Category Cooccurrence Restrictions and the Elimination of Metarules

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0. Introduction

This paper builds upon and extends certain ideas developed within the framework of Generalized Phrase Structure Grammar (GPSG). [1] A new descriptive device, the Category Cooccurrence Restriction (CCR), is introduced in analogy to existing devices of GPSG in order to express constraints on the cooccurrence of categories within local trees (i.e. trees of depth one) which at present are stated with Immediate Dominance (ID) rules and metarules. In addition to providing a uniform format for the statement of such constraints, CCRs permit generalizations to be expressed which presently cannot be captured in GPSG.

Sections 1.1 and 1.2 introduce CCRs and presuppose only a general familiarity with GPSG. The ideas do not depend on details of GPSG and can be applied to other grammatical formalisms.

Sections 1.3 - 1.5 discuss CCRs in relation to particular principles of GPSG and assume familiarity with Gazdar et al. (1985) (henceforth abbreviated 'GKPS'). Finally, section 2 contains proposals for using CCRs to avoid the analyses with metarules given for English in GKPS.

1. Category Cooccurrence Restrictions (CCRs)

1.1 The Principle of CCRs

The reasons for proposing CCRs to state restrictions on the cooccurrence of categories within local trees are analogous to those for introducing Immediate Dominance (ID) and Linear Precedence (LP) rules in GPSG (cf GKPS, pp. 44-50). A context free rule binds information of two sorts in a single statement, namely

(a) information about which daughters a root has in a local tree and
(b) information about the order in which the daughters appear.

By separating this information in ID and LP rules, GPSG is able to state generalizations of the sort "A preceeds B in every local tree which contains both as daughters," which cannot be captured in a context free grammar (CFG).

Now consider an ID rule such as the following:

(1) $S \rightarrow A, B, C$

The fundamental motivation for CCRs rests on the insight that such an ID rule itself combines two different kinds of information in a single statement, namely

(a) information involving immediate dominance relations, here that $\langle S, A\rangle$, $\langle S, B\rangle$, and $\langle S, C\rangle$ are ordered pairs of categories in which the first category immediately dominates the second and
(b) information about the cooccurrence of categories in a single local tree.

By distinguishing and separately representing these types of information it becomes possible to state generalizations of the following sort, which cannot be captured in the ID/LP format:

(2) Any local tree with S as its root must have A as a daughter.
(3) No local tree with C as a daughter also has D as a daughter.

Statements such as (2) and (3) restricting the cooccurrence of categories in local trees are Category Cooccurrence Restrictions, which are expressions of first order predicate logic using two primitive predicates, $R(\alpha, t)$ 'α is the root of local tree t' and $D(\alpha, t)$ 'α is a daughter in local tree t'. [2] CCRs have the form $\forall t: \pi$, where π is a schema and the notion of a possible schema is defined as follows:

(i) $(R(\alpha, t))$ and $(D(\alpha,t))$ are of form π;
(ii) if φ is of form π, then $(\sim\varphi)$ is of form π;
(iii) if φ and χ are both of form π, then $(\varphi K \chi)$ is of form π, where $K \in \{\wedge, \vee, \supset, \equiv\}$;
(iv) constants designating categories occur as first arguments within all constituent predicate expressions;
(v) the same variable t bound by the quantifier $\forall t$ occurs as second argument within all constituent predicate expressions;
(vi) these are all expressions of form π.

Parentheses may be omitted following the usual conventions in predicate logic.

A CCR $\forall t: \pi$ may be rewritten in conjunctive normal form as $\forall t: \varphi_1 \wedge \ldots \wedge \varphi_n$, where each clause φ_i is a disjunction of positive and negated predicate expressions, which is equivalent to $\forall t: \varphi_1 \wedge \ldots \wedge \forall t: \varphi_n$, i.e. a conjunction of simple CCRs. Let ω' be an expression of form π containing

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[2] Interpretations of $R(\alpha, t)$ and $D(\alpha, t)$ in terms of the theory of feature instantiation in GKPS would be 'the root of local tree t is an extension of α' and 'some daughter in local tree t is an extension of α'.

only the predicate D; then simple CCRs [3] have the following forms:

(4) $\forall t$: $R(\alpha, t) \supset \omega'$ iff α $\|[\omega]\|$
$\forall t$: $\omega' \supset R(\alpha, t)$ iff $\|[\omega]\|$ α iff $\sim\alpha$ $\|[\sim\omega]\|$
$\forall t$: ω' iff $\|[\omega]\|$

Quantification is ignored in the notation on the right; α replaces $P(\alpha, t)$ and $\sim\sim P(\alpha, t)$ and $\sim\alpha$ replaces $\sim P(\alpha, t)$ giving ω from ω', where P = R or D. The special brackets ' $\|[$ $]\|$ ' enclose daughters and render the indication of material implication superfluous. Using this notation, (2) and (3) may be restated as (5) and (6), respectively:

(5) S $\|[$ A $]\|$
(6) $\|[$ C $\supset \sim$D $]\|$

To reformulate a set of ID rules we thus need (a) the definition of a set of *branches* constituting mother-daughter pairs and (b) an appropriate set of CCRs. The definition of branches is permissive in the sense in which ID rules are permissive (cf GKPS, p. 76): branches with a common mother can be adjoined to form a local tree. CCRs, like the LP rules, which also apply to local trees, are restrictive and limit the class of local trees admitted by the grammar. [4] How sets of ID rules may be reformulated in this manner will be illustrated in the following section.

1.2 Examples of CCRs

GKPS (pp. 47-49) examines sets of simple context free rules and then proposes strongly equivalent descriptions in ID/LP format. One set of ID rules resulting from this reformulation is given in (7):

(7) S --> NP, VP   VP --> V, VP
S --> AUX, NP, VP   VP --> V, NP
VP --> AUX, VP   VP --> V, NP, VP

The ID rules of (7) admit local trees whose branches are among the following:

(8) <S, NP>, <S, VP>, <S, AUX>,
<VP, V>, <VP, VP>, <VP, AUX>, <VP, NP>

Since none of the local trees admitted by (7) has more than one occurrence of a given category as daughter, we may say that the grammar first admits any strictly linearly ordered set [5] of branches that share a common mother as a local tree. This set of local trees must then be filtered with appropriate CCRs so as to characterize the same set of local trees admitted by (7).

A single CCR covers the trees with S as root:

(9) CCR 1: S $\|[$ NP $\wedge$ VP $]\|$

CCR 1 states that NP and VP are obligatory in any local tree with S as its root. Since <S, AUX> is also a branch, AUX may optionally occur as daughter in such a tree.

To characterize the local trees with VP as root we first construct the following function table:

(10)

line	VP	AUX	VP	V	NP
1	0	1	1	1	1
2	0	1	1	1	0
3	0	1	1	0	1
4	1	1	1	0	0
5	0	1	0	1	1
6	0	1	0	1	0
7	0	1	0	0	1
8	0	1	0	0	0
9	1	0	1	1	1
10	1	0	1	1	0
11	0	0	1	0	1
12	0	0	1	0	0
13	1	0	0	1	1
14	0	0	0	1	0
15	0	0	0	0	1
16	0	0	0	0	0

A "1" under a category on the right side of the table indicates that the category is a daughter in a given local tree; "0" means it is absent. If a local tree with the root on the left side of the table and the daughters marked "1" in a given line is to be admitted by the grammar, then a "1" appears under the root category in the corresponding line; "0" indicates that the tree is not admitted.

A corresponding CCR of the form VP $\|[\omega]\|$ can now be formulated, where ω is a Boolean expression in conjunctive normal form. The terms of ω are constructed from the lines designating inadmissible trees as follows:

(11) $\sim$(AUX $\wedge$ V) iff ($\sim$AUX $\vee$ $\sim$V)   lines 1, 2, 5, 6
$\sim$(AUX $\wedge$ $\sim$V $\wedge$ NP) iff ($\sim$AUX $\vee$ V $\vee$ $\sim$NP)   3 & 7
$\sim$(AUX $\wedge$ $\sim$VP) iff ($\sim$AUX $\vee$ VP)   5 - 8
$\sim$($\sim$AUX $\wedge$ $\sim$V) iff (AUX $\vee$ V)   11, 12, 15, 16
$\sim$($\sim$VP $\wedge$ V $\wedge$ $\sim$NP) iff (VP $\vee$ $\sim$V $\vee$ NP)   14 & 16

The normalized terms of (11) are conjoined in the CCR of (12), which is reformulated with conditionals in (13) and then simplified in (14):

(12) VP $\|[$ ($\sim$AUX $\vee$ $\sim$V) $\wedge$ ($\sim$AUX $\vee$ V $\vee$ $\sim$NP) $\wedge$
($\sim$AUX $\vee$ VP) $\wedge$ (AUX $\vee$ V) $\wedge$ (VP $\vee$ $\sim$ V $\vee$ NP) $]\|$
(13) VP $\|[$ (AUX $\supset$ $\sim$V) $\wedge$ (AUX $\supset$ (V $\vee$ $\sim$NP)) $\wedge$
(AUX $\supset$ VP) $\wedge$ (AUX $\vee$ V) $\wedge$ (V $\supset$ (VP $\vee$ NP)) $]\|$
(14) VP $\|[$ (AUX $\equiv$ $\sim$V) $\wedge$ (AUX $\supset$ (VP $\wedge$ $\sim$NP)) $\wedge$ (V $\supset$ (VP $\vee$ NP)) $]\|$

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[3] If categories are assumed to be atomic (e.g. S, NP, V) rather than complex for the moment, then it is unnecessary to mention more than one root category in a given CCR.

[4] Note that the distinction of *permissive* vs. *restrictive* statements is closely related to that of *inherited* vs. *instantiated* feature specifications in the feature instantiation principles of GPSG. The theory would appear to gain in simplicity if a way could be found to eliminate these distinctions.

[5] In order to simplify the present exposition, local trees are assumed to contain sets rather than multisets of daughters.

Next, (14) is reformulated as the three CCRs of (15), which taken together with (8) and (9) admit the same set of local trees as the ID rules of (7):

(15) CCR 2: VP $|[$ AUX $\equiv \sim V$ $]|$
CCR 3: VP $|[$ AUX $\supset$ (VP $\wedge$ ~NP)) $]|$
CCR 4: VP $|[$ V $\supset$ (VP $\vee$ NP) $]|$

The CCRs of (15) have been formulated only on the basis of VP trees, however, and therefore fail to capture generalizations that apply to all local trees. In particular, any local tree with AUX as daughter - regardless of its root - must have a VP as sister, so CCR 3 may be restated as two simpler CCRs, CCR 2' and CCR 4', where CCR 2' does not depend on the root category. Furthermore, CCR 4 can be rewritten as CCR 5' since V cannot be a daughter of S. The following final set of CCRs thus emerges:

(16) CCR 1': S $|[$ NP $\wedge$ VP $]|$
CCR 2': $|[$ AUX $\supset$ VP $]|$
CCR 3': VP $|[$ AUX $\equiv \sim V$ $]|$
CCR 4': VP $|[$ AUX $\supset$ ~NP $]|$
CCR 5': $|[$ V $\supset$ (VP $\vee$ NP) $]|$

It may first appear that the description with CCRs in (8) and (16) constitutes no clear gain over the ID rules of (7). The latter, however, are highly redundant and express none of the generalizations achieved in (16). Furthermore, the replacement of ID rules with CCRs is the essential prerequisite for the elimination of metarules described in section 2.

1.3 The Complement-Type Principle

The attempt to replace all ID rules with individual CCRs would lead to very complicated descriptions. Fortunately, the idea of CCRs can be utilized in a general principle that replaces all *lexical* ID rules (i.e. those which have a head that is an extension of a SUBCAT category; cf GKPS, p. 54), so that only *nonlexical* ID rules need be explicitly reformulated with individual CCRs.

Shieber (1983) and Pollard (1985) have proposed that a list- or stack-valued feature (SYNCAT or SUBCAT) be introduced whose value contains the complements of a head category. This paper uses TYP as a syntactic feature with a semantically oriented and lexically determined semantic type as its value. Following the convention of GKPS (p. 189), '$\langle\alpha, \beta\rangle$' will be written for $\langle$TYP(α), TYP(β)$\rangle$ where α and β are categories. Given the structure of complex types in GKPS as single-valued functions, the types may be viewed as lists or stacks.

A Complement-Type Principle (CTP) can now be stated which has the form of a schematic CCR with conditions on variables:

(17) (a) $|[$X[BAR 0, +H, TYP $\langle\delta_1, \langle\ldots\langle\delta_{n-1}, \delta_n\rangle\ldots\rangle\rangle$] $]|$ X[TYP δ_n]

(b) $|[$X[BAR 0, +H, TYP $\langle\delta_1, \langle\ldots\langle\delta_{n-1}, \delta_n\rangle\ldots\rangle\rangle$] $\supset$ X[TYP δ_1] $\wedge\ldots\wedge$ X[TYP δ_{n-1}]$\wedge$ ~X[TYP δ'] $]|$

where

(i) $\delta' \notin \{\delta_1, \ldots, \delta_{n-1}\}$;

(ii) the mother X[TYP δ_n] and head daughter X[BAR 0, +H] are both ~[CONJ] ; [6]

(iii) (a) and (b) are simultaneously fulfilled for a given assignment of types to $\delta_1, \ldots, \delta_{n-1}, \delta_n$ for $1 \leq n$.

CTP allows the complements of a head category to be read off from its semantic type if its mother is known. According to CTP the lexical head category V[SUBCAT 46] with type $\langle$VP[-AUX, BSE], $\langle$NP, S$\rangle\rangle$ for the verb *do* has complement sisters VP[-AUX, BSE] and NP if its mother is S but has just the complement VP[-AUX, BSE] if its mother is VP, which has the type $\langle$NP, S$\rangle$. The use of CTP in dealing with metarules will be shown in section 2 below, but first another general aspect of the metarule problem must be discussed.

1.4 Metarules and Lexical Rules

GKPS introduces not only metarules, e.g. the Passive Metarule (p. 59) and the Extraposition Metarule (p. 118), but also related lexical rules involving the same phenomena, e.g. the Lexical Rule for Passive Forms (p. 219) and the Lexical Rule for Extraposition Verbs (p. 222). The lexical rules are not fully formalized but all state roughly that if a given lexeme has a certain category, translation, and semantic type, then a particular form of the lexeme has a corresponding category, translation, and type. Since lexical rules do most of the work, and given that metarules apply only to *lexical* ID rules, it is unclear why both should be needed for what is essentially one job. [7]

CTP in fact allows the reduction of both devices, metarules and lexical rules, to one, here termed 'metalexical' (ML) rules. The latter are schematic rules of the form $\alpha \Rightarrow \beta$, where α and β are category schemata which may contain variables in feature values. Ignoring the semantic translations of lexemes for the present, a ML rule states that if the lexicon contains an entry assigning α to lexeme w, then it also contains an entry assigning β to w; morphological rules determine the particular word form of w on the basis of syntactic features in the category. ML rules thus provide for an inductive definition of the lexicon. They handle not only phenomena like passive and extraposition but also, e.g. the subcategorization of *sing* with or without an indirect object, transitive or intransitive, etc. Examples follow in section 2, but next the entire formalism should be briefly summarized.

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[6] The restriction that both categories be ~[CONJ] (i.e. unspecified for CONJ) is necessary for coordination. In the structural analysis of *bought and read books* NP is the complement of the V dominating *bought and read* but not of the V dominating *read.*

[7] Uszkoreit (1984, p. 65) has already expressed a similar view.

1.5 Summary of the Formalism

The syntactic formalism proposed here proceeds by describing items (feature names and values, feature specifications, categories, and trees) with statements restricting the distribution of lower-level items within next-higher-level items. Feature names and atomic values are primitives. Complex feature values are categories or semantic types. A feature specification is an ordered pair $\langle f, v\rangle$ containing a feature name f and value v, where the latter is restricted by the feature-value range of the former. A category is a set of feature specifications such that no feature name is assigned more than one value; it is legal iff it fulfills all Feature Cooccurrence Restrictions. A local tree is an ordered pair consisting of a legal root category and a list of legal daughter categories such that (a) the Complement-Type Principle, (b) the Category Cooccurrence Restrictions, and (c) the Feature Instantiation Principles (i.e., respectively, lexical, nonlexical, and universal statements in the form of CCRs) as well as the Linear Precedence statements are fulfilled. [8] A tree is an ordered pair consisting of a legal root category and a list of daughters, where each daughter is either a tree or a word form. Word forms and their lexical categories are specified by the lexicon, defined by a list of basic lexical entries and metalexical rules.

The grammar defines two binary relations over categories, ID and LP (the latter constituting the Linear Precedence statements). A binary relation $R^{\subseteq}$ is the extensional closure of R iff for each $\langle\alpha, \beta\rangle$ in R, $R^{\subseteq}$ contains every $\langle\gamma, \delta\rangle$ such that γ and δ are extensions (cf GKPS, p. 27) of α and β, respectively. A local tree with root C_o and daughters $C_1, \ldots, C_n$ must fulfill the conditions that $\langle C_o, C_i\rangle \in ID^{\subseteq}$ for $1 \leq i \leq n$ and $\langle C_j, C_i\rangle \notin LP^{\subseteq+}$ (i.e. the transitive extensional closure of LP) where $1 \leq i \leq n-1$ and $j = i+1$.

The proposed formalism utilizes more restricted means than GPSG but offers greater possibilities for expressing generalizations. The elimination of metarules and the introduction of CCRs give it a more homogeneous structure and place cooccurrence restrictions of various kinds in the center of attention.

For the present it may be best to regard this formalism as a particular variant of GPSG since most of the central notions of the latter are retained. All that is sought is a simplification of GPSG as described in GKPS. Given the rich palette of formalisms recently proposed for kinds of unification grammar, it seems rather ingenuous to create a new name for this modification of GPSG, as though the multitude of remaining open questions were thereby answered. What we need is a metaformalism that will relate the insights of all the current formalisms through formal invariants preserved under translation from one formalism to another, and that will then truly deserve a name of its own.

[8] The assumption here is that any work done by the Feature Specification Defaults (FSDs) of GKPS can be accomplished with suitably defined FCRs and CCRs. This will be illustrated in section 2 but cannot be shown in general in this paper.

2. The Elimination of Metarules

2.1 General Remarks

GKPS allows metarules to be used in ways that intuitively seem undesirable. For example, a metarule may simply indicate that a daughter A of S is optional:

(18) $(S \rightarrow W, A) \Rightarrow (S \rightarrow W)$

The metarule is superfluous if A is enclosed in parentheses in the corresponding ID rules:

(19) S → (A), B, C
S → (A), B, D

Single optional elements in the RHS of ID rules are permitted but have no theoretical status. Here the generalization is lost, however, that A is optional in all expansions of S.

The Complement Omission Metarule proposed in GKPS (p. 124) is similar:

(20) $$\begin{array}{c} [+N, \text{BAR } 1] \rightarrow H, W \\ \Downarrow \\ [+N, \text{BAR } 1] \rightarrow H \end{array}$$

This metarule can be avoided [9] by simply adding the target of the metarule to the set of base ID rules:

(21) [+N, BAR 1] → H

But the formalism of GKPS does not permit more than one element to be enclosed in parentheses, so the following cannot be an ID rule:

(22) S → A, (B, C)

Aside from the use of parentheses to indicate single optional elements, none of the abbreviatory conventions proposed in Chomsky/Halle (1968, pp. 393-399) are employed in GPSG. Thus, the rules of (19) cannot be abbreviated with braces as in (23):

(23) $$S \rightarrow (A), B, \left\{ \begin{array}{c} C \\ D \end{array} \right\}$$

Since such abbreviatory conventions for expressing coocurrence restrictions are not provided by GPSG, it is not surprising that their work is assumed by metarules. GKPS in fact states that metarules "amount to nothing more than a novel type of rule-collapsing convention for rules" (p. 66).

Now that CCRs have been presented above in section 1.2 for restating a simple GPSG that does not contain metarules, we can examine how they may be used to eliminate metarules from the GPSG proposed for English in GKPS.

[9] Note that the metarule does not provide for the omission of a *single* complement from *a grant of money to the linguists* or *grateful to the ministry for the money.*

2.2 The Passive Metarule

GKPS (p. 59) presents a Passive Metarule (PM) of remarkable simplicity and generality:

$$
\begin{array}{lrl}
(24) & \mathrm{VP} & \rightarrow \mathrm{W},\ \mathrm{NP} \\
 & & \Downarrow \\
 & \mathrm{VP[PAS]} & \rightarrow \mathrm{W},\ (\mathrm{PP[by]})
\end{array}
$$

PM states that for every lexical ID rule expanding VP and containing NP and any multiset W of categories in the RHS, there is a corresponding lexical ID rule expanding VP[PAS] and optionally containing PP[by] in place of NP in its RHS. Although the head V dominated by VP[PAS] is not mentioned in PM, it must be specified <VFORM, PAS> in a local tree by virtue of the Head Feature Convention.

As noted in section 1.4, however, PM does only a small part of the work for passive, the main task falling to the Lexical Rule for Passive Forms. Moreover, some of the predictions of PM are incorrect. Thus, PM applies to the lexical ID rule introducing V[SUBCAT 20], to which *bother* belongs:

$$(25) \qquad \mathrm{VP[AGR\ S]} \rightarrow \mathrm{H[20]},\ \mathrm{NP}$$

But the derived ID rule for V[20, PAS] incorrectly allows a PP[PFORM by] complement. [10] Furthermore, sentences like *That Santa Claus exists is believed by Kim.* are grammatical, but PM does not apply to the lexical ID rule introducing V[SUBCAT 40] for *believe* :

$$(26) \qquad \mathrm{VP} \rightarrow \mathrm{H[40]},\ \mathrm{S[FIN]}$$

Let PAS be a Boolean-valued feature restricted to [+V, -N] categories. Then we may state the following Metalexical Rule for Passive Forms:

$$
\begin{array}{ll}
(27) & \mathrm{V[-PAS,\ AGR}\ \delta_n,\ \mathrm{TYP}\ \langle\delta_1,\langle\ldots\langle\delta_{n-1},\langle\delta_n,\mathrm{S}\rangle\rangle\ldots\rangle\rangle] \\
 & \qquad\qquad\qquad \Downarrow \\
 & \mathrm{V[+PAS,\ AGR}\ \delta_{n-1},\ \mathrm{TYP}\ \langle\delta'_n,\langle\delta_1,\langle\ldots\langle\delta_{n-1},\mathrm{S}\rangle\ldots\rangle\rangle\rangle] \\
 & \qquad\qquad\qquad \text{and} \\
 & \mathrm{V[+PAS,\ AGR}\ \delta_{n-1},\ \mathrm{TYP}\ \langle\delta_1,\langle\ldots\langle\delta_{n-1},\mathrm{S}\rangle\ldots\rangle\rangle] \\
 & \text{where} \\
 & \text{(i) } \delta_{n-1},\ \delta_n \in \{\mathrm{NP},\ \mathrm{S}\} \text{ and} \\
 & \text{(ii) if } \delta_n = \mathrm{NP} \text{ then } \delta'_n = \mathrm{PP[by]} \text{ else } \delta'_n = \mathrm{S}.
\end{array}
$$

Note that δ_{n-1} and δ_n are the categories of the direct object and subject of V[-PAS], respectively. By CTP V[-PAS] with mother VP (of type $\langle\delta_n, \mathrm{S}\rangle$) has complements $\delta_1, \ldots, \delta_{n-1}$ while V[+PAS] with mother VP (of type $\langle\delta_{n-1}, \mathrm{S}\rangle$) has complements $\delta_1, \ldots, \delta_{n-2}$ and, optionally, δ'_n.

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[10] V[PAS] is specified <SUBCAT, 2> in *John was bothered by his boss.*

2.3 The 'Subject-Aux Inversion' (SAI) Metarule

The second metarule for English discussed in GKPS is the 'Subject-Aux Inversion' (SAI) Metarule (pp. 60-65):

$$
\begin{array}{lrl}
(28) & \mathrm{V^2[-SUBJ]} & \rightarrow \mathrm{W} \\
 & & \Downarrow \\
 & \mathrm{V^2[+INV,\ +SUBJ]} & \rightarrow \mathrm{W},\ \mathrm{NP}
\end{array}
$$

This applies to all lexical ID rules expanding VP. [11] Because of (29), however, local trees are admitted only by derived ID rules produced by its application to base lexical ID rules expanding categories specified VP[+AUX]:

$$(29) \qquad \mathrm{[+INV]} \supset \mathrm{[+AUX,\ FIN]} \qquad \mathrm{(FCR\ 1)}$$

Most of the work of this metarule can be taken care of simply by the CTP since a lexical head V with the type $\langle\delta_1, \langle\ldots\langle\delta_n, \langle\mathrm{NP}, \mathrm{S}\rangle\rangle\ldots\rangle\rangle$ has the complements $\delta_1, \ldots, \delta_n$ if its mother is VP (of type $\langle\mathrm{NP}, \mathrm{S}\rangle$) and the complements $\delta_1, \ldots, \delta_n$, NP if the mother is S. Further restrictions must determine when V has which mother. In addition to the FCRs of (29) and (30), retained from GKPS, the new FCR of (31) is introduced:

$$(30) \qquad \mathrm{[+INV,\ BAR\ 2]} \supset \mathrm{[+SUBJ]} \qquad \mathrm{(FCR\ 10)}$$

$$(31) \qquad \mathrm{[INV]} \equiv \mathrm{[+V,\ -N]}$$

INV is a HEAD feature subject to the Head Feature Convention (cf GKPS, pp. 94-99), so a V^2 mother of V[+INV] must be specified <INV, +> and therefore also <SUBJ, +>. If V is specified <INV, -> (note that (31) requires it to have some specification for INV), then its mother is not an extension of V^2 (providing for coordination) or it is specified <SUBJ, -> according to the following CCR:

$$(32) \qquad [\![\ \mathrm{V[-INV]}\ ]\!]\ (\sim\mathrm{V}^2 \vee \mathrm{[-SUBJ]}) \text{ [12]}$$

Although GKPS provides for an embedded inverted sentence in *What did you see?* , no embedded nonhead S is specified <INV, +>. This fact is captured with a CCR:

$$(33) \qquad [\![\ \sim\mathrm{S[-H,\ +INV]}\ ]\!]$$

A special Feature Specification Default to account for the distribution of INV (cf CKPS, pp. 30-31) then becomes unnecessary.

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[11] Recall the use of aliases in GKPS (p. 61) whereby 'VP' stands for V^2[-SUBJ] and 'S' for V^2[+SUBJ].

[12] Note that this CCR contains a disjunction of root descriptions and thus does not conform to the schemata for simple CCRs with atomic categories presented in section 1.1 above. The disjunction is to be read "the root is not an extension of V^2 or it is an extension of [-SUBJ]."

2.4 The Extraposition Metarule

GKPS (p. 118) proposes the following metarule to handle extraposition:

$$(34) \qquad X^2[\text{AGR S}] \rightarrow W \\ \Downarrow \\ X^2[\text{AGR NP[it]}] \rightarrow W,\ S$$

The metarule correctly predicts sentences like *It bothers John that Kim drinks.* because it applies to the lexical ID rule introducing V[SUBCAT 20] for *bother* :

$$(35) \qquad VP[\text{AGR S}] \rightarrow H[20],\ NP$$

To allow *It is apparent that Kim drinks.* , however, it must also apply to the lexical ID rule introducing A[SUBCAT 25] for *apparent* :

$$(36) \qquad A^1[\text{AGR S}] \rightarrow H[25],\ (PP[\text{PFORM to}])$$

Both cases can be covered with CTP if the Lexical Rule for Extraposition Verbs of GKPS (p. 222) is replaced with the following metalexical rule:

$$(37) \qquad [+V,\ \text{BAR } 0,\ \text{AGR S},\ \text{TYP } \langle\delta_1,\langle\ldots\langle\delta_n,\langle S,S\rangle\rangle\ldots\rangle\rangle] \\ \Downarrow \\ [+V,\ \text{BAR } 0,\ \text{AGR NP[it]}, \\ \text{TYP } \langle\delta_1,\langle\ldots\langle\delta_n,\langle S,\langle NP[it],S\rangle\rangle\rangle\ldots\rangle\rangle]$$

The Extraposition Metarule of GKPS is then superfluous.

2.5 Slash Termination Metarules

Slash Termination Metarule 1 (STM1) (cf GKPS, pp. 142-144) is of particular interest because of its generality:

$$(38) \qquad X \rightarrow W,\ X^2 \\ \Downarrow \\ X \rightarrow W,\ X^2[+\text{NULL}]$$

It applies to any lexical ID rule with a category specified <BAR, 2> in the RHS and produces a rule with the specification <NULL, +> added to this category.

It turns out that STM1 may be eliminated with two simple statements. An FCR expresses the fact that a category is specified for NULL (i.e. NULL takes the value + or -) if and only if it also is <BAR, 2>:

$$(39) \qquad [\text{NULL}] \equiv [\text{BAR } 2]$$

A CCR then stipulates that a category specified <NULL, +> must have a lexical category as its sister in a local tree:

$$(40) \qquad \|[\ [+\text{NULL}] \supset [\text{BAR } 0]\ ]\|$$

This is equivalent to the condition that STM1 - like all metarules - may only apply to lexical ID rules. Note that a root category is not indicated in (40) and that parasitic gaps (cf GKPS, pp. 162 ff) are provided for.

As in GKPS, an FCR requires that a category specified <NULL, +> also be specified for SLASH:

$$(41) \qquad [+\text{NULL}] \supset [\text{SLASH}] \qquad (\text{FCR } 19)$$

The distribution of SLASH is in turn governed by the CAP, HFC, and FFP. GKPS also postulates an FSD for NULL:

$$(42) \qquad \sim[\text{NULL}] \qquad (\text{FSD } 3)$$

FSD 3 is not required in this analysis since categories specified <BAR, 2> are freely specified with values from {+, -} for NULL, while all other categories must be unspecified for NULL according to (39).

The treatment of gaps in GKPS is completed with the Slash Termination Metarule 2 (STM2) (cf GKPS, pp. 160-162):

$$(43) \qquad X \rightarrow W,\ V^2[+\text{SUBJ, FIN}] \\ \Downarrow \\ X/NP \rightarrow W,\ V^2[-\text{SUBJ}]$$

STM2 says that for every lexical ID rule introducing V^2[+SUBJ, FIN] as a daughter, there is a corresponding rule with V^2[-SUBJ, FIN] in place of V^2[+SUBJ, FIN] and with the mother specified <SLASH, NP>.

Examination of the lexical ID rules proposed for English in GKPS reveals that all V^2[FIN] daughters introduced are also specified <SUBJ, +>. We may therefore reformulate the types of the lexical head categories so that V^2[FIN] complements do not carry the specification <SUBJ, +>. The feature SUBJ is then freely specified but restricted by the FCR in (44) and the CCR in (45):

$$(44) \qquad [\text{SUBJ}] \equiv [+V,\ -N,\ \text{BAR } 2]$$

$$(45) \qquad \|[\ [\text{BAR } 0] \wedge V^2[-\text{SUBJ, FIN}]\ ]\| \quad X/NP$$

The CCR of (45) states that a local tree with V^2[-SUBJ, FIN] and [BAR 0] as daughters must have a root specified <SLASH, NP>. As in the case of STM1, the stipulation of a [BAR 0] sister is the CCR counterpart of the requirement that metarules apply only to lexical ID rules.

Taken together, the two FCRs of (39) and (44) plus the two CCRs of (40) and (45) accomplish all the work of STM1 and STM2 and result in the same analyses for English as adopted in GKPS.

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