]))$
      - $\lambda n \lambda p \lambda s.p(s[s(1)/n]))$
        - γ
        - $\lambda s.\lambda P.P(s(1))$
          - himself$_1$
      - 2

Next, let us return to our crucial example (18). In order to keep trees manageable, I will first adjoin the index of an NP directly to its functor, as shown in (31):

(31) *Notational Convention:*
Abbreviate $[_{NP} [_{NP}\ \gamma$ NP] i] as $[_{NP}$ NP γ_i].

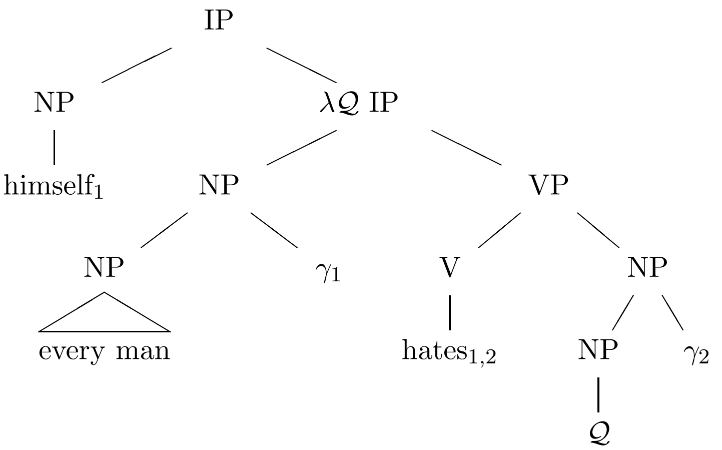
Accordingly, a possible transparent Logical Form for (18) is the following:

(32)



It is clear from the formal make up of (32) that the trace does not receive any semantic interpretation, therefore we do not get the intended meaning. The reason is basically that we did not build in reconstruction. As shown in section 2.2 this could be done quite straightforwardly; we only have to interpret the trace as a variable for generalized quantifiers and reintroduce non-compositional lambda abstraction as shown in (33):[10]

(33)

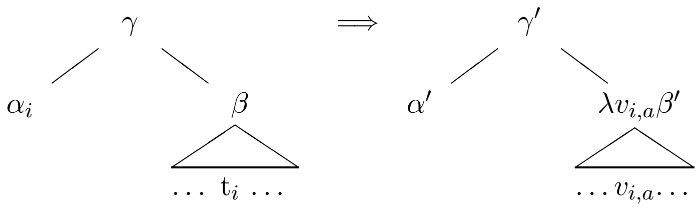


If such a representation were legitimate, lambda conversion could easily reconstruct the reflexive into its base position, as shown in (34):

[10]Accordingly, one would have to adhere to the traditional interpretative mechanism of reconstruction after movement stated in (i) and schematically depicted in (ii):

(i) **Reconstruction:**
Assume that γ immediately dominates α and β and that β contains the trace of α. Given that
a. α translates as an expression α' of type a,
b. β translates as an expression β' of type b, and
c. the trace of α translates as the variable $v_{\mathrm{i},a}$ (which must be free in β'),
then γ translates as the expression $\lambda v_{\mathrm{i},a}\beta'(\alpha')$ of type $\langle a, b\rangle$.

(ii)



(34) himself$_1$ $\lambda\mathcal{Q}$ [every man$_1$ hates$_{1,2}$ $\mathcal{Q}_2$]
$= \lambda\mathcal{Q}\lambda s(\forall x(\mathbf{man}(x) \rightarrow \gamma(\mathcal{Q})(2)(\lambda s.\mathbf{hate}(s_1,s_2))))(s[x/1])(\lambda s\lambda P(P(s_1)))$
$= \lambda s(\forall x(\mathbf{man}(x) \rightarrow \gamma(\lambda s\lambda P(P(s_1))(2)(\lambda s.\mathbf{hate}(s_1,s_2))))(s[x/1]))$
$= \lambda s.\forall x(\mathbf{man}(x) \rightarrow \mathbf{hate}(s_1,s_1))(s[x/1])$
$= \lambda s.\forall x(\mathbf{man}(x) \rightarrow \mathbf{hate}(x,x))$

But although semantic reconstruction is evidently a straightforward means to obtain *in situ* interpretations, the requirement of strong compositionality has not yet been met: there is still one non-compositional operation, namely lambda abstraction over variables of the NP-type. I will show in the next subsection how this deficiency can be overcome.

2.4 Generalizing Bennett's System

What we would like to do is to provide the system with some kind of semantic glue that works syntactically in the same way as "ordinary quantification," but instead does the semantic job of reconstruction. In other words, what we would like to express is some semantic operation $\mathcal{R}$ (= "Reconstruct") that works syntactically like γ but performs the operation defined in (35).

(35) $\mathcal{R}(\mathcal{Q})(n)(p) := \lambda g.p(g[\mathcal{Q}/n])$
where g ranges over value assignments to NPs.

However, it is obvious that (35) is explanatorily inadequate as it stands. As illustrated by (36) reconstruction can and must apply to more than one logical type:

(36) [$_{\text{VP}}$ Criticize himself$_i$]$_j$ Alice thinks that noone$_i$ will t$_j$

We here have moved a predicate away from its argument, which implies that we have to reconstract an open proposition (regardless of whether or not the subject has been generated VP-internally). In general, there seems to be no a priori restriction as to the types that can reconstruct, hence (35) is too specific. In fact, what we need is a generalization of our previous assignment function s that covers all types.

Besides the conceptual issue (which only touches strong compositionality) there is also an empirical argument showing that semantic reconstruction forces a more general account, even in a weakly compositional system. The argument reveals that simple reconstruction via lambda abstraction will fail again, as soon as the dislocated phrase contains a variable of some higher type. This can be exemplified by topicalization in German. (37-a) shows the basic verb final SOV word order before any dislocation; this sentence could of course be interpreted *in situ*:

(37) a. daß er [$_{\text{VP}}$ [$_{\text{VP}}$ [$_{\text{VP}}$ jedem nur ein einziges Buch geben] müssen]
that he to-everyone only one single book give have-to
wird]
will
'that he will have to give to everyone only a single book'

b. daß er [$_{\mathrm{NP}}$ nur ein einziges Buch]$_1$ [$_{\mathrm{VP}}$ [$_{\mathrm{VP}}$ [$_{\mathrm{VP}}$ jedem t_1 geben] müssen] wird]

In (37-b) the existentially quantified NP is scrambled out of its VP. This transformation can preserve meaning, *ie.*, the scrambled phrase can still be interpreted as being in the scope of the universal quantifier to-everyone, so that for semantic reconstruction to work properly the trace must be interpreted as an NP-variable. So far, so good. But now consider verb second main clause order. The finite verb thus has to move to the C-position, and some constituent, *eg.* a VP, undergoes topicalization; cf. (38):

(38) [$_{\mathrm{VP}}$ [$_{\mathrm{VP}}$ jedem t_1 geben] müssen]$_2$ wird$_3$ er nur ein einziges Buch$_1$ [$_{\mathrm{VP}}$ t_2 t_3]

Topicalization is still meaning invariant here, so that the existentially quantified phrase remains in the scope of the universal quantifier, which means that topicalization of the remnant VP has to be reconstructed. This time, however, semantic reconstruction runs into a problem, because the topicalized item contains a trace t_1 corresponding to a free variable of the NP-type Q. By analogy to the simple cases of reconstruction considered previously it is clear that replacing the real variable in the remnant VP by the kind of pseudo-variables we have called slots does the job. But up to now Bennett's system only allows for slots that have the semantic type e of an individual, rather than the type of an NP, which is needed to account for (38). This clearly shows that the proposed method—which accounted for reconstruction of pronouns only—is not general enough: We have to enlarge the formal language by including expressions that help to mimic assignments to variables of all types.

This can be achieved by a straightforward extension of Bennett's system. Suppose we replace expressions like $\lambda \mathrm{s.P(s(1), s(2))}$ by expressions of the form $\lambda \mathrm{g.P(g}(1, e), \mathrm{g}(2, e))$ where e is the type of individuals and g is interpreted as a value assignment for the type specified by the second argument of g. Then g will in effect interpret "pseudo variables" of all types. In order to get (35) into the object-language, it will be necessary to refer to the type of a variable in the object-language, and to define the generalized function g appropriately. I will now show how such an extension of Bennett's system can be carried out in a precise manner.

By analogy to Bennett's own extension of intensional logic, where it was sufficient to introduce only one component of traditional variables, namely their index, we now have to take into account their second component, namely the type of a variable, which now has to become a semantic object in our ontology. Furthermore, we have to add a new type g for the generalized value assignments, and a type *type* for the meta-linguistic type of the types in the ontology. This is done as follows:

(39) **Types:**
The set Type^+ of types is the smallest set Y such that

a. e, n, t, g and *type* are in Y,

b. whenever a and b are in Y, $b \neq g$, $a \neq \mathit{type}$, and $b \neq \mathit{type}$ then $\langle a, b\rangle$ are in Y.

We furthermore add the following clauses to the definition of possible denotations:

(40) **Added Denotations:**

a. $\mathrm{D}_{type} = Type$ (= the old set of types defined in section 2).

b. $\mathrm{D}_g = \{f\colon f(\mathrm{n}, a) \in \mathrm{D}_a$ for all $a \in Type$ and $\mathrm{n} \in \mathrm{D}_n\}$ (= the set of assignments).

c. Whenever $\langle a, b\rangle$ is in $Type^+$, $\mathrm{D}_{\langle a,b\rangle} = {\mathrm{D}_b}^{D_a}$.

Observe that assignments are defined (40-b) only with respect to the original set *Type* rather than $Type^+$.[11]

The next step is to extend the language and the meaningful expressions. Suppose we add variables of type g and introduce new constants and variables of type *type*, with the expected interpretation provided by an enlarged interpretation function F^+. In particular, (41) holds in every model of L^+:

(41) **Extended Interpretation:**
F^+ is such that for each $a \in Type$, there is some n such that $\mathrm{F}^+(c_{n,type}) = a$.

Since the set of types is denumerable, such an extension of F exists. Henceforth, I will use as a name for a particular constant $c_{n,type}$ its denotation, *ie.*, the respective type itself.

We then add a new symbol **type** which takes a variable as input and yields the type of the variable as output. Thus, we have the following:

(42) **Added Meaningful Expressions (1):**

a. If α is a constant or variable of type *type*, then $\alpha \in ME_{type}$.

b. For any $a \in Type$, if $\beta \in Var_a$, then $\mathbf{type}(\beta) \in ME_{type}$.

c. No other expression is in ME_{type}.

Next, we add to the interpretation F^+ a function G such that (43) holds:

(43) **Interpretation Function for $\boldsymbol{ME}_{type}$**

a. If $\alpha \in Con_{type}$, then $\mathrm{G}(\alpha) = \mathrm{F}^+(\alpha)$.

b. If $\alpha \in Var_{type}$, then $\mathrm{G}(\alpha) = \mathrm{g}(\alpha)$.

c. If $\alpha = \mathbf{type}(\beta)$, where $\beta \in Var_b$, then $\mathrm{G}(\alpha) = b$.

We then extend the definition of meaningful expressions as follows:

(44) **Added Meaningful Expression (2):**
If $\mathrm{g} \in Var_g$, $\mathrm{n} \in ME_n$, $\tau \in ME_{type}$, then $\mathrm{g}(\mathrm{n}, \tau) \in ME_{\mathrm{G}(\tau)}$.

To define the function $[\![\cdot]\!]^{\mathrm{F,g}}$, we proceed as usual and add the following clauses:

[11] This two-step procedure excludes the possibility of forming expressions of the form g(g), where g is an assignment of the meta-language and a variable for assignments. It seems to me that such a self-application is possible in Heim's system, which makes it conceptually more opake than the present one.

(45) **Extended Interpretation:**

a. $[\![\,\tau\,]\!]^{\mathrm{F,g}} = \mathrm{G}(\tau)$ for all $\tau \in ME_{type}$.

b. If $\mathrm{n} \in ME_n$, $\tau \in ME_{type}$, $\mathrm{h} \in Var_g$, then $[\![\,\mathrm{h}(\mathrm{n},\tau)\,]\!]^{\mathrm{F,g}}$ is $[\![\,\mathrm{h}\,]\!]^{\mathrm{F,g}}([\![\,\mathrm{n}\,]\!]^{\mathrm{F,g}}, [\![\,\tau\,]\!]^{\mathrm{F,g}})$.

Finally, we reach the state where it becomes possible to define modified assignments:

(46) **Modified Assignment:**
If $\alpha \in Var_g$; $\beta \in ME_g$; $\mathrm{u} \in Var_a$ for any $a \in Type$; $\mathrm{n} \in Var_n$; $\gamma \in ME_n$; and $t \in Var_{type}$, then $\beta[\mathrm{u}/\gamma]$ is to be the expression

$$\iota\alpha((\alpha(\gamma, \mathbf{type}(\mathrm{u})) = \mathrm{u}) \wedge \forall \mathrm{n} \forall t(\neg(\mathrm{n} = \gamma) \vee \neg(\mathbf{type}(\mathrm{u}) = t)) \rightarrow (\alpha(\mathrm{n}, t) = \beta(\mathrm{n}, t)))$$

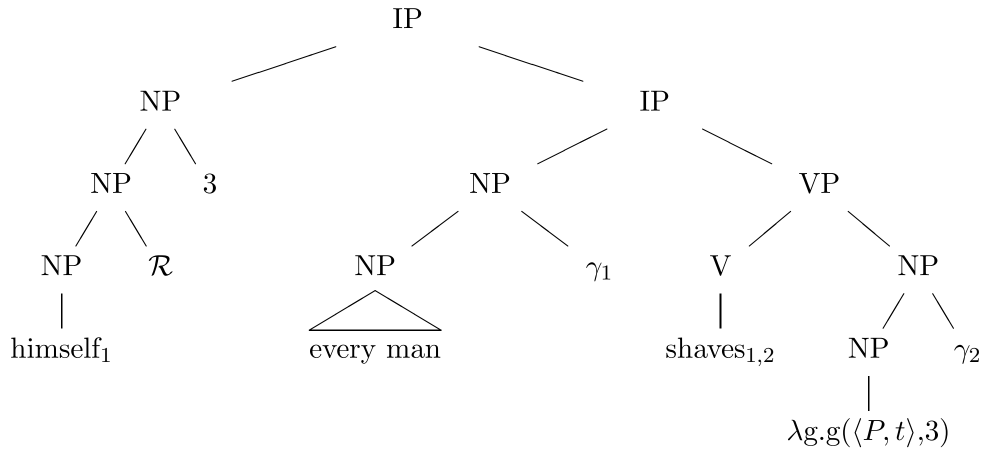
This was needed in order to be in a position to define reconstruction:

(47) **Reconstruction:**
For all meaningful expressions α whose type is an element in *Type*, let

$$\mathcal{R}(\alpha)(\mathrm{n})(\mathrm{p}) := \lambda \mathrm{g}.\mathrm{p}(\mathrm{g}[\alpha(\mathrm{g})/\mathrm{n}])$$

To see how this works, consider the final version of (33). This is represented in the following tree, with the index 3 being chosen at random:

(48)



By applying the definitions it is easy to see that this gives the desired result, as can be seen in the table on the following page.

One last remark concerns the use of indices. In order to block overgeneration we must ensure that the outer index of the NP is actually the index of some movement; *ie.*, there must be some corresponding NP in the scope of $\mathcal{R}$ that translates as λg.g(Q,3). This is a residue of the reconstruction rule in footnote 10. In general, correct indexing—whether between a trace and its antecedent, or between an argument expression and its slot—is presupposed here and should actually follow from an adequate version of the θ-criterion, a topic that will not be addressed here.

I leave it as an excercise for the reader to figure out that a corresponding analysis of (38) also yields the correct result.

3 Further Evidence for Semantic Reconstruction

In this section I will discuss some further subcases of semantic reconstruction, dealing with so-called connectivity effects in pseudo-clefts like (1-b) and in related constructions. Standard arguments against semantic reconstruction in questions are reconsidered and refuted in section 3.3. Section 4 takes up the issue of binding theory, arguing that the theory of Barss (1986) can easily be modified so as to account for the relevant data.

3.1 Pseudo-Clefts

There are a number of constructions discussed in Barss (1986) that pose the by now familiar problem of unbound anaphors, but differ from the standard examples in that the particular kind of construction makes a syntactic reconstruction approach highly unlikely:

(49) a. $[_{\text{NP}}$ a picture of himself$_i$] was what$_j$ everyone$_i$ saw t$_j$
     b. $[_{\text{CP}}$ what$_i$ everyone$_j$ saw t$_i$] was a picture of himself$_j$

As argued by Higgins (1979) and Barss (1986, 247ff), literal reconstruction is inapplicable in these and other cases to be discussed further below. To account for the connectivity effect, Barss develops a syntactic theory of indexing which explains why the anaphors in (49) are grammatical. Referring to similar examples, Higgins argues along the lines of Reinhart and Reuland (1993) in assuming that the distribution of anaphors in cases like (50) should follow from semantic considerations, rather than from any syntactic theory.

(50) a. What John$_i$ is is proud of himself/*him$_i$
     b. What Bill$_i$ did was wash himself/*him$_i$[12]

[12]Examples like these shed some doubt on the VP-internal subject hypothesis. If the hypothesis were correct there would of course be no problem for the locality of binding of the anaphor in (50); however, the argument against a transformational account applies likewise against having moved the visible subject from a VP internal position into its actual position; *cf.* also the ungrammaticality of *what they (all) did was (*all) wash themselves.*

Granted an interpretative account of anaphoric binding in (50), this still leaves us with no theory of how to interpret the apparently unbound "bound variable pronoun" in (49). Such a precise semantics, however, can easily be developed within the present framework.

Assume for the moment that the free relative clause *what everyone saw* in (49) denotes the set of assignments that satisfy the open proposition *everyone saw* x_2. Presupposing that the copula has no interesting semantics, the task is to combine the two constituents (51-a) and (51-b):

(51) a. what$_2$ everyone$_1$ saw$_{1,2}$
$= \lambda \mathrm{s} \forall x(\mathbf{saw}(\mathrm{s}[x/2](2), \mathrm{s}_1))$

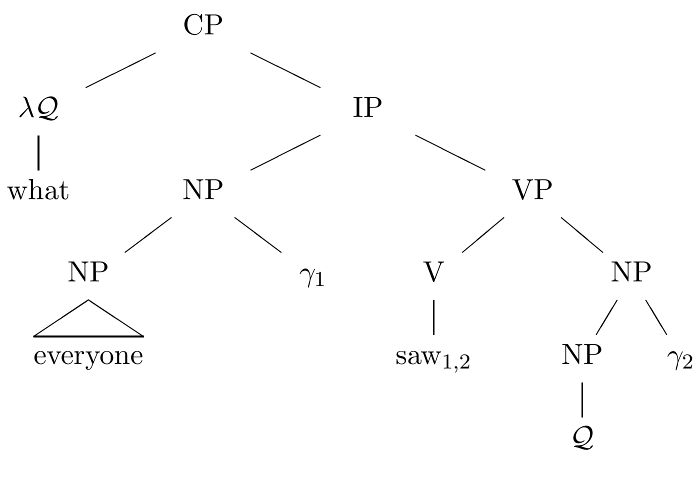
b. a picture of himself$_j$
$= \lambda \mathrm{s} \lambda \mathrm{P} \exists y(\textbf{picture-of}(y, \mathrm{s}_2) \wedge \mathrm{P}(y))$

Doing this the obvious way, namely by indexing the NP with γ, yields a wrong result, because the existential quantifier still has wide scope over the universal one:

(52) $\gamma(1)\lambda \mathrm{s} \lambda \mathrm{P} \exists y(\textbf{picture-of}(y, \mathrm{s}_2) \wedge \mathrm{P}(y))(\lambda \mathrm{s} \forall x(\mathbf{saw}(\mathrm{s}[x/2](2), \mathrm{s}_1)))$
$= \lambda \mathrm{s} \lambda \mathrm{P} \exists y(\textbf{picture-of}(y, \mathrm{s}_2) \wedge \mathrm{P}(y))(\lambda x \ldots)$

The problem could be resolved by translating the trace of *what* as a variable over NPs. Accordingly, in analogy to (33), the LF of the relative clause could be something this:

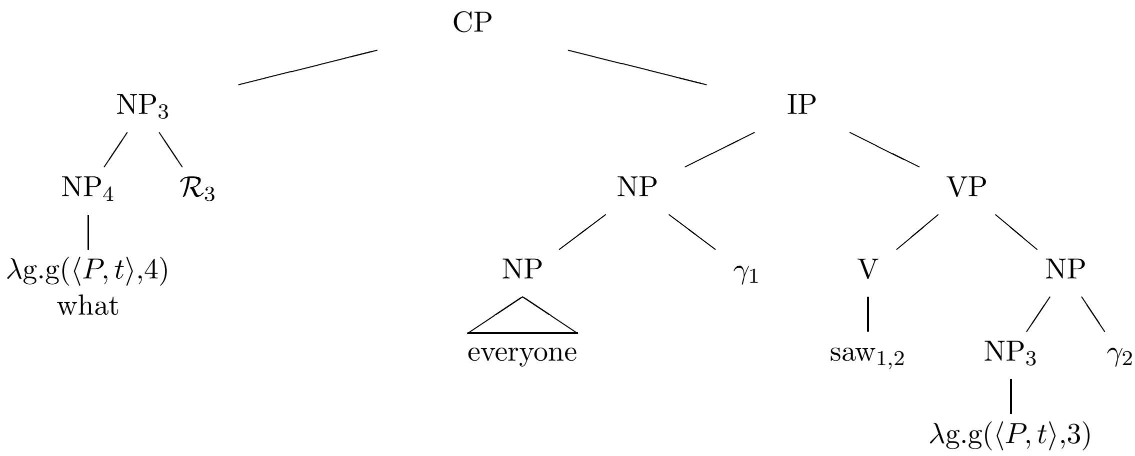
(53)



Like (33), however, (53) is only weakly compositional, because *what* is interpreted syncategorematically. This can be remedied by letting CP in (53) denote the open proposition (54-a), which can be arrived at compositionally by translating *what* as a pseudo-variable and reconstructing it into its base position. The source of reconstruction would then be (54-b) (γ's omitted), more fully displayed as a tree in (54-c):

(54) a. λg.everyone$_1$ saw g($\langle P, t\rangle$,4)

b. $\mathcal{R}(\lambda$g.g($\langle P, t\rangle$,4))(3)(λg.everyone$_1$ saw g($\langle P, t\rangle$,3)) c.



Note that this is precisely what Akmajian (1970, p. 19) seems to suggest when writing:

> ... the initial clause of the pseudo-cleft contains what is essentially a semantic variable, a semantic 'gap' which must be 'filled' or specified by the focus item... The focus item must specify a value for the variable of the clause, and it thus follows that the focus item must belong to the appropriate semantic class, i.e. the class represented by the variable.
> (cited from Higgins (1979, p. 153))

The final step of determining truth conditions (ignoring the more fine tuned analysis of focus) is to reconstruct *a picture of himself*$_1$ into the position of g($\langle P, t\rangle$,4). This can be achieved in the usual way, namely by indexing the NP with $\mathcal{R}$ and the index 4, which happens to be the index of the pseudo-variable chosen in the translation of *what*. Semantic reconstruction then proceeds in the usual way, namely by inserting γ's and doing functional application.

Above we argued that the type of the gap cannot be an individual, hence must be an NP. As argued by Zimmermann (1993), however, there is a further possibility that seems more correct than the one suggested above. He assumes that indefinite NPs translate as properties rather than generalized quantifiers. One reason relevant in the present context is that real quantifiers seem ungrammatical in several contexts, including the copula:

(55) a. *John is every man
b. *What John baked was every cake

(55-b) of course contrasts with *John baked every cake*, but the contrast cannot be accounted for if the gap in the free relative clause is a quantifier. Adopting Zimmermann's proposal necessitates a number of further adjustments; in fact, several possibilities arise concerning the translation of *what* and the copula. I leave it to the reader to work out the details for the above case; instead, I will work out more explicitly a similar example in the next section.

3.2 Further Connectivity Effects

Another construction discussed in Barss (1986) (and one to which Higgins (1979) attributes essential properties of pseudo-clefts) are *tough*-movement constructions like (56), cited from Barss (1986, p. 253):

(56) $[_{\mathrm{NP}_j}$ pictures of himself$_i$] are easy [for John$_i$] $[_{\mathrm{CP}}$ OP$_j$ [PRO$_i$ to like t$_j$]]

Here the subject is too far away from the trace, hence considerations of binding theory block movement between the overt subject and the trace. Nonetheless it is easy to give a correct interpretation of (56) by semantic reconstruction into the position of the trace. We simply have to interpret the empty operator the same way as $what_j$; the adjective then takes as its complement an open proposition, and by coindexation of OP$_j$ (= $what_j$) and the subject NP we guarantee that the subject is semantically reconstructed via $\mathcal{R}$ into the object position of *like*.

Another connectedness effect where literal reconstruction is inapplicable is the following (similar examples, but without bound variable pronouns, are discussed in Higgins (1979)):

(57) von seiner$_i$ Exfrau beleidigt zu werden, ist ein Gedanke, den niemanden$_i$
by his ex-wife insulted to be is a thought that noone
erschüttern würde
be-shocked-by would

Here again it is impossible to get the subject of the copula into the syntactic scope of *niemand* (noone); nonetheless the intuitive understanding of the sentence involves binding of the pronoun *seiner* by *niemand*. Within the present theory, no particular problems arise. To make the discussion somewhat more transparent, consider first Montague's translation of *John is a man* in PTQ:

(58)
a. John is a man.
b. λP.P(j) **be** $\lambda P\exists x(\mathbf{man}(\mathrm{x}) \wedge \mathrm{P}(x))$
c. $\lambda\mathrm{P.P(j)}(\lambda\mathcal{P}\lambda x.\mathcal{P}(\lambda y.x = y)(\lambda\mathrm{P}\exists x(\mathbf{man}(x) \wedge \mathrm{P}(x))))$
d. $\lambda\mathrm{P.P(j)}(\lambda z\lambda\mathrm{P}\exists x(\mathbf{man}(x) \wedge \mathrm{P}(x))(\lambda y.z = y))$
e. $\lambda\mathrm{P.P(j)}(\lambda z\exists x(\mathbf{man}(x)\wedge z = x))$
f. $\exists x(\mathbf{man}(x)\wedge \mathrm{j} = x)$

By analogy, one would have to translate (57) as in (59):

(59) λP.P(**being insulted by** x**'s ex-wife**) **be** λP.$\exists$p(**thought**(p) $\wedge$ **no** x **was shocked by** p $\wedge$ P(p)) =
$\exists$p(**thought**(p) $\wedge$ **no** x **was shocked by** p $\wedge$ p = **being insulted by** x**'s ex-wife**

It is clear that this cannot be the desired result, since the variable x has not been brought into the scope of the quantifier *noone*.

However, we finished the last section by considering the possiblity that the indefinite in fact translates as a property. Observe that is is exactly the function of the copula: to turn a generalized quantifier into a property. However, what has gone wrong in (59) is that Montague's copula does not bring the subject within the *scope* of the predicate. This seems possible only if the indefinite is a property right from the beginning of the calculation, as assumed in (60):

(60) **being insulted by** x**'s ex-wife**) **be** λp(**thought**(p) $\wedge$ **no** x **was shocked by** p)

The next thing to observe is that the translation does not in fact contain variables; rather we combine two expressions of the following general form:

(61) λg.α' **be** λg$\lambda\alpha$.p, where p is a proposition and $\alpha\,'$ has the same logical type as α.

It follows that the meaning of the copula is as described in (13), namely:

(62) be $\rightsquigarrow \lambda s \lambda\alpha\lambda\beta.(\alpha(s)(\beta(s))$

Applying this to the above sentence, its logical representation is as shown in (63):

(63) λs**being insulted by** s_1**'s ex-wife be** λsλp(**thought**(p(g)) $\wedge$ **no** x **was shocked by** p(s[x/1]])

Now, this is very close to what we want to get, because (63) implies the correct binding of the pseudo-variable:

(64) No x was shocked by being insulted by x's ex-wife.

However, we also get as a consequence the proposition (65), which still contains a free pseudo-variable:

(65) λs **thought**(**being insulted by** s_1**'s ex-wife**)

I take this as indicative for not yet having captured the intended meaning. This can presumably paraphrased by:

(66) No one$_i$ was shocked by the thought of being insulted by his$_i$ ex-wife

This implies that the property *thought no one was shocked by* is in fact construed as a kind of semantic reconstruction of Vergnaud raising (*cf.* Vergnaud (1974)):

(67) λsλp no one was shocked by ιp(thought(q) $\wedge$ p=q)

Given the the property N=λs.λp.**thought**(p) and the open proposition IP$_i$=*noone was shocked by* g(i), we might define the semantic reversal of Vergnau-raising as

(68) $\mathcal{V}(\mathrm{IP}_i)(\mathrm{N}) := \lambda s.\lambda x\ \mathrm{IP}(s[\iota y(\mathrm{N}(y)(s) \wedge x = y)/i])$

I leave it open here whether this should be considered a variant of a (possibly empty) relative pronoun or whether it is additional glue.

Having established that there is independent motivation to adopt a semantic account of "extended binding"—in fact one whose range of application is somewhat broader than literal reconstruction—I will now turn to another major area of reconstruction phenomena.

3.3 Reconstruction in Questions

It has frequently been argued that syntactic reconstruction is necessary in order to get the correct semantics of questions like (69):

(69) a. Whose mother died?
  b. How many books did everyone read?

Most authors presuppose a Karttunen style semantics of questions (as sets of true or possible answers) and I will basically adhere to this practice. This is, however, not essential for the problem of reconstruction which can informally made clear by the following paraphrases of (69-b):

(70) a. For which n is it the case that: there are n books such that everyone read them?
  b. For which n is it the case that: for everyone there are n books such that he read them?

The first paraphrase implies that a most informative answer gives us the maximal cardinality of books such that everyone read every book in that set. The second paraphrase implies that we ask for the smallest number n such that everyone read at least n books. In the first paraphrase the set of books has wide scope with respect to the readers, in the second it has narrow scope. In both cases the existential statement *there are n books* is inside the scope of the operator *is it the case that:*, whereas the operator is in turn inside the scope of the *for-which*-phrase. Similar considerations apply to (69-a); hence, it is argued that

(71) a. Part of the fronted *wh*-phrase has to be lowered;
  b. as evidenced by the wide scope reading (70-a) lowering is not necessarily reconstruction into the base position;
  a. moreover, it is most plausibly not reconstruction into the position of a trace (if movement would create an intermediate trace in (70), it would violate the Principle of Unambiguous Binding; cf. Müller and Sternefeld (1993));
  a. therefore semantic reconstruction (or the copy theory of movement) cannot work in this case.

From the present perspective, however, one may very well suspect the above argument (which was taken as compelling evidence for a theory of *syntactic* reconstruction) is premature. In fact, due to our non-standard encoding of syntactic types we can construct a compositional semantics that does not rely on an otherwise inaccessible intermediate trace, nor does it involve syntactic reconstruction in the first place. Let us first clarify our basic assumptions concerning the semantics of questions.

(72) a. Questions are represented as sets of propositions.
 b. There is a question operator in C whose semantics will be described immediately.
 c. In multiple questions, there is no LF-movement of *wh*-phrase into SpecC; all *wh*-phrases are interpreted at their surface position.
 d. For this purpose, the operator in C is indexed with the set of indices of *wh*-phrases that have the same scope as the fronted *wh*-phrase.
 e. The semantics of *wh*-phrases is basically that of indefinites in the theory of Heim (1982), which means that they are or contain a "free variable."
 f. The operator in C simultaneously binds these variables; more precisely: it binds the place holders that occur as an index of C.

Since propositions are intensional objects, any explicit and complete elaboration of these assumptions would force us into a discussion of intensions—a topic we hitherto tried to avoid. Fortunately, however, the relevant features of our analysis can be fully explained without going into intensions. The analysis is basically this: the semantics of question formation should be independent from any movement of *wh*-phrases. Therefore, movement into SpecC can be analyzed semantically as if it were adjunction to IP.

Note that the semantic vacuousness of *wh*-movement is the grid of the argument in Bennett (1977), who points out that (73) has at least three different analyses:

(73) John wonders where two unicorns live

The crucial one is the reading Bennett derives from an LF like *John wonders two unicorns live where*, so that the respective unicorns can live at different places, with *where* in the scope of *two unicorns*, and *two unicorns* in the scope of *wonders*. Accordingly, the syntactic fronting operation has no semantic effect, which for reasons of type theory is impossible in Karttunen's system.[13]

There are a number of further considerations that imply optional reconstruction also in *which*-questions, these having to do with the intension of the nominal restriction of *which*; *cf.* Groenendijk and Stokhof (1982). But again, having decided not to discuss intensions, these matters lie outside the scope of the present discussion. We therefore have to confine ourselves to simple cases like (74-a), with the oversimplified logical paraphrase (74-b):

(74) a. Who$_i$ C$_{i,j,k}$ t$_i$ gave what$_j$ to whom$_k$?
 b. $\lambda \mathrm{p} \exists x_i \exists x_j \exists x_k\ \mathrm{p} = \textbf{give-to}(x_i, x_j, x_k)$

[13]Unfortunately, Bennett (1977) does not contain any formal semantic analysis, in contrast to Bennett (1979), where he discusses the earlier paper and admits that his formalism does not yet capture the intuition underlying the discussion of examples like (73); cf. Bennett (1979, p. 23).

(74-b) immediately raises the issue of compositionality. In a strongly compositional semantics we must give an account of "selective binding", *ie.*, a binding operation that simultaneously binds more than one variable (but does not necessarily bind *all* variables, for some *wh*-phrases left *in situ* might be bound by a higher COMP; the term "unselective binding" in this context is a misnomer).

Let us solve this problem first. The first step is to represent the set of indices in C as its characteristic function, *ie.*, a mapping from numbers into truth values. This is needed to generalize modified assignments in the obvious way, namely with respect to indices of C and sequences of values; *cf.* (75):

(75) **Generalized Modified Assignments:**
If $\alpha \in Var_{\langle n,e\rangle}$, β and $\delta \in ME_{\langle n,e\rangle}$, $\mathrm{N} \in Var_{\langle n,t\rangle}$, and $\mathrm{n} \in Var_n$, then

$$\beta[\delta/\mathrm{N}] := \iota\alpha(\forall \mathrm{n}((\mathrm{N}(\mathrm{n}) \rightarrow \alpha(\mathrm{n}) = \delta(\mathrm{n})) \wedge (\neg \mathrm{N}(\mathrm{n}) \rightarrow (\alpha(\mathrm{n}) = \beta(\mathrm{n})))))$$

Selective quantification can then be defined as follows:

(76) **Generalized Selective Quantification:**
Let N and δ be as in (75). Then:

a. $\vec{\forall}(\mathrm{N})(\mathrm{p}) := \lambda \mathrm{s} \forall \delta \mathrm{p}(\mathrm{s}[\delta/\mathrm{N}]))$
b. $\vec{\exists}(\mathrm{N})(\mathrm{p}) := \lambda \mathrm{s} \exists \delta \mathrm{p}(\mathrm{s}[\delta/\mathrm{N}]))$

(76-b) will be part of the definition of the question operator defined below.

We then take as basic the semantics of multiple questions in languages with *wh-in-situ* only, where the required operator has to map the meaning of an open proposition into a set of proposition. Such an operator, call it **q**, takes scope over an IP and can be defined as follows:

(77) $\mathbf{q}(\mathrm{N})(\mathrm{IP}) := \lambda \mathrm{s} \lambda \mathrm{p} \exists \delta(\mathrm{p}(\mathrm{s}) = \mathrm{IP}(\mathrm{s}[\delta/\mathrm{N}]))$

Assuming, for the sake of the argument, a kind of vacuous movement analysis of (74-a), its S-structure and LF would be (78-a), which is interpreted as (78-b). We here adopt the notational convention to write values of N (characteristic functions of sets of numbers) in cornered brackets. The formula in (78-b) can then we seen to be equivalent with (78-d):

(78) a. $\mathrm{C}_{i,j,k}$ who$_i$ gave what$_j$ to whom$_k$?
b. $\mathbf{q}([\mathrm{i,j,k}])(\lambda \mathrm{s}.\textbf{give-to}(\mathrm{s}_i,\mathrm{s}_j,\mathrm{s}_k))$
c. $\lambda \mathrm{s} \lambda \mathrm{p} \exists \delta(\mathrm{p}(\mathrm{s}) = \lambda \mathrm{s}.\textbf{give-to}(\mathrm{s}_i,\mathrm{s}_j,\mathrm{s}_k)\ (\mathrm{s}[\delta/[\mathrm{i,j,k}]]))$
d. $\lambda \mathrm{s} \lambda \mathrm{p} \exists x_i \exists x_j \exists x_k(\mathrm{p}(\mathrm{s}) = \textbf{give-to}(x_i, x_j, x_k))$

Let us next turn to a language with *wh*-movement into SpecC, a case in point being (69-b). Here the set N is a singleton. The task, then, is to interpret (79):

(79) $[_{\mathrm{NP}}$ s$_i$ many books $]_k$ C$_i$ $[_{\mathrm{IP}}$ everyone read t$_k]$

Now observe that two of the crucial formal features of the present system are the following:

(80) a. IPs in this context always denote an open proposition, and

b. the fronted constituent (here: NP) is always a function from open proposition to (open) propositions.

Due to this uniformity of logical types of fronted *wh*-phrases (to which we return in section 6), we can define an operator in C, say **c**, which differs from **q** only in applying the fronted XP to the immediate argument of **c**. Accordingly, the structure in (81-a) is interpreted as shown in (81-b):

(81) a.

```
      CP
     /  \
   XP    C′
        /  \
       C    IP
      / \
     c   N
```

b. $\mathbf{c}$(N)(IP)(XP) := $\mathbf{q}$(N)(XP(IP))

Applying this to (79), the first step of the analysis is shown in (82):

(82) a. $[_{\mathrm{NP}}$ s_i many books $]_k$ $\mathbf{c}$(i)($[_{\mathrm{IP}}$ everyone read $\mathrm{t}_k]$) =

b. λsλp$\exists x$(p(s) = $[_{\mathrm{NP}}$ s_i many books $]_k$($[_{\mathrm{IP}}$ everyone read $\mathrm{t}_k]$))](s[x/i]))

The two readings of the sentence can now be derived from the two possibilities of indexing the fronted NP. If it is indexed by γ, this will yield the reading (70-b), whereas (70-a) is the result of having indexed the NP by $\mathcal{R}$ and interpreting the trace as an NP-variable.

Extending the analysis somewhat further, we have to take into account that *wh*-phrases like *who* or *where* are in fact to be interpreted as *which person*, or *which place*; this brings into play again the intension of what has been called the *restriction* of the *wh*-operator. Ignoring intensionality again and modifying slightly a proposal by Reinhart (1992), a D-structure like *which*$_1$ *man loves which*$_2$ *woman* is to be represented by something like (83-a), where f_1 and f_2 are choice functions as defined in (83-b). Accordingly, the operator **q** really quantifies over such functions (rather than over individuals), so that the ultimate truth conditions of (83) are given in (83-c).

(83) *Which man loves which woman?*

a. f_1(man) loves f_2(woman)

b. f is a *choice function*, **cf**(f), iff $\forall$P(P(f(P)).

c. λp$\exists \mathrm{f}_1 \exists \mathrm{f}_2$(p = $\mathbf{love}$(f_1(man),f_2(woman))

Within the present framework this necessitates a slight adjustment of types so that the following holds:

(84) a. Existential quantification over individuals in the definition of **q** is replaced by existential quantification over choice functions.

b. In order to index NPs uniformly with γ or $\mathcal{R}$, *which*-phrases must be encoded as generalized quantifiers,

c. the choice function in (83) is encoded as the value of an assignment; for example:

$$[\text{which}_1 \text{ woman}]_{\gamma(j)} \rightsquigarrow \gamma(\text{j})\lambda \text{g}\lambda \text{P.P}(\text{g}(1,\langle P,e\rangle)(\lambda \text{s}.\mathbf{man}))$$

This much said, the treatment of (83) should be straightforward.

Note also that we automatically account for the data in (85) (cf. Higginbotham (1980)):

(85) a. *Whose$_i$ mother hates him$_i$?

b. *Whose$_i$ mother does he$_i$ love ?

c. *Which picture of which man$_i$ did he$_i$ see ?

In these cases we do not—in contrast to the usual approach in terms of syntactic reconstruction—raise *whose* or *which man* out of their NPs. Since these NPs cannot bind the pronouns, nor can the operator **q**, an *in situ* of *wh*-phrases correctly predicts that the pronouns cannot be interpreted as bound variables.[14]

Returning to (73), and assuming that *where* is synonymous with *at which place*, we face a number of problems. First, it seems that we would have to reconstruct the preposition *at*. We will see in section 6 how this problem can be attacked in an independently motivated way. For the time being, we translate the predicate *live* as something like *live-at*. Now, the real problem associated with (73) is that application of **c** doesn't yield the narrow scope reading. Reconstruction into the base position does not help, since the translation of *which*-phrases is scopeless and therefore reconstruction cannot have any effect on truth conditions, much like reconstruction of names. Various solutions for this problem have been proposed in the literature; within the present context it seems worthwhile to discuss an alternative way of expressing scope dependence. I will return to the matter in section 5.1.

4 Reconstruction and Binding Theory

In this section I would like to evaluate arguments in favor of a theory of syntactic reconstruction that could be derived from Binding Theory. I will show that against the background of Barss's theory none of these arguments can be regarded has having the force of a knock down argument against semantic reconstruction.

4.1 The Trapping Effect

Consider first the following two examples from Lebeaux (1994):

(86) a. Two women$_i$ seem t$_i$ to be expected t$_i$ to dance with every senator (ambiguous)

[14] The fact that **q** can bind only *wh*-terms does not account for strong cross-over effect, because the *wh*-term itself can bind the crossed pronoun.

b. Two women$_i$ seem to each other$_i$ t$_i$ to be expected t$_i$ to dance with every senator (unambiguous)[15]

Whereas reconstruction (combined with clause bounded QR[16]) is optional in (86-a), (86-b) exhibits what Lebeaux calls the "Trapping Effect:" Since there must be one single level (LF) to read off the quantificational binding and the anaphoric binding, it is impossible to reconstruct the matrix subject at LF, for otherwise the anaphor is no more interpretable.

This argument is designed to show that—given that it is in principle possible that binding of anaphors is checked in the course of the derivation—there must be in addition 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 off at LF, binding of the anaphor must also be checked *there*, in contrast to other cases of binding that do not involve scope (*ie.*, bound variable pronouns), which may be checked during the derivation (*cf.* also Kuno (1987), Sternefeld (1993), and Kim (1996)). In consequence, one might argue that a theory with syntactic reconstruction plus the coherence condition can explain the Trapping Effect, whereas a theory without syntactic reconstruction seems to make wrong predictions.

Although Lebeaux is certainly right in arguing for a single level where to interpret bound variables and scope; however, the existence of such a level neither implies that BT must apply at that level nor does the argument have any impact on the issue of syntactic reconstruction. From a semantic perspective, Lebeaux's coherence condition really makes no sense as an independent principle of grammar; in fact, it seems that Lebeaux confuses binding conditions with conditions of interpretation. BT in and by itself is a syntactic module, it is not yet semantic interpretation. In other words, the output of BT must itself be interpreted semantically, and in some cases conditions of BT might be satisfied, but the structure (or better: the indexing) is nontheless uninterpretable. This is of course the case if we reconstruct in (86-b), because after semantic reconstruction the reciprocal pronoun can no longer be interpreted "correctly" (i.e. in the sense indices are interpreted by the intuitive understanding that underlies any pretheoretic exposition of BT).

To see this more clearly, let us simplify (86) by replacing the reciprocal by an anaphoric variable and the plural phrase by a singular one[17]:

(87) A woman$_i$ seems to herself$_i$ t$_i$ to be expected t$_i$ to dance with every senator

[15]Some native speakers of (American) English oppose against the grammaticality of this sentence. According to my intuitions, its analogue in German would be ungrammatical as well.

[16]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. I will discuss the clause-boundedness of QR more fully in the next section.

[17]This makes the sentence still less acceptable; cf. footnote 15.—For a treatment of plural quantification within the present framework, cf. Sternefeld (forthcomming)

We can now interpret the surface order in (87) as encoding quantifier scope straightforwardly, or we can apply semantic reconstruction into the predicate *dance-with*. The relevant question is whether we can reconstruct and at the same time bind the argument of *seem*. A moment's reflection will show that this is not the case. Via reconstruction as lambda abstraction the indefinite NP gets inside the scope of the universal quantifier (modulo QR). But for the anaphor to get the interpretation suggested by the indexing it would of course be necessary to reconstruct the anaphor as well, which is impossible in (87): there is no place left to reconstruct the anaphor into the scope of the quantifier. It follows that the above data are explained without recourse to principles of BT.

In other words, data like (87) do not have any bearing on the interaction between reconstruction and BT, hence are irrelevant for the question of whether reconstruction is semantic or syntactic.

4.2 Reconstruction and Principle (C)

In general, arguments invoking BT hinge on tacit assumptions on the existence or non-existence of LF movement of *wh*-phrases and quantifiers; authors who do adopt such processes tend to think that BT may not apply at LF, because neither covert *wh*-movement nor QR can extend the binding domain; cf. (88):

(88) a. *John$_i$ knows who owns which pictures of himself$_i$
     b. *His$_i$ mother loves everyone$_i$

The theory adopted above does not tolerate much LF-movement, hence data like (88) would be in line with lack of LF movement, but do not tell us anything about the contrast between syntax and semantics.

On the other hand, the area of reconstruction is precisely the place where we can find arguments in favor of applying BT at LF. For example, it has been argued that the difference in (89) is due to the availability of reconstruction (cf. Heycock (1995, p. 560)):

(89) a. *[How many lies aimed at exonerating Clifford$_i$]$_j$ is he$_i$ planning to come up with t$_j$
     b. [How many lies aimed at exonerating Clifford$_i$]$_j$ did he$_i$ claim that he$_i$ had no knowledge of t$_j$

In (89-a) the lies must be understood intensionally, *ie.* within the scope of *planning*, whereas in (89-b) Clifford takes the existence of lies for granted. The same contrast can be observed in (90):

(90) a. Which stories about Diana$_i$ did she$_i$ most object to?
     b. *How many stories about Diana$_i$ is she likely to invent ?
     c. *How many stories about Diana$_i$ does she want Charles to invent ?

The crucial observation is that the contrast of binding options does not depend on the understood subject of *stories* or *lies*, nor on the nature of the *wh*-phrase (*which* *vs. how*). Instead, the data in (90) imply that condition (C) effects show up only if reconstruction is involved; hence, BT is contingent on reconstruction and must therefore apply at LF.

Another interesting configuration suggesting a similar conclusion has been constructed by Lebeaux (1994). Consider the contrast in (91):

(91) a. [Which paper that he$_j$ gave to Bresnan$_k$]$_i$ did every student$_j$ think t$'_i$ that she$_k$ would like t$_i$

b. *[Which paper that he$_j$ gave to Bresnan$_k$]$_i$ did she$_k$ think t$_i$ that every student$_j$ would like t$_i$

According to Lebeaux, the relative clause is 'read' at LF as if it were in the intermediate Comp:

(92) [Which paper $\_\__i$]$_j$ did every student think (that he gave to Bresnan)$_i$ that she would like t$_j$

This seems to be the only structure consistent with BT. However, (92) as an LF-representation seems uninterpretable; at least, there is no obvious semantic mechanism that could interpret (92). Any compositional interpretion seems to call for much additional machinery that is entirely construction specific. It is therefore more than doubtful that a structure like this can be an acceptable well-formed LF.

Within the present framework, however, it is easy to see that the interpretative mechanism we adopted above would allow for the reconstruction of the entire *which*-phrase into the position of the intermediate trace. Due to the definition of **c**, reconstruction can be construed either literally or semantically, the latter yielding the following enriched LF representations of (91):

(93) a. [Which paper that he$_j$ gave to Bresnan$_k$]$_{\mathcal{R}_i}$ **c** every student$_j$ think $[\mathcal{Q}_i]_{\gamma 2}$ that she$_k$ would like$_{1,2}$

b. *[Which paper that he$_j$ gave to Bresnan$_k$]$_{\mathcal{R}_i}$ **c** she$_k$ think t$_i$ that every student$_j$ would like$_{1,2}$ $[\mathcal{Q}_i]_{\gamma 2}$

I will account for the ungrammaticality of (93-b) immediately; before doing so, let us check the semantic correctness of (93-a). By definition, this is equivalent to (94):

(94) a. **q**[Which paper that x_j gave to Bresnan$_k$]$_{\mathcal{R}_i}$ every student x_j think $[\mathcal{Q}_i]_{\gamma 2}$ that she$_k$ would like$_{1,2}$ =

b. **q** every student x_j think [Which paper that x_j gave to Bresnan$_k$]$_{\gamma 2}$ that she$_k$ would like$_{1,2}$ =

c. λp$\exists$f p = every student x_j think λP.P(f(paper that x_j gave to Bresnan$_k$))$_{\gamma 2}$ that she$_k$ would like$_{1,2}$ =

d. λp$\exists$f p = every student x_j think that she$_k$ would like$_{1,2}$ f(paper that x_j gave to Bresnan$_k$)

Closer inspection will reveal that this is precisely the so-called functional reading assigned to similar sentences in Engdahl (1980) and Engdahl (1986). It allows answers having the form of a description, like "his favorite one." This is in line with intuition, but requires some discussion of intensionality again, so as to guarantee that the choice function selects among the *actual* papers, not any papers student could think of.[18] This much granted, Engdahl's method and the one proposed above are equivalent.[19]

The discussion has revealed that there is an interesting interaction between reconstruction and condition (C) of BT; so the question is whether this should be captured by syntactic reconstruction or in some other way. Now, recall from the discussion of Barss and Higgins that we also found interactions between anaphoric binding and semantic reconstruction in cases where syntactic reconstruction was unavailable. It was for this reason that Barss extended coindexing and binding paths beyond traces of movement. Following this line of reasoning, it is obvious that enriched LFs provide for all the information needed to formulate BT much in the same way as Barss (1986) proposed in his thesis.

The basic intuition underlying an explanation for (93-b) in the sense of Barss can be expressed very elegantly by defining a reconstruction tree as follows:

(95) **Reconstruction Tree:**
Given a structure Σ and a node $\alpha \in \Sigma$, the reconstruction tree for α is the smallest subtree $T \subseteq \Sigma$ such that
  a. $\alpha \in T$,
  b. the root of T is the root of Σ,
  c. if $\beta \in T$, β is indexed by $\mathcal{R}$, and γ translates as a variable bound by $\mathcal{R}$, then $\gamma \in T$.

(96) **A-Binding** (preliminary): α is A-bound by β iff
  a. α and β are coindexed,
  b. β is in an A-position, and
  c. β is a sister of some node in the reconstruction tree of α.

(97) **Principle C**: An R-expression is A-free (*ie.* not A-bound).

For example, the reconstruction tree of *Bresnan* contains all and only the nodes that dominate Bresnan and $[\mathcal{Q}_i]_{\gamma_2}$. Coindexation between *Bresnan*$_i$ and *she*$_i$ then yields a BT violation in (93-b) but not in (93-a). Similarly, the sentences in (89) are explained straightforwardly; if there is semantic reconstruction the tree contains the

[18]The present proposal seems to support such an outcome. since reconstruction of a property evaluated at some world w implies that this world is still the evaluation index after reconstruction. Of course, if we treat world indeces on a par wih pronouns, things may urn out differently, by semantic reconstruction of the world variable into the scope of *thought*. In general, this seems to be a somewhat marked option, cf. Groenendijk/Stokhof:??.

[19]Others of Lebeaux's examples work out exactly the same way, *eg.*:

(i) a. [[His$_j$ mother's]$_k$ bread]$_i$ seems to every man$_j$ t$_i$ to be known by her$_k$ t$_i$ to be the best there is.
  b. *[[His$_j$ mother's]$_k$ bread]$_i$ seems to her$_k$ t$_i$ to be known by every man$_j$ t$_i$ to be the best there is.

position of the trace, which yields a violation of principle (C); in case there is no semantic reconstruction, a principle (C) violation is avoided by continuing the tree directly up to the root.

In order to incorporate Lebeaux's distinction between adjuncts and arguments, the data in (98) call for an amendment of the above definition. Recall from Lebeaux's (1991) theory that condition (C) is checked during the derivation, but adjuncts can be inserted on the way to S-structure, so that R-expression within adjuncts can escape condition (C) before S-structure (which is what Riemsdijk (1982) has called an *anti-cross-over* effect). This seems to be the case in the examples in (89) or (90), because *aimed at exonerating Clifford* and *about Diana* are considered adjuncts, hence the trace of movement of the larger constituent can be ignored. If something like this is the correct generalization, we still have to account for cases like (98-a), where the anaphor is not contained in an adjunct but in an argument of *claim*, in contrast to (98-b), which is already explained by the above definition of a reconstruction tree.

(98) a. *Which claim that John$_i$ was asleep was he$_i$ willing to discuss t?
b. Which claim that John$_i$ made was he$_i$ willing to discuss t?

(98) implies that a tree for α must also include semantically uninterpreted traces, unless α is contained in an adjunct. We thus have to define the "binding tree" for an R-expression as follows:

(99) **Binding Tree:**
Given a tree Σ and a node $\alpha \in \Sigma$, the binding tree for α is the smallest subtree $T \subseteq \Sigma$ that satisfies the following conditions:
a.-c. as defined in (95);
d. if $\beta \in T$ and γ is a trace of β, then $\gamma \in T$, **unless** α is an R-expression and β (reflexively) dominates an adjunct that dominates α.

(100) **A-Binding** (final): α is A-bound by β iff
a. α and β are coindexed,
b. β is in an A-position, and
c. β is a sister of some node of the binding tree of α.

The binding tree of *John* in (99) will extend to the *which*-phrase in both cases; at this point it will also extend to the trace in Accordingly, (99-d) predicts a reconstruction effect for R-expressions within arguments only, and (100-c) a reconstruction effect for all semantically reconstructed items.[20] As far as I can see this captures the facts in a simple, straightforward way.

To summarize, it seems to me that all condition (C) reconstruction effects can be handled adequately without movement, and in particular, there is no need to recon-

[20]It has sometimes been argued that condition (C) effects depend on the depth of nesting of the antecedent (*cf.* Kuno (1972), Reuland (1983), or Riemsdijk and Williams (1986)). Within Barss's framework this amounts to saying: the more deeply embedded, the less likely is the inclusion of a trace in a binding tree. The point is not that this would be an explanatory theory (I don't know of any such theory about depth of embeddings) but that it translates easily into the Barssian framework.

struct literally for the purpose of binding theory. Moreover, the effects in pseudo-cleft and *tough*-movement sentences also fall out of the theory in a general, semantically motivated way, without having to introduce special indexing conventions, as it was the case in Barss's original proposal.

4.3 Reconstruction and Principle (A)

Principle (A) brings in some pertubations, but at first sight it seems that the present proposal accounts for the facts in a somewhat more explanatory way than Barss's original theory. The obvious difference between principles (A) and (C) is that (A) involves a locality condition not operative in (C). This can be illustrated with the standard example (101):

(101) Bill$_i$ does not know how proud of himself$_{j,*i}$ John$_j$ was

The binding tree of *himself* contains a subtree that does not include *John* as a closest antecedent. The problem here is that the locality constraint embodied in (A) requires the definition of a *path* for the anaphor, otherwise the binding tree of the anaphor would permit local binding by both *Bill* and *John*. We thus have to define a *sequence* of elements of a binding tree, so that only the first subject of that sequence determines the local domain of binding. We therefore define:

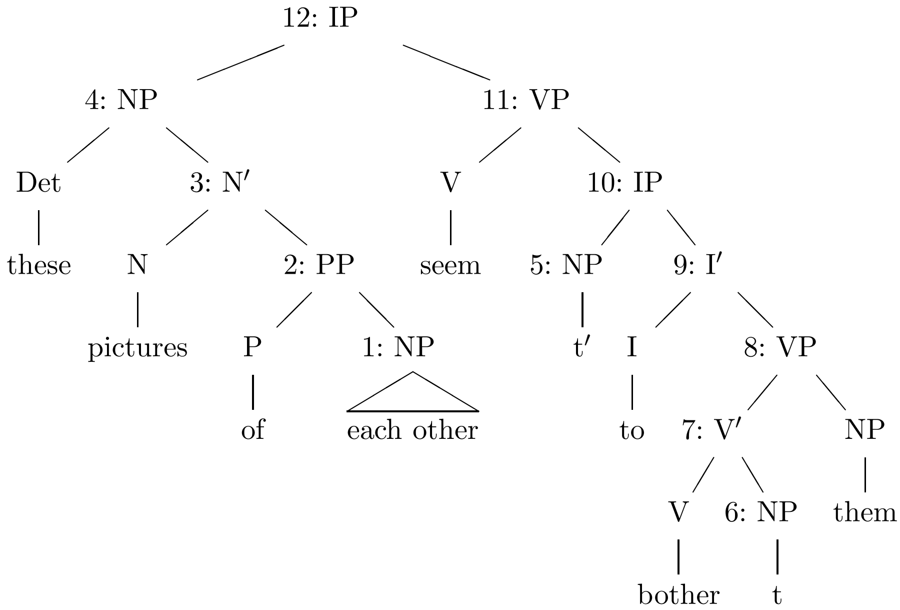
(102) **Binding Path**:
A binding path for an anaphor α is a strict ordering relation on α's binding tree that satisfies the following condition:
a. if α dominates β, then $\alpha > \beta$, and
b. if α precedes β in an extended chain, then $\alpha < \beta$.

By an extended chain we mean a chain that results either from movement or from reconstruction (or both). The binding condition can now be formulated in a sloppy way, leaving implicit the exact nature of the locality condition embodied in principle (A):

(103) *Binding Condition* (preliminary):
An anaphor looks for a possible antecedent along its binding path.

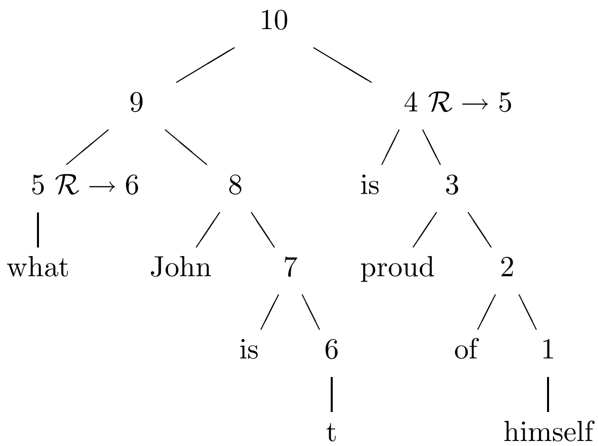
(102) implies that binding of an anaphor is reconstructed to the most deeply embedded position in the binding tree, which implies obligatory reconstruction for condition (A). For example, let us assume that a binding path starts with 1 and that, by convention, the path consists of consecutive numbers. Then the only binding path for the anaphor in (104) that is consistent with (102) is the one shown in (104) (the analysis is taken from Barss (1986, p. 116)):

(104)



The closest possible binder on the path is *them*, and indeed this gives us the correct result. Likewise, we may somewhat schematically depict the binding path in a pseudo cleft construction as in (105):

(105)



As is known since Jacobson and Neubauer (1976), however, there are cases like (106-a) where (102) makes the wrong prediction. What seems to be ignored by the literature, however, is that (102) is correct for some other languages than English. For example, the German analogues of the sentences in (106) are ungrammatical:

(106) a. John$_i$ does not know how many pictures of himself$_i$ Bill wants to sell.
b. John$_i$ does not know how many stories about himself Diana$_i$ is likely to invent ?

In fact, only a pronominal would be allowed in the position of the anaphor. It follows, then, that (102) is not *a priori* wrong, but for anaphors there might be marked options to be explained in some alternative way. As far as English is concerned, Barss's original theory was designed to account for (106) in a way that can easily be reformulated in the present framework:

(107) **Partial Binding Path**:
A partial binding path for α is any subtree of the binding of α which contains α and satisfies Barss's functional completeness condition.

(108) **Binding Condition** (English):
An anaphor looks for a possible antecedent along one of its partial binding paths.

(107) implies that anaphors may ignore reconstruction in (106) but not in (101) and similar cases like (109):

(109) *John thinks that an admirer of himself Mary became

Here a direct path from *himself* to *John* would be functionally incomplete, since the predicative NP lacks the subject *Mary*.[21]

Summarizing so far, it seems that there is no interaction between reconstruction and principle (A); but this might well be due to the logophoric nature of the English pronominal system. In a language like German, on the other hand, reconstruction from A-bar positions for the purpose of binding is obligatory, hence independent of any semantic considerations. The only significant interaction we observed seems to occur with principle (C) (and possibly (B) which we did not discuss here). This interaction has been accounted for by clause (c) in the definition of a binding tree.

Returning to our main question whether there are knock down arguments against semantic reconstruction the problem can now be rephrased as whether there are knock down arguments against a representational theory of binding in terms of enriched LFs and traces. In other words, could a theory which applies BT derivationally be superior to one that treats binding conditions representationally? At present, I have no idea which kind of data could challenge a representational account; on the contrary, problematic cases that come to mind seem corroborate the above theory. For example, successive cyclic movement should be ruled out in examples like (110), because according to the cycle condition the escape hatch is already plugged by *where*:

(110) Which picture of himself did John tell Mary where to hide t?

The sentence is correctly classified as a mild subjacency violation, but as matters of BT are concerned it should turn out as completely ungrammatical, on a par with (111):

[21] This return to Barss's original theory begs the question of whether our previous explanation in terms of (obligatory) reconstruction was a correct generalization. The question hinges on where to draw the line between normal and exceptional behavior of anaphoric pronouns which in the context of examples like (106) have sometimes been called logophoric. Unfortunately, the reference which most convincingly argues in favor of a distinction between reflexive and logophoric pronouns, namely Reinhart and Reuland (1993), does not make an attempt to characterize the syntactic conditions for logophoric pronouns in a concise theory.

(111) *John told Mary where to hide pictures of himself.

However, the theory sketched above does not imply ungrammaticality for (110). This follows from the fact that the binding path of *himself* can be any subtree that contains an antecedent. In particular, this subtree need not contain the trace, but could start with any of the nodes that dominate *Mary*. Another case in point is the following (taken from Barss (1986, p. 241):

(112) What John wants Mary to paint are pictures of himself

Since Chomsky (1986) it has become standard practice to let *want* embed an IP at D-structure, hence there is no landing site where *what* could pick up the relevant information that would be necessary to tell *himself* that binding to *John* could be an option. In the present system, however, no problem can arise, since as above the binding path of *himself* need not extend backwards to the trace of *what*.

To summarize, an interpretative account of binding seems to be called for independently from the actual syntactic analysis of movement. Moreover, as far as explanatory adequacy is concerned, both theories seem on a par, and unresolved problems concern internal issues of BT, but do not touch the issue of reconstruction.

4.4 An Inconclusive Note on Negative Polarity Items

Let us now look at another trigger for reconstruction, namely the behavior of Negative Polarity Items illustrated in (113):

(113) a. *Pictures of anyone John didn't buy.
b. What John didn't buy was any picture of Fred.

In both sentences, the NPI *any/anyone* is not in the syntactic scope of its licensor; nonetheless the structure is well-formed in the pseudo-cleft sentence, whereas it is ungrammatical in the case of topicalization.

How can we account for the difference? It has sometimes be claimed that reconstruction cannot cross negation (*cf.* Beck (1996)), hence the negative polarity item in (113-a) is not licensed at S-structure nor could it be licensed via reconstruction at LF. I hesitate, however, to adopt this explanation, because I cannot see how the NPI in (113-b) could be licensenced without assuming a semantic operation tentamount to crossing negation.[22] It has been observed that (113-b) necessitates a licensing mechanism for NPIs akin to the licensing anaphors, *ie.* via binding paths from the NPI to its negation. The above example suggests that this path can be extended

[22]Moreover, I simply do not agree with the intuitive judgments that underly the claim that reconstruction would be impossible in negative contexts. For example, I do get the reading paraphrased in (i-b) which contradicts the ban against crossing negation at LF; *cf.* also Kroch (1989) for more examples and a shared conviction:

(i) a. How many books did noone read?
b. What is the (smallest) number n such that noone read n-many books?

at LF as soon as semantic reconstruction comes into play. We may therefore try to account for (113-b) by assuming the following:

(114) A NPI can be licenced only by a suitable sister node of its reconstruction path.

Now, as regards (113-a), actual movement without reconstruction does not establish a reconstruction path that connects the NPI with negation. But as things stand, reconstruction is optional, hence there are always two analyses available: one with and one without reconstruction.[23] And, what is worse, the reconstruction analysis of (113-a) even makes intuitive sense. It therefore seems necessary to exclude licensing of NPI even if a reconstruction analysis is available. Observe also that the parallel *tough*-movement construction does not license NPI, although, according to our above analysis the structural configurations are almost identical.

(115) *Pictures of anyone are easy to ignore

I conclude that the semantic reconstruction mechanism is in fact the only one that could explain the availability of NPIs in this context, but at the same time the mechanism in and by itself is insufficient to explain the adsence of NPIs in otherwise related contexts.

5 Scope and Inversed Linking

This section contains a brief discussion of scope reversal in sentences like *A Mac adornes every desktop*. I will show that in this elementary case quantifier raising can be reanalyzed as a subcases of reconstruction. Section 5.2 deals with dynamic binding (see (1-c)). As a results of the discussion it will then be shown in section 5.3 that cases of inversed linking like (1-d) can also be handled by an *in situ* mechanism, as a combination of dynamic binding and scope inversion.

5.1 Scope Reversal

In this section we will pursue the idea that the denotation of indefinite NPs (or weak quantifiers) is the same as that of *wh*-phrases, *ie.*, they are choice functions, as suggested in Reinhart (1992), von Stechow (1996), or Winter (1996). Then (116-a) in its narrow scope reading is formalized as (116-b); its wide scope reading is given in (116-c):

(116) a. Every man loves a woman
b. $\forall x(\mathbf{man}(x) \rightarrow \exists \mathrm{f}(\mathbf{cf}(\mathrm{f}) \wedge \mathbf{loves}(x,\mathrm{f}(\lambda \mathrm{s}.\mathbf{woman}))))$
c. $\exists \mathrm{f}(\mathbf{cf}(\mathrm{f}) \wedge \forall x(\mathbf{man}(x) \rightarrow \mathbf{loves}(x,\mathrm{f}(\lambda \mathrm{s}.\mathbf{woman}))))$

[23]Note that we might subject reconstruction to economy, in the sense that a reconstruction analysis is available only if it has some semantic effect on truth conditions. This is in line with Fox's (1995) economy condition, but seems to contradict Chomsky's (1993) preference principle for reconstruction.

Here we must assume that existential quantification can be stuffed in either at the level of IP or at thel level of VP. But suppose now that choice functions can in addition depend on a (bound) variable. I will call such functions Skolem choice function:

(117) f is a *Skolem choice function*, $\mathbf{Scf}(\mathrm{f})$, iff $\forall x \forall \mathrm{P}(\mathrm{P}(\mathrm{f}(x,\mathrm{P}))$

Admitting an ambiguity between scope dependent and independent indefinite NPs, the two readings in (116) can equivalently expressed as in (118), with the existential quantification of the choice function always having wide scope:

(118) a. $\exists \mathrm{f}(\mathbf{Scf}(\mathrm{f}) \wedge \forall x(\mathbf{man}(x) \rightarrow \mathbf{loves}(x,\mathrm{f}(x,\lambda \mathrm{s}.\mathbf{woman}))))$
b. $\exists \mathrm{f}(\mathbf{cf}(\mathrm{f}) \wedge \forall x(\mathbf{man}(x) \rightarrow \mathbf{loves}(x,\mathrm{f}(\lambda \mathrm{s}.\mathbf{woman}))))$

Consider now:

(119) A Mac adornes every desktop.

Our informal representation of (119) as something like (120):

(120) $\exists \mathrm{f}_{Scf}(\mathrm{f}(x,\mathbf{Mac})\lambda y \forall x(\mathbf{desktop}(x) \rightarrow \mathbf{adornes}(y,x))$

The idea is to replace the free variable x within the indefinite by the pseudo variable which becomes bound by *every*, and to reconstruct the indefinte subject term into *every*'s scope, *ie.* into the argument position of the preposition. This is done in (121-a), which ultimately reduces to (121-d). In traditional first order notation, this is equivalent to (121-e).

(121) a. $\lambda \mathrm{s} \exists \mathrm{f}_{Scf}\mathcal{R}(\mathrm{f}(\mathrm{s}(2),\mathbf{Mac}))(1)\lambda s.\forall x\ (\mathbf{pocket}(x) \rightarrow$
$\lambda \mathrm{s}.\mathbf{adornes}(\mathrm{s}_1,\mathrm{s}_2)(\mathrm{s}[x/2]))$
b. $\lambda \mathrm{s} \exists \mathrm{f}_{Scf} \forall x(\mathbf{pocket}(x) \rightarrow \lambda \mathrm{s}.\mathbf{adornes}(\mathrm{s}_1,\mathrm{s}_2)(\mathrm{s}[x/2][\mathrm{f}(\mathrm{s}(2),\mathbf{Mac})/1]))$
c. $\lambda \mathrm{s} \exists \mathrm{f}_{Scf} \forall x(\mathbf{pocket}(x) \rightarrow \lambda \mathrm{s}.\mathbf{adornes}(\mathrm{s}_1,\mathrm{s}_2)(\mathrm{s}[x/2][\mathrm{f}(x,\mathbf{Mac})/1]))$
d. $\lambda \mathrm{s} \exists \mathrm{f}_{Scf} \forall x(\mathbf{pocket}(x) \rightarrow \mathbf{adornes}(\mathrm{f}(x,\mathbf{Mac}),x))$
e. $\lambda \mathrm{s} \forall x(\mathbf{pocket}(x) \rightarrow \exists y(\mathbf{Mac}(y) \wedge \mathbf{adornes}(y,x)))$

Note that this works only if the indefinite is—this time—not put into the derivation as a generalized quantifier, because reconstruction is into the argument position of the predicate, which is not represented syntactically. Accordingly, this implies some interesting limitations to this method of scope reversal. As noted, the NP with narrow scope cannot be a real quantifier but must be an indefinite NP or a plural NP, *ie.*, an NP that can be analyzed as having type e. As far as I can tell this seems to be a correct generalization. Secondly, we cannot reconstruct too low—a restriction that is illustrated in (122):

(122) Yesterday, a guide ensured that every tour to the Louvre was fun.

This condition is usually formulated as a restriction on QR by saying that *every tour to the Louvre* cannot be raised into the matrix clause in order to gain scope over *a guide*. Since the higher indefinite NP has its logical predicate always in the matrix clause, this NP cannot be reconstructed into the embedded clause, therefore reconstruction cannot derive any scope inversion either.

It seems, then, that both ways of handling scope inversion make roughly equivalent predictions. This is negatively confirmed the observation that neither method can explain why the existential quantifier cannot have narrow scope in double object constructions like (123):[24]

(123) Yesterday, I gave a tourist every leaflet

Neither theory can explain why QR seems to be restricted to the universal quantifier, and neither theory can explain why there seem to be language particular differences.[25] These considerations suggest that—although there are some unexplained facts pertinent to both theories—the syntactic method of QR can or should be replaced by the semantic method of reconstruction. I will discuss and explain away another case of purported QR in section 5.3. To summarize, it is most likely that QR is not a universally available option of UG.

5.2 Binding and Dynamic Conjunction

I will show in this section that dynamic binding is an automatic consequence of Groenendijk and Stokhof's (1990) rule of dynamic conjunction. The main idea developed in Groenendijk & Stokhof's *Dynamic Montague Grammar* is that a proposition α is represented by its context change potential, which is formally encoded as the set of propositions compatible with α (cf. also Smaby (1979) or Heim (1982) for exactly the same proposal). For example, *it is raining* is represented by the formula in (124), where p is a variable that ranges over intensions, *ie.*, over functions from possible worlds to truth values:

(124) $\lambda p(\textbf{it-is-raining} \wedge {}^{\vee}p)$

Since we ignore intensionality throughout the paper, nothing important will be lost if we write simply p instead of ${}^{\vee}p$). Given this simplification, the dynamic conjunction of propositions Φ and Ψ can be defined as in (125). An example is given in (126):

[24] Note, however, that the universal quantifier *can* gain wide scope if and only if it is understood as a generic NP. But, even in this case it can be shown that one can arrive at the correct interpretation with an *in situ* semantics, cf. Fox and Sauerland (1995).

[25] For me as a native speaker of German it is extremely difficult to get the inversed reading, except in special contexts. For example, it has been claimed in Hornstein (1984, p. 65, 98) that the following sentences allow wide scope for universal quantification:

(i) a. Someone expects every Republican to be elected
b. Someone wants PRO to marry everyone
c. Someone tried PRO to take every course

This is not permitted in the present approach. Since I have no competence to judge the grammaticality of data in a language like English, where QR does not obey clause-boundedness, I must leave the discussion as it stands.

(125) **Dynamic Conjunction:**
$(\Phi; \Psi) := \lambda q.\Phi(\Psi(q))$

(126) $(\lambda p(\textbf{it-is-raining} \wedge p) \; ; \; \lambda p(\textbf{it-is-snowing} \wedge p)) =$
$\lambda q \lambda p(\textbf{it-is-raining} \wedge p)(\lambda p(\textbf{it-is-snowing} \wedge p)(q)) =$
$\lambda q(\lambda p(\textbf{it-is-raining} \wedge p)(\textbf{it-is-snowing} \wedge q)) =$
$\lambda q(\textbf{it-is-raining} \wedge (\textbf{it-is-snowing} \wedge q))$

In what follows I will show that integrating the rule for dynamic conjunction into Bennett's framework immediately predicts the effects of dynamic binding; *ie.*, we automatically derive the correct interpretation of examples like

(127) A man_{17} entered. He_{17} whistled.

The only additional work to be done is some obvious adjustment of types. First, it is obvious that a proposition like *it is raining* must now be represented as either $\lambda\text{s}\lambda\text{p}(\textbf{it-is-raining} \wedge \text{p(s)})$ or equivalently $\lambda\text{p}\lambda\text{s}(\textbf{it-is-raining} \wedge \text{p(s)})$, with p having type $\langle s, t\rangle$ and the propositional variables Φ and Ψ having type $\langle s, \langle\langle s, t\rangle, t\rangle\rangle$ or $\langle\langle s, t\rangle, \langle s, t\rangle\rangle$, respectively. Let us, for the time being, assume that $\Phi, \Psi \in Var_{\langle\langle s,t\rangle,\langle s,t\rangle\rangle}$. Now observe that the rule of dynamic conjunction works exactly as before:

(128) $(\lambda\text{p}\lambda\text{s}(\textbf{it-is-raining} \wedge \text{p(s)}) \; ; \; \lambda\text{p}\lambda\text{s}(\textbf{it-is-snowing} \wedge \text{p(s)}))$
$= \lambda\text{q}[\lambda\text{p}\lambda\text{s}(\textbf{it-is-raining} \wedge \text{p(s)})]([\lambda\text{p}\lambda\text{s}(\textbf{it-is-snowing} \wedge \text{p(s)})](\text{q}))$
$= \lambda\text{q}[\lambda\text{p}\lambda\text{s}(\textbf{it-is-raining} \wedge \text{p(s)})]([\lambda\text{s}(\textbf{it-is-snowing} \wedge \text{q(s)})])$
$= \lambda\text{q}\lambda\text{s}(\textbf{it-is-raining} \wedge [\lambda\text{s}(\textbf{it-is-snowing} \wedge \text{q(s)})](\text{s}))$
$= \lambda\text{q}\lambda\text{s}(\textbf{it-is-raining} \wedge [(\textbf{it-is-snowing} \wedge \text{q(s)})])$
$= \lambda\text{q}\lambda\text{s}(\textbf{it-is-raining} \wedge \textbf{it-is-snowing} \wedge \text{q(s)})$

Next, the modified translation rules for "open propositions" is slightly more complicated, since it has to be formulated in a dynamic way. For example, the translation of an intransitive verb would now look as in (129):

(129) $\text{entered}_{17} = \lambda\text{p}\lambda\text{s}(\textbf{enter}(\text{s}_{17} \wedge \text{p(s)})$

Accordingly, Bennett's rule for binding of slots must be redefined as in (130):

(130) $\gamma(\mathcal{Q})(\text{n})(\Phi) := \lambda\text{p}\lambda\text{s}.\mathcal{Q}(\text{s})(\lambda y.\Phi(\text{p})(\text{s}[y,\text{n}]))$

The rule will be simplified later in the appendix to this subsection. We now have the following derivation:

(131) a. a man $= \lambda\text{s}\lambda\text{P}.\exists x(\textbf{man}(x) \wedge \text{P}(x))$
b. a man_{17} entered_{17} $= \Gamma_{17}(\text{a man})(\text{enter}_{17})$
$= \lambda\text{p}\lambda\text{s}.\exists x(\textbf{man}(x) \wedge \textbf{enter}(x) \wedge \text{p}(\text{s}[x/17]))$
c. he_{17} whistled_{17} $= \lambda\text{p}\lambda\text{s}(\textbf{whistle}(\text{s}_{17}) \wedge \text{p(s)})$
d. a man_{17} entered_{17}. he_{17} whistled_{17}.
$= \lambda\text{p}\lambda\text{s}.\exists x(\textbf{man}(x) \wedge \textbf{enter}(x) \wedge \text{p}(\text{s}[x/17]));\lambda\text{p}\lambda\text{s}(\textbf{whistle}(\text{s}_{17}) \wedge \text{p(s)})$

$= \lambda p[\lambda p \lambda s.\exists x(\mathbf{man}(x) \wedge \mathbf{enter}(x) \wedge p(s[x/17]))](\lambda p \lambda s(\mathbf{whistle}(s_{17}) \wedge p(s)(p)))$
$= \lambda p[\lambda p \lambda s.\exists x(\mathbf{man}(x) \wedge \mathbf{enter}(x) \wedge p(s[x/17]))](\lambda s(\mathbf{whistle}(s_{17}) \wedge p(s)))$
$= \lambda p[\lambda s.\exists x(\mathbf{man}(x) \wedge \mathbf{enter}(x) \wedge (\lambda s(\mathbf{whistle}(s_{17}) \wedge p(s))(s[x/17]))]$
$= \lambda p[\lambda s.\exists x(\mathbf{man}(x) \wedge \mathbf{enter}(x) \wedge (\mathbf{whistle}(s[x/17](17)) \wedge p(s[x/17])))]$
$= \lambda p \lambda s.\exists x(\mathbf{man}(x) \wedge \mathbf{enter}(x) \wedge (\mathbf{whistle}(x) \wedge p(s[x/17])))$

This straightforward application of dynamic conjunction reveals that the encoding of binding in Bennett's system has a "dynamic" effect in the sense that quantification as formalized above will always extend its scope over an entire text.

This result has two immediate consequences, one positive and one negative. Here is the positive: As a result of Smaby's (1979) pioneering work on dynamic interpretation it follows that the proper treatment of donkey sentences automatically falls out from the theory. Once conjunction is dynamic and binding with existential quantifiers works as outlined in section 2.2, we can automatically handle cases of donkey anaphora, illustraded in (132):

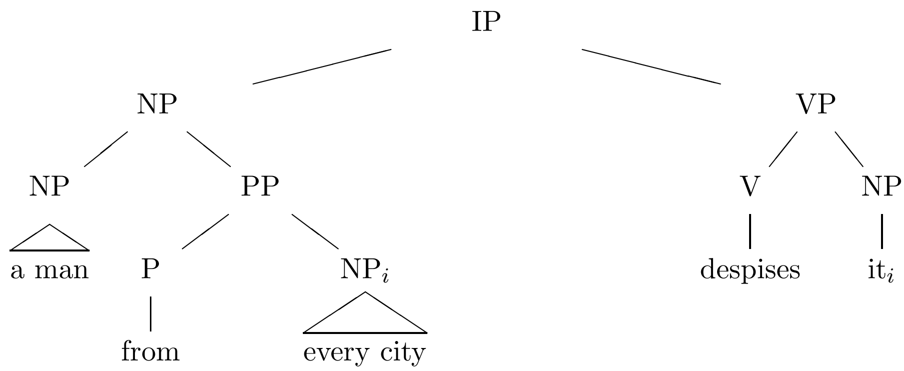
(132) every man who owns a donkey$_i$, beats it$_i$.

The negative consequence is that by the same argument, universal quantification will also become dynamic. I will return to this problem in section 5.4.

5.3 Inversed Linking

In footnote 25 I noted that the availability of QR seems to be language specific. A case in point where languages differ is the availability of inversed linking (cf. May (1977)), as exemplified by the NP in (133):

(133)



In English there is a bound reading of *it*. It is now easy to see that this reading can be derived *in situ*, by simply combining the above method of interpreting indefinites with Dynamic Conjunction.

The interpretation of indefinites gives us a reading of the NP *a man from every city*, where the universal quantifier has wide scope. Dynamic Conjunction implies that the predicate *from* is encoded in a dynamic way, *ie.*, as (134):

(134) $\text{from}_{1,2} = \lambda p \lambda s.\mathbf{from}(s_1,s_2) \wedge p(s)$

Now, given that scope reversal as described above makes *a man from every city* equivalent to

(135) $\lambda p \forall x(\mathbf{city}(x) \rightarrow \exists y(\mathbf{man}(y) \wedge \mathbf{from}(y,x) \wedge p(s[y/1][x/2])))$

it is clear that continuing with the predicate *despise*$_{1,2}$ or rather *despises*$_{1,2}$ *it*$_2$ gives the correct meaning of (133). Thus we can get an *in situ* interpretation of inversed linking: the universal quantifier has in effect wide scope over the predicate, although it is syntactically (and "semantically") embedded within the complex NP.

5.4 Appendix: Dynamic and Non-Dynamic Quantifiers

...At the end of section 5.2 we observed that (136-a) will be interpretable as (136-b):

(136) a. Every man$_{17}$ enters. He$_{17}$ whistles.
b. $\lambda p \lambda s.\forall x(\mathbf{man}(x) \rightarrow (\mathbf{enter}(x) \wedge (\mathbf{whistle}(x) \wedge p(s[x/17]))))$

Although Groenendijk and Stokhof (and subsequently many other authors) point to examples like (137-a), it is generally acknowledged that dynamic quantification with non-existential quantifiers is the exception rather than the rule; cf. (137-b) or (137-c):

(137) a. Every player chooses a pawn. He puts it on square one.
b. Every man came in. *He whistled.
c. Nobody entered. *He whistled.

The question then arises of how a more restricted type of quantification could be integrated into the system.

The traditional way of achieving this proceeds by translating the two types of quantifiers in radically different ways, integrating thereby the dynamic and the non-dynamic aspects of meaning into the semantics of the quantifiers themselves. Pursuing such an approach implies that we need more complex translations.[26]

As a first step towards that end, I will change the logical type of quantifiers so as to be able to apply the usual technique that turns dynamic semantics into static semantics. This is commonly achieved by replacing a variable in a "dynamic context" with a logical constant that stops dynamic interpretation. Assume that **True** is such a constant of type $\langle s,t \rangle$, which maps all value assignments onto "true," and that Q is a variable of type $\langle e, \langle \langle s,t \rangle, t \rangle \rangle$. The revised translations for the universal and

[26]There is independent evidence that the above semantics for quantifiers is too simplistic to account for the dynamics of donkey anaphora with relative clauses; for example, material implication as part of the meaning of universal quantification should be replaced by dynamic implication, or by a combination of dynamic conjunction and negation, as in Smaby (1979). On the other hand, this problem concerns only the internal make up of the quantifier, and therefore seems logically independent of our present problem. I will therefore put donkey anaphora aside and try to account for only the *external* behavior of the quantifier, *ie.*, the question of whether or not the quantifier is dynamic with respect to subsequent text.

the existential quantifier are given in (138). Observe that the universal quantifier contains the element **True** at exactly the position where dynamic interpretation is achieved in the translation of the existential quantifier.

(138) a. a man = $\lambda s \lambda Q \lambda p.\exists x(\mathbf{man}(x) \wedge Q(x)(p))$
b. every man = $\lambda s \lambda Q \lambda p.\forall x((\mathbf{man}(x) \rightarrow Q(x)(\mathbf{True})) \wedge p(s))$

Now, in order to make the system work more smoothly, the second change concerns the category of propositions. Henceforth, I exchange logical types and adopt the purely technical convention of writing $\lambda s \lambda p\ldots$ instead of $\lambda p \lambda s\ldots$ as the prefix of propositions. This reordering necessitates an analogous rearrangement of the types other variables, and it requires a slightly more complicated statement of dynamic conjunction, but the system as such will, of course, remain exactly the same.[27] There is also a trivial change of types in the rule of quantification repeated as (139-a). The new definition is given in (139-b).

(139) a. $\gamma(\mathcal{Q})(n)(p) := \lambda s.\mathcal{Q}(s)(\lambda x.p(s[x,n]))$
b. $\gamma(\mathcal{R})(n)(\Phi) := \lambda s.\mathcal{R}(s)(\lambda x.\Phi(s[x,n]))$

Previously, $\mathcal{Q}$ was $\langle s,t\rangle$, but now the type of an NP is $\langle s,\langle P,\langle s,t\rangle,t\rangle\rangle$, which has been calculated from (138). Similarly, propositions are dynamic now, so that the type of Ψ is $\langle s,\langle s,t\rangle,t\rangle$. With these changes in mind, reconsider *A man walks*:

(140) [A man $]_{17}$ walks$_{17}$
$= \Gamma_{17}$(a man)(walks$_{17}$)
$= \lambda s[(\text{a man})(s)(\lambda y(\text{walks}_{17}(s[y/17])))]$
$= \lambda s[\lambda Q \lambda p.\exists x(\mathbf{man}(x) \wedge Q(x)(p))\lambda y(\text{walks}_{17}(s[y/17]))]$
$= \lambda s[\lambda Q \lambda p.\exists x(\mathbf{man}(x) \wedge Q(x)(p))\lambda y(\lambda s \lambda p.\mathbf{walk}(s_{17}) \wedge p(s)(s[y/17]))]$
$= \lambda s \lambda p.\exists x(\mathbf{man}(x) \wedge \lambda s \lambda p.\mathbf{walk}(s_{17}) \wedge p(s)(s[x/17])(p))$
$= \lambda s \lambda p.\exists x(\mathbf{man}(x) \wedge \mathbf{walk}(s[x/17](17)) \wedge p(s[x/17]))$
$= \lambda s \lambda p.\exists x(\mathbf{man}(x) \wedge \mathbf{walk}(x) \wedge p(s[x/17]))$

Now, by applying the same rules to *every man*, what we get is this:

(141) Γ_{17}(every man)(walks$_{17}$)
$= \lambda s \lambda p[\forall x((\mathbf{man}(x) \rightarrow (\mathbf{walk}(x) \wedge \mathbf{True}(s[x/17])) \wedge p(s))]$
$= \lambda s \lambda p[\forall x((\mathbf{man}(x) \rightarrow \mathbf{walk}(x)) \wedge p(s))]$

It is clear, then, that the scope of the existential quantifier is "dynamic," *ie.*, it extends to the subsequent text, whereas this process is blocked in universal quantification as defined in (138-b).

[27] The required redefinition of dynamic conjunction is this:

(i) $(\Phi;\Psi) := \lambda s \lambda p.\Phi(s)(\lambda s.\Psi(s)(p))$

This looks slightly more complicated, but the additional complexity will pay off and simplify the statement of the following rule.

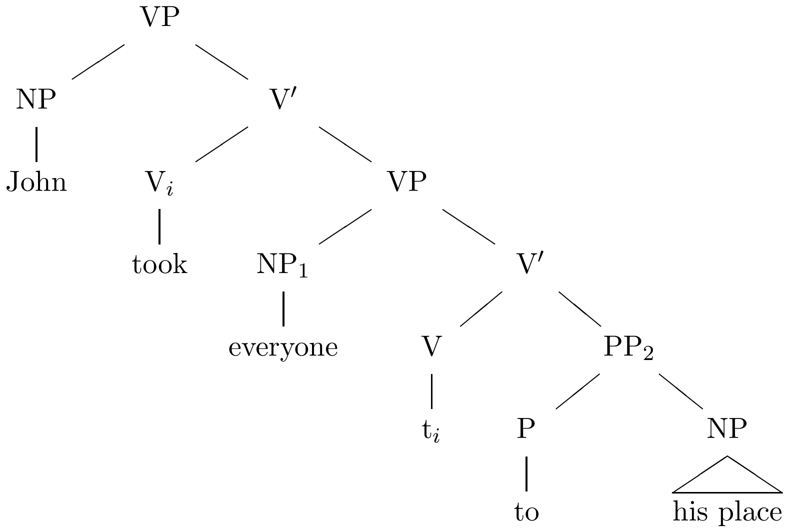
6 Binding "from inside PPs"

6.1 The Problem

Within the last decade, syntactic theories converged on the hypothesis that clause internal structure is "almost right branching," which means that the further to the right a major constituent of a clause appears in linear order, the more deeply embedded does it appear in constituent structure.[28] The pioneering work that explores the idea of analyzing (142-a) as (142-b), *ie.*, in terms of an almost right branching structure that strictly adheres to $\overline{\text{X}}$-theory, is Larson (1988); cf. also Larson (1990), Haider (1992), Kayne (1994), or Haider (1995).

(142) a. John took everyone to his place

b.



The evidence that led researchers to propose a structure like (142-b) originated from principles of binding, scoping, and negative polarity[29], which imply that any constituent that takes scope over another constituent β must "precede and command" β—a generalization that is naturally captured in terms of constituent structure if (and only if) the linear relation of precedence is encoded by the structural relation of asymmetric c-command.[30] Since PP_1 precedes and asymmetrically c-commands PP_2, (142-b) satisfies this requirement directly.

However, as shown in (143), the correspondence between linear and structural relations is not yet perfect.

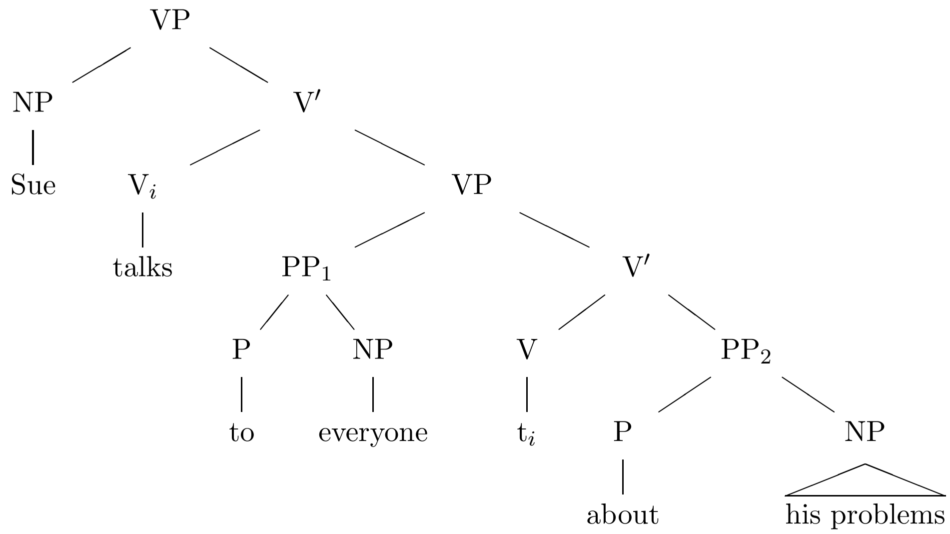
[28] In a purely right branching structure, it is required that heads always appear on right branches, as, *eg.*, in Japanese. This does not hold for "almost" right branching structures; cf. below. The qualification *almost* should be understood in a very sloppy sense; in particular I do not attempt a formal definition of the term.

[29] For relevant data, see Barss and Lasnik (1986) or Jackendoff (1990), although the theoretical conclusions reached by these authors are rather different than Larson's.

[30] For a discussion of some formal properties of asymmetric command and linearization, cf. Kayne (1994) and the comments in Sternefeld (1994).

(143) a. Sue talks to everyone about his problems.

b.



Although we can interpret *everyone* in (143) as the antecedent of *his*, no formal binding relation can be established on the basis of c-command; according to any of the current definitions of command, the NP *everyone* (c- or m-)commands only the preposition *to*; hence, there is no way to sanction binding between *his* and its antecedent in the structure given above.

Of course, the phenomenon as such was observed a long time ago in the literature, but there is still no satisfactory solution to the problem.[31] In this paper I propose a simple solution in terms of a specific logical typing of expressions in semantic interpretation. As a result, the scopal relation in (143) can be interpreted correctly without there being a command relation between the NP and the scope dependent element.

Before I develop these ideas, let me briefly discuss a syntactic solution of the problem.

6.2 Pesetsky's Solution

6.2.1 The Dual System

Pesetsky (1995) proposes a new kind of structure, so-called *Cascade Syntax*, which enables the NP *everyone* in (143) to c-command *his*. According to his theory, the structure of (143-a) is (144):

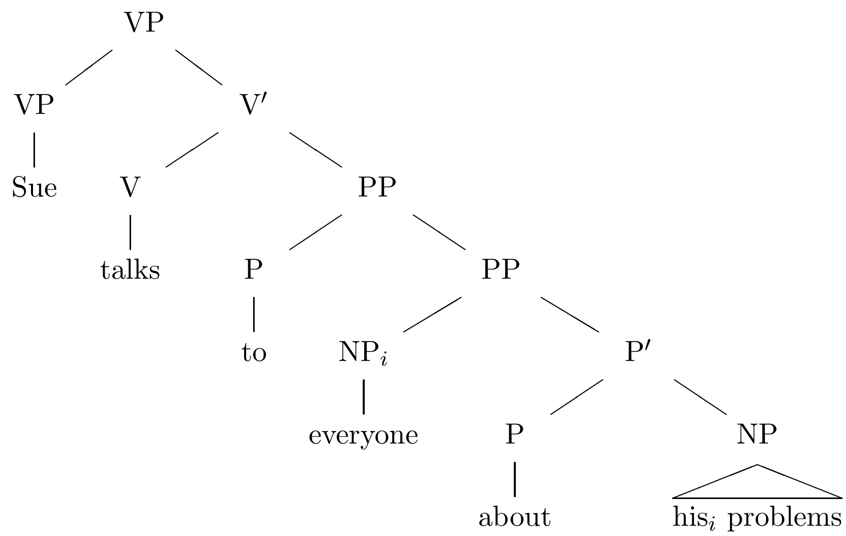
[31] In a very recent article, Baltin and Postal (1996) point to a long tradition of reanalyzing the preposition as a constituent of the verb. For example, Riemsdijk and Williams (1986, p. 203), in dealing with their sentence (31-a), propose that if "(31a) is reanalyzed to (31b), then this case is accounted for, since *Bill* does c-command the reflexive in (31b)."

(31) a. John talked [$_{PP}$ to Bill] about himself

b. John [talked to] Bill about himself

However, Baltin and Postal show convincingly that a theory of reanalysis is empirically inadequate and doomed to fail. Unfortunately, the authors have nothing to offer as a positive solution, leaving the problem as enigmatic as it was before.

(144)



It is obvious that in (144) the quantifier c-commands and binds the coindexed pronoun, and hence the interpretation of scopal relations between NPs does not pose a problem anymore.

However, the above structure—although designed to capture certain aspects of semantic interpretation—may not serve as the one and only level of LF. As Pesetsky himself notes, *Cascade Syntax* must not be considered a level "that represents semantically contentful relations among items in structure" (p. 289). In particular, the proposed structures cannot capture the relation of predication among heads and their arguments in a way that could be interpreted by any compositional system of logical semantics, *ie.*, by a system that calculates truth conditions in the usual way. The reason for this is that in *Cascade Syntax* a head can take no more than one argument α to its right, so that a second argument β must always be generated as a proper part of α—a configuration that is compositionally uninterpretable. Thus, it seems that Pesetsky's *Cascade Syntax* can handle only certain limited aspects of semantic interpretation; it is essentially confined to matters of scope, but seems to be inadequate as regards matters of argument structure.

Pesetsky himself recognizes that *Cascade Syntax* is also inadequate as a representation that feeds move-α. For example, *to everyone* in (144) should form a constituent that can be fronted or questioned, which it could not in *Cascade Syntax*. For these reasons, he proposes a *Dual System* with a traditional structure (called *Layered Syntax*) as a kind of representation that coexists with the *Cascade Syntax*. It thus seems that the latter level is confined to scopal relations between NPs, whereas *Layered Syntax* encodes scopal relations between heads and their arguments.

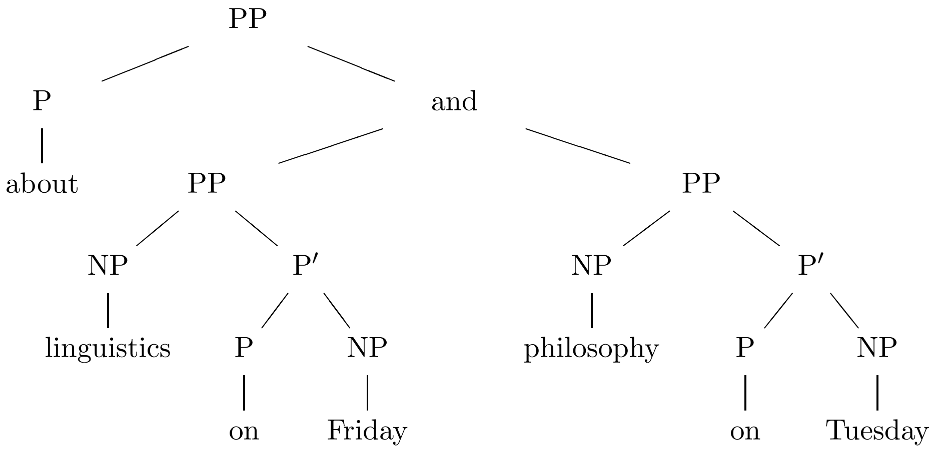
This bifurcation, however, gives us no unified representation of semantic relations; one might even claim that the *Dual System* as proposed by Pesetsky leaves us with no interpretable structure at all. To date, no theory or mechanism exists that could provide (144) with a compositional semantics. In contrast, however, there is no problem with designing a simple and natural semantic interpretation for structures like (143), as will be demonstrated in section 6.3.

6.2.2 Coordination

Before I go into this, let me touch briefly on the additional support ventured by Pesetsky as further motivation for introducing *Cascades*. This evidence is derived from coordinations as shown in (145) (from Pesetsky (1995, p. 176)):

(145) a. Sue will speak to Mary about [linguistics on Friday] and [philosophy on Thursday].

b.



Since *Cascade Syntax* analyzes the bracketed phrases *linguistics on Friday* and *everyone about his problems* as PPs, nothing more needs to be said about the possibility of coordination in (145-a).

However, as already pointed out by Jackendoff (1990), it is far from clear how coordination interacts with ellipses and gapping. If coordination were simply a matter of constituent structure, it would remain a mystery why the translation of (145) into French is totally ungrammatical:

(146) *Suzanne parlera à Marie de linguistique (le) vendredi et philosophie (le) jeudi.

The same holds for many other languages. Consider, *eg.*, the following examples from German, which *Cascade Syntax* predicts to be grammatical but which are in fact ill-formed:

(147) a. *Fritz ging in die Schule am Vormittag und den Kindergarten am Nachmittag
Fritz went to the school in-the morning and the kindergarten in-the afternoon

b. *Fritz fuhr nach Wiesbaden zu seiner Mutter und Frankfurt zu seiner Oma
Fritz drove to Wiesbaden to his mother and Frankfurt to his grandma

Although I have nothing to offer here as an explanation for the observed contrast, this situation is at odds with the purported universal character of the system[32]. Being

[32]. . . which is expressed particularly clearly in the following quote from Pesetsky (1995, p. 291):

a fundamental property of UG, *Cascade Syntax* should also be fundamental for those languages that behave differently than English. Hence, we must look for additional restrictions on coordination that are operative in French and many other languages but seem to be absent in English. Since it is far from clear how such additional restrictions could be formulated within *Cascade Syntax*, it is a simple methodological point that the above data undermine the validity of Pesetsky's explanation[33].

6.2.3 Anaphoric Binding

Another area where language specific variation undermines the purported universal character of the *Dual System* is anaphoric binding to a PP-internal antecedent. It has long been observed that, in some sense, PPs should not "count as branching," but when they *never* did, "an NP they contain should be a possible antecedent for an anaphor. It turns out to be the case that it is not" (quoted from Reuland (1983, p. 240)). For example, whereas (148-a) is considered grammatical in English (cf. *eg.* Reinhart (1983, p. 177)), its analogue in German or Dutch is ungrammatical:

(148) a. I spoke with Rosa about herself

b. daß ich mit Rosa$_i$ über sie$_i$ / sie$_i$ selbst / *sich$_i$ / *sich$_i$ selbst
dat ik met Rosa$_i$ over haar$_i$ / haar$_i$ zelf / *zich$_i$ / *zich$_i$ zelf
sprach
sprak

The ungrammaticality in (148-b) cannot be due to a general constraint on binding, because there is no problem with binding by a quantifier or negative polarity licensed by NPs within PPs; cf. the negative polarity item *jemals* ('ever') in (149-a), the acceptable coindexing in (149-b), and the possibility of interpreting the indefinite expression as scope dependent on the universal quantifier in (149-c):

(149) a. daß Fritz mit niemandem/*jemand jemals darüber sprach
that Fritz with no-one/ someone ever about-it spoke

b. daß Fritz [$_{PP}$ mit [$_{NP}$ jedem Kind]$_i$] zu seinem$_i$ Vater ging
that Fritz with every child to his farther went

Have we merely ended up with the familiar "syntactician's trade-off," whereby an analytic simplification of one module of grammar leads immediately to an equal and opposite complication of another module of grammar? I suspect that this has not happened here.

First, the Dual System explains phenomena that were not explained adequately by traditional theories—phenomena unrelated to lexical questions with which we began.

Second, the Dual System is (if correct) a fundamental property of UG [...], not the response of an individual speaker to specific experience.

From this we must conclude that the Dual System does not allow for parametric variation between languages: whether or not a certain phenomenon like coordination must be analyzed on the level of Cascades is not open to parametric variation; otherwise, we would again have a learning problem.

[33]It seems to me that despite Pesetsky's claim to the contrary, we are indeed ending up with the familiar "syntactician's trade-off" alluded to in the last footnote. The proposed solution in fact leads immediately to an "equal and opposite complication" in languages other than English.

c. daß Fritz in jedem Geschäft ein Spielzeug kauft
that Fritz in every shop a toy buys

It seems, then, that binding of negative polarity items, scoping, and variable binding out of PPs are equally grammatical in German and English, whereas binding of a reflexive pronouns is possible only in English. Why should this be so? That is, why is there parametric variation with respect to principles of Binding Theory but not with respect to scoping?

There is a clear sense in which variable binding and negative polarity are matters of scope and thereby belong to the realm of semantics (or what is sometimes called LF), whereas the choice between anaphoric and pronominal expressions is largely a matter of syntax. As we don't expect there to be much variation on the semantic side, this division of labor expects uniformity in semantic respects but allows for parametric variation with respect to the syntactic part of the analysis. Accordingly, while binding of the pronouns in (148)—whether grammatical or not—should pose no *semantic* problem, there must be an additional *syntactic* constraint on grammatical binding which is operative only in languages that behave like German.

In what follows binding of a pronoun will be shown to be achieved by an index which may be attached, at least in principle, to either a PP or an NP but which for semantic reasons may not be attached to an NP immediately dominated by a PP. It seems, therefore, that the additional *syntactic* constraint for a language like German must be that anaphors cannot accept the option of being bound by the index of a PP, implying that reflexive pronouns can be bound only by indices of NPs. This restriction rules out the reflexives in (148-b), the relevant part of the structure being given in (150):[34]

[34] German seems less strict with respect to reciprocal pronouns; cf.

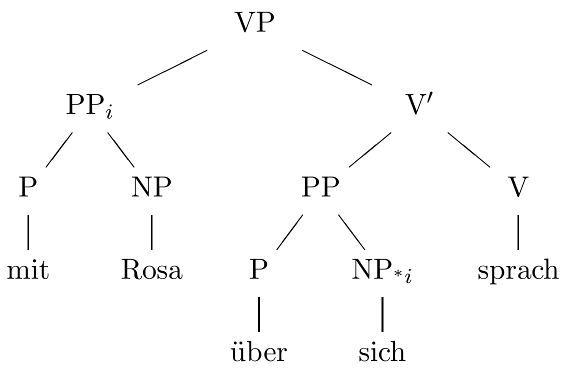
(i) a. weil er$_i$ [$_{\text{PP}}$ an alle]$_j$ Bilder von sich$_{i/*j}$/einander$_j$ schickte
because he to all pictures of REFL/REC sent

b. ?weil er mit allen gegen einander wettete
because he with all against each-other betted

It is therefore crucial to restrict the above categorial uniformity condition to the binding of reflexive pronouns only.

As for condition (B) of the binding theory, it is clear that in languages like German, inhomogeneous binding (*ie.*, binding of an NP exercised by a PP) cannot result in a violation of principle (B). Accordingly, the notions A-bound and A-free need some further qualification in the sense that we must distinguish between nominal and non-nominal A-positions. Hence, within its local domain a pronominal in German cannot be bound from a *nominal* A-position (but may very well be bound from a PP).

(150)



In English no such uniformity of binding is required; therefore, (148-a) is still permitted.

Observe again that *Cascade Syntax* offers no straightforward way even to formulate the required distinction between PPs and NPs so that, after all, we are led to conclude that this theory is on the wrong track.

6.3 PPs as Generalized Quantifiers

The envisaged solution will employ the possibility of treating PPs semantically in the same way as NPs, namely as generalized quantifiers. As such they have the same binding potential as NPs, so that the antecedent of the pronoun is, in a certain sense, the PP rather than the NP. This ultimately explains why the command relation *between NPs* seems inapplicable or irrelevant in the case at hand.

Let us now work out the details of this proposal, beginning with verb-related uses of prepositions, which involve a relation between an entity x that denotes an individual (the object of the preposition) and an entity e which denotes an event, a state of affairs, an action, a path, or whatever seems suitable in a given context. For example, *to* might express a relation $\mathbf{goal}(e, x)$ such that e is a transaction or a path, and x denotes the goal of e. We will tailor the semantic type of *to* in such a way that when combined with a generalized quantifier, the result is also a generalized quantifier. For example, the result of applying *to* to (150) is (151):

(151) to every man
$= \lambda \mathrm{s} \lambda P. \forall x(\mathbf{man}(x) \rightarrow (P(x) \wedge \mathbf{goal}(e, x)))$

Similarly, applying *to* to *no man* yields (152):

(152) to no man
$= \lambda \mathrm{s} \lambda P. \neg \exists x(\mathbf{man}(x) \wedge (P(x) \wedge \mathbf{goal}(e, x)))$

It is obvious that whenever the object of the preposition is downwards-entailing (*ie.*, a quantifier that licenses a negative polarity item), the resulting PP is also downwards-entailing, *ie.*, will also license a Negative Polarity Item. Put differently, the ability of an NP to license a NPI is hereditary; it is passed on to the PP. Therefore, from a semantic point of view, the observed facts about NPIs (cf. (149-a)) follow trivially from a purely compositional interpretation, so that there is no need for any additional syntactic maneuvering.

To make this precise, let $\mathcal{Q}$ be a variable that ranges over NP-denotations, and PREP a variable ranging over expressions of the formal language that correspond to prepositions. Then, the categorial encoding of an event-related preposition is (153), where e is a free variable ranging over events, paths, states of affairs, or whatever seems suitable for the preposition in question.

(153) $\lambda \mathrm{s} \lambda \mathcal{Q} \lambda P[\mathcal{Q}(\mathrm{s})(\lambda x[P(x) \wedge \mathrm{PREP}(e,x)]])$

Example 1: Assuming that *to* has the PREP-value **goal**, and *Bill* is translated as $\lambda P.P(\mathbf{b})$, *to Bill* denotes (154-a), which by lambda conversion reduces to the last line of (154):

(154) to Bill

$$
\begin{aligned}
&= \lambda \mathrm{s} \lambda \mathcal{Q} \lambda P[\mathcal{Q}(\mathrm{s})(\lambda x[P(x) \wedge \mathbf{goal}(e,x)])](\lambda P.P(\mathbf{b}))\\
&= \lambda \mathrm{s} \lambda P[(\lambda P.P(\mathbf{b}))(\lambda x[P(x) \wedge \mathbf{goal}(x,e)])]\\
&= \lambda \mathrm{s} \lambda P[\lambda x[P(x) \wedge \mathbf{goal}(e,x)](\mathbf{b})]\\
&= \lambda \mathrm{s} \lambda P[P(\mathbf{b}) \wedge \mathbf{goal}(e,\mathbf{b})]
\end{aligned}
$$

Example 2: Given that *with* is represented by the two-place relation **with**, *with every knife* is the expression (155-a), which by lambda conversion reduces to (155-d):

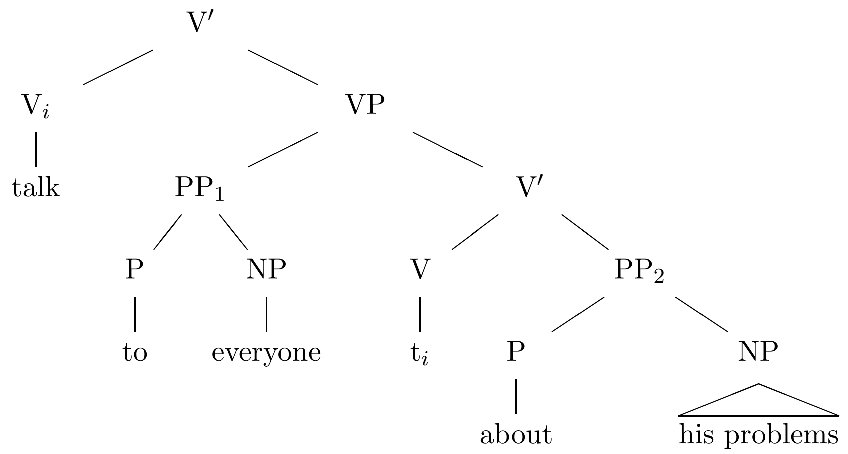
(155) with every knife

$$
\begin{aligned}
&= \lambda \mathrm{s} \lambda \mathcal{Q}(\mathrm{s}) \lambda P[\mathcal{Q}(\lambda x.P(x) \wedge \mathbf{with}(e,x))](\lambda P.\forall x(\mathbf{knife}(x) \rightarrow P(x)))\\
&= \lambda \mathrm{s} \lambda P[(\lambda P.\forall x(\mathbf{knife}(x) \rightarrow P(x)))(\lambda x(P(x) \wedge \mathbf{with}(e,x)))])\\
&= \lambda \mathrm{s} \lambda P.\forall x(\mathbf{knife}(x) \rightarrow \lambda x(P(x) \wedge \mathbf{with}(e,x))(x))\\
&= \lambda \mathrm{s} \lambda P.\forall x(\mathbf{knife}(x) \rightarrow (P(x) \wedge \mathbf{with}(e,x)))
\end{aligned}
$$

Here again, the nature of e is immaterial; the only essential assumption is that e also figures as an argument of a predicate. The occurrences of e will become bound in the course of the derivation, *eg.* by means of a general rule to the effect that formation of a VP automatically binds all VP-internal e-arguments by existential quantification. One might also add further parameters like tense or place, but these will be irrelevant in what follows.

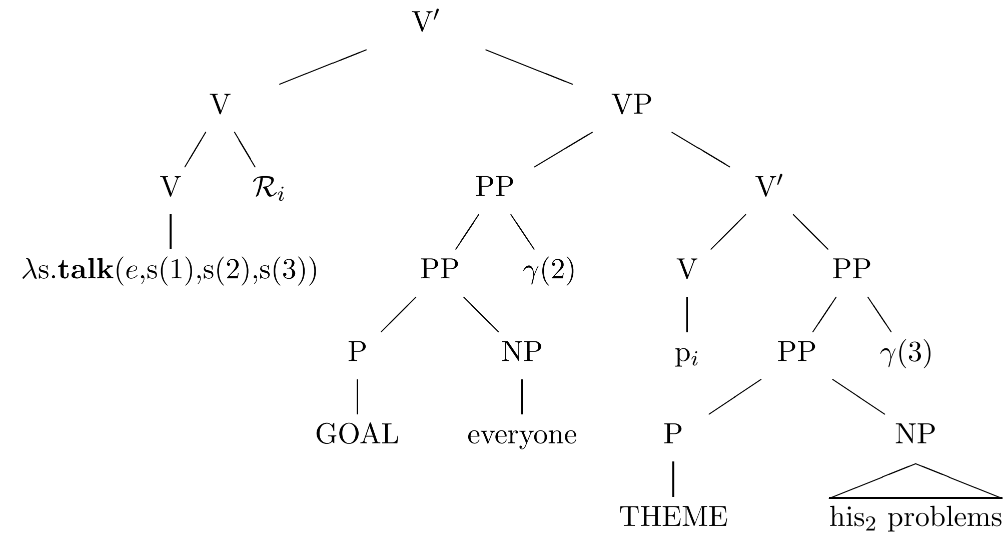
Let us now return to sentence (143), the relevant part of which being shown in (156):

(156)



The transparent Logical Form of this is (157):

(157)



It is easy to see now that this analysis yields the desired result.

Note that in the above analysis we decided to make the goal and the theme arguments of the verb. This, however, is not an essential feature of the analysis, and in fact the binding phenomena are independent of whether the PP is an argument or an adjunct. If the PP is an adjunct, the index of the PP has no matching index on the verb, but the semantics in no way hinges on that and gives precisely the correct result. For example, if neither the theme nor the goal would be an argument, the resulting LF would simply be equivalent to (158):

(158) $\lambda g \forall x(\mathbf{human}(\mathrm{x}) \to (\mathbf{goal}(e,x) \wedge \mathbf{theme}(e, x\text{'s problems}) \wedge \mathrm{talk}(e, \mathrm{g}(1))))$

6.4 The Double Object Construction

The above discussion has shown that arguments may be treated compositionally in the same way as adverbials, in the sense that it is immaterial whether we adopt a Davidsonian or a Neo-Davidsonian style of representation. In the latter case, arguments have an index that does not bind any slot of a predicate, which is precisely what happens to adjuncts in the Davidsonian theory. Although the choice of mechanism is neutral from a purely formal point of view, it might still be advantageous to adopt the original Davidsonian formalization and represent arguments as slots of predicates. One reason for doing so is derived from Larson's basic intuition that underlies his theory of double object constructions. Recall from Larson (1988) that for a verb to undergo Dative Shift, it is mandatory that the preposition be superfluous in the sense that the theta role it assigns (*eg.* the role that *to* assigns in the above example) is already assigned by the verb (*give*) to the same NP. This is what Larson calls "recoverability of deletion": there is no loss of "information" in the transition from (159-a) to (159-b):

(159) a. John sent a book to me.
      b. John sent me a book.

This semantic intuition is formally captured by two properties of the above system: First, the fact that the slot x_k is both an argument of the verb and the object of the preposition directly reflects Larson's hypothesis that one and the same position is theta-marked twice. Second, the fact that recoverability demands identity of theta roles is now more indirectly reflected by the semantics of the verb. Given the meaning postulate in (160), it follows that the preposition is redundant and therefore in a sense "recoverable."

(160) $\mathbf{give}(e, x_i, x_j, x_k) \rightarrow \mathbf{goal}(e, x_k)$

Accordingly, the relevant criterion for recoverability is not exactly identity of theta roles but semantic entailment. In a certain sense, then, this semantic rephrasing of Larson's condition *explains* why identity of theta roles seems to be required as a prerequisite of recoverability.

6.5 *Only*

I will assume in this section that *only* can occur in at least two syntactic environments, namely as a modifier of VP, as described in Rooth (1985), and as a modifier of NP/PP. Evidence for the latter can be gained from German, where only one constituent can be topicalized in front of the finite verb. From this it follows that, *eg.*, *only a millionaire* is a constituent in (161):

(161) $[_{\text{CP}}\ [_{\text{NP}}$ nur ein Millionär $]_i$ kann$_j$ $[_{\text{IP}}$ t$_i$ das bezahlen t$_j$ $]]$
      only a millionaire can this afford

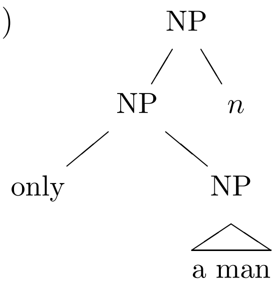
The aim of this section is to explain why (162) is ungrammatical:[35]

(162) *John gave the book to only a man

[35] The problem has been addressed recently also by Bayer (1996) and Büring and Hartmann (1996), who reach conclusions that are inconsistent with the solution proposed below.

Within the present system, we might conjecture that *only* when combined with an NP or PP is a complex function that operates syntactically like γ. Then, the syntax of *only a man* is as shown in (163), and its semantics is something like in (164), with (164-a) describing the presupposition and (164-b) describing the content of *only*:

(163)



(164) a. $\text{ONLY}(\mathcal{Q})(\text{n})(\text{p}) := \gamma(\mathcal{Q})(\text{n})(\text{p})$

b. $\text{ONLY}(\mathcal{Q})(\text{n})(\text{p}) := \exists x\text{p}(\text{s}[x/\text{n}]) \rightarrow \gamma(\mathcal{Q})(\text{n})(\text{p})$

Thus, according to (164), *only a millionaire can afford this* means *If anyone can afford this, then a millionaire can afford this.*

If something like this is on the right track[36], we can immediately explain why *only* cannot modify an NP within a PP. This follows directly from the semantic type of *only* as a modifier of NP/PP, which requires two arguments: an NP/PP and a second argument which is interpreted as the scope of *only* and which must be a proposition. It follows, then, that constructions like $*$*in only England* and (162) are simply uninterpretable, because *only NP* no longer has the semantic type of an NP and hence cannot serve as an argument of the preposition.

7 Conclusion

What can we conclude from the above exercise in formalization? I think the basic insight might be that the logician's use of free variables in the translation of natural language is somehow misguided, since, as we have seen, pronouns do not really behave as do free variables in logic. After all, it seems that the logician's technique of binding is less adequate than the way binding can be handled in Bennett's system.

Another lesson to be learned is this. Current theories of *Dynamic Interpretation*, and also Heim's system of *Flexible Binding*, are notationally very elegant, but nonetheless conceptually extremely complex, with the complexity being hidden behind the scene, *ie.*, in the meta-language. This contrasts sharply with Bennett's system, where all that needs to be expressed is already there in the language of representation. This strikes me as a pedagogical virtue, but whether or not it is a theoretical advantage that pays off remains to be seen.

[36]But compare Fintel (1994), where the semantics for *only a man* is construed rather differently than it is here.

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