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## SOME PROBLEMS ON THE DESCRIPTION OF RELATIVE CLAUSE CONSTRUCTIONS IN MONTAGUE GRAMMAR

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0. A fairly new approach has been taken within the last decade in compositional semantics to analyze relative clause constructions as in the work of Cooper(1975), Bach & Cooper(1978), Gazdar(1981), and Janssen(1981, 1983).

Preceding these works, Partee(1972) argued that a CN-S analysis, rather than an NP-S analysis or a Det-S analysis, could provide a better basis for the semantic interpretation of relative clause constructions.

Rejecting the conclusion reached by Partee, Cooper(1975) and Bach & Cooper(1978) suggested the possibility of using the NP-S analysis. They assumed every NP to contain in the translation level a free variable R which denotes a property. By substituting this free variable R for the meaning of the relative clause, the meaning of the whole nominal is obtained. They claimed this NP-S analysis would allow us to give an adequate semantic description of relative clauses of English, as well as of Hittite, in a unified way.

Although slightly different in detail, Gazdar(1981) follows essentially the same NP-S analysis introduced by Cooper and Bach & Cooper. All NPs and all relative clause sentences are assumed to contain a free variable R.

Based on his "variable principle", Janssen(1981, 1983) claimed that any logical variable should be introduced into the translation level as the translation of some syntactic variable. He assumed a syntactic variable of  $\text{kind}_n$  in the syntactic generation of the head NP as the subcategorization of the CN phrase. This syntactic variable of  $\text{kind}_n$  translates into the logical variable  $K_n$ . Using this free variable  $K_n$ , Janssen examined various analyses to see whether the framework of Montague compels us to a specific choice for the syntactic analysis for restrictive relative clauses.

In what follows I would like to examine the validity of assuming these free variables R, R, or  $K_n$ , and point out some problems underlying these assumptions.

1-1. As is well known, every NP was assumed to denote a set of properties in the original Montague

version. Under this assumption it became possible for us to deal with proper nouns and quantified nouns in a unified way. In addition to Montague's assumption, Cooper and Bach & Cooper assumed that every NP contained a free variable R which denotes a property. They introduced this free variable R in order to deal with the lexical ambiguity of the NP which defined by the context of use.

In the compositional semantics, as Janssen pointed out, there is a restriction on the translation of lexical elements and on the translation rule. That is to say, a syntactic variable translates into an expression which contains a free occurrence of a logical variable and this is the only way to introduce a free occurrence of logical variable.

The free variable R introduced by Cooper and Bach & Cooper, however, is a logical variable which does not have any corresponding syntactic counterpart. What is more, they did not make it clear where this free variable R comes from, at which stage it is introduced, or by which syntactic rule.

This approach of Cooper and Bach & Cooper shows a strange inconsistency with respect to the occurrence of this free variable within NPs. Some NPs(such as head NPs) do not have any constituent element which has the free variable R, while other NPs(such as relative clause nominals) do have a constituent element which has the free variable R. For example, the relative clause nominal every man who loves Mary has a free variable which comes from one of its constituents who loves Mary, while the head NP every man has a free variable which comes not from any of its constituents.

Another kind of inconsistency with respect to the assumption of this free variable exists. In their formulations, Cooper and Bach & Cooper assumed every relative clause sentence to denote a property and to be translated into an expression which contains the free variable R. But this assumption was not extended to elements with other syntactic categories which are assumed to denote properties(e.g., CN, ADJ, IV, etc.). These elements, though they function differently syntactically, function semantically in the same way, denoting properties. They did not give any explicit reason for assuming the free variable R only to relative clause sentences, but not to the other property-denoting elements.

1-2. In these respects, the formulation given by Janssen(1981, 1983) seems much more reasonable, since he introduces the syntactic variable of kind<sub>n</sub> which corresponds to the semantic variable  $K_n$ . Janssen assumed this syntactic variable of kind<sub>n</sub> to be combined with a CN to yield another CN phrase.

In my opinion, however, the concatenation operation of the syntactic variable of kind<sub>n</sub> with the CN seems to involve a contradiction at the semantic level as well as at the syntactic level. This is

because the semantic type  $t/e$  of the CN and the semantic type  $t/e$  of the syntactic variable  $\underline{\text{of kind}}_n$  cannot be combined in the compositional semantics to yield the resulting semantic type  $t/e$  of the new CN phrase except by the conjunction operation — and clearly, this is not a case of conjunction. If the result of the concatenation is another CN phrase of semantic type  $t/e$ , then the semantic type of the variable  $\underline{\text{of kind}}_n$  should not be  $t/e$  as Janssen assumed, but should be  $t/e / t/e$ . This is not the type of properties but of functions from properties to properties. Therefore, the translation of the syntactic variable  $\underline{\text{of kind}}_n$  should not be  $K_n$  of semantic type  $t/e$ , but should be  $\widehat{P} \widehat{y} [P(y) \wedge K_n(y)]$ , of semantic type  $t/e / t/e$ . The syntactic category given to the syntactic variable  $\underline{\text{of kind}}_n$  should not be Prop, but should be something like Prop/Prop.

Let me make this point a little bit clearer by considering the different uses of an adjective in the following examples (1) and (2).

(1) every young man

(2) every man who is young

The adjective young in (1) is attributive and its syntactic category is CN/CN, of semantic type  $t/e / t/e$ . On the other hand, the adjective young in (2) is predicative and its syntactic category is ADJ, of semantic type  $t/e$ . Note that these two kinds of adjective should not be translated into the same logical expression young', since their semantic types are different. The logical expression young', always appears in the translation level as a predicative of semantic type  $t/e$ . So the translation of the attributive adjective young should receive the different translation other than young'. Probably it would be something like  $\widehat{P} \widehat{y} [P(y) \wedge \text{young}'(y)]$  of semantic type  $t/e / t/e$ , since this will give us a desirable translation  $\widehat{y} [\text{man}'(y) \wedge \text{young}'(y)]$  by combining with the CN man. Note that the logical expression young' in  $\widehat{y} [\text{man}'(y) \wedge \text{young}'(y)]$  is not the immediate translation of the attributive adjective young in (1), but a part of the translation. The attributive adjective young in (1) never translates into the logical expression young'.

Now let us get back to the syntactic variable  $\underline{\text{of kind}}_n$  which Janssen assumed. This syntactic variable is attributive in the same sense as the adjective young in (1) is — that is to say, an element that combines with the CN to yield another CN phrase. Instead of giving this attributive variable the translation  $K_n$  of semantic type  $t/e$ , Janssen should have given the translation  $\widehat{P} \widehat{y} [P(y) \wedge K_n(y)]$ , of semantic type  $t/e / t/e$ , since the logical variable  $K_n$  is nothing but a part of the translation of the syntactic variable  $\underline{\text{of kind}}_n$ . Janssen's misunderstanding lies in his translation of the attributive syntactic variable  $\underline{\text{of kind}}_n$  into the logical variable  $K_n$ .

Since Janssen substitutes this syntactic variable  $\underline{\text{of kind}}_n$  for the relative clause sentence, this problem shown above has an immediate relation to another, namely, his assumption that the relative

clause sentence denotes a property. But, as the syntactic variable of kind  $\underline{\text{kind}}_n$  has the semantic type  $t/e$  /  $t/e$ , so, at any stage of generation, it can never be substituted for the relative clause sentence, which is assumed to denote a property and to have the semantic type  $t/e$ . The only case we can substitute is when we assume the relative clause sentence to denote a function from properties to properties and to have the semantic type  $t/e$  /  $t/e$ . In fact, I assume so in order to treat (1) and (2) in a unified way to yield the same translation as in (3).

$$(3) P \forall x [ \text{man}'(x) \wedge \text{young}'(x) \rightarrow P(x) ]$$

1-3. Not only Janssen but also Cooper, Bach & Cooper, and Gazdar all assumed relative clause sentences to denote a property of semantic type  $t/e$ . This assumption originally came from the relative clause constructions in Hittite language. Judging from the data given by Cooper and Bach & Cooper, the relative clause sentence of Hittite certainly seems to denote a property. For, unlike English, the Hittite relative clause sentence, which occurs in front of the main clause, has the CN within it. This CN within the relative clause sentence might correspond to the antecedent of English relative clause sentence. This means that the relative clause sentence of Hittite corresponds to the relative clause sentence plus the antecedent CN in English, which denote a property when combined together. This is the reason why I claim that relative clauses in English denote functions from properties to properties.

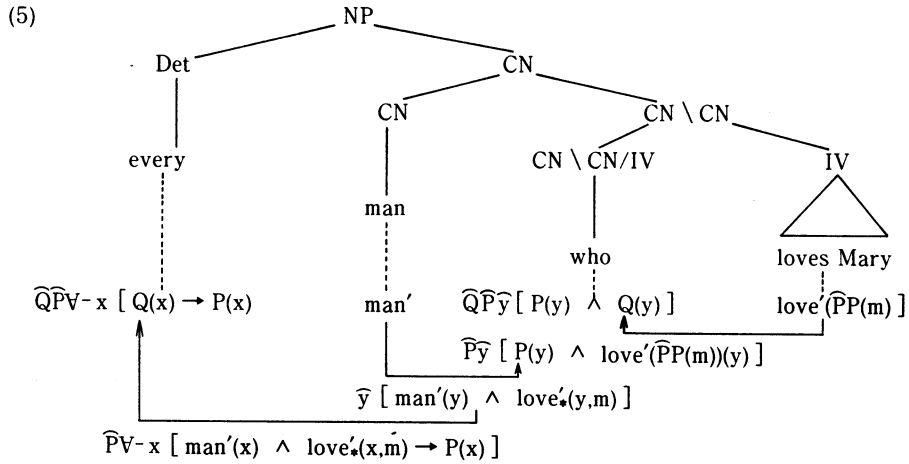
When we use concatenation to analyze Hittite relative clauses, the only problem left to be resolved is that of discrete constituents which involve the combination of the relative clause sentence with the determiner in the main clause. My investigation has not yet reached the point where the discussion is useful, but I think it might be helpful to use the functional notation which was suggested in Hayashi(1982) or the ortax notation proposed by Hausser(1982).

2. So far we have seen some problems of assuming free variables  $R, R,$  or  $K_n$  in relative clause constructions. Underlying these assumptions there is another common assumption that relative clauses in English are property-denoting as well as those in Hittite. But, as shown above, there seem to be other reasons to believe that relative clause sentences of English are of the kind that denotes a function from properties to properties. The idea might remind us of Partee's CN-S analysis which combines the CN with the relative clause sentence, but recall that Partee took the relative clause sentence to be property-denoting(or class-denoting).

In my analysis, the relative pronoun translates into something like  $\widehat{Q} \widehat{R} \widehat{y}$  [  $P(y) \wedge Q(y)$  ] whose syntactic category is  $CN \setminus CN/IV$  and whose semantic type is  $t/e \setminus t/e / t/e$ . (Note that the

slash notation is based on the bidirectional functor analysis.) Thus, for example, the relative clause nominal (4) will be analyzed and translated into as shown in (5).

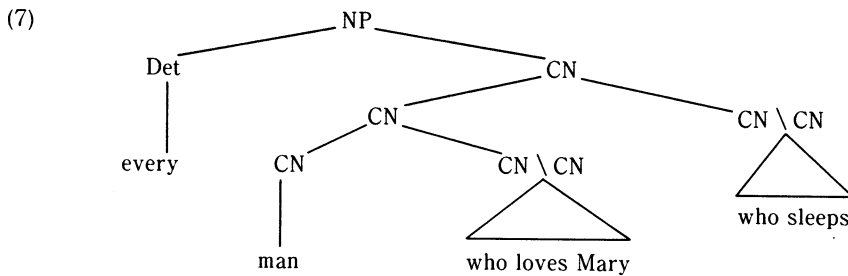
(4) every man who loves Mary



Note that the relative clause sentence who loves Mary is analyzed as a kind of adjectival phrase which denotes a function from properties to properties. Its semantic type is  $t/e \setminus t/e$ .

Suppose we are to interpret a structure such as (6) in terms of this CN-CN \ CN analysis, we can analyze the structure as in (7) and give its interpretation as in (8).

(6) every man who loves Mary who sleeps



(8)  $\widehat{PV}-x [\text{man}'(x) \wedge \text{love}'_*(x,m) \wedge \text{sleep}'(x) \rightarrow P(x)]$

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