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GAPPING AS CONSTITUENT COORDINATION*

"Bluebirds and Thrushes work beautifully together," said Bravura.

To Mock a Mockingbird, R. Smullyan

A number of coordinate constructions in natural languages conjoin sequences which do not appear to correspond to syntactic constituents in the traditional sense. One striking instance of the phenomenon is afforded by the "gapping" construction of English, of which the following sentence is a simple example:

(1) Harry eats beans, and Fred, potatoes

Since all theories agree that coordination must in fact be an operation upon constituents, most of them have dealt with the apparent paradox presented by such constructions by supposing that such sequences as the right conjunct in the above example, *Fred, potatoes*, should be treated in the grammar as traditional constituents, of type *S*, but with pieces missing or "deleted".

The present paper extends earlier analyses relating coordination to unbounded dependency in terms of a "combinatory" generalization of the Categorial Grammars (CG) of Ajdukiewicz, Bar-Hillel, and others. The generalization shares with CG a view of natural language categories as comprising *functions* and their *arguments*, but allows these categories to combine by operations other than mere functional application. The operations to be described below include Functional Composition and Type-raising, whose inclusion in natural language syntax and semantics

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has a precedent in the work of Lambek (1958, 1961) and Geach (1972). Functional composition is a very simple example of a general class of operations on functions and arguments called "combinators", which were proposed by Curry and Feys (1958) in order to define the class of "applicative systems" that includes the lambda calculi. An applicative system is simply a calculus which defines the notions of functional application and functional "abstraction", where the latter term essentially means the definition of a function or concept in terms of some other(s). It is therefore hardly controversial to suggest that natural language syntax is a reflection of some such system. Curry's combinators are of interest because they allow the notion of abstraction to be defined without invoking variable-binding. While almost all theories of coordination and unbounded dependency can be seen as reflections of an underlying applicative system, most appeal to the notion of variable binding in some form. The relevance of the combinators to the present purpose is that they allow a treatment of these phenomena without the use of bound variables, and therefore without the need to invoke "empty categories" – in particular, "Wh-trace" – as their linguistic correlate.[1]

The inclusion of functional operations like composition has the effect of generalizing the notion of surface constituent, if what is meant by that term is any grammatical entity which is: (a) operated upon by grammatical rules, and (b) interpretable. Not only are verbs and verb phrases constituents under this analysis, but also sequences like *might eat* and *Mary might*. (The former arises because verbs like *might* are functions over VPs, and are allowed to compose with other functions into categories of the appropriate type, like *eat*, which is a function from NPs into VPs. The latter arises via type raising of the subject, to make it a function over the predicate category, and composition with the verb, which is a function into the predicate category). This controversial notion of surface constituency allows a large number of otherwise puzzling "reduced" coordinate constructions to be subsumed under a simple rule paraphraseable as "conjoin constituents of like type", without requiring rules of deletion or movement to derive such fragments from more traditional constituents. The theory captures as theorems a number of well-known constraints on coordinate

[1] Curry himself followed Ajdukiewicz and others in suggesting the existence of a close link between applicative systems and natural language syntax (see Curry and Feys, pp. 274–75). Curry and Feys (Chap. 5) still provides the simplest introduction to the theory of combinators, while Smullyan (1985), provides the most entertaining exposition, in which combinators take the form of birds. The system Smullyan describes is a close relative of the present one, which in his terms could be called "Bluebird, Thrush, and Starling grammar".

structures. For example, Steedman 1985a (hereafter, "D&C") applies the combination of type raising and composition to the coordination of NP sequences in Germanic so-called "Backward Gapping", and Dowty (1988, written in 1985) extends a similar treatment to English coordinates like *Mary gave* [*Harry bread and Barry potatoes*]. Both authors point out that the theory accounts for well known universals concerning the direction of gapping in verb-initial and verb-final languages without the use of any additional apparatus. Thus, verb-initial languages can only allow "forward" gapping, on the pattern of (a) below, while verb-final languages allow "backward" gapping and generally exclude the forward variety, as in (b) (Ross, 1970; Mallinson and Blake, 1981, Chap. 4, esp. 218–226):[2]

(2)a.	VSO:	VSO and SO,	*SO and VSO
b.	SOV:	*SOV and SO,	SO and SOV
c.	SVO:	SVO and SO,	*SO and SVO

However, both authors stop short of a complete account of verb-medial gapping, as in English *Harry ate bread and Barry, potatoes*. In particular, they fail to explain why such languages should pattern with the verb-initial ones in permitting forward, but not backward, gapping (Ross, 1970), as in (c) above.

The present paper completes the account of gapping within CG, subsuming it to the same mechanism as all other coordination. The argument has two parts. First it is shown that gapped right conjuncts like *Barry, potatoes* also have the status of constituents under the present theory, and can therefore potentially coordinate under the same rule. Such constituents also have an interpretation which enables them to combine with the missing verbal component to yield a correct interpretation for the whole. The principles of "Adjacency", "Consistency", and "Inheritance" proposed in Steedman (1987, hereafter, "CGPG"), together with the "order preserving" constraint on type raising that any relatively fixed order language must have, allow just the rule that is required for an SVO language to compose a subject and an object (say) into a non-standard constituent bearing the category of a leftward-looking forward-gapped function over transitive verbs. No rule which will produce a rightward-looking backward-gapped function from the English SVO subject and object categories is permitted by these principles.

According to this theory, the "gapped" conjunct is interpreted not by

[2] This generalization requires some qualification. Some languages like German which are usually classed as verb-final show both backward and forward gapping in certain verb-final constructions. This point is addressed later.

recovery of a deleted verbal entity, or by anaphora to material in the left conjunct, but by constituent coordination with an entity of the same type in the ungapped conjunct. The second part of the argument shows how this "hidden" constituent can be recovered, despite not being a continuous constituent of the left conjunct, even under the present liberal definition. The *associativity* of functional composition induces semantic equivalence over certain classes of derivations. Furthermore, the *parametric neutrality* of combinatory rules like composition and application allows the recovery of certain constituents under one derivation from the result of another. This property is central to the apparatus which Pareschi (1986) and Pareschi and Steedman (1987) propose for a CG parser which copes with the proliferating syntactic analyses of the present theory via what they call "lazy" chart-parsing, using a single rule to recover a hidden constituent. However, associativity and parametric neutrality are also properties of the rules of Combinatory Grammar, and can therefore be invoked in the grammar itself to complete the definition of the well-formed orders of constituents under coordination. The theory generalizes to the coordination of certain discontinuous VPs in German, discussed by Hoehle (1983), who relates them to verb gapping under the name of "subject gapping".

1. Intuitive Basis of Combinatory Grammars

1.1. *Pure Categorial Grammar*

Combinatory Categorial Grammar (CCG) is an extension of Categorial Grammar (CG). Elements like verbs are associated with a syntactic "category" which identifies them as *functions*, and specifies the type and directionality of their argument(s) and the type of their result. The present paper uses a notation in which the argument or domain category always appears to the right of the slash, and the result or range category to the left. A forward slash / means that the argument in question must appear on the right, while a backward slash \ means that the argument must appear on the left. All functions are "Curried", so the category of a simple transitive tensed verb is as follows:[3]

[3] The reader is warned that other superficially similar but different notations are used by some of the other authors referred to here. The present notation has the advantage of being easy to read, because the order of range and domain is consistent. Because of the present concern with semantics, and with comparisons across languages with similar semantic types but different word-orders, this consistency is crucial. It will be apparent in Section 3 below,

(3) *eats*: $= (S\backslash NP)/NP$

Curried functions are functionally equivalent to "flat" functions of many arguments, and it will be convenient to refer to S in the above function as its range, and the two *NP*s as its domain or arguments.

Such categories should be regarded as both syntactic and semantic objects. They can be represented computationally by a single data structure uniting syntactic type and semantic interpretation in unification-based implementations like those of Zeevat, Klein and Calder (1986), Pareschi and Steedman (1987), and Pareschi (1989) (Cf. Karttunen 1986; Uszkoreit 1986; Shieber 1986; and Wittenburg 1986 for related approaches.) The categories can be represented in full in an expanded notation (which will be used as sparingly as possible), in which each elementary category is associated with a term representing its interpretation using the symbol ":". The above category appears as follows in this notation:[4]

(4) *eats*: $= (S{:}eat'\ np2\ np1\backslash NP{:}np1)/NP{:}np2$

Syntactic categories are uppercase, and semantic constants bear primes. The lowercase identifiers without primes, like *np*1, can be thought of as semantic variables. However, they are really more primitive entities than variables, and should be thought of as nodes in a directed acyclic graph representing the category in one of the unification formalisms mentioned above. Note that application "associates to the left", so that the expression *eat' np*2 *np*1 is equivalent to (*eat' np*2) *np*1.

It is the semantic aspect of the category that determines the grammatical or functional role of the first argument to be that of the object of the eating, and the second to be the subject. Although the syntactic and semantic roles of categories and the rules that combine them are unified in the theory in this way, the above category is cumbersome and hard to read. Usually, the syntactic category alone, which represents the *type* of the category, will be all that is needed.

Such functions can combine with arguments of the appropriate type and

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where the full theory is presented, that the notation used in this paper is an abbreviation for a notation in which directionality that is, relative position is a property of the argument of a function. In the full notation, the category of the transitive verb is written $(S/-NP)/+NP$, where the slash / is *non*-directional, and the arithmetic prefixes − and + are features of the domain, and indicate that the argument in question appears to the left and right of the verb, respectively.

[4] In earlier papers this category is sometimes abbreviated as $(S\backslash NP)/NP$: *eat'*, where the expression to the right of the colon identifies the interpretation of the whole category. The change, and the consequent changes in the notation of combinatory rules that follow, is a notational convenience. There is no difference in the theory.

position by rules of functional application, written as follows:

(5) **The Functional Application Rules:**

a. $X/Y \quad Y \quad \Rightarrow \quad X \quad (>)$

b. $Y \quad X\backslash Y \quad \Rightarrow \quad X \quad (<)$

Such rules are both syntactically and semantically rules of functional application. X and Y in such rules are variables over categories, including interpretations in the full sense exhibited in example (4). They can be thought of as variables in a unification-based formalism, such as the programming language Prolog, (cf. Pereira and Shieber, 1987) or PATR-II (Shieber, 1986). Such variables are instantiated by unifying them with terms identifying categories of appropriate type, like the verb *eats* of example (4) (in which the variables can also be directly represented by Prolog or PATR variables) and an argument *apples*.[5]

For a full exposition of the concept of unification, the reader is directed to Shieber (1986). The intuition behind the notion is that that it is an operation which amalgamates compatible terms, and fails to amalgamate incompatible ones. The result of amalgamating two compatible terms is the most general term that is an instance of both the original terms. For example, the following pairs of terms unify, to yield the results shown:

(6)
$$\begin{array}{lll} x & a' & \Rightarrow a' \\ f'(g'a') & x & \Rightarrow f'(g'a') \\ f'x & f'(g'y) & \Rightarrow f'(g'y) \\ f'a'x & f'yy & \Rightarrow f'a'a' \end{array}$$

The following pairs of terms do not unify:

(7)
$$\begin{array}{lll} a' & b' & \Rightarrow \mathit{fail} \\ f'x & g'y & \Rightarrow \mathit{fail} \\ f'a'b' & f'yy & \Rightarrow \mathit{fail} \end{array}$$

It is emphasized that the use of unification in the present theory is solely as a transparent implementation based on graph reduction for combinatory operations like functional application. Unification does no autonomous work in the theory of grammar. In particular, it does not mediate long distance dependencies, and is not used to simulate Wh-trace or co-indexing thereof.

The functional application rules (5) allow derivations like the following:

[5] There is no significance to the distinction between upper and lower case for these two kinds of variables. It is merely typographically convenient.

(8)

```
Harry     eats       apples
-----  -----------   ------
 NP    (S\NP)/NP      NP
       ------------------>
             S\NP
-----------------<
         S
```

(Underlines indicate combination via the application rules, and the annotations mnemonically indicate which rule has applied.) In the full notation, this derivation appears as follows:

(9)

```
  Harry                      eats                        apples
----------  -------------------------------------   -------------
NP:harry'   (S:eat' np2 np1\NP:np1)/NP:np2          NP:apples'
            ------------------------------------------------------>
              S:eat' apples' np1\NP:np1
-----------------------------------------------<
        S:eat' apples' harry'
```

The derivation thus builds a compositional interpretation. (Semantic constants like apples' are mere placeholders for a real semantics, intended to do no more than illustrate this compositionality.) Of course, such a "pure" categorial grammar is context free.

1.2. *Coordination*

In earlier papers on the present theory, coordination was introduced via the following schema, which goes back at least as far as Chomsky (1957, p. 36, ex. 26), and can be paraphrased as "conjoin like categories".[6] For the moment we will ignore its notoriously obscure semantics, except to annotate the arrow in the rule to indicate that it is obtained from that of

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[6] The notion of "like category" is of course problematic for any theory of syntax, as well-known examples like the following reveal (Sag et al., 1985):

(i) Pat is a Republican and proud of it

We shall not discuss such problems here, assuming that some finer-grained feature-based categorization of atomic categories like NP (such as the one offered by Sag et al., themselves) can be applied to the present theory.

the conjuncts by a functional $\mathbf{\Phi^n}$ (of which more later) of that semantics *and'*.

(10) **Simplified Coordination Rule** (⟨&⟩):

$$X \quad conj \quad X' \quad \Rightarrow_{\Phi^n and'} \quad X''$$

X, X' and X'' are categories of the same type but different interpretations. The rule is a schema over (a subset of) the categories of the grammar, each instance of the schema having a different semantics. The n in $\mathbf{\Phi^n}$ corresponds to the number of arguments for the type X. Using such a rule schema, transitive verbs (for example) could coordinate as follows:

(11)

```
I    cooked    and     ate     the beans
--  --------   ----  --------  ---------
NP (S\NP)/NP  conj  (S\NP)/NP      NP
   ----------------------------<&>
            (S\NP)/NP
            ---------------------------->
                    S\NP
-----------------------------------<
                S
```

However, such a rule runs counter to Ross's observation (1967, p. 90; as 1986, p. 99) that in English (as opposed to other languages cf. Schacter 1985, p. 47), conjunctions are "prepositional" – that is, they associate structurally with the right conjunct, not the left.

The natural expedient for a categorially-based approach might seem to be to eschew such syncategorematic rules, and drive coordination from the lexical category of the conjunct. One might for example follow Lambek (1958, 1961), who proposed to associate the following categorial type with sentential conjunctions like *and*:

(12) $and := (X''\backslash X)/X'$

where the lexical category itself includes polymorphic type variables ranging over functions of the same type, written X, X' and X''.

However, such a category won't quite do, because conjuncts do not behave like other categories with respect to the rules developed below (nor even with respect to the rules permitted by Lambek – see note 26). Instead, we replace the single rule (10) by two rules.[7]

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[7] The rule simulates a second order system in first-order notation. There are limits to this trick, and it will break down in the face of coordination of intrinsically second order terms, such as the subject categories discussed below. This problem (see Moore, 1989 for discussion) is common to all first-order systems. It does not affect any of the present claims, so we shall continue to use the first-order notation.

The first, capturing the prepositional character of SVO conjunctions, marks the category to its right as a conjunct:

(13) **Forward Coordination Rule:(>&)**
$conj \;\; X \;\; \Rightarrow \;\; [X]_{\&}$

The rule has no semantic consequences. It merely marks the category that it combines with using a feature written &. The square brackets indicate that the feature belongs to the *entire* category, and since combinatory rules such as the application rules (5) make no mention of this feature, it has the effect of blocking their application.[8] But such a category *can* combine by a second special-purpose rule, which is indexed <&:

(14) **Backward Coordination Rule (<&):**
$X \;\; [X']_{\&} \;\; \Rightarrow_{\Phi^{n}and'} \;\; X''$

Again, this rule is a schema over categories of the grammar, each instance having a different semantics. For present purposes, we can assume that there is a bounded number of such instances:[9]

The instance relevant to the present example (11) is the following rule:

(15) $(S{:}s1\backslash NP{:}np1)/NP{:}np2 \;\; [(S{:}s2\backslash NP{:}np1)/NP{:}np2]_{\&}$
$\Rightarrow (S{:}and'\ s1\ s2)\backslash NP{:}np1)/NP{:}np2$

The variables s1 and s2 are variables over terms which will in practice always be terms in two variables.[10] Thus the rule combines the two transitive verbs (a) and (b) below to yield (c):

(16)a. $(S{:}cook'\ np4\ np3)\backslash NP{:}np3/NP{:}np4$
b. $(S{:}eat'\ np6\ np5)\backslash NP{:}np5/NP{:}np6$
c. $(S{:}and'\ (cook'\ np2\ np1)(eat'\ np2\ np1)\backslash NP{:}np1)/NP{:}np2$

[8] If categories are represented as Prolog terms, then the feature & is a function constant, applied to the core category.

[9] This proposal is itself something of a simplification. See below for remarks concerning a more general but more notationally laborious solution to the problem, which makes English conjunctions closer to the Latin clitic coordinator *-que*. The present paper will not consider coordination of other than sentential functions. The problem of generalizing coordination to more than two conjuncts, and the semantics that goes with this generalization, are discussed in Steedman (1989a) (hereafter, "CCCG").

[10] The generalized rule of functional composition introduced below induces an in principle unbounded number of categories to the grammar. If *n* in the coordination schema were truly unbounded, Weir (1988) has shown that the automata-theoretic power of the system would be increased. This power stems from the fact that the two instances of the polymorphic type variable X must unify with functions of the same syntactic type, and therefore give the rule a certain kind of "counting" ability. See Weir (1988) and Weir and Joshi (1988) for further discussion of the power that is implicated. See Gazdar (1988) for linguistic arguments that this power may be required for the grammar of languages like Dutch.

The following derivation is therefore allowed by the rules for (11), and delivers an appropriate interpretation:

(17)
```
I    cooked     and   ate          the beans
-  ----------   ----  -----------  ---------
NP (S\NP)/NP   conj  (S\NP)/NP      NP
               ----------------->&
                  [(S\NP)/NP]&
   -------------------------------<&
               (S\NP)/NP
               -----------------------------> 
                        S\NP
-------------------------------<
                 S
```

1.3. *Functional Composition*

In order to allow coordination of contiguous strings that do not constitute traditional constituents, CCG generalizes the grammar to allow certain operations on functions related to Curry's combinators (Curry and Feys, 1958). For example, functions may *compose*, as well as apply, under the following rule

(18) **Forward Composition** (>B):
$X/Y \quad Y/Z \quad \Rightarrow_{\mathbf{B}} \quad X/Z$

The most important single property of combinatory rules like this is that they have an invariant semantics. The semantics of this rule is almost as simple as functional application. It is in fact functional *composition*. The combinator which composes two functions F and G is called **B** by Curry, and is Smullyan's Bluebird. It can be defined by the following equivalence:

(19) $\mathbf{B}FGx \equiv F(Gx)$

A convention that application associates to the left is again followed, so that the left hand side is equivalent to $((\mathbf{B}F)G)x$. It follows that we can consider the application of **B** to F and G as producing a new function equivalent to abstracting on x in the above expression, thus:[11]

(20) $\mathbf{B}FG \equiv \lambda xF(Gx)$

[11] The equivalence sign in these definitions is supposed to indicate that the combinators are *primitives*, not that they are defined in terms of the abstraction operator λ.

The new rule (18) is semantically a typed version of this combinator. Hence the arrow in the rule is subscripted $\Rightarrow_{B}$, and the application of the rule in derivations is indexed >B. For example the categories of the verbs *might* and *eat* compose as in (21) below, via the unification of the two terms *VP:pred*1 *np*1 and *VP:eat' np*2 *np*3 with the variable *Y* in the rule, which makes the variable *pred*1 equal to the term *eat' np*2, and unifies the two variables *np*1 and *np*3. Note that the subject of the infinitival is explicitly represented in the interpretations, and that *pred*1 is a second order variable. The interpretation of the infinitival subject *np*3 is thus reminiscent of similar treatments within LFG and Montague frameworks, in occurring at the level of the interpretation, rather than at the level of surface structure. It is bound to the interpretation *np*1 of the syntactic subject of the sentence by the composition. This process plays no part in mediating the unbounded dependency and related coordination phenomena that are the present concern.[12]

(21)

```
                 might                                   eat
---------------------------------------------  -------------------------
(S:might'(pred1 np1)\NP:np1)/VP:pred1 np1      VP:eat' np2 np3/NP:np2
------------------------------------------------------------------------>B
         (S:might'(eat' np2 np1)\NP:np1)/NP:np2
```

What is going on here is that the composition combinator is being interpreted via graph reduction or substitution, implemented using unification, very much in the manner that Turner (1979a, b) has proposed for functional programming languages based on combinators.[13]

Using this rule, which is indexed in derivations as >B, sentences like *I*

[12] The fact that *pred*1 is a second-order variable means the notation is going a little beyond first-order systems like Prolog at this point. Those familiar with Prolog will realize that this kind of second-order property can easily be simulated in that language, by treating terms as individuals (cf. Pereira and Shieber, 1987), as is done below for the type-raised categories.

[13] Turner proposes that applicative programming languages like LISP based on the λ-calculus should be compiled into combinatory expressions, because the combinatory expressions can be interpreted by purely graph structural operations, without the use of bound variables, and hence without the attendant computational overheads of keeping track of binding environments. In CGPG, I conjecture that the same reasons of computational efficiency may provide an explanation for why the constructions in human languages under discussion here are realized as a variable-free combinatory system.

cooked, and might eat, the beans can be accepted. Crucially, the fact that the semantics of the rule is functional composition guarantees that the derivation yields the appropriate interpretation, assuming again that a semantics is also provided for the coordination rules:

(22)

```
I    cooked     and   might      eat   the beans
--  ---------  ----  ---------  -----  ---------
NP (S\NP)/NP   conj (S\NP)/VP   VP/NP     NP
                    ----------------->B
                        (S\NP)/NP
               ---------------------->&
                        [(S\NP)/NP]&
    --------------------------------<&
               (S\NP)/NP
               ------------------------------->
                             S\NP
-----------------------------------<
               S
```

Of course, the grammar continues correctly to exclude examples like the following, because only *adjacent* like categories can coordinate:

(23) *I cooked the beans and might eat

The earlier papers point out that a generalization of composition is required for sentences like the following, which though clumsy is parallel to examples which Abbott (1976) shows should be included in the grammar of English:

(24)

```
I   offered,         and   may        sell,       my pink Cadillac  to your mother
--  ---------------  ----  ---------  ----------  ----------------  --------------
NP  ((S\NP)/PP)/NP   conj  (S\NP)/VP  (VP/PP)/NP        NP                PP
                           ---------------------->Bn
                              ((S\NP)/PP)/NP
```

The generalization simply allows composition into certain functions of more than one argument. It is stated as a schema over functions of indefinitely many arguments, as follows:

(25) **Generalized Forward Composition** (>Bn):
$X/Y \quad Y/...Z \quad \Rightarrow_{\mathbf{B}^n} \quad X/...Z$

The notation $Y/...Z$ is here defined as a schema over functions combining to their right with one or more arguments.[14] The rule itself is thus also a schema. The semantics of each instance depends on the number of arguments that this function has, and is one of the series of combinators called **B**, $\mathbf{B}^2$, $\mathbf{B}^3$,... . It is represented by Curry's own schematization of these composition combinators as $\mathbf{B}^n$, as the annotation on the arrow indicates. In English, we can assume without loss of generality that the instances of this schema are bounded by the maximum number of rightward arguments subcategorized for by lexical functions, which seems to be $n = 3$.[15]

1.4. *Type-raising*

Combinatory grammars also include type-raising rules, which turn arguments into functions over functions-over-such-arguments. Since these rules allow arguments to become functions, they may by that token compose with *other* functions, and thereby take part in coordinations like *I cooked, and you ate, the legumes.* Like composition, the type-raising rules have a simple and invariant semantics. The semantics corresponds to another of Curry's basic combinators, which he called $\mathbf{C}_*$ but which we will here call **T** for type-raising, in homage to Rosser and to Smullyan (1985), in whose book it is the Thrush. It is defined by the following equivalence:

(26) $\mathbf{T}xF \equiv Fx$

It follows that **T** applied to an argument creates the following abstraction over the function:

(27) $\mathbf{T}x \equiv \lambda F\, Fx$

For example, the following rule, indexed >T, is needed for coordinate sentences like *Harry found, and I cooked, the mushrooms.*

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[14] In essence this makes the rule a schema over verbs of the English lexicon. In earlier papers, the corresponding schema was defined slightly more generally, leading to some overgeneration. I am grateful to Glyn Morrill for drawing my attention to this error.

[15] This limitation is possible because other properties of the grammar of English prevent composition from "growing" categories that have unboundedly many arguments. However, even a grammar with a limit of $n = 2$ may have this growth property. (Consider for example the language with three lexical entries $a := (S/B)/S$, $b := B$, and $c := S$.) The Dutch construction discussed in Section 3 below has the growth property, and shows that the bound in Dutch may be greater than the lexical bound, if there is a bound at all. The same generalization is implicit in the backward coordination rule, whose semantics is defined by Curry's combinator Φ^n. See Weir (1988), Weir and Joshi (1988) for arguments that in both cases, unbounded n, in conjunction with the full set of rules developed in Section 3 below, engenders increased power in the grammar.

(28) **Subject Type-raising** (>T):
$NP \Rightarrow_T S/(S\backslash NP)$

The category of a subject *Harry* that is delivered by this rule is the following somewhat strange expression:

(29) $S{:}s/(S{:}s\backslash NP{:}harry')$

The variable s again ranges over terms, which in practice will always be terms in a variable which unification will bind to *harry'*.[16] For example, if the category applies to a predicate, such as *walks* in (a) below, it will yield the proposition, (b), since both instances of the variable are bound by the unification:

(30)a. $S{:}walks'\ np1\backslash NP{:}np1$
b. $S{:}walks'\ harry'$

It can also compose with a transitive verb, as follows:

(31)
```
Harry                     found
--------------------      ----------------------------------
S:s/(S:s\NP:harry')       (S:find' np2 np1\NP:np1)/NP:np2
---------------------------------------------------------->
            S:find' np2 harry'/NP:np2
```

Derivations like the following are therefore allowed, and deliver appropriate interpretations:

(32)
```
Harry     found      and   I        cooked      the mushrooms
-------   --------   ---   -------  ----------  -------------
  NP      (S\NP)/NP  conj  NP       (S\NP)/NP        NP
-------->T                 -------->T
S/(S\NP)                   S/(S\NP)
------------------->B      ------------------->B
        S/NP                      S/NP
                     -------------------->&
                           [S/NP]&
        -------------------------<&
                     S/NP
                     -------------------------------------->
                                 S
```

[16] The category is again a first order simulation of a second order category. The limits on such simulations with respect to coordination were noted above.

Of course, the following example is excluded, because, once again, only *adjacent* categories can coordinate:

(33) *[I will cook]$_{S/NP}$ [the mushrooms]$_{NP}$ and [Betty will eat]$_{S/NP}$

Type-raising may look like a strange notion to include in natural grammar. However, the intuition behind it is precisely the same as the linguists' notion of *cases*, like nominative and accusative. For example, nominative case morphology in a language like Latin determines a noun-phrase argument like *Balbus* to be something which must combine with a predicate, like *ambulat*, or *murum ædificavit*, to yield a proposition *walk' balbus'* or *build' wall' balbus'*. In categorial terms, nominative case turns *Balbus* into a function whose interpretation is precisely **T***balbus'* – that is, a function over functions-over-subjects, or predicates. Similarly, accusative case turns nounphrases into functions over a different type of functions, functions over objects, with a semantics which is again defined in terms of **T**. Thus, the only cause for surprise at this ingredient of CCG is that English behaves like a cased language without marking case morphologically.

The comparison with Latin points to an option in the theory. Should we consider type-raising to be an operation of active syntax, like composition, or to be a rule of the lexicon or of morphology, as the identification with Latin case would suggest? In the latter case, of course, not only nominative NPs like *I*, but also uncased NPs like *Mary*, and even articles like *the* would have to bear additional categories like *S*/(*S**NP*), (*S*/(*S**NP*))/*N*, and so on. Hepple (1987), has shown that the difficulty of processing in the face of category-changing operations makes it likely that the lexical alternative must be adopted for parsing. However, as far as the theory of grammar goes, the distinction can be ignored.

One category related to type-raising that we certainly want to be lexically assigned is the category of the relative pronoun, for the addition of type raising and composition to the theory of grammar provides everything needed in order to account for leftward extractions in relative clauses. So on the further assumption that relative pronouns bear a lexical category (*N**N*)/(*S*/*NP*) – a function from fragments like *I cooked* to noun modifiers which is itself closely related to a type-raised category – the following is accepted:

(34)
```
(the apples)   that          I             cooked
             -----------  ----------->T  -----------
             (N\N)/(S/NP) S/(S\NP)       (S\NP)/NP
                          ------------------------->B
                                   S/NP
             ----------------------------->
                        N\N
```

It should be obvious that the theory immediately predicts that leftward and rightward extraction will be unbounded, since embedded subjects can have the raised category, and composition can apply several times, as in the following:[17]

(35)a. I think that I cooked, but I doubt whether you ate, the beans.
b. The beans which I think that I cooked, but I doubt whether you ate.

Both types of extraction will be subject to the "across-the-board" condition on extraction out of coordinates, because the grammar does not yield categories of like type for the conjuncts in examples like the following:

(36)a. *(Mushrooms which) [I will cook]$_{S/NP}$ and [Betty might eat them]$_{S}$
b. *(A man who) [I met]$_{S/NP}$ and [married Mary]$_{S\backslash NP}$

The rules of composition and type-raising will potentially allow certain non-conjoinable sequences like *I ate the*$_{S/N}$ and *I met a woman who kept*$_{S/NP}$ to compose, and therefore to coordinate, or be extracted over, in violation of well-known "island" constraints on such constructions. The important question of the source of these phenomena is only tangentially related to the discussion, so it has been relegated to a necessarily brief appendix to the present paper.

The freedom for subjects to type-raise and compose seems at first glance to allow a bizarre overgeneration whose status is relevant to the discussion of gapping below.[18] Strings like *I doubt whether Harry* look as though they will compose to yield a category with the same type as a subject, $S/(S\backslash NP)$, thus:

(37)
```
   I         doubt     whether   Harry ...
--------  ----------  -------  ---------
S/(S\NP)  (S\NP)/S'    S'/S    S/(S\NP)
-------------------->B
      S/S'
      ------------------->
            S/S
            ---------------------------->
                  S/(S\NP)
```

---

[17] In offering a common origin for phenomena of coordinate structure and relativization, the present theory has some affinity to GPSG (Gazdar, 1981; cf. Gazdar et al., 1985). See the earlier papers and Szabolcsi (1983, 1986, 1987) for details, including remarks concerning ECP/**that-t* filter, right-roofs and pied piping.

[18] See the discussion of example (113) in Section 3.3 below

Such constituents threaten to allow the following overgenerations, by coordination with a subject:

(38)a. *[Harry] but [I doubt whether Fred] went home.
b. *[I think that Fred] and [Harry] went home.

There are at least two ways to prevent such sentences. One is to include in the type of true raised categories the information that they are still nominal. The other is to forbid the "bogus" categories like (37) from coming constituents in the first place, via a restriction on the composition rule. The question depends on whether such marginal sentences as the following, which attempts to conjoin such putative constituents, are held to be grammatical or not:

(39) ?I am confident that Fred, but doubt whether Harry, will support the reforms.

I here follow the analysis in CCCG in assuming that they should be excluded from the grammar, via the following restriction on forward composition, which forbids such composition into functions taking tensed predicates as arguments:

(40) **Forward Composition** (>B):
$X/Y \quad Y/Z \quad \Rightarrow_{\mathbf{B}} \quad X/Z$
where $Z \neq S\backslash NP$

Since subjects are the only such categories, the only effect of the restriction is to exclude categories like (37), and examples like (38).

1.5. *The Concept of Surface Structure*

It will be clear from the discussion in the previous sections that combinatory grammars embody an unusual view of surface structure, according to which strings like *Betty might eat* are, quite simply, constituents. According to this view, surface structure is also more ambiguous than is generally realized, for such strings must also be possible constituents of non-coordinate sentences like *Betty might eat the mushrooms*, as well. It follows that such sentences must have several surface structures, corresponding to different sequences of composition, type raising and application. (An entirely unconstrained combinatory grammar would in fact allow any bracketing on a sentence.) Such families of derivations form equivalence classes, for of course they all deliver the same interpretation, determining the same function-argument relations. (It is assumed here that the level of interpretation in question is neutral with respect to non-argument-structure dependent aspects of meaning such as quantifier scope.) Indeed, there is a close relation between the canonical interpretation structures that they deliver according to the theory sketched above, and traditional notions of constituent structure.

It follows that grammatical phenomena that depend on structural relations like c-command that have traditionally been related to surface structure must be re-defined at the level of interpretation structure, a move which has also been proposed within a Montague Grammar (MG) framework by Bach and Partee (1980), and within the Lexical-functional Grammar (LFG) framework by Bresnan et al. (1982). Since these interpretations are "projected" from the lexicon by the combinatory rules, many of these phenomena, notably those of binding and control, will be handled there, another affinity with MG and LFG, (and, less directly, with GB). From such a point of view, the combinatory rules can be identified with a constrained instantiation of the concept of "reanalysis" (Zubizarreta, 1982; Goodall, 1987), as Hoeksema (1989) has pointed out.

However, the proliferation of surface analyses also creates problems for parsing written text, because it compounds the already grave problems of local and global ambiguity in parsing by introducing numerous semantically equivalent potential derivations. The problem is acute: while it clearly does not matter which member of any equivalence class the parser finds, it has to find *some* member of *every* semantically distinct class of analyses. The danger is that the entire forest of possible analyses will have to be examined in order to ensure that all such analyses have been found. This problem has been referred to as the problem of "spurious" ambiguity by Wittenburg (1986).[19]

It has already been noted that the associativity of functional composition ensures that all the derivations that arise from composing functions in different orders for a given set of given function-argument relations will produce the *same* interpretation.[20] This fact both sanctions the coherence

---

[19] This term is somewhat misleading. See Steedman (1989b) for an argument that these semantically equivalent derivations are functionally distinct, in that they convey distinctions of discourse information, and that the extra structural ambiguity that they introduce is largely resolved by intonation in spoken language.

[20] These assumptions amount to saying that the functions in question are one-to-one mappings. It follows that we are talking about an interpretation which is neutral with respect to distinctions of meaning that are not solely dependent upon function-argument relations, such as quantifier scope ambiguities. Most importantly, all and only the variables in the semantics of the result of a function are represented in the semantics of its arguments. This assumption is discussed further by Pareschi and Steedman, 1987, under the name of the Transparency assumption, and I am indebted to Michael Niv for pointing out the need for the present reformulation.

of the grammar itself, and points to a solution to the parsing problem: if these analyses are equivalent, it clearly doesn't matter *which* of them we find, just so long as we find *one*. A couple of simple strategies immediately suggest themselves as the basis for a parser that just finds one analysis in each equivalence class, paraphraseable as "combine as soon as you can", or "only combine when you have to". A&S suggested that the first alternative, expressed as a "reduce first" strategy embodied in a shift-reduce parser, augmented by a means for handling non-determinism, would be the basis for an algorithm to do this. This regime favours predominantly left-branching analyses like the above, where the grammar permits them, rather than the standard right-branching surface structures.[21] The problem for that commonsense parser, as for other left-to-right processors, arises from the nondeterminism introduced by the presence of *backward modifiers*. There are a number of proposals for dealing with this problem, including Wittenburg (1986, 1987), Pareschi and Steedman (1987), and Hepple and Morrill (1989).

2. Limits on Possible Rules

All the combinatory rules exemplified above conform to the following three principles, which are conjectured in earlier papers to be universal:

(41) **The Principle of Adjacency:** Combinatory rules may only apply to entities which are linguistically realized and adjacent.

(42) **The Principle of Directional Consistency:** All syntactic combinatory rules must be consistent with the directionality of the principal function.

(43) **The Principle of Directional Inheritance:** If the category that results from the application of a combinatory rule is a function category, then the slash defining directionality for a given argument in that category will be the same as the one defining directionality for the corresponding argument(s) in the input function(s)

The first of these principles is simply the assumption that some set of combinators, typed over terms, will do the job. The other two are argued in CGPG to follow from deeper assumptions about the nature of categories

[21] In this respect, the processor resembles the one proposed by Hausser (1986). However, it is here the *parser* that is as left-associative as the grammar permits, not the grammar itself.

themselves.[22] They allow the following instances of composition and type raising:[23]

(44) **The Possible Functional Composition Rules:**

a.	X/Y	$Y/...Z$	$\Rightarrow_{\mathbf{B}^n}$	$X/...Z$	(>B)
b.	X/Y	$Y\backslash...Z$	$\Rightarrow_{\mathbf{B}^n}$	$X\backslash...Z$	(>Bx)
c.	$Y\backslash...Z$	$X\backslash Y$	$\Rightarrow_{\mathbf{B}^n}$	$X\backslash...Z$	(<B)
d.	$Y/...Z$	$X\backslash Y$	$\Rightarrow_{\mathbf{B}^n}$	$X/...Z$	(<Bx)

---

[22] Both principles can be viewed as following from the assumption that directionality is a property of the argument of a function, just as its syntactic category or its semantics is, as in the Unification Categorial Grammar of Zeevat et al. (1987). This property encodes the string position of that argument relative to the function. Under this assumption, the directional slashes in a category like that of the transitive verb $(S\backslash NP)/NP$ are a shorthand for a more explicit notation which we might write $(S/-NP)/+NP$, where the prefixes to the arguments represent their position relative to the function in question. This property of an NP is of course undefined in the lexicon, and becomes defined when the NP occurs in a string. In this extended notation, rules which violate the Principle of Consistency are contradictory, and cannot be implemented via unification. For example, consider the following version of functional application:

(i) $* -Y \quad X/+Y \;\Rightarrow\; X$

The Principle of Inheritance follows from the fact that the semantics of combinators like composition forces directionality to be inherited, like any other property of an argument. Again, unification is transparent to this property, and will block rules like the following:

(ii) $*X/+Y \quad +Y/+Z \;\Rightarrow\; X/-Z$

However, crossed composition is allowed.

The constraints that are imposed upon the type-raising rules by the assumption that directionality is heritable in this way are less obvious. Type raising (whether lexical or syntactic) is a unary rule, so the relative position of the raised category and its argument is not defined. When such a category combines with a function in the appropriate direction the directionality will be specified. But at least if type-raising occurs off-line, in the lexicon, it does not seem to be necessarily restricted to the order preserving kind. For example, the type-raising rule >Tx (which is defined below) can be written in this notation as follows

(iii) $X \;\Rightarrow\; \mathrm{T}/+(\mathrm{T}/+X)$

The result is non-order-preserving in the sense that it induces a word order opposite to that of its argument function $+(\mathrm{T}/+X)$. However, unification does not block the rule, since relative position is unspecified on the input. It may or may not be possible to formulate type raising in a way that excludes such rules from universal grammar, but for the present I tentatively conclude that they do not violate the principle of consistency, (*contra* an earlier claim in CGPG). It is not clear that this result is desirable, for the uses for non-order preserving type raising remain very few.

[23] The combinator called S mentioned in an earlier note, and included in the theory in order to accommodate "parasitic" multiple dependencies also engenders four instances, two of which are non-order-preserving. The reader is referred to the earlier papers for details.

(45) **The Possible Type-raising Rules**:

a. $X \Rightarrow_{\mathrm{T}} \mathrm{T}/(\mathrm{T}\backslash X)$ (>T)

b. $X \Rightarrow_{\mathrm{T}} \mathrm{T}/(\mathrm{T}/X)$ (>Tx)

c. $X \Rightarrow_{\mathrm{T}} \mathrm{T}\backslash(\mathrm{T}/X)$ (<T)

d. $X \Rightarrow_{\mathrm{T}} \mathrm{T}\backslash(\mathrm{T}\backslash X)$ (>Tx)

(It will become apparent below that the interpretation of schematized functions like *Y*/ . . . *Z* here must be slightly more general than the particular interpretation given earlier for the English forward composition rule (25).)

The Principle of Inheritance also limits coordination rules like (10) and (14) to ones in which the input and output categories are identical in directionality, as well as all other aspects.

It is important to note that some of these rules – namely >Bx, <Bx, >Tx, and <Tx – are *not* theorems of the Lambek calculus, and their inclusion in syntax represents a point of divergence between the present theory and linguistic theories derived from the Lambek calculus, such as Moortgat's. The significance of this departure is twofold.

First, the rules that *are* theorems of the Lambek calculus – that is, >B, <B, >T, and <T have an *order-preserving* property. That is to say that the inclusion of these rules in a categorial grammar with a given lexicon induces no re-ordering, but only some new *derivations* (although the inclusion of higher types may also induce new strings). Since the language induced by a categorial lexicon and functional application alone is context-free, grammars including only order-preserving rules are also context-free (cf. Zielonka, 1981). The other rules that are not theorems of the Lambek calculus are *non-order preserving*, and induce reordering. Indeed, Moortgat (1988b), following van Benthem (1986), shows that systems including completely unconstrained non-order-preserving rules generate the permutation closure of the context free language defined by the lexicon.

(46) **Order-Preserving Rules:** >B, <B, >T, **and** <T
Non Order-Preserving Rules: >Bx, <Bx, >Tx, **and** <Tx

It follows that any combinatory grammar for a configurational language that includes any of the non-order preserving rules must restrict their application to certain types. For example, if a language is to be classified as configurational at all, it must almost entirely exclude the non-order-preserving instances of type raising. The inclusion of type restrictions on rules in combinatory grammars for individual languages is another point of divergence from the Lambek tradition (cf. Moortgat, 1988b, esp. pp. 94 and 117).

Nevertheless, the existence of non-configurational languages suggests that much of the freedom allowed by the three principles via the non-order-preserving rules may be exploited in other languages (cf. D&C; Zwarts, 1986; Bouma, 1986). In particular, the earlier accounts suggest that the combinatory grammars of English and Dutch require *all* of the above composition rules, both order-preserving and non-order-preserving, although productive type raising across general categories like NP is almost entirely confined to the two order-preserving varieties, as it must be in relatively fixed-order languages.[24]

For example in order to account for coordinate sentences like the following, Dowty (1988) introduces the order-preserving rules <B and <T:[25]

(47)

```
 give          a dog             a bone     and      a policeman       a flower
 ---------- ---------------------<T --------<T ----- ---------------------<T ---------<T
 (VP/NP)/NP (VP/NP)\((VP/NP)/NP) VP\(VP/NP) conj (VP/NP)\((VP/NP)/NP) VP\(VP/NP)
            --------------------------------<B      -------------------------------<B
                 VP\((VP/NP)/NP)                          VP\((VP/NP)/NP)
                 ----------------------------------------------------------------<&>
                                  VP\((VP/NP)/NP)
 --------------------------------------------------<
                 VP
```

I will follow Schacter and Mordechai (1983), in referring to such sentences as "left node raised". The important fact to note about this derivation is that the type-raised categories of the indirect and direct objects are simply those that are allowed by the order preserving backward type-raising rule (45)c, given the category of the English verb. The *only* rule of composition that will permit these two categories to combine is (44)c:

(48) **English Backward Composition** (<B):
$Y\backslash Z \quad X\backslash Y \quad \Rightarrow_{\mathbf{B}^n} \quad X\backslash Z$

---

[24] The only exception in English is that sentence-initial topicalized constituents appear to require a rule related to >Tx. All other non-order preserving type-raised categories (such as relative pronouns q.v.) are lexically unique words, strikingly prone to case marking. Because of their unique position and intonational markedness, it may be reasonable to regard English topics in effect as lexically special items.

[25] Dowty, p. 17, points out that the combinatory theory makes a number of correct predictions about the construction. For example, it correctly allows such right node-raised non-standard constituents to "strand" prepositions, just as standard constituent coordinates can. The acceptability of such strandings appears to be precisely parallel to island constraints on leftward extraction, as is predicted by the fact that both rightward and leftward extraction depend according to the present model on the possibility of assembling the residue into a single entity via the composition rule.

This rule also is order preserving.[26] It follows that the non-standard constituent $[a\ dog\ a\ bone]_{VP\backslash((VP/NP)/NP)}$ can *only* form from an indirect object and an object in the canonical order, and can only combine with a verb to its left.[27] It does not appear to be necessary to generalize the rule beyond **B**. This fact could be argued to stem from the fact that the generalization (which would be written using the schema $Y\backslash \ldots Z$ to mean a function over n arguments to its left) is limited by the maximum number of leftward arguments subcategorized for in the English lexicon – that is, $n = 1$.

Thus, the possibility of left node raising coordinations like the above is predicted by exactly the same ingredients of the theory that were introduced to explain ordinary leftward extraction and right node raising – namely, order-preserving type raising and composition. The existence of left node raising in SVO languages, together with the related dependency of so called "forward" and "backward" gapping on VSO and SOV word-order discussed below, is in fact one of the strongest pieces of confirmatory evidence in favour of the present proposal to base the theory of grammar on these two combinatory operations. It is in respect of these constructions that the theory should be contrasted with other closely related function-oriented and unification-based theories, such as those advanced by Kartunnen (1986), Uszkoreit (1986), Joshi (1987), Zeevat et al. (1987), and Pollard and Sag (1987).

The grammars of both English and Dutch also require *non*-order-preserving composition. For example, in order to accommodate heavy NP shift and related coordinations like the following, it is proposed in CGPG to include an instance of Backward Crossed Composition <Bx, restricted to composing into functions into some predicate category such as VP:[28]

---

[26] It will be clear at this point why we could not use a category of the form $(X''\backslash X)/X'$ for conjunctions. Such a rule would make right conjuncts like and *he talks* into backward S-modifiers, of category $S\backslash S$. Given the backward composition rule <B, such a category could compose with a predicate under this rule among others to permit violations of the "across the board" condition on right node-raising and all other movement out of coordinate structures, as in:

(i) *(a man who) $[\text{walks}]_{S\backslash NP}$ $[\text{and he talks}]_{S\backslash S}$

[27] Since this construction shows that not just subjects but *all* arguments must on occasion be type-raised, the way is clear at this point to make type-raising obligatory. The obvious way to do this is in the lexicon.

[28] That is, the symbol VP is simply a shorthand for $S_{inf}\backslash NP$. The restriction is needed to exclude overgeneralizations like $*the_{NP/N}\ walks_{S\backslash NP}\ dog_N$.

(49)
```
I    shall      buy    today  and  cook tomorrow the mushrooms etc
--  ---------- ------ ------ ---- ------ -------- --------------
NP (S\NP)/VP  VP/NP  VP\VP  conj VP/NP   VP\VP         NP
              ------------<Bx      ------------<Bx
                  VP/NP                VP/NP
                  -------------------------<&>
                            VP/NP
                            ---------------------------------->
                                          VP
```

(50) **English Backward Crossing Composition** (<Bx):
$Y/...Z \quad X\backslash Y \quad \Rightarrow_{\mathbf{B}^n} \quad X/...Z$
where $Y = S_x\backslash NP$

(The schema $X/...Y$ has the same interpretation as in the English forward composition rule (25).) This is only the simplest of a number of constructions which demand non-order preserving rules. For example, the account of the parasitic gap construction in CGPG makes extensive use of the backward crossing substitution rule <Sx, which is not discussed in the present paper, but is non-order preserving in the same sense. More importantly for present purposes, the account of Dutch Cross-serial Dependencies presented in D&C shows that an instance of the last of the four composition rules (44), the forward crossing version >Bx is at work there:[29]

(51)
```
dat    ik     Wim Henk de paarden   zag          helpen          voeren
-----------  ---- ---- ----------  ----------- -------------  -------------
 S/(S\NP)    NP   NP       NP      (S\NP)/Sinf (Sinf\NP)/Sinf  (Sinf\NP)\NP
                                   ------------------------->Bnx
                                      ((S\NP)\NP)/Sinf
                                      ------------------------------------->Bnx
                                              (((S\NP)\NP)\NP)\NP
                           ----------------------------------------<
                                        ((S\NP)\NP)\NP
                   -------------------------------<
                              (S\NP)\NP
              -------------------------<
                       S\NP
 ----------------------------->
              S
```

that I Bill Harry the horses saw help feed
"that I saw Bill help Harry feed the horses"

---

29 The notation of the earlier paper is updated in keeping with the present theory. The rules given there have certain further constraints to prevent overgeneralization to sentences like the following, which are not allowed in standard Dutch:

The rule in question can be written as follows (note that the generalized form of composition is crucial here):

(52) **Dutch Forward Crossing Composition** (>Bnx):
$X/Y \quad Y\backslash ...Z \quad \Rightarrow_{\mathbf{B}^n} \quad X\backslash ...Z$
where $Y\backslash ...Z$ is a generalized verb.

We define the restriction to mean that the subsidiary function $Y\backslash ...Z$ can be any function into S, taking n arguments, of which all but the first are to its left. The first argument may have either directionality. This specification is simply a generalization of the form of Dutch verbs. However, we do not assume that the limit on n is the same as the maximum number of arguments subcategorized for by lexical verbs. The question of whether this construction and the related coordinations allow *any* limit to be placed on n is open (cf. Gazdar 1988). The specification of the class of such schematizations that is permitted in UG also remains an important open problem, but it is very striking that the restrictions required in both Dutch and English are most naturally phrased in terms of lexical classes. The affinity between the lexicon and the constituents permitted by this construction and other consequences of composition suggests a close relation between the present proposal and those of Moortgat (1988b) and Hoeksema (1989), who treat the entire construction lexically. The reader is referred to them and to D&C for further discussion of the Dutch construction in categorial terms. The important result is not only that the rule types that the theory requires for the grammar of English can capture this essentially non-context-free construction, without the invocation of additional rules of "reanalysis" (cf. Haegeman and van Riemsdijk, 1986). It is also that the principles of Inheritance and Consistency *require* a language with the lexicon of Dutch (as opposed to German) to have cross serial dependencies of this kind.

The second part of the present paper shows that a more restricted version of this rule is implicated in English Gapping conjunctions, and therefore that all of the four possible composition rules are implicated in the grammar of English.

(i) *(Ik denk dat) ik zag Wim helpen Henk zwemmen.
I think that I saw Wim help Henk swim.

However, such additional orders *are* allowed in the corresponding sentences of Swiss German (Shieber, 1985; Cooper, 1988), and are characteristic of the related *te*-infinitives in standard Dutch sentences with raising verbs like the following:

(ii) (ik denk dat) ik probeer Henk te leren zwemmen.
I think that I try Henk to teach swim.

3. Gapping

Dowty (1988) and D&C point out that the tactic of applying order-preserving type-raising to arguments, composing them, and then conjoining the resulting non-standard constituents, permits the "backward gapping" construction characteristic of coordinate clauses in SOV languages. Thus, a subject and an object NP can compose, via the forward type-raising rule and forward composition:

(53) SOV: `eats:= (S:eat' np2 np1\NP:np1)\NP:np2`

```
Barry          potatoes                    brought
--------->T    ---------------------->T    ----------
S/(S\NP)       (S\NP)/((S\NP)\NP)          (S\NP)\NP
------------------------------------->B
             S/((S\NP)\NP)
             ------------------------------------------>
                               S
```

The resulting non-standard constituent can therefore conjoin:

(54) [Barry potatoes]$_{S/((S\backslash NP)\backslash NP)}$ and [Harry bread]$_{S/((S\backslash NP)\backslash NP)}$ eats$_{(S\backslash NP)\backslash NP}$

What is more, the Principles of Adjacency, Consistency, and Inheritance, together with the order-preserving constraint on type raising that is the *sine qua non* of an order-dependent language, again limit the possible constituent orders. They do not permit any raised categories or rules of composition that would produce a *leftward* looking function, so that no other constituent orders, in particular the corresponding "forward gapping" construction, are allowed on the SOV lexicon:

(55)a. *Bread Harry and potatoes Barry eats
b. *Harry bread eats, and Barry potatoes

As Ross (1970) points out, this asymmetry tends to be characteristic of SOV languages. However, a number of important qualifications to the generalization have to be made. First, like other germanic languages, Dutch, as discussed in D&C *does* allow coordinations on the pattern of (b) in subordinate clause conjunctions. This exception to the SOV pattern is presumably related to the fact that these languages possess an SVO clause constituent order as well. Second, many SOV languages have rich case systems (Greenberg, 1963: Universal 41). Some of these, such as Japanese, while rigidly verb final, and therefore excluding sentences on the pattern of (b) (Mallinson and Blake, 1981, p. 218), have free argument order, and do permit sentences on the pattern of (a). This fact may be explainable in present terms on the assumption that their case system embodies non-order-preserving type-raising. There is some evidence from the possibility of omitting case inflections in less formal registers of Japanese and Korean that both free word order and gapping depend upon the presence of case, as this proposal would predict (Jee-In Kim, p.c.).

As Dowty pointed out, the position is reversed for verb-initial languages. Again a subject and object can raise and compose to yield a single function over the verb, this time via leftward type-raising and composition, and again the non-standard constituent can coordinate:[30]

(56)

```
VSO: eats := (S:eat' np2 np1/NP:np2)/NP:np1

      Eats             Barry            potatoes
  ----------  -------------------<T  ----------<T
  (S/NP)/NP   (S/NP)\((S/NP)/NP)      S\(S/NP)
              ---------------------------------<B
                        S\((S/NP)/NP
```

(57) Eats$_{(S/NP)/NP}$ [Barry potatoes]$_{S\backslash((S/NP)/NP)}$ and [Harry bread]$_{S\backslash((S/NP)/NP)}$

Again, the three principles exclude any other constituent orders, including the "backward gapping" construction which appears to be universally disallowed in verb-initial languages:

(58)a. *Eats bread Harry and potatoes Barry
b. *Harry bread, and brought Barry potatoes

Thus, according to the combinatory theory, verb-initial "forward gapping", verb-final "backward gapping", and "right node raising", reduce (as Maling's 1972 article implicitly suggests they should) to simple constituent coordination, together with Dowty's English double object coordinations. But what about sentence-*medial* ellipsis? In particular, what about gapping in SVO languages like English?

[30] The alert reader will note that the derivation assumes that the subject is the *first* argument of the VSO verb, not the last, as in the Germanic languages. This assumption seems to be a forced move under the present theory, at least for VSO languages that permit gapping and do not have elaborate case systems.

It is noted in D&C that the theory so far affords almost everything we need to account for gapping in English. For a start, both the residues and the gapped element itself in each of the following well-known family of gapped sentences are all constituents under one or other of the possible analyses of *you want to try to begin to write a play*:

(59) I want to try to begin to write a novel, and . . .
a) you, to try to begin to write a play
b) you, to begin to write a play
c) you, to write a play
d) you, a play

What is more, in all of the earlier examples the coordination of sequences of arguments was brought under the general mechanism of constituent coordination by type-raising the arguments and composing to yield a function over verbal and sentential functors – as in the English example (47), repeated here:

(60) give$_{(VP/NP)/NP}$ [a dog a bone]$_{VP\backslash((VP/NP)/NP}$ and [a policeman a flower]$_{VP\backslash((VP/NP)/NP}$

It is therefore tempting to believe that the sequence of arguments that is left behind by gapping is also a constituent assembled by type-raising and composition, and that gapping is also an instance of constituent coordination under the extended sense of the term implicated in combinatory grammar. Such a constituent would semantically be a function over a tensed verb, so its syntactic category would have to follow suit, as in:

(61) (A dog likes a bone, and) [a policeman, a flower]$_{S\backslash((S\backslash NP)/NP)}$

Under this account, gapping requires the recovery of the *arguments* from the left conjunct, rather than the recovery of the verb. The proposal raises two further questions. The first is whether the universal rules of composition and type-raising will permit the formation of this novel constituent as the *right* conjunct (and whether they will forbid the formation of a similar type of constituent as a left conjunct). The second is the question of how a second constituent of this type can be derived from the ungapped *left* conjunct, in which the arguments of the verb were not contiguous. These two questions are logically independent.

3.1. *The Category of the Right Conjunct*

Given the SVO category of the English transitive verb, and the type-raised categories that are permitted for the subject and complement of the verb under the order-preserving constraint on English type raising, the twin Principles of Consistency and Inheritance allow exactly one rule that will combine them, yielding exactly the category that is required, and no other. The Forward Crossing Composition Rule (44)b, which was required in the grammar of the Dutch example (51), but which has not yet been used in the grammar of English, will allow the English type-raised subject category to compose with an English type-raised object category to its right to yield a leftward category with an appropriate interpretation. The rule is the following:[31]

(62) **English Forward Mixing Composition** (>Bx)
$[X/Y]_{\&} \quad Y\backslash Z \quad \Rightarrow_{\mathbf{B}} \quad [X\backslash Z]_{\&}$
where $Y = S\backslash NP$

It bears a similar restriction to the other crossing rule, <*Bx*, example (50), allowing it to apply in English only when Y is tensed $S\backslash NP$. In English, the rule is also restricted to apply only to type-raised arguments that have been marked as a right conjunct, by the Forward Coordination Rule (13), which embodies the "prepositional" character of conjunctions like *and*. The rule therefore permits the derivation of gapped right conjuncts like the following:

(63)

SVO: `eats := (S:eat' np2 np1\NP:np1)/NP:np2`

```
Harry eats beans,  and  Barry          potatoes
                   ---- --------->T ---------------------<T
                   conj S/(S\NP)   (S\NP)\((S\NP)/NP)
                   ------------->&
                    [S/(S\NP)]&
                    -------------------------------------->Bx
                               [S\((S\NP)/NP)]&
```

It may seem odd that in all other cases of coordination, the right-hand conjunct is completely formed *before* being marked as a conjunct, whereas here, part of it is marked and then goes on to combine with more material, inheriting the marking. However, this anomaly is more apparent than real. Since the forward coordination rule is semantically vacuous, *all* of

[31] As in the case of the backward composition rule, the rule does not generalize beyond **B**, and this can be related to the absence from the English lexicon of functions taking more than one argument to the left.

the combinatory rules could have been permitted to apply with a leftmost item marked with the feature &, and *all* could have been assumed to pass this marking to their result. With the further stipulation that the conjunction itself only combines with a *lexical* item to its right, this analysis would make the conjunction not merely prepositional but *proclitic*. This analysis has much to commend it. For example, it is exactly the analysis that would be required to account for clitic conjunction particles in languages like Latin. The Latin enclitic coordinator *-que* attaches as a suffix to (usually) the first word of the righthand conjunct (cf. Lewis and Short, 1879, *que*, VII), as in

(64) Balbus [murum aedificavit], [ingentissimumque castrum delevit]
"Balbus built a wall, and destroyed a very large castle"

If this analysis were extended to English, then the only special feature of the gapping rule (62) would be that whereas other rules permit the conjunction feature to be either present or absent on the leftmost argument, this rule only applies when the feature is present. To make this analysis explicit clutters up the notation, but the cost of the present simplification is to make this rule seem more singular than it is.

Whatever the notation for the prepositional conjunction, the restrictions forbid the following, because the subject is not so marked:[32]

(65)
```
 *Eats      Harry        beans
 --------   ---------   -------------------
 (S\NP)/NP  S/(S\NP)    (S\NP)\((S\NP)/NP)
            ---------------------------------*
                  S\((S\NP)/NP)
 ----------------------------------<
                  S
```

The rule will correctly allow the assembly of non-standard constituents corresponding to the gapped conjunct in sentences like *Harry ran quickly, and Fred, slowly*:

[32] It is interesting that subject inversion of the kind exhibited in this example is characteristic of Dutch, which has the less restricted version of this rule given at (52).

```
(66) Harry ran quickly, and   Fred          slowly
                        ---- ---------->T -----------
                        conj S/(S\NP)    (S\NP)\(S\NP)
                        --------------->&
                         [S/(S\NP)]&
                         ------------------------------->Bx
                                [S\(S\NP)]&
```

It even allows the assembly of the gapped conjunct in sentences like *Harry gave a dog a bone, and Fred, a policeman a flower*:

```
(67) Harry gave a dog a bone, and  Fred,     a policeman a flower
                              ---- -------->T ---------------------
                              conj S/(S\NP)  (S\NP)\(((S\NP)/NP)/NP)
                              ------------->&
                               [S/(S\NP)]&
                              ------------------------------------->Bx
                                    [S\(((S\NP)/NP)/NP)]&
```

The rule also allows the following, adapted from Aoun et al. (1987), on the assumption that *which woman* is the subject of a clause of some kind, say an indirect question S_{iq}:

```
(68) I wonder  which man saw Fay,  and  which woman,       Kay
     --------  -----------------  ----  -----------  -----------------
     S/Siq           Siq          conj  Siq/(S\NP)  (S\NP)\((S\NP)/NP)
                                  ----------------->&
                                   [Siq/(S\NP)]&
                                        ------------------------------->Bx
                                            [Siq\((S\NP)/NP]&
```

However the rule immediately excludes all of the following (also from Aoun et al., 1987), because the material to the left of the gap cannot combine to yield $[S/(S\backslash NP)]_{\&}$:

(69)a. *which man did Fay introduce to Ray, and which woman, Jon to Ron?

b. *Fay wondered what Kay gave to Ray, and what Jon, to Ron.

As in the earlier examples like (47), the three principles of Adjacency, Consistency and Inheritance, in conjunction with the SVO category of the English tensed verb, and the limitation on type-raising demanded by an ordered language, will not permit any *other* type of function over tensed verbs to be constructed. In particular, the Principle of Inheritance requires that the composite function be *backward* looking, just as in the case of a VSO language (cf. examples (56) and (57)). Now, if only example (63) had the following analysis, we would have an answer to the question of why SVO languages pattern with the VSO alternative, and gap on the right:

(70) $^*\text{eats}_{(S\backslash NP)/NP}$ $[\text{Harry beans}]_{S\backslash((S\backslash NP)/NP)}$ and $[\text{Barry potatoes}]_{S\backslash((S\backslash NP)/NP)}$

The non-standard constituent is leftward looking, so it must occur to the right of the verb. That fact would enable the coordination rule (14) to apply to yield a gap on the right. A gap on the left would be impossible with this category, just as it is in VSO languages.

Of course, the above is *not* a possible surface analysis of sentence (63), and we still need to say how the appropriate non-standard constituent can be recovered. But the directionality result is a strong one, and it suggests that we should resist any solution to this problem which extends the calculus by including rules which violate the principle of Adjacency. The next section proposes one possible alternative.

3.2. *The Hidden Left Conjunct*

It is crucial that any proposal for revealing a "hidden" adjacent non-standard constituent in the left conjunct should conform to the Principles of Adjacency, Consistency, and Inheritance, if it is not to compromise the claims of the previous section. Fortunately, there is a way of using the rules of the grammar itself to yield the hidden constituent, so that the grammar as a whole continues to respect the basic constituent order specified in the lexicon in the way it has up to this point, despite the fact that the subject and the object are not contiguous in the string.

The device in question depends upon a property of the combinatory rules that was first pointed out by Pareschi (1986), and was proposed by Pareschi and Steedman (1987) as a possible basis for a technique for parsing in the face of so-called spurious ambiguity. This property will here be termed *Parametric Neutrality*. It can be stated as follows:

(71) **Parametric Neutrality**
Specifying any two categories that are related by a given binary combinatory rule determines the third.

That is to say that we normally think of a rule like application as taking a function X/Y and an argument Y on the left of the rule as input parameters, and combining them to yield the result X on the right. But we can if we choose consider *any pair* of the three categories that the rules relate as the input parameters, and use the rule to determine a third, because any two categories between them specify all the information that is required to specify its type. For example, we can define the argument Y and the result X to determine a category X/Y, although of course this category will be a trivial *constant* function which can only combine with a particular Y to yield a particular X. For syntactic (and hence semantic) types, this property (which would not hold for arbitrary combinators such as Schonfinkel's **K**) obviously holds for the present rules, as the reader may verify by inspecting the three rule-types exemplified below. (The third type of rule was first used linguistically by Szabolcsi (1983), and is used in CGPG to accommodate parasitic gaps. It is included here for completeness. It was called **S** by Curry, and it is Smullyan's Starling).

(72) *Application*: $X/Y \quad Y \quad \Rightarrow X$
Composition: $X/Y \quad Y/Z \quad \Rightarrow_{\mathbf{B}} X/Z$
Substitution: $Y/Z \quad (X\backslash Y)/Z \quad \Rightarrow_{\mathbf{S}} X/Z$

It is interesting for present purposes to consider what happens if we fix the *result* of the function, and the *leftmost* category in the rule, an alternative which Pareschi and Steedman called *Left-branch Instantiation* of the rule. For example, if we fix the result X of forward application to be the S category meaning *Mary loves John*, as in (a) below, and the function X/Y to be the function (b) of type S/NP, then we determine the third category Y to be the NP (c), because the terms corresponding to all occurrences of X, Y, etc. must unify:

(73)a. $X = S{:}love'\ john'\ mary'$
b. $X/Y = S{:}love'\ x\ mary'/NP{:}x$
c. $Y = NP{:}john'$

Slightly less obviously, if we fix the result X of the backward application rule to be the same S, and fix the argument category Y to be the subject NP (b), then we get the slightly odd category (c) for the predicate $X\backslash Y$, for the same reason:

(74)a. $X = S{:}love'\ john'\ mary'$
b. $Y = NP{:}mary'$
c. $X\backslash Y = S{:}love'\ john'\ mary'\backslash NP{:}mary'$

The predicate category (c) that is delivered by this process is a *constant* function, and it is typed for a *particular* argument. That is, it is a function that can *only* trivially combine with an NP meaning *mary'*, to yield an S meaning *love' john' mary'*.

At first glance, this use of the combinatory rules might appear quite pointless. What is the use of producing categories which can only recombine to yield the original result? The most obvious use for such categories is in parsing. Pareschi and Steedman (1987, following Pareschi 1986), suggest that a "reduce-first" style parser much like the one sketched in section 1.5 above might be able to avoid the costs of backtracking in the face of spurious ambiguity by exploiting left-branch instantiation of rules to reveal constituents that are only implicit in the default derivation.

The "hidden" discontiguous left conjunct that we have hypothesized to be available in the left conjunct of gapped sentences also has properties analogous to the implicit categories that are revealed by the technique. For example, the category *Harry, beans* of type $S\backslash((S\backslash NP)/NP)$ hypothesized in the left conjunct of *Harry eats beans, and Barry, potatoes* can be represented as a constant function from the gapped transitive verb *eats* (b) to the clause *Harry eats beans* (a). This category would be written in full as in (c):

(75)a. $S{:}eat'\ beans'\ harry'$
b. $(S{:}eat'\ np2\ np1\backslash NP{:}np1)/NP{:}np2$
c. $S{:}eat'\ beans'\ harry'\backslash((S{:}eat'\ np2\ np1\backslash NP{:}np1)/NP{:}np2)$

Such a category could coordinate with the right conjunct, since it has the same type.

These observations suggest that the property of parametric neutrality could be exploited within the grammar itself to subsume gapping to ordinary constituent coordination, if only a way can be found of making available the second category required for left-branch instantiation. The rule that would reveal the hidden left conjunct in SVO gapping can be provisionally stated as the following left-branch-instantiating production, related to backward application:

(76) **The Left Conjunct Revealing Rule (Provisional)**(<decompose)
$X \Rightarrow Y\ \ X\backslash Y$
where $X = S$
and Y *is provided somehow*

It will be convenient to refer to such exploitation of left- (and right-) branch instantiation of combinatory rules in the grammar as "category decomposition". The application of this rule in derivations will be indicated by a *double* underline, and the index <decompose, identifying the combinatory rule involved as backward application.[33]

[33] Allowing decomposition in the grammar technically threatens to allow *infinitely many* equivalent derivations, via cycles of decomposition and recombination. However, the way for the parser to get round this problem is obvious.

The attraction of category decomposition is twofold. First, it exploits exactly the same rules as the original grammar. Second, provided that a way can be found of providing the essential second category – the gap – without appealing to notions of parsing or reified derivation, then the technique will be essentially declarative. The argument for treating gapping in this way has two parts. First we must be sure that it works for all varieties of gapping, and consider what *other* varieties of discontinuous construction we might predict if rules of category decomposition are allowed. Second, we must show how such rules find their second fixed category.

The above as yet incompletely specified rule will deliver left conjuncts of the appropriate type and interpretation for more complex gaps than mere lexical transitive verbs. Consider the example with which the last section concluded:

(77) Harry will buy bread, and Barry, potatoes.

The gapped right conjunct can be assembled in the usual way into a leftward-looking function over transitive verbs, of the following category:

(78) $S{:}s\backslash((S{:}s\backslash NP{:}barry')/NP{:}potatoes')$

The category of the leftmost clause is the following:

(79) $S{:}will'(buy'\ bread'\ harry')$

The left conjunct revealing rule (76) will use this S to define something of the same type $S\backslash((S\backslash NP)/NP)$ as the right conjunct *Barry potatoes* as a right sister of a transitive verb, of type $((S\backslash NP)/NP$, provided as always that the transitive verb itself is made available. The transitive verb that is needed is the following:

(80) $(S{:}will'(buy'\ np2\ np1)\backslash NP{:}np1)/NP{:}np2$

The revealed constituent will then have the following type:

(81) $S{:}will'(buy'\ bread'\ harry')\backslash((S{:}will'(buy'\ np2\ np1)\backslash NP{:}np1)/NP{:}np2)$

Once again, this is a constant function which can only combine with the verb in question to trivially yield the original S. However, the category can first coordinate with the right conjunct (78), above, since it has the same type. The result is the following category:

(82) $S{:}and'(will'(buy'\ bread'\ harry'))(will'(buy'\ potatoes'\ barry'))\backslash((S{:}will'(buy'\ potatoes'\ barry')\backslash NP{:}barry')/NP{:}potatoes')$

This curious category is a constant function over a constant function, and arises on the assumption that the backward coordination rule (14) causes the unification of the two functions' argument sub-expressions (a) and (b) below to yield (c):

(83)a. *S:will'(buy' np2 np1)\NP:np1)/NP:np2*
b. *S:s\NP:barry')/NP:potatoes'*
c. *S:will'(buy' potatoes' barry'\NP:barry')/NP:potatoes'*

In fact, in the absence of some further non-declarative strategem such as copying of terms, the category of the gapped verb (80) will be bound by the unification, so that it too becomes the same category, (83c). However, the function (82) corresponding to the conjuncts can still apply to it, and therefore reduces to yield the following correct interpretation for the whole sentence *Harry will buy beans, and Barry, potatoes*:

(84) *S:and'(will'(buy' beans' harry'))(will' (buy' potatoes' barry'))*

It is important to note that if the leftmost term had been the *functor*, and the left-branch instantiated rule had been *forward* application, then the trick would not have worked. The leftmost category would have been similarly side-effected by the unification, to become itself a constant function that would have refused to re-combine with anything but its newly revealed right sister. In Prolog-based parsers which exploit the left-branch instantiation more generally, such as the one proposed by Pareschi, the problem is usually solved by *copying* the category in question. We do *not* assume such copying is available in syntax proper.

The derivation can be summarized as follows

(85)

```
 Harry will buy bread,         and Barry, potatoes
----------------------         -------------------
          S                     [S\((S\NP)/NP)]&
======================<decompose
(S\NP)/NP S\((S\NP)/NP)
          ----------------------------------------<&
                     S\((S\NP)/NP)
-----------------------------------<
                S
```

This derivation involves three steps which are characteristic of all uses of category decomposition proposed here. First, a constant function of the appropriate type is defined by a rule of *Decomposition*, such as the Left Conjunct Revealing Rule (76), from its result and an argument. Second, the constant function is modified by a rule of *Attachment*, such as the

Backward Coordination Rule (14), to create a new constant function typed for the *same* argument. Third, there is an *Application* of this modified function to that argument, the only one that it *can* apply to.

Because rules of category decomposition are instantiations of the basic combinatory rules, they do not weaken the explanatory force of the original proposal. The fact that gapping in English is *forward* gapping, a fact that Ross (1970) argued stemmed from Universal Laws depending on the base order of constituents, and which in Section 3.1 was shown to be a theorem of the present theory, remains so when category decomposition is included. Even if the grammar of an SVO language allowed a subject and an object to raise and compose on the left of a conjunct, as well as on the right, backward gapping on the SOV pattern would still be excluded by universal principles. The recovery of the hidden conjunct would require a rule of decomposition that violated the Principle of Consistency:

(86)
```
*Barry, potatoes     and    Harry bought bread
-----------------    ----   ------------------
S\((S\NP)/NP)        conj           S
                            ==================*
                            S\((S\NP)/NP) (S\NP)/NP
```

Nor does the inclusion of category decomposition permit "anti-gapping" – that is, overgenerations of the following kind, in which the *leftmost* product of decomposition is made available for coordination, rather than the rightmost:[34]

(87)
```
*Cooks,     and     John eats beans
---------   ----   ----------------
(S\NP)/NP   conj          S
                   ================<decompose
                   (S\NP)/NP  S\((S\NP)/NP)
            -------------->&
          [(S\NP)/NP)]&
--------------------------<&
          (S\NP)/NP
          -----------------------------<*
                          S
```

If the verb *eats* is available in the gapping construction, then in principle it could be so here. If so, the left-conjunct revealing rule (76) could apply.

[34] I am grateful to Dick Oehrle for drawing my attention to this example.

However, the rest of derivation is blocked without any further stipulation. The left conjunct revealing rule must again yield a *constant* function over the verb *eats*. This function cannot recombine with the result of the coordination *cooks and eats*. Nor could this construction be permitted by writing a "right conjunct revealing rule", invoking backward application via *right*-branch instantiation, and supplying the *rightmost* category $S\backslash((S\backslash NP)/NP)$. In the absence of noncompositional devices like copying, such a function would after unification end up as the following constant function category:

(88) $S{:}eat'\ beans'\ john'\backslash((S{:}eat'\ beans'\ john'\backslash NP{:}john')/NP{:}beans')$

Such a function cannot recombine with the the coordinate verb *cooks and eats*. Nor can it ever yield an S with the right interpretation.

There is nothing about the left conjunct revealing rule (76) that requires the gapped material to be verb-like. It could in principle be nominal, say a subject. In English, this possibility has no interesting consequences. However, many Germanic languages, including Dutch, German and Yiddish, allow coordinations on the following pattern (cf. Hoehle 1983):[35]

(89) Toen kwam Jan binnen en dronk bier met ons
Then came John in and drank beer with us

These languages have a "V2" requirement on main clauses, so because the adverb is preposed, the first conjunct must be subject-aux inverted. As a result, the VP in the first conjunct is discontinuous. Nevertheless, VP Coordination is allowed.

The temptation to capture this construction by allowing derivations parallel to gapping is strengthened by the following observation. Germanic preposing does not have the "marked" character of the English topicalization construction. An inverted clause like the first conjunct seems to be just a main clause, bearing the same type as a clause with a subject before

---

[35] Not all sentences of this general type are acceptable. For example van Oirsouw (1985 p. 371, ex. 32), correctly points out that there is something wrong with the following.

(i) ?Soms eet Jan vlees en drinkt bier
Sometimes eats John meat and drinks beer

Nevertheless, there is no doubt that in general the construction (which poses problems for van Oirsouw's account) is allowed, and even common, in these languages. I am indebted to Jack Hoeksema, Ellen Prince, Beatrice Santorini and Arnim von Stechow for conversations and access to work in progress on this question, and all data are theirs.

the verb, as the possibility of conjoining inverted and non-inverted clauses suggests:

(90)a. Toen heeft Maria de fles gebracht,
Then has Maria the bottle brought,
en Hendrik heeft het vergif gedronken
and Harry has the poison drunk

b. Maria heeft de fles gebracht,
Maria has the bottle brought
en het vergif heeft zij gedronken
and the poison has she drunk

If both preposed and canonical orders yield an identical S, and if the subject *Jan* is available to act as the second fixed category, then it follows that the first conjunct in sentence (89) should be decomposable by the left conjunct revealing rule (76) into a subject and predicate, despite the fact that the predicate was not represented by a continuous string, as follows:[36]

```
(91) Toen kwam Jan  binnen   en dronk bier met ons
     ----------------------  ---------------------
              S                   [(S\NP)]&
         =========<decompose
         NP    S\NP
               ------------------------------<&
                        S\NP
         ------------------<
                   S
```

On the assumption that Dutch *kommen* is $(S\backslash NP)\backslash ADV$, the revealed predicate is the following constant function:

(92) $S{:}come'\ in'\ john'\backslash NP{:}john'$

Once again, the revealed predicate has an interpretation which when combined with the right conjunct can only recombine with the subject to (trivially) yield the appropriate interpretation. Once again, this result is appropriate.

[36] While this analysis is in one sense the converse of Hoehle's, who regards the second conjunct as containing a "subject gap" in postverbal position, the present account supports his more general claim that this construction is closely related to the verb-medial gapping construction.

As in the case of English gapping, we have yet to see where the second fixed category – in this case, the NP *Jan* – can come from. An important clue is provided by the observation that, whether they are verbal (as in gapping) or nominal (as in the present case), *such categories are restricted to those that the grammar itself makes available*. Thus, derivations like the following are not possible:

```
(93)    *Toen kwam Jan binnen,  en Hendrik
         ____________________  ________
                  S             [NP]&
            ==============*
            S/NP         NP
```

This restriction must be related to the fact that the grammar of Dutch does not permit the assembly of a grammatical category of type *S/NP* with the same meaning as the predicate *kwam binnen*, (cf. (92)). That is, the following is not a legal category of Dutch, as we know from the impossibility of sentences like **Kwam binnen Jan*:

(94) $*S{:}come'\ in'\ np1/NP{:}np1$

It therefore cannot take part in left-branch instantiation. We shall see below why this conspiracy with the rest of the grammar must obtain.

The same example illustrates a further property of rules of decomposition. The subject of the left conjunct, *Jan* clearly *is* a category that the grammar permits, and therefore looks as though it might be able to act as the *right* daughter for purposes of decomposition via "right branch instantiation", thereby permitting the derivation by revealing a "hidden" *S/NP* that the grammar would not otherwise permit. However, even if this decomposition is permitted, the derivation still blocks. The reason is of course that the revealed category is the following constant function:[37]

(95) $*S{:}come'\ in'\ john'/NP{:}john'$

This function cannot combine with any other subject but *Jan*. In particular, it cannot combine with *Jan en Hendrik*. In general, decomposition in which the two fixed categories are grammatically well-formed can only give rise to derivations that involve a third category which is also permitted by the original grammar.

At this point, the following generalizations can be stated, concerning rules of category decomposition and the categories that they relate:

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[37] In point of fact, in the absence of some strategem such as copying, the category (94) would also be coerced by unification to be this category.

(1) Rules of decomposition must be instantiations of the basic combinatory rules.

(2) The three categories involved in a decomposition must all be categories that the grammar independently permits.

(3) If the process of attachment or modification is to the *rightmost* daughter, (as it is in the case of SVO coordination) then in general the fixed category must be the *left* daughter and must be an *argument*. The type of decomposition must be *left* branch instantiation of backward application.

But how can the essential ingredient of the decomposition, the leftmost category, the gap itself, be made available?

3.3. The Gap

There can be no question of appealing to the parser, or to some reification of the derivation, as a source of the gapped category. There is no reason to suppose that the parser makes the corresponding constituent available in the course of analysing the first conjunct. Indeed, in cases like the following the parser *cannot* have built the gapped material as a constituent, because the "missing" transitive verb *wants to win* is discontinuous in the leftmost conjunct:

(96)

```
Harry wants Ipswich to win          and Barry, Watford
--------------------------          ------------------
            S                       [S\((S\NP)/NP)]&
 =========================<decompose
 (S\NP)/NP S\((S\NP)/NP)
           ------------------------------------------<&
                        S\((S\NP)/NP)
-------------------------------------------<
               S
```

As was seen above, discontinuous gapping of this kind is even more widespread in Germanic main clause coordinations, like the following, because of the "V2" requirement:

(97) Jacob *heeft* appels *gegeten*, en Hendrik, peren.
Jack *has* apples *eaten*, and Henry, pears

Discontinuous gaps strongly suggest that the source of the gapped material must lie elsewhere than in either parsing or pure syntax. To see where the source *does lie*, we must turn to some apparent constraints upon the gapping construction that have been noted in previous literature.

A large number of apparent constraints on the gapping construction have been described within the transformational theory by Jackendoff (1971), Hankamer (1971), Langendoen (1975), Stillings (1975), Hankamer and Sag (1976), and Sag (1976), later summarized by Neijt (1979). Examples like the following, all of which are allowed by the present theory, have been held by some of the above authors to be ungrammatical under the readings indicated by the brackets:

(98)a. Harry [went to] London, and Barry, Detroit.
b. Harry [will give] a bone to a dog, and Barry, a flower to a policeman.
c. Harry [claimed that hedgehogs eat] mushrooms, and Barry, frogs.

However, Kuno (1976) has shown that the acceptability of gapped sentences is crucially dependent upon discourse context. The above sentences are acceptable when preceded by sentences establishing appropriate topics, presuppositions, and "open propositions" (in the sense of Wilson and Sperber, 1979, and Prince, 1986), such as the following questions, which we will assume are asked in the context of a discussion of Harry and Barry:

(99)a. Which city did each man go to?
b. Which man will give what to whom?
c. What did each man each claim that hedgehogs eat?

Indeed, even the most basic gapped sentence, like *Fred ate bread, and Harry, bananas*, is only really felicitous in contexts which support (or can accommodate) the presupposition that the topic under discussion is *Who ate what*.

An open proposition is a proposition with some arguments still to be filled in, and is often (but not exclusively) introduced into the context by a Wh-question. That is to say that they are *abstractions*, of exactly the kind that are familiar from the λ-calculus, and that have been associated with the combinatory translations of constituents in the CCG analyses above. The present paper must necessarily remain vague on the question of exactly how the context is to be represented, and how the above questions modify it. Nevertheless, it is extremely striking that the open propositions that intuitively seem to be introduced by the above questions are in each case closely related to the translations of the missing constituents in the gapped sentences (98). For example, the open proposition established by the question *Who ate what*? (or the corresponding intonation on the first conjunct of *Fred ate bread, and Barry, bananas*) is $\lambda y \lambda x$ *eat' yx*, or more simply *eat'*. Similarly, the topic established by the first question (a) above might be represented by the *Wh*-phrase *Where each man went to*. The corresponding open proposition is the composition of *went* and *to*, as in (i) below (both λ and combinatory notations are given):

(100)a. $\lambda y \lambda x\ go'(to'y)x \equiv \mathbf{B}\ go'to'$

Similarly, the discourse topic introduced by questions (b) and (c) might be paraphrased as *What each man will give to whom* and *What each man claimed that hedgehogs eat*:

(101)b. $\lambda z \lambda y \lambda x \quad will'(give'xyz) \equiv \mathbf{B} \quad will'give'$
c. $\lambda y \lambda x \quad say'(that'(eat'y) \quad hedgehog')x \equiv$
$\mathbf{B} \quad say'(\mathbf{B} \quad that'(\mathbf{B}(\mathbf{T} \quad hedgehog') \quad eat'))$

The present paper will remain agnostic on the question of exactly how such contextually open propositions are represented in the context, and how they interact with sentence grammar. However, it is clear that they correspond closely to the "given" information of the leftmost disjunct, in Halliday's (1967) sense of the term, or the "topic" in the terms of the Prague School (cf. Hajičová and Sgall, 1987, 1988), and that this fact is reflected in the strongly marked intonation characteristic of gapped sentences.[38] It therefore seems reasonable to assume that such Hallidean given information is realized for the purposes of sentence grammar in the form of the corresponding grammatical categories. Thus the question *Who ate what*? supports the transitive verb category (S: *eat'* $np2$ $np1 \backslash NP$: $np1/NP$: $np2$) as given information, while the questions in (99) respectively support the following categories in the same role:

(102)a. $(S{:}go'\ (to'\ np2)\ np1 \backslash NP{:}np1)/NP{:}np2$
b. $((S{:}will'(give'\ np2\ pp1\ np1) \backslash NP{:}np1)/PP{:}pp1/NP{:}np2$
c. $((S{:}say'(that'(eat'\ np2\ hedgehog'))\ np1 \backslash NP{:}np1)/NP{:}np2$

In each case, these categories are the ones that are required for the decompositions in the corresponding gapped sentences in (98).

The claim of the present theory is therefore the following: *The second*

---

[38] For example, the following dialogue, in which the gapped material in the response is *not* given information, seems absolutely impossible, whether it is spoken or written:

A: Does Harry like beer, and Fred, wine?
B: #No, Harry *loathes* beer, and Fred, wine!

fixed category that is required for category decomposition to reveal the hidden category in a leftmost conjunct S is provided by the Hallidean given information for that S. This information takes the form of a grammatical category.

We can therefore rewrite the rule that reveals the hidden gapped S in the left conjunct as the following left branch instantiating production, related to backward application:

(103) **The Left Conjunct Revealing Rule** (< decompose)
$X \Rightarrow Y \quad X\backslash Y$
where $X = S$
and $\quad Y = given(X)$

The given information in the left conjunct must be contextually supported (or accommodated), or the sentence will be rejected. However, that is not to say that the corresponding open proposition has to have received explicit *mention*. All kinds of *Wh*-questions can support a gapped sentence like (96), *Harry wants Ipswich to win and Barry, Watford*, from *Which team does each man want to win*? to *Who do Harry and Barry like in the final*? Nor does the context provide the category corresponding to the given information. This category is derived from the linguistic content of the left conjunct itself.

The question of exactly how the Hallidean given information of the left conjunct is realized as a grammatical category during its analysis, available to sentence grammar in general, and to category decomposition in particular, remains open. I conjecture that this "given" category must actually be represented at the level of interpretation or logical form. This conjecture is lent some support by the observation that the same assumption appears to be necessary in order to provide an account of intonation in spoken utterance. (Cf. Chomsky, 1970; Jackendoff, 1972; Selkirk, 1984. See Steedman, 1989b for a discussion of the implications of the present proposal for the theory of intonation.) Indeed, it seems certain that the very marked intonation on the left conjunct in spoken gapped sentences is centrally implicated in this process. If so, then the question of how the gapped category comes into being and why it obeys the same rules of grammar as other constituents may largely be answered for the case of spoken language by saying that it is a constituent of the left conjunct marked by low pitch (the null tone, in the terms of Pierrehumbert (1980)). However, it remains to be shown how this observation generalizes to the discontinuous gaps typified by (96), and to the case of written language.

Support for the proposal that the second fixed category in the decomposition corresponds to the contextually supported given information in the leftmost conjunct, rather than from a syntactic constituent of that conjunct, is provided by the impossibility of the following derivation, despite its superficial similarity to (66), *Harry ran quickly, and Fred, slowly*:[39]

```
(104)   *Harry ran,     and  Mary,      quickly
        -----------     ---- ---------- ---------------
             S          conj S/(S\NP)   (S\NP)\(S\NP)
                        ----------------->&
                         [S/(S\NP)]&
                         ------------------------------->Bx
                                  [S\(S\NP)]&
        ===========*<decompose
        S\NP S\(S\NP)
             ------------------------------------<&
                        S\(S\NP)
        -------------------------<
                    S
```

Although this derivation looks as though it might be allowed, meaning something like *Harry ran, and Mary ran quickly*, it is not possible under the present assumptions. The gapped predicate *ran* could be made given via one of the following contextual questions:

(105)a. Who ran?
b. How did Harry and Mary run?

But in the first case, the second conjunct is not an answer to that question, while in the second case the first conjunct is similarly infelicitous.

A related sentence shows that, while contextual support is necessary, a gap must also be linguistically compatible with the first conjunct. The following sentence (a) is a perfectly good answer to the question *How did Harry and Mary run?*, since jogging means something like *run slowly*:

(106)a. Harry jogged, and Mary ran quickly
b. *Harry jogged, and Mary, quickly

However, the gapped sentence (b) is quite impossible, because no context can possibly make ran be given information in the first conjunct in Halliday's sense of the term. The category is therefore not available for category decomposition of the first conjunct.

For the same reason, neither of the following examples, adapted from

[39] Cf. discussion by Wood, 1988.

Sag (1976), are possible, because the grammatical categories corresponding to *hates* and *walks* as given information in the left conjunct are of type $(S\backslash NP)/NP$, not the categories that would be required for decomposition:

(107)

```
*Fred hates reptiles,     and Harry, to talk to strangers
 ------------------       -------------------------------
         S                     [S\((S\NP)/VPto)]&
==============================<*
(S\NP)/VPto S\((S\NP)/VPto)
```

(108)

```
*Beth walked the dog,     and Harry, up the road
 -------------------      ----------------------
          S                  [S\((S\NP)/PP)]&
==============================<*
(S\NP)/PP S\((S\NP)/PP)
```

The proposal that the source of the gapped material lies in given information, rather than syntactic derivation, is also supported by the possibility of "discontinuous gaps", as in the earlier example (96), repeated here:

(109) Harry *wants* Ipswich *to win*, and Barry, Watford

The gapped material here includes the infinitival VP: that is, the sentence means something like (a) below, not (b):

(110)a. Harry wants Ipswich to win, and Barry wants Watford to win.
b. Harry wants Ipswich to win, and Barry wants Watford.

The fact that the missing constituent is discontinuous is baffling, until it is recalled that one natural context for this utterance is as a reply to the question *Which team does each man want to win*? The Hallidean given open proposition here is the composition of *want* and to *win*.[40] It is striking that these elements are contiguous in the direct question and the related topic *Whom each man wants to win*. As noted earlier, the important further question of how the corresponding syntactic category is made available from the analysis of the left conjunct remains open.

The theory also explains why there is a conspiracy between strings that can be gapped and strings that can be extracted over, as noted by Neijt

[40] If the analysis of raising verbs proposed in Steedman (1988) is followed, it will in fact be the composition of to *win* (a type-raised argument) with *want*, but the result is the same, and the distinction can be ignored. See Jacobson (1989) for an alternative proposal.

(1979), following Kuno (1976). The impossibility of the following sentences (a) can be accounted for by the impossibility of the Wh-questions (b) that would be required to establish the requisite contextual open propositions:

(111)a. *Fred [wants to try to begin to write a] play, and Harry, movie
b. *What does each man want to try to begin to try to write a?

(112)a. *Fred [wants to try to begin to] write a play,
and Harry$_{S/(S\backslash NP)}$, [cease to make a movie]$_{(S\backslash NP)\backslash((S\backslash NP)/VP)}$
b. *What does each man want to try to?

The impossibility of these Wh-questions is due to certain island effects that are discussed in the appendix to the present paper. If given information is represented as a grammatical category, it is reasonable to assume that it is subject to the same constraint. (In fact, the treatment of island effects in the appendix forces this assumption.)

Of all the constraints upon gapping that have been observed by the authors cited earlier, the most robust is exemplified by the following nonsentence:

(113) *I think (that) Fred [might eat] bread, but I doubt whether Harry, beans

If successive compositions were permitted to assemble a constituent of type $S/(S\backslash NP)$ corresponding to *I doubt whether Harry*, then the crucial part of the derivation would be allowed as follows:

(114)

```
I think that Fred might eat bread, ...

   ... *but I doubt whether Harry,       beans
       ---- ---------------------   ---------------
       conj      S/(S\NP)           (S\NP)\((S\NP)/NP)
       ------------------------->&
          [S/(S\NP)]&
          ------------------------------------------------>Bx
                         [S\((S\NP)/NP)]&
```

However, such derivations have already been excluded for quite independent reasons to do with the illformedness of sentences like (38) in section 1 above, via a restriction (40) on forward composition. Further support for their exclusion comes from the fact that fragments like *I doubt whether Harry* are forbidden in *all* elliptical constructions. Thus "stripping" and

"VP-ellipsis", as well as the related ellipses for answering Wh-questions, can leave almost anything *but* such fragments. For example, in answering questions like *Who ate the biscuits*?, the following possibilities emerge:

(115)a. Harry.
b. Harry did.
c. *I think that Harry.
d. I think that Harry did.

3.4. Other Elliptical Phenomena

The present theory of gapping via category decomposition is grammatically quite weak. Sluicing (a) and VP Ellipsis (b) do not appear to be amenable to analysis in these terms, since the requisite rules would violate the Principle of Consistency, even on the optimistic assumptions about the categories of the elided conjuncts embodied in the following example:

(116)a. [John did something with the beans]$_S$, but [I don't know what]$_{S/(S \backslash NP)}$
b. [Somebody has to eat the beans]$_S$, but [I know that I won't]$_{S/VP}$

Such constructions must in the present terms be regarded as mediated by a quite separate, presumably anaphoric, mechanism, as their freedom to occur outside the context of coordination suggests, rather than syntactically mediated, as gapping is according to the present theory.[41] Their constituent categories are presumably the following, which trivially conform to the assumption of the present paper that only like types can coordinate:

(117)a. [John did something with the beans]$_S$, but [I don't know what]$_S$
b. [Somebody has to eat the beans]$_S$, but [I know that I won't]$_S$

The conclusion that gapping is unrelated to Sluicing and VP-ellipsis is contrary to Hankamer and Sag (1976, Sag and Hankamer, 1984), who have argued that all three fall into their "surface anaphoric" or "elliptical" class of constructions, as opposed to their other class of elliptical constructions mediated by the "deep" or "model-interpretive" anaphora" that is characteristic of pronouns. However, see Williams (1977a, b), Schacter (1977), and Chao (1987, pp. 112–127) for persuasive arguments for a position compatible with the present proposal, according to which VP

[41] See Szabolcsi, in press, for a proposal concerning VP ellipsis that is compatible with the present account.

ellipsis and sluicing are mediated by model interpretive anaphora, like pronouns, and their more restricted character arises from the special nature of their antecedents. Gapping, by contrast, is claimed here to be purely syntactic, and not to be mediated by anaphora of any kind, pragmatically specialized though it is.

4. Conclusion

This paper has attempted to demonstrate the following claims:

(1) that the generalization of the notion "surface constituent" that is engendered by including combinatory rules in a categorial grammar, and the profusion of fragmentary, non-standard constituents that results, allow a wide variety of coordinate structures to be subsumed under the heading of simple constituent conjunction without rules of deletion or anaphora;

(2) that the twin principles of "Directional Consistency" and "Directional Inheritance", which limit the form of possible syntactic combinatory rules, correctly predict the observations of Ross and Maling concerning the dependency of "forward" and "backward" "gapping" in coordinate structures upon the "base" order of clause constituents in any given language, including the observation that SVO languages pattern with VSO languages in forbidding the backward variety;

(3) that the "associativity" property of functional composition, and the "parametric neutrality" property of all the combinatory rules, provide a simple way of capturing "discontinuous" constituency of the kind that this theory implicates in SVO gapping, as well as in the "subject gapping" coordinations of discontinuous main clause VP coordinations that are widespread in Germanic languages, and that this technique preserves the order-dependency result.

According to this account, gapped sentences arise from the coordination of two non-standard constituents – in descriptive terms, two gapped sentences – and their combination with a third constituent – the gap. In this respect, it stands in contrast to theories in which gapping arises from the restoration of the gapped conjunct to the status of a standard clause, the gapped material being accessed via processes of anaphora or structure-copying. The third category is provided according to the present theory in the form of the contextually supported Hallidean given information, reified as a grammatical category, and thereby made available to sentence grammar. The details of this process remain a vital open question. However, the benefits of the approach are considerable. An analysis including an interpretation can be achieved by combination of elements that are strictly adjacent by strictly syntactic operations. In further explaining why constituent order under coordination exhibits certain known universal dependencies on basic constituent order across languages, and in bringing discontinuous coordinate structures under the heading of constituent coordination, the theory compares favourably with the alternative proposals, and with related analyses by Stump (1978), van der Zee (1982), Cremers (1983), Hudson (1984), Dowty (1988), Wood (1988), and Oehrle (1987), which also extend the notion of constituency.

Many other questions raised in the paper also remain open. In particular, a finer-grained theory of the primitive atomic categories (cf. Sag et al., 1985), the interaction of inversion and negation with gapping in English (cf. Siegel, 1984), and the specification of larger fragments of Germanic languages, are important problems for further research. However, the results to date seem to offer a considerable simplification in the theory of coordinate structures in natural language. According to the present theory, everything that can coordinate, including "gapped" conjuncts, is a constituent under the generalized definition of that notion that is afforded by combinatory grammars.

Appendix: Remarks on Islands

The rules of composition and type-raising will potentially allow certain nonconjoinable sequences to compose, and therefore to coordinate, or be extracted over, in violation of well-known constraints on such constructions. For example, under the assumption that determiners are *NP/N*, we could derive the following, by composing a transitive verb with a determiner:

(118)

```
*I must   cook  a,    and   eat  the,   potato.
 ------   ----- ----  ----  ----- ----  ------
  S/VP    VP/NP NP/N  conj  VP/NP NP/N    N
          ---------->B      ---------->B
             VP/N              VP/N
                      ------------>&
                          [VP/N]&
             ------------------<&
                    VP/N
```

A very general version of the NP Constraint could be imposed by adding a condition on the forward composition rule, forbidding the variable Y to be instantiated as NP. Alternatively, such a condition would follow automatically and without stipulation if the category NP in determiners and other nominal categories were replaced throughout the lexicon by type-raised categories, as envisaged in the earlier discussion.

However, the well-known greater acceptability of other extractions out of NP, such as the following, suggests that the problem is not purely syntactic:

(119)a. will cook three, and eat two, of those delicious-looking potatoes.
b. I want cooked, and he wants uncooked, potatoes.
c. I will paint a picture of, and write a novel about, the potato.

The grammaticality/acceptability of the examples seems to depend upon the good sense or otherwise of the concept that arises in the interpretation of the composition across the NP boundary. In some of the derivations above, such a constraint is tacitly assumed, without any particular commitment to where precisely in the grammar it arises.[42]

Unconstrained type-raising also threatens to allow island violations. For example, given forward composition and subject type-raising alone, the fact that adjuncts tend to be "islands" to extraction would follow without stipulation. Thus the derivation of the following very marginal sentence is blocked, because the incomplete adjunct *without cooking* cannot combine with the VP until it gets an NP, but it cannot combine with the relative pronoun until it combines with the intervening VP:

```
(120)  ?(the apples)    that          I         met Mary   without cooking
                     ----------  ----------->T  --------  -------------------
                     (N\N)/(S/NP) S/(S\NP)       S\NP     ((S\NP)\(S\NP))/NP
```

However, the earlier discussion shows that the subject type-raising rule must be regarded as merely a special case of the more general forward

[42] To the extent that this constraint does indeed arise from the conceptual anomaly of the interpretation associated with compositions like $\#[\textit{eat the}]_{VP/N}$ in comparison with ones like $[\textit{eat two}]_{VP/N}$, a theory like the present one which will actually provide an interpretation for such fragments via the composition rule may be more helpful than one which does not. It is also worth remarking that the natural place to embody the information in grammar in present terms is the lexicon. Note that if the NP constraint is regarded as arising from lexical type raising then exceptions like the above must be regarded as arising from (lexically) raising the verb over the raised NP category. See Bouma, 1987, and Hepple, in preparation, for further discussion of islands in categorial terms.

type raising rule (45)a, which is written as follows:

(121) $X \Rightarrow_{\mathrm{T}} \mathrm{T}/(\mathrm{T}\backslash X)$

The symbol T is a (polymorphic) variable standing for any category that the grammar permits.[43]

However, as in the case of the forward composition rule (18), such a free type-raising rule threatens to over-generalize. For example, it potentially permits VPs to raise over adjunct categories, to allow derivations like the following for the previous island violation example (120)

(122)

```
?(apples)      that          I              met Mary               without cooking
          ------------  ---------->T  --------------------   ------------------------
          (N\N)/(S/NP)  S/(S\NP)             S\NP            ((S\NP)\(S\NP))/NP
                                      ---------------------------->T
                                      (S/NP)/((S\NP)\(S\NP))
                                      ------------------------------------------------>B
                                                        (S\NP)/NP
                        -------------------------------------------->T
                                           S/NP
          ----------------------------------------->
                        N\N
```

Once again, the marginal acceptability of this extraction, and of related examples discussed by Chomsky (1982, p. 72), and the similar marginality of a number of related constraints such as Ross's Complex NP constraint, suggests that what is wrong with it is a matter of the good sense of the predicate *meet Mary without cooking*. Again, we pass over the question of the precise nature of this constraint, merely noting that the lexicon is its natural locus under the present assumptions. (That is, exceptions can be allowed by including additional lexical entries for the verbs in question, related to the basic categories by type-raising the category VP over the relevant modifier, thereby turning the modifier into an argument.)

According to the present theory, such phenomena as the above are quite different in origin to asymmetries in extractability of subjects and objects, illustrated by familiar examples like the following:

---

[43] Since the generalized form of composition introduced above and in the earlier papers allows grammars to include unboundedly many categories, this very permissive version of type raising technically threatens to render CCGs undecidable. However, there are some obvious ways of restricting type raising which eliminate this problem. The most obvious one is to adopt the tactic mentioned at a number of points above, of type raising nominal categories over a fixed set of categories (possibly schematized, as in D&C) in the *lexicon*,

(123)a. (a man whom) [I think that]$_{S/S}$ [Mary likes]$_{S/NP}$
b. *(a man whom) [I think that]$_{S/S}$ [likes Mary]$_{S\backslash NP}$

Such asymmetries are possible in languages like English which have SVO lexicons, because the crucial compositions that potentially permit them require different instances of the composition rules. The non-extractability of the subject in a strongly configurational SVO language like English is, furthermore, a forced move, because such an extraction would require a non-order-preserving rule, which would undermine configurationality. Such constraints thus arise as corollaries of the present theory, rather than as stipulations. See CGPG and Hepple (1989) for further discussion, including a lexically-based proposal for the extractability of subjects of bare complements, as in:

(124)a. (a man whom) I think Mary likes
b. (a man whom) I think likes Mary

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