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Quantifying into NP*

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The semantic theory presented in Montague (1974) permits quantification into a number of different syntactic categories, including t, CN and IV (S, N' and VP, respectively, in more familiar notation). In this note I point out facts concerning so-called "inverse linking constructions" which indicate that quantification must also be permitted into term phrases (NPs) if Montague's account of intensional transitive verbs such as *seek* and *want* is to be retained intact. A simple rule of NP quantification is formulated which allows these facts to be accomodated. I go on to discuss an apparent problem with pronominal binding in inverse linking structures and suggest an approach to this problem within an account developed by Cooper (1983), involving the notions of quantifier storage and quantifier retrieval.

1.0. Inverse Linking Constructions

May (1977, 1985) discusses an interesting class of scope phenomena involving quantificational noun phrases in the object position of an NP-modifying PP. Consider (1) below ((26) in May (1985)):

(1) [Someone from every city] despises it

As May points out, on the salient reading of (1) the order of quantifiers is the inverse of their surface linear arrangement, i.e., the embedded quantifier *every city* has scope over *someone*. Under this reading *every city* can be understood as binding the pronoun *it* and hence the sentence can be taken as asserting that each city contains someone who despises that city.

Similar remarks apply to example (2) (= (2.2a) in May (1977)), which contains three quantified NPs:

(2) [Some exits from every freeway in a large California city] are badly constructed

According to the salient reading of (2) there is some city in California, each of whose freeways has badly constructed exits. Again under this interpretation the order of quantifiers is the inverse of their surface syntactic order. Note further that on this reading each quantified NP binds a variable in the NP immediately within its scope. This becomes clearer if we examine an informal logical representation for (2):

(3) [for some x, a large CA city] [for all y, a freeway in x] [for z, an exit from y]
z is badly constructed

In view of the properties of scope inversion and variable binding, I will refer to the quantifiers in such structures as “inversely linked” (again following May (1977)).

2.0. Inverse Linking in Intensional Objects

Montague (1974) has presented a semantic analysis of transitive verbs such as *want* and *seek* which accounts for the familiar intensional properties of NPs occurring as their objects: lack of specific reference, possible failure of reference in the actual world, failure of substitution of nouns with identical reference. The basic proposal is to take such verbs as denoting relations between individuals and noun phrase intensions (see Dowty, Wall and Peters (1981)). On this analysis, intensionality results from combining an NP directly with a verb of this class, as argument to function.

Consider now the examples in (4), which involve inversed linked structures in the object position of an intensional verb:

(4) a. Max needs [a lock of mane from every unicorn in an enchanted forest]
b. Felix wants [a story about every dogcatcher in a large California city]
c. Peter has been looking for [a debutant from every small town in an obscure midwestern state]

(4a) has a natural reading of the object noun phrase in both *a lock of unicorn mane* and *an enchanted forest* are read *de dicto* but in which the latter is read with broader scope. Imagine Max requiring locks of unicorn mane for the performance of some magic spell. The spell stipulates no particular forest nor any particular pieces of mane. It is only necessary that he have some bit of mane from every unicorn in whatever forest is selected. Similarly, (4b) has a reading where Felix (crusading reporter) requires stories about dogcatchers, and where it doesn’t matter which California city or which story about each dogcatcher is to be provided. It is only necessary that each dogcatcher be employed in the city and that Felix have some story about each one. And so on for (4c).

In view of the inverse scope relations in these examples, the various NPs in the objects of *need*, *want* and *look for* must evidently be quantified-in. However if we are to retain Montague’s analysis of intensional object NPs, then the fact that each of these NPs may be read *de dicto* clearly entails that such quantification must take place before the object NP is combined with the intensional verb. Given the syntax of (2a-c), the only candidate node for quantification is NP. Thus these data suggest that the derivation of the verb phrase in (4a), for example, should be in (4a’):

(4) a.'

need a l-of-m from every unicorn in an enchanted forest

need **a l-of-m from every unicorn in an enchanted forest**

an enchanted forest **a l-of-m from every unicorn in him$_1$**

every unicorn in him$_1$ **a l-of-m from him$_0$**

The NP *every unicorn in him$_1$* is quantified-into *him$_0$* in the NP *a lock of mane from him$_0$*, giving the former scope over the latter. The noun phrase *an enchanted forest* is then quantified into the outcome, giving it widest scope. Finally, the entire noun phrase *a lock of mane from every unicorn in an enchanted forest* is combined with the intensional verb *need*, resulting in a *de dicto* reading for the complex object expression.

The additions to Montague's PTQ which would permit the derivation in (4a') and assign it the appropriate semantic result appear straightforward:

(5) S. 100 If $\alpha \quad P_T$ and $\beta \quad P_T$, then $F_{10,\ n}(\alpha, \beta) \quad P_T$
T. 100 If $\alpha \quad P_T$ and $\beta \quad P_T$, and α, β translate as α', β', respectively, then $F_{10,\ n}$ (α, β) translates as $\lambda P[\alpha' (\hat{}\lambda x_n[\beta' (P)])]$

To illustrate these rules, assume an analysis of PPs as NP modifiers along the lines suggested by Bach and Cooper (1978) for relative clauses.[1] Then the IL translation of the first NP quantification in (4a) can be given as in (6):

(6) **a l-of-m from him$_0$** $\quad \lambda R \ \ x[\mathbf{l\text{-}of\text{-}m'}(x) \ \& \ \mathbf{from}'(x, x_0) \ \& \ R\{x\}]$
every unicorn in him$_1$ $\quad \lambda S \ \ y[\mathbf{unicorn}'(y) \ \& \ \mathbf{in}'(y, x_1) \rightarrow S\{y\}]$
a l-of-m from every unicorn in him$_1$ $\quad \lambda Q[\lambda S \ \ y[\mathbf{unicorn}'(y) \ \& \ \mathbf{in}'(y, x_1) \rightarrow S\{y\}](\hat{}\lambda x_0 [\lambda R \ \ x[\mathbf{l\text{-}of\text{-}m}'(x) \ \& \ \mathbf{from}'(x, x_0) \ \& \ R\{x\}](Q)])]$

After lambda-conversion the latter reduces to:

(7) $\lambda Q \ \ y[\mathbf{unicorn}'(y) \ \& \ \mathbf{in}'(y, x_1) \rightarrow \ \ x[\mathbf{l\text{-}of\text{-}m}'(x) \ \& \ \mathbf{from}'(x, y) \ \& \ Q\{x\}]]$

The interpretation for the remaining NP quantification in (4a) is computed in an analogous way. The interpretation of *an enchanted forest* is applied to an expression formed (essentially) by taking lambda abstraction over the x_1 variable in (7):

(8) $\lambda R[\lambda P \ \ z[\mathbf{en\text{-}forest}'(z) \ \& \ P\{z\}] (\hat{}\lambda x_1 [\lambda Q \ \ y[\mathbf{unicorn}'(y) \ \& \ \mathbf{in}'(y, x_1) \rightarrow$
$x[\mathbf{l\text{-}of\text{-}m}'(x) \ \& \ \mathbf{from}'(x, y) \ \& \ Q\{x\}]](R)])]$

(8) then reduces to (9), which is intuitively the correct result:

(9) $\lambda R\ \ z[\mathbf{en\text{-}forest}'(z)\ \&\ \ \ y[\mathbf{unicorn}'(y)\ \&\ \mathbf{in}'(y, z) \rightarrow\ \ x[\mathbf{l\text{-}of\text{-}m}'(x)\ \&\ \mathbf{from}'(x, y)\ \&\ R\{x\}]]$

This interpretation for *a lock of mane from every unicorn in an enchanted forest* can then combine directly with *need* to derive the desired *de dicto* reading of the object NP.

3.0. Inverse Linking and Pronoun Binding

The rule of NP quantification in (5) derives the correct result for the example in (4a); however, it does not appear to provide a fully adequate account of the scope of inversely-linked NPs when other examples are examined. Consider the derivation tree for (1) (repeated below) shown in (10):

(1) Someone from every city despises it

(10) **someone in every city despises him$_0$** (3)

someone in every city, 10, 0 **despise him$_0$**, 5 (2)

every city **someone in him$_0$** (1)

As we recall, (1a) has a reading where the object pronoun *it* is construed as bound by the quantified NP *every city* appearing within PP.[2] As (10) indicates, if we employ the NP quantification rule proposed above in the step from line (1) to line (2), then the pronoun object of *despise* will remain unbound at the point when subject and object are combined (the step from line (2) to line (3)). This suggests that on the bound reading of *it* (1) must be derived, not by term phrase quantification, as in (10), but by familiar sentence quantification, as in (11):

(11) **someone in every city despises it**, 10,0

every city **someone in him$_0$ despise him$_0$**

On this derivation *every city* would get scope over *someone* and over the two pronouns, allowing the desired reading. The same considerations apply to a variant of our earlier example (2):

(2') [Some exits from every freeway in a large California city] have signs posting its current population

Here again there is a reading of (2') where *a large California city* binds the pronoun *it*. NP quantification will not apparently give the former scope wide enough to bind the latter; again, S quantification seems required.

An appeal to S quantification for the bound pronoun reading of (1) and (2’) obtains the correct semantic result for these examples, however this move also involves significant problems. Note that while an NP may apparently get scope out of inverse-linked structures in the examples in (1), this is not possible in other cases. For example, in (12) below, where the $[_{NP}$ NP PP] structure appears in object position, no “ 2 ” is available; i.e., no reading whereby every city is such that two politicians (perhaps differing with each choice of city) spy on someone (perhaps differing with each choice of politician) from that city:

(12) Two politicians spy on [someone from every city]

The only sensible reading of (12) appears to be one in which for every city there is someone (perhaps differing with each choice of city) such that two politicians spy on him/her. That is, *every city* can only get scope over *two politicians* if the entire NP containing *every city* together with *someone* does. Analogous remarks apply to (13):

(13) Two engineers repaired [some exits from every freeway in a large California city]

As we observed, a natural reading of this sentence is one in which *a large California city* gets scope over the other quantified NPs in the bracketed string. Notice, however, that there is no reading of (13) in which *a large California city* gets scope over *two engineers* and the other NPs without the latter also getting scope over the former. That is, there is no reading of (13) with order of quantifiers: “for a large CA city x, for two engineers y, for every freeway z in x, for some exits w from z, y repaired w.”

The point of these examples is straightforward: if the bound pronoun reading of (1) and (2’) were provided by S quantification, then we would expect S quantification also to provide the “missing” readings of (12)-(13). Thus in parallel with the derivation in (6), we would expect a derivation as in (8):

(14) **two politicians spy on someone from every city**, 10,0

every city **two politicians spy on someone from him$_0$**, 4

two politicians **spy on someone from him$_0$**

where *every city* is quantified into *two politicians spy on someone from him$_0$*, giving it scope over *two politicians* and *someone*, and where the latter has minimal scope. Such a reading is simply not available however.

An examination of further examples reveals that the scopal restrictions observed in (12)-(13) are in fact quite general – that $[_{NP}$ NP PP] is typically an “island” for quantifier scope. This evidently correlates with the familiar fact that $[_{NP}$ NP PP] is an island for *wh*- movement ((15) = May’s (30a)):

(15) *Which city does [someone from e] despise it?

(16) a. *Which city did two engineers repair [someone exits from every freeway in e]?
b. *Which freeway in a large California city did two engineers repair [some exits from e]?

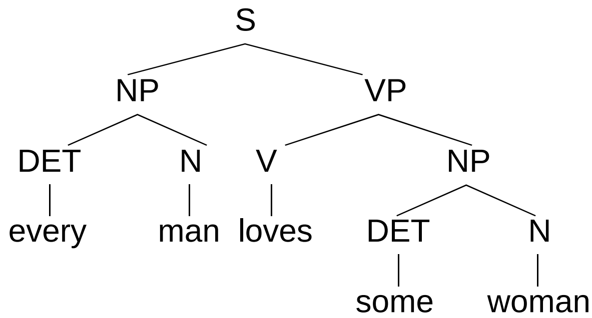
Thus, *wh*-quantification into inverse linked NPs is impossible whether the latter is in subject or object position. The data in (15)-(16) can be brought together with those in (12)-(13) under the reasonable proposal that quantifiers and *wh*-phrases obey similar structural constraints with respect to variable binding – e.g., Subjacency.[3] Binding like that in (14)-(16) will involve quantification which crosses two "bounding nodes" – the S node of the matrix clauses, and the NP node bracketing the $[_{NP}$ NP PP] structure – and hence will be correctly disallowed. Of course if these proposals are adopted then the derivation in (11) will also be disallowed, since it also violates Subjacency. We seem, therefore, to arrive at an impasse: NP quantification results in a scope too narrow to permit pronominal binding in examples like (1) and (2). On the other hand, S quantification requires a scope which is "too wide" – one in which two or more bounding nodes intervene between quantifier and variable.

4.0. A Cooper – Storage Account

The observations in section 3 raise an interesting question: can we give an analysis for (1) which places *it* within the scope of *every city*, allowing it to be bound, but which still respects the island character of $[_{NP}$ NP PP] constructions? What I will show now is that this is possible within an account of quantificational phenomena developed in recent work by Cooper (1978, 1983).

Cooper (1983) presents a treatment of scope ambiguities which is a modification of the account of quantifier scope given in Montague (1974). In the latter the ambiguity of *every man loves some woman* is captured by assigning this sentence two distinct syntactic analysis trees, which receive different IL translations and hence different interpretations. In Cooper's account a single tree is assigned to *every man loves some woman* and the ambiguity is handled by means of two new formal devices: quantifier storage and quantifier retrieval. Thus the sentence is assigned the single phrase marker in (17):

(17)



However when this tree is interpreted (from the bottom up) we have the option of “storing” NP interpretations at the point where we put these together semantically with other sentence constituents.[4] Suppose we begin to interpret (17), starting at the bottom. First we encounter the NP *some woman*, to which we assign the interpretation **some woman**’. When we semantically combine the object NP with the verb, we have the option of storing this interpretation. If we choose not to store it, we obtain the interpretation **love**’(^**some woman**’) for VP, and ultimately arrive at the narrow scope interpretation for S:

(18) **every man**’ (^**love**’ (^**some woman**’))

On the other hand, if we choose to store **some woman**’, then VP receives the interpretation

(19) **love**’ ($^\wedge\lambda P[P\{x_0\}]$), **some woman**’, x_0

where , **some woman**’, x_0 is in store and x_0 is the <u>variable address</u> for **some woman**’. The stored NP interpretation is carried up the tree until it is ultimately retrieved from store at the S node and quantified in. The result is the wide scope interpretation for S:

(20) **some woman**’ ($^\wedge\lambda x_0$[**every man**’ (^ **love**’ ($^\wedge\lambda P[P\{x_0\}]$))]) .

The interpretations in (18)-(20) are identical to those assigned under an account making use of scopally disambiguated syntactic representations such as Montague’s.

The character of certain syntactic configurations as islands for quantifier scope can be accommodated naturally with the storage and retrieval mechanisms available in Cooper’s account. We can view such island constraints as limiting the passage of stored quantifiers upward in the semantic processing of a tree. More precisely, let INT be the function which compositionally assigns interpretations to sentence constituents, and assume that the set of islands can be identified in terms of some set of syntactic nodes I. For our purposes we may let I = {NP,Q,R}, where Q and R are simply [+WH] S’s, the former with an interrogative element in COMP and the latter with a relative pronoun in COMP. Then we can state the following Constraint on Quantifying out of Islands:[5]

Constraint on Quantifying out of Islands: If α is a structural description and α I, then INT assigns no interpretation β' to $[_\beta \ldots \alpha \ldots]$, where $\beta' = \phi\ Q', x_n$, and where $\alpha' = \psi\ Q', x_n$.

Thus if α is an island node with a quantifier Q', x_n in store, CQI forbids Q', x_n from being "passed upward" and becoming a store in the interpretation of a node β which immediately dominates α. The effect of CQI is therefore, in general, to require that all stored quantifiers in the interpretation of an island node be quantified out or "discharged" before that node is combined semantically with another constituent. There is one circumstance under CQI in which a stored quantifier may legitimately pass beyond a bounding node without being discharged. We will see what that circumstance is shortly.

Let us return now to the issue of inverse linking structures. What I would propose is that the data discussed earlier can be handled in a straightforward way if we make two simple additions to the apparatus outlined above: first, we specify that the quantifier store assumed by Cooper is in fact a "push down" device; this allows us to have not only interpretations of the form $\phi,\ Q', x_i$, where ϕ' is the interpretation of some sentence constituent ϕ, but also interpretations $\phi,\ Q',\ Q', x_j\ , x_i$, where Q', x_j is in the store of a quantifier which is itself stored.

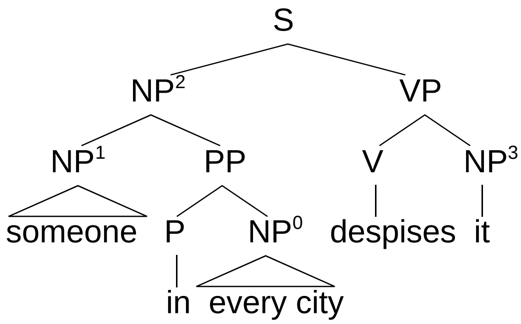
The second modification of Cooper's account is a revision of his rule of quantifier retrieval. This is in order to accommodate stored quantifiers containing stored interpretations of their own:

Quantifier Retrieval (QR): Suppose that S has the interpretation
$\alpha',\ \beta_1', \ldots, \beta_n'$ where β_1' is the stored quantifier
$Q_1',\ Q_2', \ldots\ Q_{m-1}'\ Q_m', x_m\ , x_{m-1} \ldots , x_2\ , x_1$, $1 \leq m$, then S has the interpretation
$Q_m'(\hat{}\lambda x_m [Q_{m-1}'(\hat{}\lambda x_{m-1}[\ldots Q_1'(\hat{}\lambda x_1[\alpha'])\ldots])]), \beta_1', \ldots , \beta_{i-1}', \beta_{i+1}', \beta_n$

QR states that when we are at an S node we are allowed to retrieve a stored quantifier β_i' from the store and quantify it in. Furthermore, QR specifies that if the retrieved quantifier interpretation contains m quantifiers "nested" in its store, then these m quantifiers must also be retrieved and quantified out in the order of their nesting. In the case where β_i' contains no quantifiers in its own store (i.e., where m = 1), then QR simply reduces to Cooper's rule of quantifier retrieval.

To see how these proposals bear on the inverse linking data, consider a by-now familiar example: *someone in every city despises it*, with the constituent structure in (21):

(21)



We interpret (21), again working bottom-up. Beginning with VP, NP^3 will interpret as $\lambda P[P\{x_0\}]$, and V will interpret as **despise**', hence VP will receive the interpretation:

(22) **despise**' $(\hat{}\lambda P[P\{x_0\}])$

Next we consider the constituents of the subject noun phrase. NP^0 *every city* is assigned the interpretation **every city**' (= $\lambda P\ \ x[$**city**'$(x) \rightarrow P\{x\}]$). In combining this NP semantically with the preposition *in* we are free to store or not store **every city**'. If we do not do so, then *every city* will be read narrowly with respect to *someone* and *it* will be unbound. The sentence thus gets the odd reading 'some person who has the property of being in every city despises it,' where the pronoun it refers deictically. Suppose that we do store **every city**'. Then the interpretation of PP is:

(23) **in**' $(\hat{}\lambda P[P\{x_0\}])$, $\lambda P\ \ x[$**city**' $(x) \rightarrow P\{x\}]$, x_0

PP' is then combined with the interpretation of NP^1, (= $\lambda Q\ \ y[$**person**'$(y)\ \&\ Q\{y\}]$). The result is:

(24) $\lambda Q\ \ y[$**person**'(y) & **in**'$(y,x_0)\ \&\ Q\{y\}]$, $\lambda P\ \ x[$**city**'$(x) \rightarrow P\{x\}]$, x_0

the interpretation of NP^2.

Now by assumptions NP is a member of I, the set of island nodes; according to CQI, then, we cannot combine (22) and (24) as things stand, since this would involve the stored quantifier $\lambda P\ \ x\ [$**city**'$(x) \rightarrow P\{x\}]$, x_0 becoming a store in the interpretation of S. As noted earlier, one way to permit combination is to empty the store by quantifying-out *every city*. This will give the latter scope over NP^2 only, and so will not permit binding of the pronoun *it* in the VP. There is another option however. Suppose that instead of quantifying out $NP^{0'}$ we instead store $NP^{2'}$ at the point where the subject noun phrase and the VP are semantically combined. This will yield the following interpretation for S:

(25) $\lambda P[P\{x_1\}]$ $(\hat{}$**despise**' $(\hat{}P[P\{x_0\}]))$, $\lambda Q\ \ y[$**person**'(y) & **in**'$(y,x_0)\ \&\ Q\{y\}]$,
$\lambda P\ \ x[$**city**'$(x) \rightarrow P\{x\}]$, x_0 , x_1

which reduces to:

(26) $\mathbf{despise}'(x_1, {}^\wedge\lambda P[P\{x_0\}]),\quad \lambda Q\ \ y[\mathbf{person}'(y)\ \&\ \mathbf{in}'(y,x_0)\ \&\ Q\{y\}],\quad \lambda P\ \ x[\mathbf{city}'(x) \rightarrow P\{x\}],\ x_0\ ,\ x_1$

Note carefully that the interpretation of S does <u>not</u> inherit the stored NP^0 interpretation here. Instead it receives a store within which the latter is contained. There is thus no violation of the CQI, despite the fact that the interpretation of NP^2 remains undischarged from the store. Under CQI, then, there is one case in which a stored quantifier Q', x_1 may pass beyond a bounding node α, namely, where α is an NP and therefore may itself undergo storage. If α is a stored then Q', x_1 passes upwards as the "store of a store".[6]

The stored quantifier $NP^{2'}$ in the interpretation of S may now be retrieved and quantified in. Since $NP^{2'}$ itself contains a stored quantifier interpretation - viz., $NP^{0'}$ – according to the rule QR we must also retrieve $NP^{0'}$ and quantify it into the outcome of quantifying $NP^{2'}$ into S'. This yields the result in (27):

(27) $\lambda P\ \ x[\mathbf{city}'(x) \rightarrow P\{x\}]({}^\wedge\lambda x_0[\lambda Q\ \ y[\mathbf{person}'(y)\ \&\ \mathbf{in}'(y,x_0)\ \&\ Q\{y\}]({}^\wedge\lambda x_1[\mathbf{despise}'(x_1, {}^\wedge\lambda P[P\{x\}])])])$

After lambda conversion this expression reduces to (28), which is, of course, the desired result.:

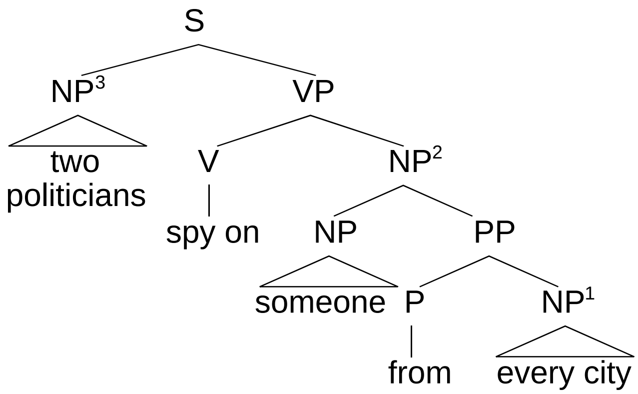
(28) $x[\mathbf{city}'(x) \rightarrow\ \ y[\mathbf{person}'(y)\ \&\ \mathbf{in}'(y,x)\ \&\ \mathbf{despise}'(y, {}^\wedge\lambda P[P\{x\}])]$

An analogous derivation can be given for the more complicated example (2). We store each quantified NP when it is put together semantically with a preposition to obtain PP'. Furthermore, the entire subject noun phrase interpretation is stored at the point where it was combined with VP'. The result is an interpretation for S in which three quantified NPs are stacked in the store. As in the previous example, these quantifiers will be drawn out simultaneously by QR, in the order of their appearance on the stack, and will be quantified-in. The interpretation of VP will fall within the scope of each of the quantified NPs, and thus in particular within the scope of **a large CA city**'. This then allows for the bound reading of *it* in (2').[7]

4.1. Further Consequences

The use of storage and the formulation of CQI allows us to derive the bound pronoun readings of the inversely linked structures (1) and (2'). Note moreover that they do this without also permitting unwanted readings and "Subjacency violations" of the sort discussed earlier. Recall (12) once again, with the structure in (29):

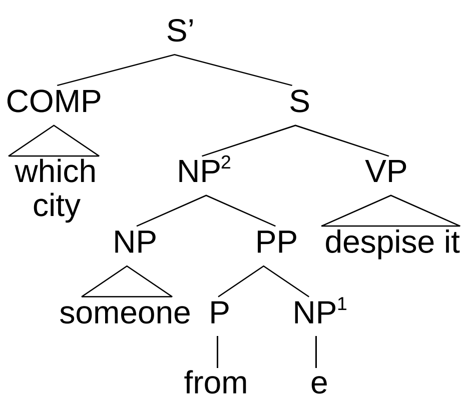
(29)



Under the above account it will correctly turn out that there is no ‘ 2 ’ reading of this sentence. The reason is not hard to see. In order to give *every city* scope wider than *someone* we must store its interpretation; this will yield an interpretation for NP^2 with **every city**’ in store. Now given CQI and the island status of NP^2, it will be possible to carry **every city**’ higher up the tree only if we store $NP^{2'}$ as well. Since we will not be able to draw **every city**’ from store without also simultaneously drawing out **someone (from)**’, it will correctly follow that there is no way to give **every city**’ scope over **two politicians**’ without also giving **someone**’ scope over it as well.

Recall also subjacency violations like (15), with the structure in (30):

(30)



We may follow Cooper in assuming that the processing of a trace $[_{NP}\ e]$ involves the obligatory storage of a pronoun interpretation $\lambda P[P\{z\}], x_1$, which can only be drawn from store at the point where *wh-* is encountered – i.e., at the S’ node. Thus $NP^{2'}$ will contain a stored NP interpretation which can be carried farther up the tree only if the interpretation of *someone from e* is itself stored. However notice now what this entails. We just stipulated that a stored trace interpretation can only be retrieved at S’, yet “normal” quantified NPs like **someone (from e)**’ presumably must be retrieved at S. If we retrieve **someone (from e)**’ at S, therefore, this will (under QR) require a premature retrieval of the trace interpretation. On the other hand to obtain the correct scope for the trace, we would have to delay its retrieval past the point where **someone (from e)**' can be drawn from store. It is reasonable to suppose that in such a situation the processing of (9a) (and similarly (9b,c)) simply blocks. Thus our account correctly observes the island-hood of $[_{NP}$ NP PP] structures.

Finally, note that the account proposed here can accommodate in a natural way a well-known contrast between the scope of quantifiers contained in a relative clause and those contained in PPs:[8]

(31) a. John knows [someone in every city]
     b. ##John knows [someone who is in every city]

As we know, the bracketed NP in (31a), which has the structure $[_{NP}$ NP PP], permits a sensible reading in which the quantified NPs *someone* and *every city* are inversely linked: ‘in every city x there is some person y that John knows,’ etc. On the other hand, (31b) allows no inversely linked reading of the quantifiers; rather it has only the pragmatically bizarre reading where John knows some omnipresent individual. Suppose that the relative clause R node is a member of the set of island nodes I:

(32) $[_{NP}$ $[_{NP}$ someone] $[_{R}$ who is in every city]]

Under standard model-theoretic assumptions relative clauses do not designate quantifiers (i.e., families of sets (cf. Barwise and Cooper (1981)) but rather sets, and so R’, the interpretation of R, will not be able to undergo quantifier storage. It follows, then, that there will simply be no way under the CQI to pass the stored **every city**’ beyond R, hence no way to give it scope wider than **someone**’.

4.2. A Concluding Question

An analysis of inversely linked structures in terms of Cooper storage appears to have the central virtues we were looking for: it preserves the subjacent character of quantifier scope, but at the same time allows pronominal binding in cases like (1) and (2’). Furthermore, the account operates with simple, easily-motivated constituent structures, like that in (21). The basic move which permits this result is to give the Cooper store a “push down” structure.

In concluding, it is worth noting that the modifications to Cooper’s analysis proposed here raise an important question regarding the relation between Cooper’s approach and other competing frameworks. Given the connection between push down automata and context-free grammars it is evident that an account which assumes a context free syntax and a push down scopal interpreter will share many features with an analysis which simply posits two levels of context-free syntactic representation – one corresponding to “surface” syntax and one corresponding to “scopal” syntax.[9] Accounts of the latter variety are of course quite familiar within the framework of the Extended Standard Theory, wherein syntactic representation is assumed to include a level of S-structure and a level of Logical Form. It is conceivable that the two such accounts are equivalent at an appropriate level of abstraction, hence it would be interesting to know whether the treatment of inversely linked NPs in Cooper's system could be shown to <u>require</u> no less than a push down device of the sort proposed above.

Notes

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1. More precisely, I assume (pace Montague (1974)) that prepositions are of category (t///e)/T, i.e., functions from term phrases to set denoting expressions. Furthermore I assume, following Back and Cooper (1978), that noun phrase translations contain a free variable over properties. On the view *some man* translates, not as

(i) $\lambda P\ \ x[\mathbf{man}'(x)\ \&\ P\{x\}]$

as in Montague (1974), but rather as

(ii) $\lambda P\ \ x[\mathbf{man}'(x)\ \&\ R\{x\}\ \&\ P\{x\}]$

(ii) can be rendered "the sets of properties P such that some x who is a man and has the property R has P." The rule for translating $[_{NP}$ NP PP] makes use of the R variable:

(iii) $[_{NP}\ NP^{1}\ PP\ ]$ translates as $\lambda R[\ NP^{1'}\ ](\hat{}PP')$

Thus as in Bach and Cooper's treatment of restrictive relative clauses, PPs can be viewed as supplying the value of the variable R over properties.

In deriving the formulae in (6)-(9) I also assume meaning postulates (similar to MP8 in PTQ (Montague, 1974)) which guarantee the extensionality of prepositions like *in* and *from*.

2. Bach and Partee (1980) suggest that *it* is not in fact bound by the embedded quantifier in examples like (1) and (2) but rather is a "donkey pronoun". However, May (1985) points out that the claim that *it* is bound in (1) and (2) is supported by facts concerning so-called "sloppy identity". Reinhart (1983) has observed that sloppy identity is possible only in structures permitting bound anaphora. Thus in (i) (= (20a) in Reinhart (1983), p.153)), there is a reading in which Zelda bought Felix a present on his, Felix's, day. On the other hand no such sloppy reading is available in (ii) (= (20b) in Reinhart (1983)):

(i) Zelda bought <u>Siegfried</u> a present on <u>his</u> wedding day, and Felix too (i.e., she bought Felix … too)

(ii) Zelda thought about <u>Siegfried</u> on <u>his</u> wedding day, and about Felix too.

This correlates with the fact that bound anaphora is much more available between the indicated positions in (i)/(iiia) than in (ii)/(iiib):

(iii) a. Zelda bought <u>every man</u> a present on <u>his</u> wedding day
b. ??Zelda thought about <u>every man</u> on <u>his</u> wedding day

Consider now (iv) (= (29) in May (1985)):

(iv)Nobody from New York rides its subway, but everyone from Tokyo does

(iv) permits a sloppy reading of the pronoun, such that Tokyo inhabitants ride their own city's subways. This argues that NPs in the PP object position of a $[_{NP}$ NP PP] structure can indeed bind a pronoun in VP, when this structure appears in subject position.

3. The relation between scope of quantifiers and *wh*- has been discussed by Bach and Partee (1980), Chomsky (1981), Higginbotham (1980), May (1977, 1985), Reinhart (1979, 1983), Rodman (1976), among others.

4. I depart here in various ways from Cooper's account of quantifier storage, both for simplicity of presentation and for reasons of substance. I assume that storage is performed as part of the semantic rules which assemble the interpretations of co-constituents. Under this present analysis, the grammar will contain interpretation pairs of the form:

$[_S$ NP VP] interprets as:

(i) a. NP' (^VP') , or
b. (^λP[P{x_n}](^VP'), NP', x_n

and
$[_{PP}$ P NP] interprets as:

(ii) a. P' (^NP') , or
b. P' (^λP{x_n}]), NP', x_n

The 'b.' members of (i) and (ii) are assumed here to be generated by means of a metarule on interpretation rules which takes the 'a.' members as input. Cooper (1983) does not assume pairs as in (i) and (ii), but rather a separate semantic rule of NP storage, unconnected with any syntactic rule. The difference is important with respect to the exact formulation of the 'island conditions' for quantification adopted here (see below and fn.6).

5. This diverges from Cooper's statement of the CQI, which is reproduced (in it essentials) below:

> <u>CQI</u>: If α is a structural description which is an island, then INT(α) does not yield any interpretation with a binding operator in its store.

This version of CQI appears problematic, even within the context of Cooper's own analysis. Consider interrogatives. *Wh*-clauses are well-known barriers for extraction:

(i) a. *?What did you ask who to buy e?
    b. *?Where did you wonder who left the car?

This leads us to classify interrogatives Ss ('Q's in Cooper's syntax) as islands with respect to CQI (i.e., Q   I). However the treatment of multiple interrogation in Cooper (1983) requires iterated retrieval of stored *wh*-operators from a Q node, which means that multiple question interpretation must always involve the interpretation of a Q node with a binding operator in store, contra CQI. Thus Cooper's own treatment of multiple *wh*-questions runs afoul of his CQI. Furthermore, as we will see, it is important to the account of inversely linked NPs suggested here, that INT assign an interpretation to NPs with a quantifier in store. Given the status of NPs as bounding nodes – i.e., as islands – this would be prohibited under Cooper's CQI.

6. This entails that stored Qs won't be able to pass beyond a non-NP island node α, even as the "store of a store" since α' itself won't be able to undergo storage. (see discussion of (31)).

Notice now the importance of assuming that storage occurs as part of the rules which semantically combine NPs with other sentence constituents (cf. fn.4). If storage occurs at NP nodes (as in Cooper's (1983) analysis), then the interpretation of NP^2 with subject in store would be:

(i) $\lambda P[P\{x_1\}]$, $\lambda Q\ \ y[\mathbf{person}'(y)\ \&\ \mathbf{in}'(y,x_0)\ \&\ Q\{y\}]$, $\lambda P\ \ x[\mathbf{city}'(x) \rightarrow P\{x\}]$, x_0 , x_1

The CQI stated in the text would prohibit the store in (i) from being passed to S, since NP is an island node. Hence the interpretation for S in (25) would simply be impossible. However if storage occurs at the point where NP is combined with VP, then there is nothing in the store at the NP^2 node which is passed up to the store of S; storage occurs "after" the interpretation of NP^2 is calculated.

7. It is interesting to explore how this storage analysis would be translated into a more standard Montague grammar account (e.g., one like that found in PTQ). Essentially,

what is required is a meta-rule for producing certain derived quantificational rules from rules which put NPs together with other constituents. This is best clarified by means of examples. Consider the by-now familiar (1) under the reading where **every city**' binds *it*. This sentence can be derived by means of the quantificational rule in (i):

S4.' If α, β P_T and γ P_{IV}, then $F_{10, n, 4}(\alpha,\beta,\gamma)$ P_t, where $F_{10, n, 4}(\alpha,\beta,\gamma) = F_4(F_{10, n}(\alpha,\beta), \gamma)$

The corresponding translation rule is T4' (where g is Montague's translation function):

T4.' If α, β, γ translate into α', β', γ' (resp.), then $F_{10, n, 4}(\alpha,\beta,\gamma)$ translates into $g(F_{10, n}(\alpha, g(F_4(\beta, \gamma))))$

In view of the definition of g, the latter amounts to:

$$\alpha'(\hat{}\lambda x_n[\beta'(\hat{}\gamma')]).$$

S4' allows the following derivation tree for the sentence in question:

Someone in every city despises it, 10, 0, 4

every city **someone in him$_0$** **despises him$_0$**

⋮ ⋮ ⋮

The NPs *every city* and *someone in him$_0$* are put together simultaneously with the verb phrase *despise him$_0$*, such that the first is inserted into the second and the resulting expression then combined with the third according to F4. Under the translation rule T4 (taken together with the stipulations regarding PP in fn.1), the above example is assigned the translation in (28), the desired result.

In a completely analogous way the bound pronoun reading of (2') would involve an operation "$F_{10, n, 10, m, 4}$" on three term phrases and an IV phrase, and a rule S4" making use of the $F_{10, n, 10, m, 4}$ operation. This rule would insert *a large CA city* into *every freeway in him$_0$*, then insert the result into *some exits from him$_1$*, then combine the outcome with the VP according to F4:

some exits from every freeway in a large CA city have signs posting its current population, 10,0,10,1,4

a large CA city **every freeway in him$_0$** **some exits from him$_1$** **have signs posting his$_0$ current population**

The translation rule T4" would quantify the interpretations of *a large CA city* and *every freeway in him$_0$* into the sentence produced by combining *some exits from him$_1$* with the VP *have signs posting his$_0$ current population*.

This account has some of the virtues of the storage analysis. In the sequence of operations which assemble the sentence together, no quantifier is lowered past more than one "bounding node". The rules thus correctly fail to produce the readings discussed in connection with (12)-(13). Furthermore, such rules do not involve unmotivated constituent structure. This latter claim may appear dubious at first blush since the derivation trees above seem to involve constituent structures in which 3 or 4 expressions (resp.) are equally sisters under S. This is an illusion however. If we allow syntactic rules to enclose phrases of category XP in labeled brackets, then the first tree above has the derivation below:

$[_S$ $[_{NP}$ Someone in $[_{NP}$ every city]] $[_{VP}$ despises it]], 10,0,4

$[_{NP}$ every city] $[_{NP}$ someone in him$_0$] $[_{VP}$ despises him$_0$]

⋮   ⋮   ⋮

where the top node receives a standard constituent structure. Finally, the quantification rules S4', S4", … are all derivable from S4 in a recursive way, so their production can be handled by means of a meta-rule on the basic rules in a PTQ-style fragment which involve term phrases. The chief drawback of this Montagovian approach is that such a meta-rule will (and indeed must) produce an infinite number of rules in order to accommodate the recursive embedding of $[_{NP}$ NP PP] structures.

8. The contrast in (31) was first noted (to my knowledge) in Rodman (1976) on the pair of examples:

(i) a. Guinevere has a bone in every corner of the house
    b. G. has a bone which is in every corner of the house

As Marcia Linebarger has pointed out to me, however, this pair does not in fact make Rodman's point since it is dubious that NP and PP in (ia) form a constituent. Unlike normal NP modifiers the PP in (ia) freely preposes: *in every corner of the house G. has a bone*. Compare this with **about every author John wrote a book*, where PP is an undoubted NP complement.

9. It has been suggested to me by James Higginbotham (p.c.) that the two accounts might be separated on the basis of their treatment of the "island violations". These are ruled out on semantic grounds in Cooper's analysis, but would be ruled out on syntactic grounds in an account appealing to LFs. Higginbotham points out that the very ability of speakers to assign a semantic interpretation to sentences which violate island constraints constitutes an argument against viewing the latter as constraints on interpretation. Such an ability seems more comensurate with the idea that island violations are syntactically ill-formed, but semantically interpretable.

This argument, while important in my view, cannot be held decisive in the absence of a general theory of sentence processing and the resources upon which it might draw. We do not know pre-theoretically what conceptual resources are brought to bear in interpreting examples like (i):

(i) What do you know the man who stole?

It is conceivable that such sentences do indeed run afoul of the semantic processor and are interpretable only by appeal to extra-linguistic inferential abilities and the listener's meta-grammatical knowledge about the structure and interpretation of relative clauses and questions. Without a general theory of sentence processing the import of "ungrammatical" examples and their interpretation thus seems quite unclear.

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