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DEPENDENCY AND COÖRDINATION IN THE GRAMMAR OF DUTCH AND ENGLISH

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It is argued that a wide range of extraction and coördination phenomena in English can be accounted for by a simple extension of Categorial Grammar. The same extension will account for a similar range of related phenomena in Dutch, including certain notorious cases of 'intersecting' dependency among discontinuous constituents of Dutch infinitival complements. Some universal implications of the theory are considered, and the relation of such grammars to processors which carry out incremental semantic interpretation is discussed.*

Categorial Grammar (CG)—as originally proposed by Ajdukiewicz 1935, Lambek 1961, Bar-Hillel et al. 1960, Lyons 1968 and others—is simply an alternative formalism for context-free (CF) grammar, although it uses a comparatively unfamiliar notation which distinguishes constituents as functions and arguments, and includes operations of functional application for combining the two. A number of extensions to the basic form have been proposed in order to accommodate the vagaries of natural language grammars, some involving more or less orthodox transformations (Lewis 1970, Partee 1975), others using less familiar devices (Geach 1972, Bach 1979, 1980). To account for extraction and unbounded dependencies within CG,[1] Ades & Steedman 1982 (written in 1979; hereafter A&S) proposed to augment the basic CG apparatus with operations of functional composition. In §1 below, I revise this proposal, and extend the analysis to English coördinate constructions.

Intersecting or 'crossed' dependencies arise when the elements of a discontinuous constituent (such as a relative pronoun and the verb that governs it in a relative clause) are intercalated in the surface string with elements of another discontinuous constituent. CF grammars are not capable of capturing these dependencies with strong adequacy. The phenomenon is therefore important to linguists in choosing among the various available extensions to CF grammar. Interestingly enough, crossed dependencies remain in a distinct minority—a

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[1] Terms drawn from transformational theory, such as 'extraction' and 'movement', are only used descriptively, and have no theoretical significance.

fact which prompted Fodor 1978 to propose a 'Nested Dependency Constraint' on natural languages, and which A&S took as evidence that natural language grammar is some rather minimal generalization of CF grammar. The question of whether all natural languages happen to be CF in the technical (weak) sense remains open (cf. Pullum & Gazdar 1982); but many of them undoubtedly include constructions with intersecting dependencies. An example that has recently received considerable attention arises in Dutch infinitival complement constructions, illustrated by the following subordinate clauses:

(1) a. ... *omdat* *ik*$_1$ *Cecilia*$_2$ *de nijlpaarden*$_2$ *zag*$_1$ *voeren*$_2$.
because I Cecilia the hippos saw feed
'... because I saw Cecilia feed the hippos.'

b. ... *omdat* *ik*$_1$ *Cecilia*$_2$ *Henk*$_3$ *de nijlpaarden*$_3$ *zag*$_1$ *helpen*$_2$ *voeren*$_3$.
because I Cecilia Henk the hippos saw help feed
'... because I saw Cecilia help Henk feed the hippos.'

The subscripts indicate the dependencies between NP's and verbs that are generally assumed to be represented in the semantics of these sentences, as reflected in deep structure or the equivalent. The construction (which is commonly used) will be examined in detail below; but note that, although some dialects allow variation in the order of the verbs (Evers 1975, Zaenen 1979), the above are preferred and in most cases obligatory. The phenomenon is therefore of intense interest, both because of its strength and because it arises in a language so closely related to English, for which most formal systems of grammar have first been developed. In §2 below, I show that the theory proposed in §1, to account for extraction and coördination in English, will also account for the Dutch crossed dependencies, and for the (somewhat different) possibilities for extraction and coördination that Dutch allows.

This proposal constitutes a theory of competence grammar in the orthodox sense; therefore it does not stand or fall on considerations of computational complexity and efficiency, of chronometric psycholinguistic evidence, or of strategies for limiting the computational explosion of proliferating analyses which result from local ambiguities. Berwick & Weinberg 1982, 1983 have shown at some length that the relation between grammars and algorithms which parse according to them can, in principle, be so obscure that no competence grammar whatever could be confirmed or ruled out by such evidence. The adequacy with which the theory accounts for grammatical phenomena of dependency and coördination in the languages under consideration remains the ground on which it must be judged.

Nevertheless, as Bresnan & Kaplan 1982 point out, a grammar which is adequate in this respect is at an advantage in terms of parsimony (particularly when child language acquisition and evolution are considered) if its rules are also directly compatible with the operations of a processor—regardless of the particular mechanism that it may use to resolve local ambiguities as to WHICH rule to apply. The working assumption that natural language grammars are of this kind is referred to by them as the 'strong competence hypothesis'. The present theory actually exacerbates the degree of local ambiguity in the grammar, because of the unorthodox view of surface syntax that it embodies. However, the details of this unorthodox syntax, plus the fact that it has a compositional semantics, mean that the rules of the grammar can be seen as corresponding directly to the operations of a processor which builds semantic interpretations incrementally, word by word, interleaved with syntactic analysis. Marslen-Wilson & Tyler have argued in a number of papers (e.g. 1980) that incremental interpretation is characteristic of the human sentence processor; Crain 1980, Crain & Steedman 1982, and Altmann 1985 have suggested that it is a powerful influence in the resolution of local ambiguities. The fact that a grammar is directly compatible with incremental semantic interpretation may therefore be an important criterion of its psychologically explanatory qualities.

The argument will proceed as follows. In §1, I am solely concerned with the grammar of English. I begin by reformulating and extending the earlier analysis of unbounded leftward extraction, developing an improved categorial notation. The implications of the theory for the notion of surface structure are then discussed, together with certain implications for the psychological sentence processor under the strong competence hypothesis. The analysis is then shown to explain a range of coördination phenomena, all of which are brought within the domain of simple constituent coördination without deletion. The theory thus captures and extends an insight of G[eneralized P[hrase] S[tructure] G[rammar] (cf. Gazdar 1981) concerning the relation of unbounded dependency and coördinate structure. This sets the stage for §2, in which the theory is applied to the Dutch infinitival construction and some related problems in the syntax of Dutch (and, by implication, German). In §§2.1–2.2, I show that a grammar confined to the same kind of rules as are required for the English fragment not only allows crossed dependencies in a language like Dutch, but actually demands them. The rule corresponding to functional composition plays a crucial role in this grammar. In §§2.3–2.4, I extend the analysis to cope with the possibilities for extracting NP's and other preverbal complements from this and other Dutch constructions. The theory is then shown to account for a wide range of Dutch coördinate constructions using exactly the same rule of simple constituent coördination that was advanced for English in §1. A number of coördinate structures that have frequently been assumed to demand some kind of backward gapping are also shown to reduce to simple constituent coördination. The proposal of Maling 1972 concerning the relation of so-called backward gapping and right-node raising in Germanic languages is thus captured in non-transformational terms, and the earlier generalization relating unbounded dependency and coördination is extended to a single principle of grammar. In §3, I examine the possible universal implications of the theory. I argue that the observed rarity of crossed dependencies is to be expected within the present theory—given some well-known, independently motivated, cross-linguistic generalizations concerning the form of natural grammars. An equally well-known generalization concerning the relation of gapping and the order of constituents in natural languages, derived from Ross 1970 as modified by Maling, is also explained by the theory; this implies that the devices exploited in the grammar of Dutch may be related to grammatical case, and may be widespread among verb-final languages.

English

1.1. Augmenting Categorial Grammar using functional composition. A categorial grammar of the present kind consists of two components. The first is a categorial lexicon—which, in A&S and the present paper, is order-free. The second component consists of a small number of phrase structure (PS) rule schemata, called 'combination rules' because of their direct relation to the operations of a 'Shift and Reduce' parser (see A&S, and Aho & Johnson 1974). In A&S and the present paper, it is the combination rules which bear the responsibility for defining the linear order of constituents. In the following paragraphs, I will summarize the earlier proposal, revising it in a number of respects.

1.11. The categorial lexicon. The categorial base is defined as a lexicon, in which each entry includes a 'category', defining the kind of constituent (if any) with which the word in question can combine and the kind of constituent that results. The category of a pronoun like *me* or *that* is simply NP. The category of a transitive verb like *eat* is written VP/NP, identifying it as combining with an (object) NP to yield a VP. Similarly, the category of a ditransitive verb like *give* is (VP/NP)/NP: something that combines with an (indirect object) NP to yield something which still needs an (object) NP to yield a complete VP.[2] (Naturally, any word, including the verbs mentioned above, may have more than one lexical entry.)

Items having categories of the form X/Y, (W/X)/Y etc. are to be thought of as functions over Y. Thus the category VP/NP of transitive verbs identifies them as functions from NP's into VP's; and the category (VP/NP)/NP of ditransitive verbs identifies them as functions from NP's into functions-from-NP's-into-VP's. Such functions can be thought of as mapping between entirely syntactic domains. However, the categories can also be thought of as a shorthand for the semantics of the entities in question. Although I will here remain entirely uncommitted concerning the nature of the semantic representations of the categories themselves (as opposed to the combination rules), the assumption is parallel to the basic 'rule-to-rule' notion prevalent in Montague Grammar (cf. Bach 1980): syntactic rules and categories have a functional correspondence with rules of semantic interpretation. The shorthand in question is very elliptical, in the interests of simplifying the syntactic rules. For example, we would probably want to consider the category VP as representing a semantic predicate; this could be more directly represented as a function of the form S/NP from (subject) NP's into (some infinitival variety of) S, as in the treatment of Dutch infinitivals below. However, it is assumed that the semantic categories are related to the syntactic ones under the more restricted version of the rule-to-rule relation which Klein & Sag 1984 have called 'type-driven translation'.

[2] In earlier presentations of this theory, a convention was adopted that (in the absence of brackets explicitly indicating the contrary) slashes were 'associated to the left'; categories like the above were thus written VP/NP/NP, leaving the bracketing implicit.

The function categories can therefore be thought of as mapping between semantic representations. It is further assumed that it is this semantic function which defines the functional role of its argument; e.g., it is the semantics of a ditransitive verb (VP/NP)/NP which means that the first argument with which it combines is the indirect object, while the second is the direct object.[3]

The categories that are used in this and the earlier papers (like those used by Cresswell 1973, but unlike those of Bach 1983), do not define the linear order of function and argument. The other component of the grammar—the combination rules—is used here to define the legal orders for the language. Four very simple types of combination rule will be considered here (three of them were used in the original proposal for English). The first two rules allow the simple combination of a function with an argument to its right and to its left, respectively. The semantics of these rules is simply the application of the corresponding semantic function to the semantic representation of the argument term.

1.12. TWO RULES OF FUNCTIONAL APPLICATION. The first rule of functional application allows a function to combine with an argument immediately to its right:[4]

(2) Forward Combination
$$X/Y \ Y \Rightarrow X$$

In this and all the rules that follow, X, Y, Z ... are to be read as variables which match any category. The categories in question are often basic ones (e.g. NP, VP, S etc.), but they may also be functors, like VP/NP.

In the example of Figure 1, the VP's are each accepted by two successive forward combinations. Combination of two entities is indicated by a solid line indexed with the initial(s) of the rule, with the resulting category written underneath. In Fig. 1a, the categories which match X and Y of Rule 2 are atomic. In Fig. 1b, X matches VP/NP in the first combination.

```
a.  Eat     the    cake        b.   Give         me   that.
    -----   -----  ----             -----------  ---  ---
    VP/NP   NP/N   N                (VP/NP)/NP   NP   NP
            -----------F            ----------------F
                NP                      VP/NP
    -------------------F                 ------------------F
         VP                                   VP
```

FIGURE 1.

[3] This treatment differs from the related categorial analyses of Dowty 1978, 1982 and Bach 1979, according to which ditransitives are functions which first combine with their DIRECT object, via a discontinuous combination rule of 'right wrap'. The present analysis therefore implies a rather different passivization rule, defining a passivizable object as an NP which is the first argument of the verb. A referee has pointed out the violence that such a treatment does to the relational hierarchy, and the fact that it implies a different analysis from Bach's (1980) concerning the difference in passivizability of *promise* and *persuade*.

[4] Because of the omission of the left-association convention that was used in earlier presentation (cf. fn. 2), the notation of this and the other combination rules is simpler than in other presentations. The notations are formally equivalent.

Such diagrams are in every way equivalent to the more familiar trees associated with PS grammars. Since it is assumed that the categories directly mirror the semantics, the combinations can also be considered as operating directly on these semantic entities to map them into other semantic entities. The point is uncontroversial: any grammar with a rule-to-rule relation between syntax and semantics could be thought of in the same way.

The question of how a subject and a tensed VP can combine to give a sentence is a complex one, and it is far from obvious what categories the subject and the verb should bear. (Cf. Steedman 1983b, hereafter CSST; Schmerling 1983 and Jowsey 1984 also offer proposals for English auxiliaries which are compatible with the present grammar.) For present purposes, I shall assume an analysis related to that of Montague 1973 (the 'PTQ analysis'), according to which all tensed verbs are functions yielding the category FVP (for Finite Verb Phrase), while all subjects bear the category S/FVP—a function over finite VP's into S.[5] Under this analysis, the sentence *He left* is accepted by a forward combination, as in Figure 2.

```
  He     left.
------  ----
S/FVP   FVP
-----------F
     S
```

FIGURE 2.

The assumption of these categories leaves many questions unanswered—in particular, the problems of subject/auxiliary inversion and subject extraction. However, these questions are not relevant to the present purpose; in all the examples discussed here, the PTQ analysis is consistent with the fuller proposals. The question of how the subject acquires the category S/FVP is similarly left open. In a predominantly cased language like German, it would be reasonable to suppose that a nominative article, like *der*, bears the category (S/FVP)/N—a function over nouns into the novel subject category. The subject NP *der Mann* would then acquire its category by the combination rules in the normal way. (Non-cased languages like Dutch and English would of course need ambiguous lexical categories for such entities.) Alternatively, a 'substitution rule' could be included among the combination rules, and could on occasion replace the category NP by S/FVP. These solutions are equivalent for present purposes. Neither compromises compositionality of the semantics, although both appear to induce problems for the ambiguity-resolving mechanism during parsing.

[5] This is not the analysis proposed by A&S, and it is a simplification of the CSST proposal. However, all examples used in the present paper are consistent with the fuller analysis, and with Schmerling's analysis. It is assumed that the category FVP is, like the category VP, an abbreviation for a predicate category that would be more directly represented as S/NP. Every non-finite verb VP, VP/X, (VP/X)/Y ... has a corresponding finite form FVP, FVP/X (FVP/X)/Y ..., presumably induced via a lexical rule. The finite category is assumed to have an identical semantic type.

The second rule of functional application is that of backward combination. We might want to regard the Dutch verb as occasionally finding NP's and certain other complements to its left by this rule, to yield VP's like *appels eten* 'to eat apples'. The rule that would be required is similar to 2, except that the function finds its argument to the left:

(3) Backward Combination

$$Y \ X/Y \Rightarrow X \text{ WHERE } X = [+V, -N \ldots]$$

The condition on the rule restricts it to functions which deliver a category which is verbal, using the assumptions of the X-bar hypothesis of Chomsky 1970 and Jackendoff 1977; it excludes Dutch prepositions, for example, from combining with NP's by this rule, but allows Dutch VP's like that in Figure 3.

appels	*eten*
NP	VP/NP
——— B	
VP	

FIGURE 3.

Very few functor categories in English get their arguments from the left; but a major class of constituents which we might want to regard in this way are English postmodifiers, such as sentential adverbials S/S, verb-phrase adverbials VP/VP, and noun-phrase modifiers NP/NP. However, in the present paper, the only adverbials that are considered are those which show subcategorization by the verb, and which can therefore legitimately be regarded as arguments. Certain NP modifiers, such as relative clauses, are also treated as arguments. In fact, it will turn out that the Backward Combination Rule (3) is not required at all in the fragments of English and Dutch that are considered here.[6]

1.13. TWO RULES OF FUNCTIONAL COMPOSITION. The order-free categorial lexicon and the two directional rules of functional application merely constitute a novel notation for CF grammar. They differ from the more usual PS notation only by specifying IN THE SYNTAX which of the daughters in a production is the function, and which are its arguments—a matter which PS grammar typically leaves to semantics. Such a grammar does not yet explain how discontinuous constituents can be handled, as in this topicalized sentence:

(4) Apples, he likes!

If the subject *he* and the finite verb *likes* could here be assembled into a single function *he likes* of category S/NP, requiring an NP as an argument and yielding

[6] The fact that postmodifiers are functions combining with arguments to their left would probably be better handled by restoring directionality to the lexical categories, as in Bach's theory, and excluding directionality from the combination rules. This is because certain other categories of the form S/S, VP/VP, and NP/NP—created by the rules to be considered next—must not be allowed to backward-combine. (See also fn. 19, concerning the Coördination Rule.)

a sentence, then the NP *apples* could be picked up by some version of Rule 3.

Because CG, unlike other CF formalisms, distinguishes function and argument categories, it provides a notationally transparent and semantically coherent implementation of such a function-combining operation. The subject and verb can be assembled into the requisite entity of category S/NP, using a new kind of combination rule that 'partially' combines the subject $[he]_{S/FVP}$ with the verb $[likes]_{FVP/NP}$ to yield $[he\ likes]_{S/NP}$. The rule can provisionally be written as follows:

(5) Forward Partial Combination

$$X/Y \ Y/Z \Rightarrow X/Z$$

Using this rule, the extraction of the object NP in ex. 4 might be accepted as in Figure 4—given a suitably restricted form of the backward rule, allowing functors of the form S/X to find arguments to their left. (The restrictions in question are spelled out in A&S, in which preposed arguments combine by the Backward Combination Rule 3 in this way. However, another solution is proposed in §1.15, below.)

```
Apples,   he      likes!
-------  -----   -------
  NP     S/FVP   FVP/NP
         --------------FP
              S/NP
    -----------------B
            S
```

FIGURE 4.

The implications for syntax of including such a 'partial' combination rule are considerable, and will form the major concern of the rest of the paper. However, we should pause here to examine more closely the nature of this rule—in particular its semantics.

It will be convenient to distinguish the two functors X/Y and Y/Z in Rule 5 as the 'main' and the 'argument' functor, respectively. The rule gives the appearance of 'canceling' Y in main and argument functors, as if they were numerical fractions undergoing multiplication. This appearance follows from the fact that the categories are functors in the strictest sense of the term: just as the earlier operations of simple forward and backward combination corresponded to the application of a function to an argument, so this rule corresponds to the equally fundamental operation of 'composing' the two functions.

Functional composition of two functions f and g, commonly written '$f \circ g$', is an operation defined by the following equivalence:

(6) Functional Composition

$$f \circ g(x) = f(g(x))$$

That is, it produces a new function; and the effect of applying this function to an argument x is identical to the effect of applying f to the result of applying g to x.[7] The fact that partial combination corresponds to functional composition, together with the rule-to-rule assumption, has the important consequence that the rule has a coherent semantics. In fact, its semantics is also functional composition—this time, of the corresponding semantic functions. There is an interesting precedent for rules of functional composition in Geach's use of 'recursive' rules, and in the related work of Potts 1978 and Levin 1982. Finer 1982, Oehrle 1983, and Abe 1984 have also argued for rules of functional composition in syntax. Moortgat 1983 proposes such rules in the lexicon, while Kaplan 1975 and Cormack 1983 argue for their involvement in semantics.

The basic rule of partial combination has many of the properties that are required to capture discontinuous constituency. Thus repeated applications of the rule allow extraction over more than one intervening category—as in 'preposition stranding', exemplified in Figure 5.

```
This place   he     comes    to.
----------  -----  -------  -----
    NP      S/FVP  FVP/PP   PP/NP
            ---------------FP
                 S/PP
                 ----------------FP
                       S/NP
  ---------------------------B
              S
```

FIGURE 5.

In §1.2, I show that such extractions are potentially unbounded. On the assumption that the Backward Combination Rule is only allowed to pick up the maximal categories NP, PP, AP, VP and S′, ungrammatical constructions like 'determiner stranding', as in Figure 6, can readily be excluded.

```
*Cake    I      ate     the.
 ----  -----  ------   ----
  N    S/FVP  FVP/NP   NP/N
       -------------FP
        S/NP
          ------------------FP
                 S/N
  -----------------------*B
            S
```

FIGURE 6.

Just as with the simple combination rules, the theory potentially allows a backward version of the partial rule, in which the main functor X/Y composes

[7] In lambda calculus terms, the function f∘g is therefore $\lambda x\,[f(g(x))]$. In terms of the combinatory logic (CL) of Curry & Feys 1968, composition is the combinator **B**, which in some versions of CL is taken as a primitive; and the function f∘g is **Bfg**.

with an argument functor Y/Z on its left:

(7) Backward Partial Combination

$$Y/Z \; X/Y \Rightarrow X/Z$$

This rule does not seem necessary for the very restricted range of English categories considered here. However, it is within the capacity of the theory. We may therefore expect to see it used in a more comprehensive grammar of English; and it is shown below to be implicated in the grammar of German and Dutch. As pointed out by A&S, the absence of Rule 7 from the grammar automatically imposes the Left Branch Condition (LBC) of Ross 1967, which forbids extractions like the one in Figure 7.

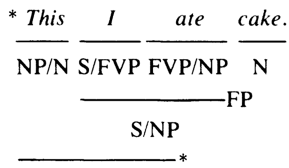

FIGURE 7.

1.14. A GENERALIZATION OF FUNCTIONAL COMPOSITION. To handle extraction of the leftmost NP complement of a ditransitive verb, the Forward Partial Combination Rule (5) must be generalized slightly. Consider Figure 8.

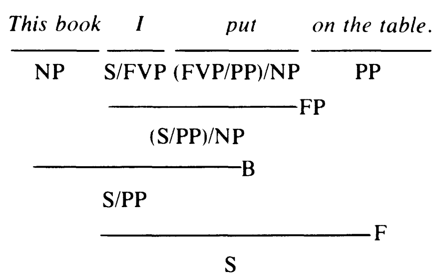

FIGURE 8.

The subject and the tensed verb must partially combine as shown, if the extraction is to be accepted; but Rule 5 does not allow this to happen. To generalize the rule appropriately, we need a formal device which is simple in principle, but slightly laborious to state:

(8) THE \$ CONVENTION. Let X and Y be any two categories. Let X\$ be some member of the set Σ of categories recursively defined as the smallest set such that $X \in \Sigma$, and for all categories α, β, if $\alpha \in \Sigma$ then $\alpha/\beta \in \Sigma$. Then for any categories $Z_1 \ldots Z_n$, if X\$ = $(\ldots (X/Z_n)/\ldots)/Z_1$, then Y\$ is the corresponding category $(\ldots (Y/Z_n)/\ldots)/Z_1$.[8]

[8] This definition of the symbol \$ is essentially the same as that in A&S, but is differently phrased because of the changes in notation (cf. fn. 2).

In other words, if X is the atomic category S, then X$ is some member of the set including S, S/NP, (S/NP)/NP etc. If Y is the atomic category VP, and if X$ is S, then Y$ is VP; if X$ is S/NP, then Y$ is VP/NP; if X$ is (S/NP)/NP, then Y$ is (VP/NP)/NP etc. The requisite generalization of Rule 5 can now be stated as follows:[9]

(9) Forward Partial Combination
X/Y Y$/Z ⇒ X$/Z

Given this rule, a main functor X/Y can combine with any member of the appropriate class of functors Y$/Z to give the corresponding functor X$/Z. Thus a subject S/FVP can combine as main functor with tensed *put* (FVP/PP)/NP to yield (S/PP)/NP, and the derivation in Fig. 8 can proceed. The corresponding revision of Rule 7 is:

(10) Backward Partial Combination
Y$/Z X/Y ⇒ X$/Z

The function X$/Z that results from Rules 9–10 again corresponds to a composition of the two functions, although we are now dealing with a very natural generalization of the most basic notion of function composition.[10] Again, the function allows the extracted item to be associated with its governing category without the mediation of additional devices; and again, it can be considered as mapping directly between semantic entities. It is the generalized form of the rule that is crucial in the analysis to be presented in §2 for the Dutch infinitivals.

An important principle is implicit in the form of these four rules:

(11) THE ADJACENCY PROPERTY. The combination rules are unable to combine two non-adjacent items, unless the intervening item(s) can first be combined with one or the other of them.

1.15. TYPE-RAISING. The use in Figs. 4, 5, and 8 of some unspecified version of the Backward Combination Rule, to allow composed functions like *he likes*$_{S/NP}$ to pick up their arguments, has the undesirable consequence of potentially allowing ungrammatical 'multiple topic' sentences, as in Figure 9.

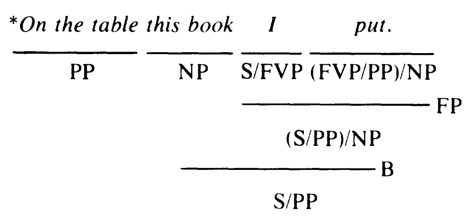

FIGURE 9.

[9] Rule 9 constitutes a schema for an infinite set of PS rules, unlike Rule 5; this fact has implications for the power of the grammar.

[10] As a preliminary to a definition of this generalization, it will be helpful to note that, as first pointed out by Schönfinkel 1924 and discussed in Dowty 1982, the *n*th-order unary functions of the form $(\ldots(X/Z_n)/\ldots)/Z_1$ that are used in the present theory are equivalent to first-order *n*-ary functions of the form $X/Z_1, \ldots, Z_n$. The new operation of composing an *m*th-order unary function

A further undesirable consequence of treating preposing in this way is that the S which results from topicalizing the object in *Apples he likes* is not distinguished from the canonical *He likes apples*. These undesirable effects can be avoided if we assume that all leftward-extracted items, e.g. topics and relative pronouns, bear a 'type-raised' category.[11] Type-raising—according to which an entity such as a noun phrase is not an argument category NP, but rather a function over those functions which take it as argument into the results of those functions—is widespread in the categorial literature (Lewis 1970, Montague 1973, Partee & Rooth 1982, Rooth & Partee 1982). A topic NP will now bear the raised category as T/(S/NP), where T stands for an S marked with some feature value, say [+TOPIC]. Similarly, the object relative pronoun *who(m)* bears the category R/(S/NP), where R stands for an S marked as a relative clause. The derivation in Fig. 4 proceeds as in Figure 10. (Only the maximal categories NP, PP, AP, VP, and S′ can be type-raised in this way; so the ungrammaticality in Fig. 6 is still excluded.)

Apples, *he* *likes!*
T/(S/NP) S/FVP FVP/NP
———— FP
S/NP
———— F
T

FIGURE 10.

However, in order to accomplish the extraction in Fig. 8, there must be slightly more to the raised topic category than appears in the above derivation. The category must be generalized, taking the $ Convention to be T$/(S$/NP), where the output category T$ CORRESPONDS to S$ in the input in the sense defined above. The derivation then proceeds as in Figure 11.

This book *I* *put* *on the table.*
T$/(S$/NP) S/FVP (FVP/PP)/NP PP
———— FP
(S/PP)/NP
———— F
T/PP
———— F
T

FIGURE 11.

X/Y with an *n*th-order unary function Y$/Z can then be defined, both syntactically and semantically, as the operation which produces an $m+n$th-order unary function X$/Z; this is equivalent to the result of applying the basic composition operation to compose X/Y with the first-order *n*-ary function corresponding to Y$/Z. In terms of CL (Curry & Feys, 66; cf. fn. 7, above), this is the combinator $\mathbf{B}^n$.

[11] A different solution, using feature restrictions on backward combination, is proposed by A&S.

Since the result of combining the topic with the sentential functor (S/PP)/NP is marked as topicalized T/PP, it cannot provide a suitable argument for a second topic T$/(S$/PP); thus the double topicalization in Fig. 9 is prevented.

The semantics of the raised categories is simply to apply their argument function to the original NP (or PP etc.) It is assumed that a topic acquires its raised category by virtue of its sentence-initial pre-subject position, while the raised category of the relative pronoun is given in the categorial lexicon.[12] With this treatment of preposing, the present grammatical fragment (which excludes non-subcategorized-for adverbials and other such postmodifiers) does not require the Backward Combination Rule at all.

1.2. Extraction, coördination, and surface structure. Despite the limitation manifested in the Adjacency Property (11), the inclusion of Rule 9 allows extractions to be unbounded and allows certain 'reduced' constructions to conjoin, as the following sections show. It also allows a natural expression of island constraints, although the present paper will go no further than to indicate how certain very general constraints could be implemented; all discussion of the interesting group of constraints which specifically relate to the grammatical subject will be left for another day.

1.21. Unbounded extraction. On the reasonable assumption that one category of complement-taking verbs like *believe* is VP/S′, a function over *that* complements, the extractions exemplified earlier can occur over unbounded amounts of intervening material with no modification to the theory. Forward partial combination is used repeatedly in Figure 12 to compose an entity [*I can believe that she will eat*]$_{S/NP}$ (cf. A&S, 546). (The fact that other sequences of combinations which accept this sentence are possible will be discussed in §1.22, along with the heterodox view of surface structure that they imply.)

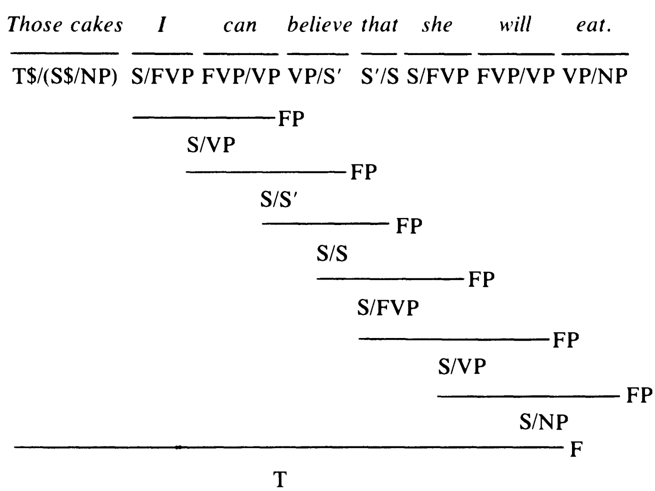

Figure 12.

[12] More formally, the semantics of the type-raised categories of the form T$/(S$/X) and R$/(S$/X) is as follows. Let the interpretation of the original unraised category be X′, an object of type

The unbounded extraction of WH-expressions can be handled very similarly. I assume for present purposes that (restrictive) relative clauses and certain other NP postmodifiers are arguments of their head NP. To ensure that such arguments are relative clauses, rather than something else, I will stipulate that (common) nouns are given in the lexicon not only as N, but as functions N/R over relative clauses;[13] furthermore, relativized entities like WH-pronouns bear the raised categories introduced above, according to which a non-subject relative pronoun is R\$/(S\$/NP), a function over sentences lacking a complement NP.[14] This category allows a derivation equivalent to a 'determiner-nominal' analysis, as in Figure 13. (The string *I can believe that she will eat* is composed as in Fig. 12.)

```
 a     cake    which      I can believe that she will eat
 ----  ----  ---------  ----------------------------------
 NP/N  N/R   R$/(S$/NP)              S/NP
             ------------------------------------F
                            R
        -------------------------F
                    N
 -------------------F
         NP
```

FIGURE 13.

Given these categories, a second derivation is possible for this NP—one equivalent to an 'NP-modifier' analysis, as in Figure 14.

```
 a     cake      which       I can believe that she will eat
 ----  ----   ----------   ----------------------------------
 NP/N  N/R    R$/(S$/NP)                S/NP
 ----------FP
 NP/R
              ------------------------------------------F
                               R
 ----------------------------------F
                NP
```

FIGURE 14.

τ_X. Let f be a variable ranging over the interpretations of functions of category S\$/X; i.e., f is a function of type $\langle \tau_X, \tau_{S\$} \rangle$. Then the interpretation of the raised category, ignoring the marking of the result as relativized or topicalized, is λ f[f(X')], a function of type $\langle\langle \tau_X, \tau_{S\$} \rangle, \tau_X \rangle$. Since the nonce category FVP encodes the predicate category S/NP, it will be apparent that the subject category S/FVP is also implicitly type-raised.

[13] The semantics of the function N/R is only opaquely encoded by its syntactic category. The category R of relative clauses must encode a function over nouns. The function N/R must take such functions as argument, and its semantics must be to apply the function in question to the interpretation of the original noun. Presuming that the operations which the semantics may apply to the input of the function is strictly limited, the above assumptions are consistent with a rule-to-rule semantics and type-driven translation. A seemingly more transparent analysis of the noun phrase would see relative clauses as functions N/N or NP/NP, combining via the Backward Combination Rule (3). As Flynn 1983 points out, this analysis seems easier to reconcile with the fact that relative clauses may reduplicate, as in *the cake that I bought which Harry stole*; but it appears to be ruled out by the facts of coördination (see below).

[14] It is assumed that 'pied piped' relative entities like *to whom* bear analogous categories like

The Forward Partial Combination Rule thus allows all the benefits of the determiner-nominal and NP-modifier analyses, whose rival attractions are discussed by Partee 1975 and by Bach & Cooper 1978.[15] At the same time, it excludes the ungrammatical **a cake I can believe she will eat which.*

The analysis of relativized entities as functions into R again automatically forbids the occurrence of more than one preposed item in any given clause, because the relative pronoun can take only an unrelativized sentential function as argument. Certain other constraints on extraction, such as the LBC, were dealt with in §1.13; and leftward extraction of entities other than NP, AP, PP, VP, and S′ is again forbidden because of the restrictions on type-raising discussed in §1.15. However, a further, apparently language-specific constraint on partial combination is required if the Complex Noun Phrase Constraint (CNPC) of Ross 1967 is to be obeyed, preventing the extraction in Figure 15.[16]

```
*a cake   which      I met   a woman   who    ate
-------  ---------  ------  -------  -----  ------
 NP/R    R$/(S$/NP)  S/NP     NP/R   R/FVP  FVP/NP

                    -------------- FP ------------ FP
                         S/R                R/NP
                         ----------------------- FP
                                   S/NP
         ----------------------------------F
                         R
 ------------------------F
           NP
```

FIGURE 15.

The simplest such restriction would prohibit all forward partial combination into NP (cf. A&S, 544):

(12) X/Y Y$/Z ⇒ X$/Z WHERE Y ≠ NP

The restriction means that the category matching Y cannot be NP; thus partial combination is blocked across the noun phrase boundary, achieving the effect of the NP constraint of Horn 1974 and of Bach & Horn 1976.[17] Alternatively, a less general constraint related to the CNPC itself could be imposed by forbidding forward partial combination into R:

(13) X/Y Y$/Z ⇒ X$/Z WHERE Y ≠ R

R$/(S$/PP)—and that the subject relative pronoun *who* bears the related category R/FVP, rather than the normal subject category S/FVP. This analysis of subject relatives is not the one offered by A&S or by Steedman 1983a,b, 1984, where all relative pronouns are simply inert NP's, and are picked up by backward combination. The alert reader will notice that the analysis of subject relatives as R/FVP fails to explain how their extraction can be unbounded, just as the analysis of other subjects offered here does. This important problem is deferred.

[15] Barwise 1981 gives a precedent for a system in which both determiner–nominal and NP–modifier analyses are produced by the involvement of functional composition.

[16] The grammar already excludes the much more serious violations of CNPC which involve crossing dependencies, as in **a woman who I bought a cake which ate.*

[17] The restriction differs slightly from the related one offered by A&S.

Again, the very general A-over-A constraint of Chomsky 1964 could be imposed, by stipulating that X not be equal to Z. I will remain entirely agnostic on the complex question of exactly how this particular group of island constraints should best be specified—or, indeed, whether they should be specified in the syntax at all. The important point is that such restrictions on partial combination achieve the effect of island constraints by entirely local means. Fodor 1983 has pointed out that they are parallel to the conditions on 'projection paths' of Koster 1978, and on slash-percolation in GPSG (cf. Gazdar 1982:175–6), which have a similarly local character. However, the present mechanism has rather different consequences, to which I now turn.

1.22. ON THE NOTION 'SURFACE STRUCTURE'. Implicit in the account of unbounded extraction given above is the claim that the surface structure of *Those cakes I can believe that she will eat* includes constituents corresponding to these substrings: *I can*; *I can believe*; *I can believe that*; *I can believe that she*; *I can believe that she will*; and *I can believe that she will eat*. In fact, since other possible sequences of forward simple and partial combination will accept the sentence, the theory implies the possibility of constituents such as *can believe that she will eat*; *believe that she will eat*; *that she will eat*; *she will eat*; and *will eat*. Since these constituents are defined in the grammar, it necessarily follows that the surface structure of the canonical *I can believe that she will eat those cakes* may also include them; thus Figure 16 represents only one of several possible analyses. (For once, I use orthodox tree representation, lest the novelty of the categorial notation should obscure the point.) The effect of the Forward Partial Combination Rule is that the right-branching structure which would result from simple forward combination of the lexical categories is converted into a left-branching structure.[18]

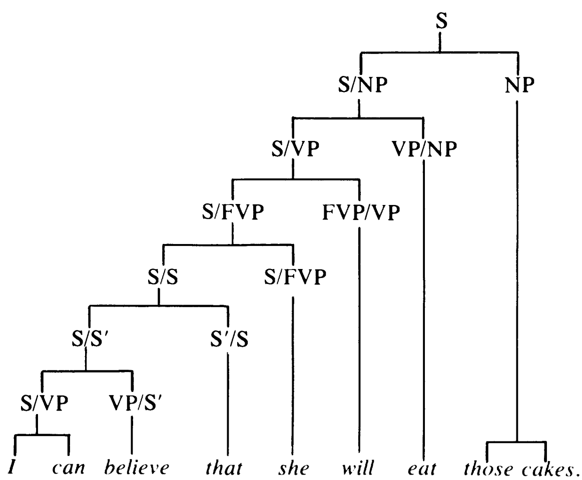

FIGURE 16.

[18] Of course, the possibility of using the rule to produce such structures remains subject to restrictions like those introduced above to capture the island constraints.

The proliferation of possible analyses that is induced by the inclusion of function composition might seem, at first glance, to have disastrous implications for processing efficiency, since it exacerbates the degree of local ambiguity in the grammar. But in another respect, functional composition has very desirable implications for processing under the strong competence hypothesis. In a grammar which maintains a rule-to-rule relation between syntactic and semantic rules, left-branching allows incremental interpretation of the sentence by a left-to-right processor. In Fig. 16, such a processor would, as it encountered the successive words of the sentence, be able to build a single constituent successively corresponding to *I*; *I can*; *I can believe*; *I can believe that*; *I can believe that she*; *I can believe that she will*; and *I can believe that she will eat*—before finally combining the latter with *those cakes*. And since the Forward Partial Combination Rule has a corresponding semantic rule, each of these constituents can immediately be interpreted—indeed, no reason exists for any autonomous syntactic representation, as distinct from the interpretation itself, to be built (cf. A&S). Introspection strongly supports the 'incremental interpretation hypothesis' that our own comprehension of such sentences proceeds in very much this fashion, despite the right-branching structures which they traditionally involve. Crain 1980 (discussed in Crain & Steedman 1982) and Altmann 1985, in experiments on the effect of referential context on traditional 'garden path' effects, have provided suggestive evidence that incremental interpretation and evaluation with respect to a referential context may be the most important factor in the resolution of local ambiguities by the human sentence processor.

Nevertheless, no performance considerations can override grammatical evidence; and it is perhaps hard to accept that long-standing and seemingly self-evident assumptions about the nature of surface structure could be wrong—allowing that unremarkable sentences like the above can be so ambiguous in their surface constituency, and include such extremely non-standard constituents. However, within theories of grammar developed in direct connection with parsing implementations, e.g. the Augmented Transition Network grammars of Woods 1973, the concept of surface structure plays only an incidental role. A surface structure is no more than a record of the operations that a processor goes through in building a meaning representation—e.g. a deep structure, or the interpretation itself. Such a record is not something which ever needs to be built or referred to in the grammar; and the only constraint on a theory of surface structure thus interpreted is that the operations which it represents should produce the correct semantic representation. It follows that there is no grammatical reason why a sentence should not have several different surface analyses, so long as they all produce semantically equivalent results. The ambiguity introduced by the partial combination rule is of this non-essential kind. Because functional composition and functional application are 'associative' operations, like arithmetical addition, the end results of all possible analyses of a sentence with multiple verbs, e.g. *I can believe that she will eat these cakes*, will be semantically equivalent.

This view of the nature of surface grammar makes it less surprising that so little unequivocal experimental or linguistic evidence exists for the psychological reality of traditional surface structure. Results from 'click' experiments and other such paradigms show psychological correlates of SOME level of constituency, for what that is worth. But they can equally well be interpreted as reflecting deep structure, or indeed any other kind of meaning-related representation (Johnson-Laird 1974). Nor does linguistics proper offer any clearer evidence. Native speaker intuitions and prosodic phenomena—as well as evidence from auxiliary reduction, coördination, gapping, and ellipsis—are every bit as equivocal. In fact, coördination phenomena provide strong support for the present theory.

1.23. COÖRDINATION. A formulation which is essentially equivalent to that used by Gazdar 1981 (attributed by him to Dougherty 1970), but which has rather different consequences within the present theory, can be written as the following PS rule schema:[19]

(14) Coördination

$$X^{+}\ \text{CONJ}\ X \Rightarrow X$$

X stands (as usual) for any category, whether atomic or a functor. The superscript '+' means 'one or more', and CONJ stands for conjunctions like *and*. Such a schema will, obviously, allow coördination of complete phrases like $[\textit{apples}]_{NP}$ and $[\textit{pears}]_{NP}$, or $[\textit{comes}]_{FVP}$ and $[\textit{goes}]_{FVP}$, so that the following examples require no deletion:[20]

(15) a. She eats [apples and pears].
b. Harry [comes and goes].

It will also allow conjoining of functors like $[\textit{one}]_{NP/N}$ and $[\textit{two}]_{NP/N}$, or $[\textit{cooked}]_{FVP/NP}$ and $[\textit{ate}]_{FVP/NP}$, so long as they are of like category:

(16) a. [one or two] apples
b. Mary [cooked and ate] beans.

More interestingly, since functions like $[\textit{Harry cooked}]_{S/NP}$ and $[\textit{Mary ate}]_{S/NP}$ can be constructed by partial combination, they too can conjoin to yield a single function taking an NP as argument. Like Gazdar's related schema, Rule 14 (whose operation is indicated by the index 'C' in Figure 17a) will therefore automatically conform to the Coördinate Structure Constraint of Ross 1967, as in Figures 17b–c, but at the same time permit certain exceptions allowed by the Across-the-Board Constraint of Williams 1978.

[19] It is perhaps somewhat inconsistent to handle coördination syncategorematically—rather than, say, by making *and* bear a category which might be written $(X/X^{+})/X$, and allowing it to combine by suitably restricted instances of the Forward and Backward Rules of simple combination; or by introducing a related directional category, as with postmodifiers (cf. fn. 6).

[20] As in Gazdar's schema, sentences like (a–b) below require some other analysis, because they involve the coördination of non-constituents (they are assumed to arise from gapping of the tensed verb—but see Hudson 1982 for a counter-argument):

(a) I gave the books to Mary and Ø the records to Sue.
(b) I gave Mary the books and Ø Sue the records.

Gapping is briefly discussed below.

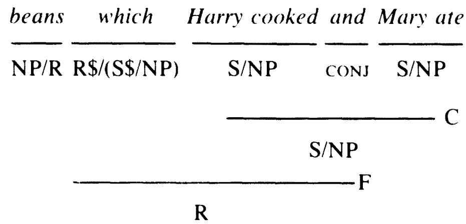

FIGURE 17a.

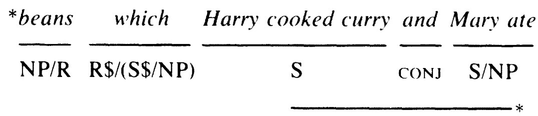

FIGURE 17b.

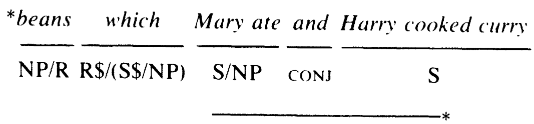

FIGURE 17c.

Since a function of the form S/X can combine with its argument X by the Forward Combination Rule, it follows that anything that can extract to the left from a conjunction of S/X's will also potentially be allowed to occur immediately to its right, and vice versa.[21] Coördination (14) will therefore also allow the Right-Node Raising (RNR) construction of Figure 18.

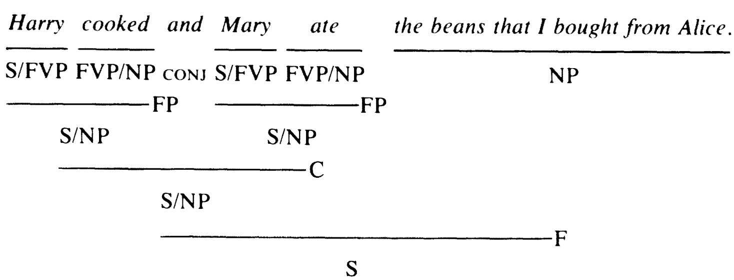

FIGURE 18.

The present theory thus embodies a generalization similar to that of Gazdar 1981 concerning the relation of leftward movement, rightward movement, and coördination—though unlike Gazdar (ex. 74), it does not require an extra rule

[21] That is not to say that any entity that can extract in one direction necessarily WILL extract in the other; thus no leftward movement occurs within the NP, because of the absence of backward combination and the restrictions on type-raising. But as will become apparent below, the NP does exhibit rightward movement of a kind.

schema to link the right extraposed NP to the conjoined S/NP: the Forward Combination Rule also does that.[22] Thus all the unorthodox constituent types that are introduced by the Forward Partial Combination Rule (see the start of §1.22) can conjoin under Rule 14, in a fashion like that in Fig. 18. It follows that rightward extractions must potentially be unbounded, obeying those constraints on leftward extraction which stem from restrictions on partial combination.[23] Thus, where leftward extraction is impossible—because partial combination is prohibited from forming a constituent by the island constraints, as in 17a—RNR is also prohibited, as 17b shows:

(17) a. *This picture [I know the woman who painted].
b. *[I know the woman who painted, and you met the man who stole], the picture that Harry was so fond of.

The converse does not apply: RNR is not subject to the same restrictions as preposing, because it does not involve type-raising. The theory therefore correctly predicts the grammaticality of the following (18b is from Bresnan 1974):[24]

(18) a. I [believe (that) Harry and know (that) Mary] will lend you the money.
b. I [have been wondering whether, but wouldn't want positively to state that,] your theory is correct.

Harlow 1984 has noted the problems that these sentences pose for more recent incarnations of GPSG (Gazdar et al. 1985).

A number of more important differences exist between GPSG and the present theory. Because the categories include higher-order functors with multiple slashes, like (S/PP)/NP, it necessarily follows that the Coördination Rule will also allow those functors to conjoin. It will thus potentially allow more than one item to be extracted. In §1.15, type-raising of preposed categories was used to prevent leftward extraction of more than one item; and this restriction will necessarily extend to coördinate sentences as well. However, sentences in which one extraction is to the right and one to the left are correctly allowed:

(19) a. [To which woman]$_{T\$/(S\$/PP)}$ [did Harry offer, and will Mary actually give,]$_{(S/PP)/NP}$ [an autographed copy of *Syntactic structures*]$_{NP}$?
b. [This woman]$_{T\$/(S\$/NP)}$, [Harry offered, and Mary actually gave,]$_{(S/NP)/NP}$ [an autographed copy of *Syntactic structures*]$_{NP}$.

Maling & Zaenen (1982:255) have pointed out the problems that related sentences with double extractions pose for GPSG. The possibility of their existence is an automatic consequence of the present proposals.

Multiple rightward combinations are also allowed, so that the grammar will allow RNR of more than one argument of the verb—again unlike the grammar of Gazdar 1981. Ex. 20, which is from Abbott 1976, is indeed grammatical, as

[22] Gazdar's schema is equivalent to the Forward Combination Rule 2.

[23] See Gazdar 1981 for arguments against Ross' 1967 proposal of a 'Right Roof Condition'.

[24] The theory does not explain, however, why 18a–b are distinctly worse than the following similar sentences which do not 'strand' complementizers or subjects:

(a) I [saw him and heard her] feed the hippopotamuses.
(b) I [have been hoping, and will continue to pray,] that your theory is correct.

predicted (Hudson 1982 and Oirsouw 1982 have pointed out the problems that such examples pose for Gazdar's account):[25]

(20) [[Joan offered] and [Mary actually gave]]$_{(S/PP)/NP}$ [a gold Cadillac]$_{NP}$ [to Billy Schwartz]$_{PP}$.

However, the present grammar will for the same reason also allow RNR of both NP's in ditransitives, to give the unacceptable

(21) *John offered, and Harry gave, Sally a Cadillac.

But it will allow such double RNR only if it preserves the 'nesting' order, excluding crossed dependencies without further stipulation. Abbott suggests that the unacceptability of 21 is pragmatic; and Kuno 1976 notes that it stems to a considerable extent from the involvement of proper names. If full NP's are substituted, particularly when they are 'heavy' (as RNR demands), then the sentence is much improved:

(22) John offered, and Mary actually gave, a very heavy policeman a rather pretty flower.

The rule will correctly allow RNR of the rightmost NP complement of a ditransitive like *give* in 23a. But in 23b, since *Harry sold a bicycle* is not a constituent—because of the category (VP/NP)/NP of ditransitive verbs—the rule will correctly prevent RNR of the leftmost NP:[26]

(23) a. [[Harry sold Barry] and [Don gave John]]$_{S/NP}$ [the bicycles that they stole from Mary]$_{NP}$.
b. *[Harry sold a bicycle] and [Mary gave a pen] to [the man they met at Sally's]$_{NP}$.

Finally, while leftward extraction has no analog within the English NP, the construction does exhibit the equivalent of RNR:

(24) a. [the missing and the remaining] [part or parts] of the sentence
b. [people who like, and people who dislike,] potatoes
c. [a picture and a novel] by the author of 'Beltrafio'
d. [pictures of, and novels by,] the author of 'Beltrafio'
e. a [picture of, and novel by,] the author of 'Beltrafio'.

Such examples will be accepted by Coördination Rule 14, under the analysis of the NP advanced in §1.21—according to which postnominal modifiers are arguments of the head noun, and partial combination is allowed within the NP. (In the absence of rules of deletion, these examples rule out all the alternative analyses mentioned there, including solely determiner–nominal and NP–mod-

[25] The implicit assumption that one category of verbs like *give* is (VP/PP)/NP, so that the PP is an argument of the verb, is not the only one possible, but it seems to be implied by subcategorization—i.e. by the possibility of stranding the preposition, given the account of preposition stranding exemplified in Fig. 5 above.

[26] More strictly, the constituent must have the wrong meaning, since the category is assumed to define the grammatical relations of the NP's. For the same reason, the schema will not allow left-extraction of indirect objects out of coördinate structures. The greater acceptability of (a–b), below, by comparison with 23b, remains unexplained:

(a) (a man) who(m) Harry sold a bicycle and Mary gave a pen
(b) (a book) which Harry sold to Mary and she put on the shelf.

ifier analyses, as well as those in which postnominal modifiers are functions over N or NP.)

Thus, despite differences in the means used and the detailed conclusions, the present theory captures and extends the generalization of Gazdar 1981; many possibilities of extraction and coördination that have previously been ascribed to forward and backward conjunction reduction, right-node raising, and backward gapping are related under the single grammatical principle embodied in the function-composing Forward Partial Combination Rule, whereby they reduce to simple constituent coördination.

A few truly elliptical constructions remain unaccounted for. They include VP ellipsis (a), comparative ellipsis (b), and forward gapping (c–d):

(25) a. John ate some beans, and [I did Ø, too].
b. John ate more beans than [Harry did Ø peas].
c. John ate beans and [Harry Ø peas].
d. John wants United to win, and [Harry Ø Ipswich Ø].

A full analysis of elliptical constructions goes beyond the realm of syntax proper, as shown by Kuno 1976, 1981, and will not be attempted here. But it is worth considering the following well-known set of gapped sentences:

(26) (I want to try to begin to write a novel, and)
you to try to begin to write a play.
you to begin to write a play.
you to write a play.
you a play.

It has frequently been pointed out (cf. Jackendoff 1971:25, following Ross, and Neijt 1979) that these are very naturally described on the assumption that the VP is, in part, left-branching, and that the non-standard constituent on the left branch can be deleted. The suggestion has been as frequently suppressed. But the alternative is to allow a rule of gapping which is unique among transformations in being conditioned by the constituent structure of its output, rather than that of its input. According to the present theory, all the gapped strings in 26 can be assembled by the Forward Partial Combination Rule to bear categories of the form FVP/X; they are as much constituents as the remaining parts of the sentence. One possible constituent structure for 26 is Figure 19.

This analysis assigns constituent status to the gap *want to try to begin* in the conjunct ... *and you, to write a play*. The implication is that, whatever other problems are presented by gapping and the other constructions in 25, they all confine ellipsis to the right conjunct; and in the case of gapping at least, both the missing and the remaining part or parts of the sentence are all constituents in the present extended sense—although gapping is of course very restricted as to exactly which of these novel constituents may be omitted or remain, and the present theory has nothing to say about how the missing constituent can be recovered. I return to this point in §2.4, where the theory of coördination is applied in the discussion of Dutch infinitival complements, for which the stage is now set.

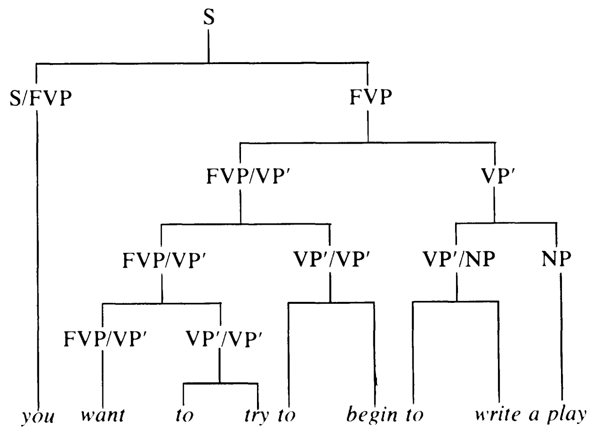

FIGURE 19.

DUTCH

2.1. CONSTITUENT ORDER AND THE INFINITIVAL COMPLEMENT. The grammatical orders of constituents in the Dutch clause resemble, to some extent, those of German. In subordinate clauses, all the verbs generally occur in a clause-final group, with arguments such as NP's and adverbials preceding the verb group in the sentence. In main clauses, the same verb-final pattern generally holds; but the tensed verb itself (which may of course be the only verb) must occur in first or second position in the sentence. (This constraint is somewhat confusingly called the 'verb second' or V/2 constraint, and is widespread among Germanic languages—although the English topicalized clause constitutes an exception.) Dutch differs from German in that the left-to-right order of the auxiliaries and other non-main verbs in the clause-final verb group is predominantly the same as in English. Thus the basic orders for a Dutch clause including a subject, a tensed modal, a main verb, and an NP complement are as follows:

(27) a.	*Zij moet appels eten.* she must apples eat 'She must eat apples.'	(Declarative)
b.	*Moet zij appels eten?*	(Interrogative)
c.	*Appels moet zij eten!*	(Topicalization and Obj. Question)
d.	(... *dat*) *zij appels moet eten.*	(*That* Complementation and Subj. Relative)
e.	(*appels*) *die zij moet eten*	(Obj. Relative)

German predominantly requires the verbs to be in the mirror-image order, with the tensed verb rightmost,[27] in contrast to 27d:

[27] There are many exceptions to this rule, some of which are discussed below.

(28) (... *dass*) *er Äpfel* [*essen muss*].
(... that) he apples eat must
'(... that) he must eat apples.'

It is because of this combination of verb-finality with the English verb order that Dutch frequently exhibits crossed dependencies between verbs and the NP's which they govern, in nested infinitival complements of certain verbs of perception and causation, e.g. *zien* 'see' (past tense *zag*) and *helpen* 'help' (cf. Seuren 1973, Evers 1975, Huybregts 1976, Zaenen 1979, de Haan 1979, Bresnan et al. 1982). In subordinate clauses, the constructions illustrated in 1a–b (repeated here) result:[28]

(29) a. ... *omdat* ik_1 $Cecilia_2$ *de* $nijlpaarden_2$ zag_1 $voeren_2$.
because I Cecilia the hippos saw feed
'... because I saw Cecilia feed the hippos.'
b. ... *omdat* ik_1 $Cecilia_2$ $Henk_3$ *de* $nijlpaarden_3$ zag_1 $helpen_2$ $voeren_3$.
because I Cecilia Henk the hippos saw help feed
'... because I saw Cecilia help Henk feed the hippos.'

The standard orders for the parallel German sentences are given below (however, Evers 1975:51, following Bech 1955, notes that German sentences which include multiple verbs tend strongly to have all but the two most deeply embedded verbs in the Dutch tensed-first order; cf. §2.2 below):

(30) a. ... *weil* ich_1 $Cecilia_2$ *die* $Nilpferde_2$ $füttern_2$ sah_1.
b. ... *weil* ich_1 $Cecilia_2$ $Hans_3$ *die* $Nilpferde_3$ $füttern_3$ $helfen_2$ sah_1.

Because the construction can embed, indefinitely many crossed dependencies are allowed in Dutch.[29] In most dialects the alternative in which the verb group has the German order is actually disallowed (cf. Zaenen, fn. 3), and in all dialects it seems to be uncommon, particularly when there are more than two verbs:

(31) a. ...?*omdat* ik_1 $Cecilia_2$ *de* $nijlpaarden_2$ $voeren_2$ zag_1.
b. ...**omdat* ik_1 $Cecilia_2$ $Henk_3$ *de* $nijlpaarden_3$ $voeren_3$ $helpen_2$ zag_1.

That this option can be excluded or dispreferred is remarkable, however, for it would restore the nested dependencies exhibited in the corresponding German constructions between the verbs and their complements. No dialect allows sentences which have any of the NP dependencies in the reversed, nesting order—except when these NP's are so-called 'clitic' pronouns, which are ignored here.[30]

The verbs which demand the construction are all verbs of perception and

[28] The example is adapted from Huybregts 1976.

[29] An increasing load in processing makes such multiple embeddings increasingly unacceptable. However, by well-known arguments (cf. Chomsky & Miller 1963), such considerations are irrelevant to questions of grammaticality.

[30] But cf. Seuren 1984 for a discussion of the problems which Dutch clitic pronouns pose for the present grammar.

causation, plus a few that probably also belong under the causation heading, e.g. *helpen* 'help' and *leren* 'teach'. The rather similar verbs such as *besluiten* 'decide', *schijnen* 'seem', and *toelaten* 'allow', which take the other Dutch infinitive with the particle *te* (cf. Eng. *to*), behave similarly in that they allow crossing, but differently in certain alternative orders which they permit (cf. Zaenen). I shall ignore these complications for the moment, returning to them briefly below.

In the next two sections, the syntax of the verb group and the NP sequence in these sentences will be considered in turn.

2.2. The verb sequence. Although some controversy surrounds the surface structure of sentences like 29, all the scholars quoted above agree that the entire verb group *zag* ... *voeren* constitutes a surface constituent of type V. There is less agreement about how this constituent is structured internally, or how the NP sequence is structured. There is consensus that the deep structure (or whatever) underlying 29a is as in Figure 20; but again, there is considerable disagreement as to how this deep structure is turned into a surface structure.

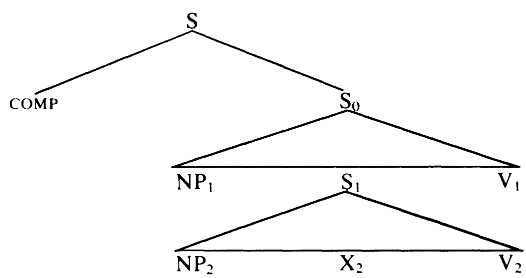

Figure 20.

Within the present theory, the entity closest to traditional base grammar is the categorial lexicon. One set of categories which could accept structures like that in Fig. 20, given functional application alone, is given below. Presuming that all infinitival verbs are functions from whatever the verb takes as complement into functions-from-NP's-into-infinitival-S's, and that all tensed verbs are (as usual) functions from the verb's complement into FVP's, then, if the stem *zie-* of *zag* and *zien* is VP/Sinf, a function over infinitival S, and everything else has the obvious category, we get the following categories:[31]

(32)	*zag*:	FVP/Sinf
	zien, helpen:	(Sinf/NP)/Sinf
	voeren:	(Sinf/NP)/NP

Remarkably, the surface orders of Dutch main and subordinate clauses which include nested infinitival complements can be accepted, on the basis of just

[31] It is assumed that these categories are given in the lexicon. The infinitival category could be simply induced by the following lexical rule, where the symbol $ is defined as in 8:

VP$ + *en* → (Sinf/NP)$

these categories, when the same function-composing Forward Partial Combination Rule that is required for English is included.

Let us begin by considering a simple but slightly overgeneralizing set of combination rules, before showing how these rules can be restricted. The basic set involves forward, backward, and forward partial combination—differing from English only by the imposition of some feature-based restrictions on forward and backward combination, to ensure that Dutch verbs combine with NP's and other non-verbal complements to the left by the backward rule, rather than to the right by the forward rule. A first approximation to a grammar for the Dutch fragment then includes the following:[32]

(33) Forward Combination

$X/Y\ Y \Rightarrow X$ WHERE $X \notin \{S\$, Sinf\$, FVP\$, VP\$, \ldots\}$
OR $Y \notin \{NP, PP, AP\}$

(34) Backward Combination

$Y\ X/Y \Rightarrow X$ WHERE $X \in \{Sinf\$, FVP\$, VP\$, \ldots\}$
AND $Y \in \{NP, PP, AP\}$

These rules, together with Rule 9, accept main and subordinate clause word-order of sentences with infinitival complements, as in Figures 21a–c. (The dependencies between NP's and the functions that take them as arguments are indicated by subscripts. These are included purely for the reader's convenience: the grammar itself does not include or require them.)

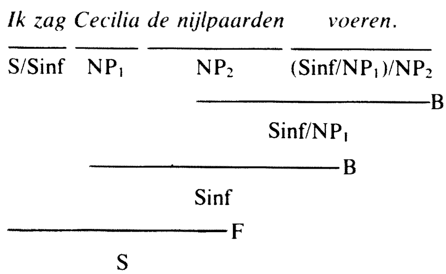

FIGURE 21a.

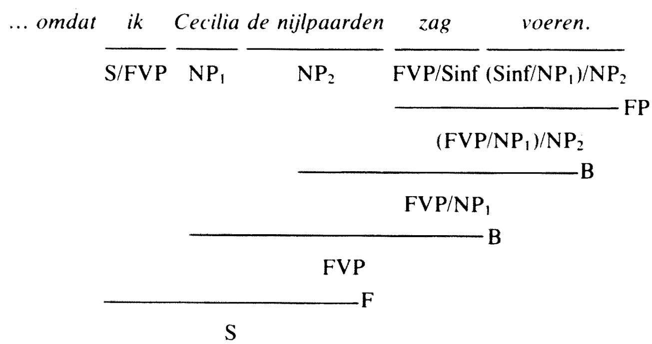

FIGURE 21b.

[32] This simple set of combination rules will not accept inverted main clauses. Nor will it accept those main-clause orders which have NP's etc. on the right, as in *Ik zag Marie*, or RNR sentences.

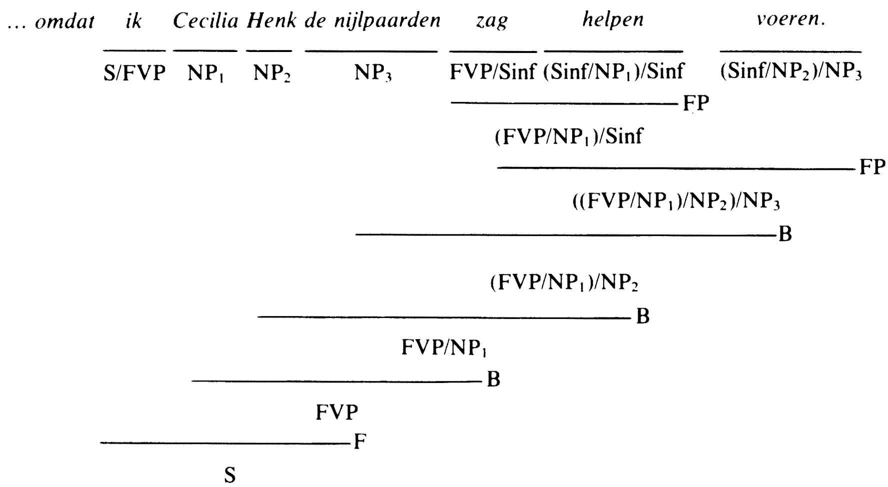

FIGURE 21c.

These surface orders are accepted because the grammar includes the Forward Partial Combination Rule, which was expressly introduced on the basis of apparently unrelated extraction phenomena in English, in order to glue functions like verbs together in advance of their combination with any other arguments. The examples illustrate the fact that verbal functions which combine under this rule will necessarily produce as their composition a function which, if it is to find its arguments to the left, demands them in the crossed, rather than the nested order.[33]

While the marginal example 31a (repeated here as 35a) is allowed, the unacceptable 31b (= 35b) is not allowed by the present grammar, in contrast to the Lexical-Functional Grammar account of Bresnan et al. (633), because of the exclusion of backward partial combination and the restrictions on backward combination (Rule 34):

(35) a. ...?*omdat* ik_1 $Cecilia_2$ *de* $nijlpaarden_2$ $voeren_2$ zag_1.

b. ... **omdat* ik_1 $Cecilia_2$ $Henk_3$ *de* $nijlpaarden_3$ $voeren_3$ $helpen_2$ zag_1.

Without some further restriction on the operation of the combination rules, the grammar overgeneralizes; e.g., it allows subordinate clauses with main-clause order:

(36) *... *omdat ik zag Cecilia Henk de nijlpaarden helpen voeren.*

It also allows certain other unacceptable word orders:

(37) *... *omdat ik zag Cecilia helpen Henk de nijlpaarden voeren.*

As with all matters relating to main-clause order and the Germanic V/2 rule, these questions are deferred.

[33] In Fig. 21c, a second derivation is possible, with the verbs combining by two partial combinations in the opposite order. Because of the associativity of partial combination, the end result is the same entity $((FVP/NP_1)/NP_2)/NP_3$. The particular order of Fig. 21c has been chosen because it is the one that would be favored by a left-to-right processor that tried to combine as soon as possible. Some implications of the present grammar for the theory of the processor will be discussed in §3.

However, as is frequently the case in Dutch and German, main clause word-orders actually are required in subordinate clauses for certain other verbs. The relevant verbs here are those like *trachten* and *proberen* 'try', which allow related constructions (Seuren 1973, Zaenen 1979). Given the present account of infinitives and the possibility of 38c–d below, these verbs must (when tensed) bear the category FVP/(S*te*-inf/NP), where S*te*-inf is the category of a *te*-infinitival clause; and the composition of *te* with an infinitival verb must yield a category parallel to the bare infinitival but distinguished in the same way, so that *te leren* 'to teach' is (S*te*-inf/NP)/Sinf, and *te zingen* 'to sing' is (S*te*-inf/NP)/NP. The tensed verb may either be at the front of the final group, or in second position in a subordinate clause:

(38) a. ... *omdat ik Jan het lied probeer te leren zingen.*
because I John the song try to teach sing
'... because I try to teach John to sing the song.'
b. ... *omdat ik probeer Jan het lied te leren zingen.*

The following alternatives are also grammatical (Seuren 1973):

(38) c. ... *omdat ik probeer Jan te leren het lied te zingen.*
d. ... *omdat ik Jan probeer te leren het lied te zingen.*

A further more questionable pattern is the following:[34]

(38) e. ... ?*omdat ik Jan probeer het lied te leren zingen*

It therefore seems reasonable to assume that the overgeneralizations should be excluded by minor rules in the form of feature-based restrictions on the combination rules. For example, the following more restricted form of backward combination—restricted to functions ultimately yielding FVP or S*te*-inf, and excluding functions into Sinf—would allow the derivations in Figs. 21b–c, and in exx. 38a–e, while excluding exx. 36–37 and other related overgeneralizations:

(39) Backward Combination

$$Y \ X/Y \Rightarrow X \text{ WHERE } X \in \{S\textit{te}\text{-inf, FVP}\} \text{ AND } Y \in \{\text{NP, PP, AP}\}$$

(The rule would, by the same token, exclude 35a, as well as the main clause in Fig. 21a. However, the former has already been noted as marginal, and the latter must await a fuller analysis of the main clause than is possible here.)

It is an advantage of the present theory that the corresponding German construction—with the same elements, but with the corresponding verbs in mirror-image order, and the dependencies nesting—can be accepted in exactly the same way, using exactly the same categories, as in Figure 22. The only difference is that the verb group must be assembled by a suitably restricted form of the backward version (10) of the Partial Combination Rule, instead of the forward one.[35]

[34] This sentence is starred by Seuren 1973. However, there seems to be considerable doubt among native speakers as to whether it is in fact ungrammatical. See Seuren 1984 for an extended discussion of these verbs in relation to the present theory.

[35] As in the Dutch example of Fig. 21c, there is an alternative analysis to the one given here, in which the partial combinations of the verbs occur in another order. Again, the present order is the one that would be favored by a left-to-right processor combining as early as possible.

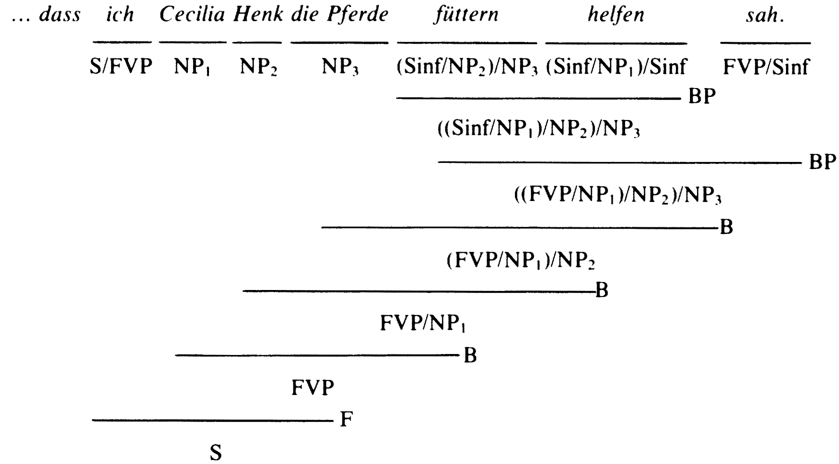

FIGURE 22.

Moreover, within the present theory it is not surprising that German occasionally deviates from the mirror-image verb order. Evers (51, 55, following Bech) states that, in sentences including tensed auxiliaries and multiple infinitives, all but the two most deeply embedded verbs may occur in the Dutch tensed-first order, requiring forward partial combination within the verb group (*dass man ihn hier wird können lassen liegen bleiben*) and potentially inducing crossed dependencies in German. Certain dialects of German even appear to allow *sah füttern helfen* in the example of Fig. 22; and some Swiss dialects noted by Shieber 1985 appear to allow the full Dutch order, which would yield *sah helfen füttern*. However, a number of remaining problems reveal that the analysis assumed above for the NP group is incorrect.

2.3. THE PREVERBAL NP SEQUENCE. Derivations like those in Fig. 21 imply that the example of Fig. 21b will have the kind of surface structure illustrated in Figure 23.

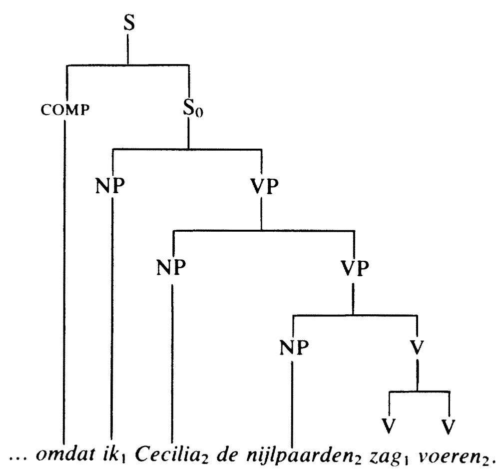

FIGURE 23.

So far as the verb group goes, this structure is pretty orthodox; in fact, the Forward Partial Combination Rule achieves an effect much like a verb-raising transformation (cf. Evers). However, the right-branching structure imposed upon the NP sequence by the backward combination of the verb-composite is not in keeping with any standard transformational account. It also implies that Dutch does not exhibit the tendency to left-branching that was noted earlier for the grammar of English. It was conjectured that this tendency arises from a processing requirement for rapid assembly of complete constituents, associated with the possibility of incremental semantic interpretation. The implication that the preverbal NP sequence in Dutch subordinate clauses remains without structure until the verb group is complete, and that Dutch cannot be incrementally understood in the same way as English, is opposed by common sense and by the introspections of native speakers, who invariably report that Dutch is just like English in this respect. In fact, the structure in Fig. 23 can be shown to be incorrect on purely grammatical evidence from extraction and coördination phenomena.

2.31. The extraction problem. Any of the NP's (and other arguments) in the preverbal sequence may be extracted under relativization, disrupting the normal cross-serial order of the sequence:[36]

(40) (*de appels*) *die ik het meisje Ø zag plukken*
(the apples) which I the girl Ø saw pick
'(the apples) which I saw the girl pick Ø'

This cannot be accepted by the grammar of §2.2, because the verb complex *zag plukken* is separated by the NP's *ik* and *het meisje* from the relative pronoun *die*, and from the subject *ik* by the NP *het meisje*. The problem does not lie in the earlier account of the verb sequence; it is a more general problem in Dutch/German syntax. For example, either object of a ditransitive can be extracted from the preverbal NP sequence in a simple relative clause:

(41) a. *de appels die ik het meisje Ø gaf*
the apples that I the girl Ø gave
'the apples that I gave the girl Ø'
b. *het meisje dat ik Ø appels gaf*

Whatever the category of the verb, one of these extractions will be blocked for the same reason.

The general problem of relativizing German and Dutch preverbal NP's (and other arguments) can be stated as follows. The construction begins with a subject, ends with a group of verbs, and has a group of n NP's (or whatever) in between. Of these, the ith, say, is extracted and placed as a relative pronoun to the left of the subject. The subject, as always, bears the category S/FVP;

[36] The deeper the extracted NP, the more cumbersome the resulting sentence—presumably for pragmatic reasons. Where the semantics permits ambiguity, as in *de jongen die ik het meisje zag kussen* 'the boy that I saw kiss the girl / the boy that I saw the girl kiss', some subjects will accept only the extraction of the higher complement NP. However, in examples like 40, where semantics will permit only the deeper extraction, they will accept it; so the limitation is not in the grammar.

and the verbs can be composed by partial combination into a single verb-like entity (... $(FVP/NP_1)/ \ldots)/NP_n$—requiring the *n* NP's in the crossed order, as above. (In Dutch, this partial combination is generally of the forward kind, and in German it must be predominantly of the backward variety; but the result is the same.) The general form of the German/Dutch relative clause can therefore be written

(42) $R\$/(S\$/NP_i)\ S/FVP\ NP_1 \ldots NP_h\ \emptyset\ NP_j \ldots NP_n\ (\ldots(FVP/NP_1)/\ldots)/NP_n$

The verb group can pick up NP_n to NP_j in the usual way by backward combination, to yield

(43) $R\$/(S\$/NP_i)\ S/FVP\ NP_1 \ldots NP_h\ \emptyset\ ((\ldots (FVP/NP_1)/\ldots)/NP_h)/NP_i$

But at this point, the construction is blocked.

Within the present framework, there is only one way that any extraction can ever be accommodated. Under the Adjacency Property (11), all material between the relativized item R\$/(S\$/X) and the verb which requires X as an argument must be composed by the combination rules into a single entity S/X. In the case of a relativized NP_i, the implication is that the subject, along with NP's 1 to *h* and and the complex that includes NP's *j* to *n* and the verb group, must all combine into a single entity S/NP_i. Since there may be arbitrarily many such NP's, they must all be functions—just as topics, relatives, and the subject are—and must combine by partial combination.

2.32. Type-raised non-verbal complements. The present theory already includes type-raising, which was introduced precisely to turn arguments into functions, in order to capture the grammar of preposing in English. We are therefore free to suppose that Dutch and German NP complements bear a category similar to English topics and relative pronouns; they are functions whose domain is certain verbal functions which take such NP's as their arguments, and whose range is that of their results. As in the previous analysis, I will begin with a simple but overgeneralizing proposal, and then proceed to restrict it. Since more than one kind of verbal function takes an NP complement to its left, we need a variable v which ranges over a suitably restricted set of categories. And since some of the functions are of higher order, we need the \$ notation. We can then provisionally write the following very general type-raised functor:

(44) NP Complement Category
v\$/(v\$/NP)

The syntactic restrictions which this category requires will become apparent when we consider its behavior under the combination rules. Its semantics is simply to apply the function matching v\$/NP to the original unraised NP, to yield v\$, its result.[37]

[37] In earlier versions of this theory, the NP Complement Category appears as v/(v/NP). The semantics of the novel raised NP category, and the analogous categories for PP's etc.—which are all of the form v\$/(v\$/X)—is analogous to that of the topicalized and relativized categories given in fn. 12. That is, they are functions of the form λ f[f(X')] and of type $\langle\langle \tau_X, \tau_{v\$}\rangle, \tau_X\rangle$, where τ_X is the type of an expression X′ constituting the interpretation of the original category, and f is a variable ranging over functions of type $\langle \tau_X, \tau_{v\$}\rangle$.

It will be assumed below that other non-verbal arguments of verbs, e.g. prepositional and adverbial phrases, can bear analogous categories of the form v$/(v$/X), where X is PP, ADV and the like. As in the case of the nominative subject category, NP's and the like could acquire novel categories like 44 either via the lexicon and the combination rules,[38] or via a rule substituting the category for NP.

2.32.1. FORWARD COMBINATION OF v$/(v$/X). The novel categories which include object NP's of the form v$/(v$/NP) can combine with verbs, and with verb groups that result from partial combination by forward combination. Thus the Dutch complement ... *dat hij appels at* '... that he ate apples' is accepted as in Figure 24.

```
... dat   hij      appels        at.
         -----  -----------  ------
         S/FVP  v$/(v$/NP)   FVP/NP
                -------------------F
                        FVP
         --------------------F
                  S
```

FIGURE 24.

The application of the Forward Combination Rule with the novel category assumes an intuitively obvious 'matching' process, whereby the v$/NP is constrained to equal FVP/NP by the argument term. Because of the semantics of the NP Complement Category, the end result of this process is the same as the corresponding derivation using backward combination: the function FVP/NP is applied to the NP, and yields FVP. It is therefore simplest to assume that ALL arguments of the verb group that appear between it and the subject must bear the novel kind of category. In particular, all complement NP's in subordinate clauses will always have Category 44, and can only combine with the verb group by forward combination. (As in English, the Backward Combination Rule can then be limited to postmodifiers such as adverbials.)

However, if the type-raised category is not to cause overgeneration, it must be restricted—for a start, to taking VERBAL functions as its argument. Other functions over NP, such as prepositions, must be excluded, since Dutch is not a postpositional language.[39] Second, the discussion at the end of §2.2, concerning the exclusion of certain overgenerations via restrictions on backward combination (39), shows that—so long as we are dealing only with subordinate clauses—the only verbal functions that we want these NP's to combine with are those yielding FVP and S*te*-inf. We can therefore write the type-raised category as follows, using v$ as a variable which may only match those two categories:[40]

[38] In this case, the category of the Ger. masculine accusative article *den* (as opposed to the corresponding nominative *der*) would be (v$/(v$/NP))/N.

[39] Riemsdijk's analysis of a restricted class of postpositions in Dutch (1978) implies that, in present terms, these postpositions are functions into a verbal category, like the particles which they strikingly resemble.

[40] In earlier versions of the theory, the restriction on the NP Complement Category is less specific.

(45) NP Complement Category
v$/(v$/NP) WHERE v ∈ {FVP, S*te*-inf}

With these restrictions, the grammar is equivalent to the earlier one. The derivations of the infinitival sentences in Figs. 21b–c will go through just as before, except that the combinations of the verb complex with the preverbal objects will be by forward, rather than backward, combination. For example, the derivation in Fig. 21c goes as in Figure 25.

... dat ik Cecilia Henk de nijlpaarden zag helpen voeren.

S/FVP v$/(v$/NP_1) v$/(v$/NP_2) v$/(v$/NP_3) ((FVP/NP_1)/NP_2)/NP_3
——— F
(FVP/NP_1)/NP_2
——— F
FVP/NP_1
——— F
FVP
——— F
S

FIGURE 25.

Because of the semantics of the novel function categories, the result is the same as in Fig. 21c, using the simple NP category and the Backward Combination Rule. The restriction imposed on v in 45 has exactly the same effect as the parallel restriction on backward combination embodied in Rule 39: the overgeneralizations 35a–b, 36–37, and the main-clause order are excluded, but the grammatical constructions are allowed. However, the problematic right-branching structure over the NP's remains unchanged; thus the possibility of extraction remains unexplained until we consider the interaction of the novel category with forward partial combination.

2.32.2. FORWARD PARTIAL COMBINATION OF v$/(v$/X). Since the novel categories of the form v$/(v$/X) simply encode sets of functors like FVP/(FVP/NP), they can act as the 'argument' functor in partial combination. For example, a subject and an object may compose under the rule to give a function which can forward-combine with the verb, as in Figure 26.

... dat hij appels at.

S/FVP v$/(v$/NP) FVP/NP
——— FP
S/(FVP/NP)
——— F
S

FIGURE 26.

Again, an intuitively obvious matching process is assumed, whereby the variable v$ in the argument functor is constrained to be equal to the FVP required by the main functor.[41] Because of the semantics of partial combination and of the novel NP Complement Category, the result of this derivation is exactly the same as was produced in Fig. 24 by two forward combinations. The result of such a partial combination can in turn partially combine with a further NP bearing the novel category, and the result can do so as well. The result of such iterated forward partial combination is a function over exactly the kind of verbal functions that were produced from the composition of the verb group in §2.2; and it can combine with the verb group by forward combination, as in Figure 27.

```
... omdat  ik     Cecilia          Henk            de nijlpaarden    zag helpen voeren.
          -----  ----------     -----------      --------------    ------------------
          S/FVP  v$/(v$/NP1)    v$/(v$/NP2)      v$/(v$/NP3)       ((FVP/NP1)/NP2)/NP3
          -------------------FP
            S/(FVP/NP1)
            ----------------------------FP
                  S/((FVP/NP1)/NP2)
                  ---------------------------------------FP
                        S/(((FVP/NP1)/NP2)/NP3)
                        -------------------------------------------------------------F
                                                   S
```

FIGURE 27.

The surface structure of the NP sequence that is induced by partial combination into the novel category is left-branching. This fact will prove crucial in the analysis of extraction presented below. (Certain further implications for a processor which conforms to the strong competence hypothesis are discussed in §3.)

Before returning to the problem of extraction, however, two further possibilities for partial combination of the novel category must be considered. When both main and argument functors are categories of the novel kind, partial combination has no effect on the weak generative capacity of the grammar. It allows certain additional derivations for sentences like the one in Fig. 27—e.g., that in Figure 28. But it allows no sentences that are not already permitted, because of the associativity property of functional composition.

```
... omdat  ik     Cecilia      Henk           de nijlpaarden    zag helpen voeren.
          -----  ----------   -----------    --------------    ------------------
          S/FVP  v$/(v$/NP1)  v$/(v$/NP2)    v$/(v$/NP3)       ((FVP/NP1)/NP2)/NP3
                 ----------------------FP
                   v$/((v$/NP1)/NP2)
                   -------------------------------FP
                         v$/(((v$/NP1)/NP2)/NP3)
          ------------------------------------FP
                 S/(((FVP/NP1)/NP2)/NP3)
                 ---------------------------------------------------------F
                                              S
```

FIGURE 28.

[41] In Steedman 1984, this matching process is made explicit in a separate instance of the Forward Partial Combination Rule, equivalent to

X/Y v$/(v$/Z) ⇒ X/Z.

A further opportunity for forward partial combination of the novel category, where it would act as the 'main' functor, must not be allowed. Such a rule would overgeneralize, allowing NP's to appear in the ungrammatical nesting order, as in Figure 29.

```
... *dat  ik     de nijlpaarden      Cecilia        zag voeren.
         ______  ______________   ______________  ________________
         S/FVP   v$/(v$/NP2)      v$/(v$/NP1)  (FVP/NP1)/NP2
         ______________________FP ________________________________*FP
            S/(FVP/NP2)                      FVP/NP2
            ________________________________________________F
                                 S
```

FIGURE 29.

Allowing this third possibility would lead to very free constituent order indeed.[42] Both the above types of partial combination can be excluded by the following very restricted version of the Forward Partial Combination Rule:

(46) $X/Y \; Y\$/Z \Rightarrow X\$/Z$ WHERE $X \neq v\$$

To exclude only the latter type, we need a slightly more complex restriction, allowing X to be v$ just in case Y is too:

(47) $X/Y \; Y\$/Z \Rightarrow X\$/Z$ WHERE $X \neq v\$$
OR $Y = v\$$

In §2.42, concerning coördination in Dutch, I will argue that the latter is the correct version.

2.4. EXTRACTION AND COÖRDINATION. The Forward Combination Rule (33) and the restricted versions 46–47 of the Forward and Forward Partial Combination Rules allow the following three types of combination for the novel categories of the form v\$/(v\$/Y), where the restrictions of 45 mean that X is either of the form FVP\$ or S*te*-inf\$:

(48) a. Forward combination (Rule 33): $v\$/(v\$/Y) \; X/Y \Rightarrow X$
b. Forward partial combination (Rules 46–47): $W/X \; v\$/(v\$/Y) \Rightarrow W/(X/Y)$
c. Forward partial combination (Rule 47 only): $v\$/(v\$/Y) \; v\$/(v\$/Z) \Rightarrow v\$/((v\$/Y)/Z)$

With the categories introduced in the earlier analysis, together with the novel categories and these possibilities for forward and forward partial combination, the grammar will account for a wide variety of extraction and coördination phenomena exhibited by infinitival subordinate clauses.

2.41. RELATIVE CLAUSES. Extraction of relativized items is now allowed. For example, the complex NP which translates as *the teacher who I saw Cecilia help Ø feed the hippos* is accepted as in Figure 30 (overleaf).

[42] The free word-order consequent upon unconstrained composition coupled with type-raising has been noted by Benthem 1983. The exclusion of such combinations from the grammar of Dutch leaves open the possibility that other languages will not be so restricted—cf. §3.2 and fn. 46, below. A related suggestion is made by Hoeksema 1983, commenting on Benthem.

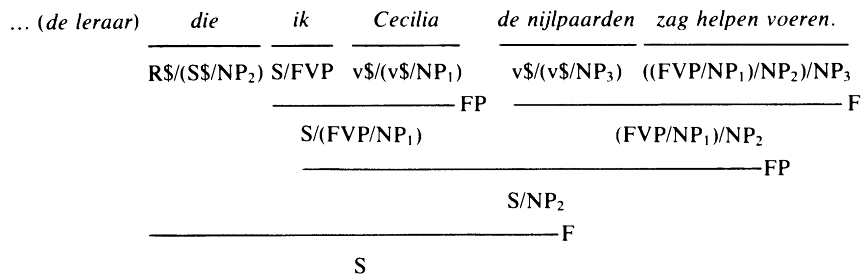

FIGURE 30.

The derivation involves the following steps. First the subject S/FVP partially combines with the object *Cecilia*, which bears the category $v\$/(v\$/NP_1)$, to yield $S/(FVP/NP_1)$. Next, the object [*de nijlpaarden*] $v\$/(v\$/NP_3)$ combines with the verb group, $((FVP/NP_1)/NP_2)/NP_3$, by simple forward combination. The entity [*ik Cecilia*] $S/(FVP/NP_1)$, resulting from the earlier partial combination, can now partially combine with the new result [*de nijlpaarden zag helpen voeren*] $(FVP/NP_1)/NP_2$, to give [*ik Cecilia de nijlpaarden zag helpen voeren*] S/NP_2—a function with which the relative pronoun can combine by simple forward combination, as usual. (Of course, the grammar correctly allows two further derivations for Fig. 30, which is ambiguous in Dutch. These further readings correspond to Eng. *the teacher who I saw Ø help Cecilia feed the hippos*, and the semantically anomalous *the teacher who I saw Cecilia help the hippos feed Ø*.)

The general case 42, defined in §2.31, can be accepted in an analogous fashion. That is, the subject and the complement NP's 1 to *h* that precede the site of extraction can combine, by successive forward partial combination, into a function of the form $S/((\ldots(FVP/NP_1)/\ldots)/NP_h)$. (As the last example shows, the processor must somehow cope with the problem of deciding where the extraction site actually is; but that is not a problem of grammar.) The complement NP's *j* to *n* that follow the extraction site can combine with the verb complex by successive forward combination into a single entity $((\ldots(FVP/NP_1)/\ldots)/NP_h)/NP_i$. These two entities can then undergo forward partial combination in the usual way, as if canceling $((\ldots(FVP/NP_1)\ldots)/NP_h)$—to give a single entity S/NP_i, with which the relative pronoun $R\$/(S\$/NP_i)$ can finally combine by the Forward Combination Rule to yield R. At every stage, the semantics of the object category $v\$/(v\$/NP)$, plus the fact that partial combination corresponds to the composition of functions, ensure that the correct dependencies are established in the semantics. Exactly the same apparatus will allow either NP in 41 (but not both) to be extracted.

The introduction of type-raised categories for NP complements adds to the already unorthodox view of surface structure discussed in §1.22, and justified in terms of the account of English coördination phenomena in §1.23. The next section shows that the novel structures have the same kind of independent support from Dutch coördination phenomena.

2.42. COÖRDINATION. If all coördination in Dutch and German is mediated by the schema introduced at 14 and repeated here as 49, the grammar outlined above will permit some clear predictions concerning the kinds of clause fragments that may potentially conjoin:

(49) X^{+} CONJ $X \Rightarrow X$

Of course, whether the constructions in question will be accepted by native speakers is a more complex question—perhaps involving pragmatic difficulties, with which RNR constructions are particularly fraught. Although such factors appear to intrude at a couple of points below, the freedom in Dutch to coördinate almost any continuous sub-sequence of the clause seems strikingly consistent with the theory. The detailed predictions are as follows:

(A) It should be possible to conjoin any continuous sub-sequence of verbs, since these can combine by the basic Forward Partial Combination Rule (9) to make a verbal constituent:

(50) a. ... *omdat ik Marie de paarden zag* [*voeren en wassen*].
because I Mary the horses saw feed and wash

b. ... *omdat ik Marie de paarden* [*zag voeren en hoorde wassen*].
because I Mary the horses saw feed and heard wash

c. ... *omdat ik Marie de paarden* [*zag en hoorde*] *wassen*.

d. ... *omdat ik Henk de kinderen zag* [*leren en helpen*] *zwemmen*.
because I Henk the children saw teach and help swim

e. ... *omdat ik Henk de paarden zag* [*leren zwemmen en helpen springen*].
because I Henk the horses saw teach swim and help jump

f. ... *omdat ik Henk de kinderen* [*hoorde leren en zag helpen*] *zwemmen*.

A sentence parallel to 50f receives a '*?' rating from Bresnan et al. (618), and is used to justify the assumption of a right-branching surface structure for the verb group (following Evers). Many speakers will allow it; and it is arguable that the source of its anomaly is pragmatic, not grammatical. The present theory allows the verbs to combine in either left- or right-branching fashion, and therefore allows all the above.

(B) Simple conjunction of NP's will allow 51a, below. But it should also be possible to conjoin any sub-sequence of the preverbal NP sequence which includes the subject, as in 51b–d, since such sequences can compose by iteration of the Forward Partial Combination Rule, as in 48b, to yield a single constituent:

(51) a. ... *dat Jan* [*de kinderen en de paarden*] *zag zwemmen*.

b. ... *dat* [*Jan de kinderen en Marie de paarden*] *zag zwemmen*.

c. ... *dat* [*Jan Marie en Cecilia Henk*] *de kinderen zag helpen zwemmen*.

d. ... *dat* [*Jan Marie de kinderen en Henk Cecilia de paarden*] *zag helpen zwemmen*.

Exx. 51b–d have commonly been attributed to some form of backward gapping; and 51b is parallel to the following example, given by Oirsouw (555, ex. 8b)—apart from the fact that the latter has the verbs in the German order, as is common with *hebben*:

(52) *Ik geloof dat Jan* SYNTACTIC STRUCTURES *en Piet* ASPECTS
I believe that Jan and Piet
gelezen heeft.
read has
'*I believe that Jan *Syntactic structures* and Piet has read *Aspects*.'

On the assumption that forward gapping in Dutch, just like English gapping, can omit the verb group in right conjuncts (by a mechanism which the present theory does not specify), Oirsouw's ex. 8c also leaves a single constituent before the gap in the right conjunct:

(53) *Ik geloof dat Jan* SYNTACTIC STRUCTURES *gelezen heeft, en Piet* ASPECTS.

(C) With the most restricted Forward Partial Combination Rule (46), the grammar will not allow preverbal sequences that do not include the subject; hence the following will be excluded:

(54) a. ... *dat Jan de kinderen [een treintje aan Piet*
that Jan the children a train to Piet
en een pop aan Henk] zag geven.
and a doll to Henk saw give

b. ... *dat Jan [de meisjes een treintje aan Piet en de jongens*
that Jan the girls a train to Piet and the boys
een pop aan Henk] zag geven.
a doll to Henk saw give

c. ... *dat Jan [de meisjes een treintje en de jongens een pop] aan Henk zag geven.*

However, if the less restricted version 47 is included, allowing combination on the pattern of 48c, then 54a–c are all allowed, on the assumption that the dative PP *aan Henk* has the category v\$/(v\$/PPdat) and that one category of the stem *geef-* 'give' is (VP/NP)/PPdat. Ex. 54a is completely acceptable. A sentence parallel to 54b is assigned the '??' degree of grammaticality by Bresnan et al. (619), and is used to justify a rather different account of the NP sequence. It is widely accepted by other consultants. Ex. 54c is not discussed by Bresnan et al., but is also widely accepted.[43]

(D) Since the complete verb sequence can combine by the Forward Combination Rule, on the pattern of 48a, with preverbal NP's in the crossed order, any sub-sequence which includes all the verbs and some rightmost sub-sequence of the preverbal NP sequence can be a constituent, and may

[43] The fact that main-clause and subordinate-clause orders for multiple arguments are the same in Dutch, with the related fact that such multiple argument groups can display RNR (cf. Neijt), may also be explained by the inclusion of this version of the rule, and the consequent possibility of treating those NP sequences as constituents as well.

also conjoin:

(55) a. ... *dat ik Henk [de paarden zag voeren en de olifanten hoorde wassen]* '... that I saw Henk feed the horses and heard him wash the elephants.'

b. ... *dat ik [Cecilia de nijlpaarden zag voeren en Henk de olifanten hoorde wassen].*

(E) However, unless such conjuncts include the entire verb group, the combination with the NP's will be impossible with the rules as set out above. It follows that sentences like the following are excluded by the present grammar:

(56) a. ... *omdat ik Cecilia [de nijlpaarden zag en de olifanten hoorde] wassen.*

b. ... *omdat ik [Cecilia de nijlpaarden zag en Henk de olifanten hoorde] wassen.*

Some speakers will tolerate these. According to the present theory, they can only be accepted in a grammar of Dutch which includes the appropriate form of German-style backward partial combination. Such a grammar could be made to allow constituents like the one in Figure 31 to be composed, and therefore to conjoin under Rule 14.

... *Cecilia* *de nijlpaarden* *zag* ...

$v\$/(v\$/NP_1)$ $v\$/(v\$/NP_2)$ FVP/Sinf

——————— FP

$v\$/((v\$/NP_1)/NP_2$

——————— BP

$FVP/((Sinf/NP_1)/NP_2)$

FIGURE 31.

Thus it is unsurprising that acceptance of these examples appears to be linked to those dialects allowing other constructions that implicate such a German-style rule:

(57) a. ... *dat zij appels* ETEN MOET. (cf. 27d)

b. ... *omdat ik Cecilia de nijlpaarden* VOEREN ZAG. (cf. 31a)

However, no attempt to specify the relevant restrictions on the combination rules will be made here.

The above cases exhaust the possibilities for conjoining continuous subsequences of NP's and verbs. However the doubtful cases may be resolved, it is striking that so much freedom is allowed in Dutch—and that all of it can be accounted for by the present grammar, using rules which have a well-defined compositional semantics.

It is even more striking that, within alternative theories, many of these constructions have appeared to demand a rule of backward gapping, with no parallel in English. Such a rule would have extremely anomalous properties, as the following asymmetry between forward and backward gapping in main and subordinate clauses shows:

(58) a. Forward gapping in subordinate clause
... dat Jan appels at en Piet bonen Ø.
... that John apples ate and Pete beans
b. Backward gapping in subordinate clause
... dat Jan appels Ø en Piet bonen at.
c. Forward gapping in main clause
Jan at appels en Piet Ø bonen.
d. Backward gapping in main clause
**Jan Ø appels en Piet at bonen.*

Maling has argued, on the basis of related evidence, that the relevant constructions in German are most simply accounted for in terms of RNR, rather than gapping—a proposal which is consistent with my analysis. In the terms of the present theory, RNR always reduces to simple constituent coördination; and the reason that 58d is not well-formed is that it does not offer two adjacent like constituents. Dutch thus has exactly the same mechanism of constituent coördination as English, and exactly the same restriction of gapping to the forward variety. In Dutch as in English, the possibilities for extraction and coördination are related to the single principle of grammar embodied in forward partial combination, and the corresponding operation of functional composition.

Conclusions

3. The above account necessarily suffers from many omissions. Many important questions—including adverbial placement, negation, main-clause orders in Dutch and German, and inversion and extraction of the grammatical subject—have been deferred or ignored entirely. However, since the theory establishes that long-range dependencies, including those that intersect, are connected with so-called reduction of coördinate structures, it seems worthwhile to consider some broader implications.

Every grammar for a particular natural language is implicitly a theory of universal grammar. Every degree of freedom in the theory that is exploited in order to capture all and only the constructions of the given language constitutes an implicit prediction that the grammar of other languages will exploit the other alternatives that are available under that degree of freedom—subject only to limitations which can be attributed in a principled way to such influences as the semantics that the grammar reflects, or the pressures of acquisition and processing. The challenge that is offered by discontinuous constituents in general, and crossing dependencies in particular, is therefore twofold. Any proposed extension to CF grammar must be powerful enough to capture the constructions themselves. But the extension will inevitably allow a great many grammars which, it is certain, are not possible human ones: even mere CF grammar does that. The non-occurrence of these grammars should be explainable on principled grounds, just as the non-occurrence of certain kinds of CF rules and combinations of CF rules in grammars can be explained in terms of non-transparency with respect to the semantics, and its effects on learning and processing. The study of the Dutch data leads to two main contentions. The first is that the crossed dependencies are explained by the involvement of the partial combination rules of functional composition. The second is that extraction and coördination possibilities demand that preverbal NP's and the like should bear functor categories. The broader implications of these two proposals will be considered in turn.

3.1. Crossed dependencies. I noted at the outset that crossing dependencies are comparatively rare. Although many, and perhaps most, natural languages seem to include a few such dependencies, no language entirely crosses dependencies, or even crosses a majority of them. The question of why they are so rare therefore remains crucial for any theory that allows them at all. Grammars of the kind proposed here allow crossed dependencies when they include higher-order function categories which combine with some of their arguments to one side, and with others to the other side.[44] In §2, we saw that the grammar of Dutch has this character. Its verbs come predominantly in the same (rightward) order as those of English, and must therefore find verbal argument functors to their right, by essentially the same (Forward) Partial Combination Rule as English. But NP's and the like occur on the left of the verbs.[45]

It is well known from cross-linguistic studies—e.g. by Greenberg 1966, Vennemann 1973, Lehmann 1978, Comrie 1981, Hawkins 1980, 1982, and Mallinson & Blake 1981—that languages of the world have a strong tendency to place like constituents, such as VP and PP, in a consistent order of head and complement (German and Dutch are rather unusual in this respect). The trend is generally supposed to originate in semantic similarities between such categories, and in a requirement for natural grammars to reflect semantics as transparently as possible. The latter requirement is equally widely supposed, in turn, to reflect requirements of ease of learning, or processing, or both.

In terms of the present theory, this observation translates into a tendency for semantically related function categories to find their arguments consistently to one side or the other, as has been noted within other categorial approaches to universal grammar (Venneman 1973, Keenan & Faltz 1978, Flynn 1983). It follows that the conditions under which crossed dependencies can arise according to the present theory are known, for independent reasons, to be rare. To that extent, the rarity of the crossed dependencies themselves is explained.

3.2. Type-raising, verb-finality, and grammatical case. According to the theory proposed here, the possibility of extraction out of the Dutch/German subordinate clause forces us to postulate functor categories for NP's and other arguments of the verb, so that they can be composed into a single function

[44] With the inclusion of higher-order functions and the general forms of the Partial Combination Rules (9–10), grammars of the present kind can easily be made to generate some classic non-CF languages, such as 'XX' languages (which comprise all and only strings made up of any sub-string X on the lexicon followed by the same sub-string X), and related languages such as $a^nb^nc^n$.

[45] The complications introduced in §2.3 in order to accommodate extraction phenomena (which, I argue below, are related to the concept of case) do not affect this picture; however, the replacement of NP's by the novel accusative category v$/(v$/NP) changes the rule by which verbs and complement NP's combine from the backward to the forward version.

which takes the verb group as argument. It follows that such categories must be included in other verb-final languages which allow extraction.

There is one clear piece of evidence that the novel categories are indeed present elsewhere. It is well known that the asymmetrical pattern of forward and backward deletion exhibited by Dutch coördinate sentences (cf. ex. 58) is widespread in verb-final languages. Ross 1970 and Maling 1972 have observed that so-called backward gapping of V is apparently limited to SOV languages—or more properly to SOV constructions, at least among SO languages. In some rigidly verb-final languages, such as Japanese, it is the only kind of (verbal) gapping that is allowed. By contrast, SVO and VSO languages and constructions seem never to allow it. Thus the following possibilities exist:

(59) a. SVO + SO, but *SO + SVO
b. VSO + SO, but *SO + VSO
c. SOV + SO, and SO + SOV

Maling concludes, as noted, that so-called backward gapping is equivalent to RNR—while true gapping is confined to the forward version, as in the present theory. However, the possibility of bringing SO + SOV under the same heading as RNR, via simple constituent coördination (Rule 14), depends in the present theory upon SO being a constituent, which depends in turn on the involvement of the novel categories. The Ross generalization therefore implies that the mechanism invoked for Dutch is widespread among verb-final languages.

These observations make it seem highly probable that the novel function categories are related to the phenomenon of case, which has also long been thought to be highly correlated with verb-finality. (See Mallinson & Blake for a survey of recent opinion.) It is surely significant in this connection that German has a comparatively active (although ambiguous) case system; however, since Dutch does NOT have one, explicit case-marking is apparently not a necessary concomitant of the novel categories.[46]

The possibility of Dutch and German derivations like that in Fig. 27, where successive NP's are composed, one-by-one and in left-to-right order, into a successively more and more complex function, is a direct result of the inclusion of the novel categories. They therefore restore to the grammar of German and Dutch (and potentially to other verb-final languages) the property that was noted in §1 for the grammar of English. That is, the rules suggest a tendency to combine constituents as rapidly as possible from left to right—a tendency which means that the grammar is directly and obviously compatible with incremental semantic interpretation in processing, with the addition of no further apparatus other than a mechanism for resolving local syntactic ambiguities.[47]

[46] Since case and so-called free word-order are also strongly correlated, we may further conjecture that certain languages with more elaborate case systems, e.g. Classical Latin and Hungarian, may achieve such freedom by exploiting some of the further opportunities for composing cased categories that have been eschewed in the grammar of Dutch, as in Fig. 29, rather than by belonging to a separate 'non-configurational' class of languages.

[47] The further apparatus which would be required by a grammar without functional composition would presumably amount to doing in the semantics exactly what the present grammar does in syntax, namely composing functions (see Pollard & Sag 1983 for a proposal of this kind within GPSG).

3.3. SUMMARY. According to the argument given here, the following linguistic facts are all related by a single underlying principle of grammar:

(a) the possibility of unbounded rightward and leftward extraction in English and Dutch (and by implication German);

(b) a wide range of apparently reduced coördinate constructions in those languages;

(c) the possibility of intersecting dependencies in Dutch infinitival complements;

(d) the comparative rarity of intersecting dependencies among natural languages in general;

(e) a well-known cross-linguistic generalization about the distinctive character of coördinate structures in verb-final languages, first noted by Ross 1970.

These results follow from the assumption that natural language grammars include rules of functional composition. In addition, such grammars appear to reflect, in a direct and obvious way, the possibility of incremental interpretation by a left-to-right processor of what, in traditional terms, are considered incomplete right-branching constituents. The implication is that a very close relation may hold in natural languages between syntax, semantics, and the computation performed by the processor.

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