Phrase Structure Grammar
and Categorial Grammar

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This paper is concerned with the bearing of certain linguistic data on phrase structure grammar (PSG) and categorial grammar (CG) theories of syntax. The paper comes in three main parts. In section 1 I present the extraction and coordination data that is of concern here; this includes an array of 'compound' instances of phenomena that are usually considered in isolation. In section 2 I discuss the data in relation to phrase structure grammar, in particular Generalised Phrase Structure Grammar (GPSG) and Head-Driven Phrase Structure Grammar (HPSG). In section 3 I discuss the data in relation to categorial grammar; I assess the adequacy of Combinatory Categorial Grammar (CCG), and I present a metarule-based account.

1. Non-Canonicality

In accounts of natural language grammar, a distinction is usually drawn between expressions like (1a) and (2a), and their counterparts (1b) and (2b):

(1) a. I liked London
     b. London I liked

(2) a. I liked London but Suzy hated London
     b. I liked but Suzy hated London

The 'a' examples are typically considered to be more 'basic' than the 'b' examples. For instance, in classical transformational grammar the former might be base-generated while the latter are only derived via transformation. I will refer to the former as *canonical* and the latter as *non-canonical.* Non-canonical expressions will be annotated with indexed 'fillers' and 'gaps', and with structure-indicating brackets, to help indicate their pertinent properties. (But this does not indicate a theoretical commitment to such concepts as empty categories.) Thus the (1b) and (2b) examples may be written:

(3) $London_i$ I liked e_i

(4)   [Mary liked e_i but Suzy hated e_i] $London_i$

In section 1.1 below I discuss simple non-canonicality, in section 1.2 I discuss compound non-canonicality[1].

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[1] The terms *simple* and *compound* are used informally in this theory-neutral presentation of data. As for the canonicality/non-canonicality dichotomy itself, the distinction implied will presumably be precisely formulable with respect to particular theories.

1.1. Simple Non-Canonicality

Examples such as (5), repeated from above, are described as 'right node raising' (RNR; Postal 1974 pp125-128; Bresnan 1974).[2]

(5)   [I liked e_i but Suzy hated e_i] London$_i$

Transformationally, the object shared by the two verbs in (5) is viewed as having been 'raised' out of the coordinate structure. RNR is not a local phenomenon; in (6) it crosses a clause boundary.

(6)   [John said that Sue likes e_i and Fred said that Sue dislikes e_i] [newsletters full of trivia]$_i$

Another kind of non-canonicality is 'left extraction', which includes topicalisation and relativisation:[3]

(7)   a.   London$_i$ I liked e_i
       b.   the town which$_i$ I liked e_i

Again such left extraction can be over an arbitrarily long distance, and the relation between the filler and gap is sometimes referred to as 'long distance dependency' or 'unbounded dependency':

(8)   a.   London$_i$ I think that John argued that Sue likes e_i
       b.   the town which$_i$ I think that John argued that Sue likes e_i

Constructions such as the following, in which verbs appear outside of coordinate structures containing their modifiers,[4] are described as 'left node raising' (LNR) by Schacter and Mordechay (1983):

(9)   a.   I met$_i$ [e_i John on Monday and e_i Sue on Tuesday]
       b.   I gave$_i$ [e_i John a book and e_i Mary a record]

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[2] Note that transformational terms are used here purely descriptively.

[3] I take the parallelism between these phenomena to be sufficient motivation to group them together; the theories considered here all provide parallel treatments of topicalisation and relativisation.

[4] Note that I use *modifiers* as embracing both *complements*, which are subcategorized for, and *adjuncts*, which are not.

'Right extraction' phenomena include 'heavy noun phrase shift' (HNPS) and 'right extraposition'. HNPS refers to the appearance of a first object to the right of its usual position; acceptability is dependent on this constituent being large:

(10)   I gave e_i to John [the most recent version of the paper/*it]$_i$

A noun modifier appearing right of its normal position is referred to as 'right extraposed':

(11)   A man e_i arrived [who spoke Russian]$_i$

The final phenomenon of concern is 'parasitic extraction' (Taraldsen 1979; Engdahl 1981, 83). This refers to extraction in which one filler fills two extraction sites.[5] One of these is often an 'island', that is the result of extracting from this position alone is largely unacceptable; this latter gap is described as being 'parasitic' on the former:

(12)   a.   ?a paper which$_i$ I filed the records without reading e_i
       b.   a paper which$_i$ I filed e_i without reading e_i

(13)   the man who$_i$ I told the friends of e_i that Mary envies e_i

1.2. Compound Non-Canonicality

The last section was concerned with cases where there was a single filler or displaced element, although corresponding to this there may have been more than one gap. This section is concerned with cases where there is more than one displaced element.

The first examples are cases of double RNR (Abbott 1976):

(14)   [Mary sent e_i e_j or John gave e_i e_j] [a full report]$_i$ [to every student]$_j$

Here a subject is combining with a verb taking two complements before either of these complements. Other expressions normally combining with a complete verb phrase can also combine before two complements. In (15) an auxiliary does so.

(15)   Mary [has given e_i e_j or will send e_i e_j] [a full report]$_i$ [to every

          student]$_j$

Also, in (16) a subject relative pronoun combines with a verb before each of the verb's two complements, and in (17), the same is done by an adverbial preposition taking a present

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[5]The phenomenon is distinct from so-called 'across-the-board' extraction where one filler corresponds to gaps in each of a number of conjuncts, because parasitic extraction does not involve coordination, see e.g. Engdahl (1983).

participial verb phrase.

(16)   the people [who gave e_i e_j and who sent e_i e_j] [these reports]$_i$ [to the students]$_j$

(17)   He lived [without loaning e_i e_j and without donating e_i e_j] [any pictures]$_i$ [to the gallery]$_j$

As well as complements, adjuncts can be RNRed. Thus, assuming the adverb is not sentential, in the following both the complement and the adverb are RNRed:

(18)   [John searched e_i e_j and Mary waited e_i e_j] [for John]$_i$ patiently$_j$

Noun modifiers can be RNRed from noun phrases. In the following, a complement and an adnominal are:[6]

(19)   [a hope e_i e_j and a belief e_i e_j] [that Mary will come back]$_i$ [which I do not share]$_j$

Two verb complements can be HNPSed past an adverbial:

(20)   I posted e_i e_j yesterday [a copy of the newsletter]$_i$ [to every student]$_j$

As well as it being possible to extract two verb modifiers, it is possible to extract one, while also extracting from another. In (21) there is extraction *from* the adverbial, and extraction *of* the complement:

(21)   He [met e_i during e_j and married e_i after e_j] [the great war]$_j$ [a woman whom I've always thought of as my Aunt]$_i$

It is possible to right extrapose a subject's relative clause while also left extracting from the verb phrase:

(22)   a paper which$_i$ a woman e_j presented e_i [who has been studying computational linguistics for six years]$_j$

Two subject modifiers can be extracted; in (23) one is left extracted and the other right extracted.

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[6]Adnominals such as restrictive relative clauses are assumed to modify nominals of lower projection than noun phrases.

(23)   a woman [about whom]$_i$ an argument e_i e_j started [which went on all

night]$_j$

Compound non-canonicality can involve parasitic phenomena. Consider (24).

(24)   a paper which$_i$ he showed e_j e_i before submitting e_i [a good number of

his colleagues]$_j$

The main verb's second complement and the subordinate verb's object are parasitically left extracted, and the main verb's first complement is HNPSed. A twin case is one where the gap in the adverbial is parasitically identified not with the left extracted second complement, but with the right extracted first complement:

(25)   a picture which$_i$ he showed e_j e_i without forewarning e_j [the unsuspect-

ing members of the jury]$_j$

It was shown above that two modifiers can be RNRed. In (26) both a determiner and a transitive verb are LNRed from conjuncts consisting of a noun and an adverbial:

(26)   I see$_i$ each$_j$ [e_i e_j boy on Monday and e_i e_j girl on Tuesday]

There can be extraction from a predicate verb phrase at the same time that a subject determiner is LNRed:

(27)   a play which$_i$ each$_j$ [e_j boy liked e_i and e_j girl disliked e_i]

While a verb is LNRed, it is possible to also extract from the left or right modifiers comprising the conjuncts; indeed it is possible to have parasitic extraction from both the modifiers. First, extraction from the right modifier:

(28)   a topic [about which]$_i$ I lent$_j$ [e_j John a book e_i and e_j Mary a paper e_i]

The extraction is also possible if the second modifier is an adjunct as opposed to a complement:

(29)   I met$_i$ [e_i John before e_j and e_i Mary during e_j] [the second session]$_j$

Second, extraction from the left modifier:

(30)   a topic [about which]$_i$ I lent$_j$ [e_j a paper e_i to John and e_j a book e_i to

Mary]

Thirdly, parasitic extraction from both modifiers:

(31)   a town which$_i$ I bought$_j$ [e_j a ticket to e_i not wanting to visit e_i and e_j a ticket from e_i not wanting to leave e_i]

In LNR where the conjuncts consist of a verb's second complement and an adverbial, a gap in the adverbial can be parasitically identified with the first complement of the LNRed verb:

(32)   the subjects who$_i$ we gave$_j$ [e_j e_i stimulus A before drugging e_i and stimulus B after drugging e_i]

Alternatively, in LNR where the conjuncts consist of a verb's first complement and an adverbial, a gap in the adverbial can also be parasitically identified with the second complement of the LNRed verb:

(33)   a report which$_i$ he showed$_j$ [e_j John e_i before reading e_i and e_j Mary e_i after reading e_i]

Finally, it is possible to LNR elements themselves containing gaps. In the following the verb phrases and right extraposed relative clauses form conjuncts from which the subject with the relative clause gap is LNRed:

(34)   [Numerous statues]$_i$ [e_i e_j were erected [of the new president]$_j$ and e_i e_k were knocked down [of the old one]$_k$]

2. Phrase Structure Grammar

In this section non-canonicality is discussed in relation to GPSG and HPSG. Description of the theories is necessarily simplified, and is limited to the relevant features.

2.1. Generalised Phrase Structure Grammar

A context-free grammar contains rewrite rules such as

(35)   a. S → NP VP

      b. VP → TV NP

All category symbols are atomic objects. In GPSG categories are feature matrices, including a slash feature which takes a category value: a category S/NP means a sentence with a noun phrase gap, and this would be the category of the subexpression *I liked* in

(36)   London$_i$ I liked e_i

S/NP is also the category of the conjuncts in

(37)   [I liked e_i but Suzy hated e_i] London$_i$

In general a category X/Y is the category of an expression of category X containing a gap of category Y.

For this discussion, it suffices to assume that coordination in both PSG and CG is carried out under a schema such as the following which Gazdar (1981) attributes to Dougherty (1970):

(38)   [X Coord X]$_X$

This states that conjuncts of like category can be coordinated to form a coordinate structure of that category. The identity of conjunct categories ensures 'across-the-board' (ATB) extraction. Thus the following, in which only one conjunct contains a gap, is not possible because the conjunct categories are different:

(39)   *the town which$_i$ [I liked e_i]$_{S/NP}$ and [Suzy liked London]$_S$

In GPSG an account of the relation between gaps and fillers comes in three parts. First, there is introduction of gaps at the site of their occurrence. Second, there is mediation of gap information between the gap site and the filler site. Third, there is filler introduction. A gap is introduced by a gap introduction metarule which states, in essense, that if there is a rule

(40)   X → ... Y ...

then there is a rule

(41)   X/Z → ... Y/Z ...

where X/X → e. For example, given a rule

(42)   VP → TV NP

there is also the derived rule

(43)   VP/NP → TV NP/NP

Thus the transitive verb *liked* can be analysed as of category VP/NP, where it is understood to be followed by an empty category (trace).

Such a metarule also provides for filler-gap mediation. Thus, application to

(44) $S \rightarrow NP\ VP$
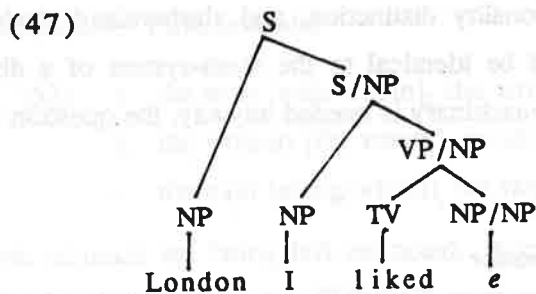
can yield

(45) $S/NP \rightarrow NP\ VP/NP$

so that a subject NP *I* can be combined with *liked*, of category VP/NP, to form *I liked*$_{S/NP}$. This was the treatment in earlier versions of GPSG, but in Gazdar et al (1985), metarules are restricted to apply to lexical rules, such as rules introducing verbs, and filler-gap mediation is governed by feature percolation conventions, and the function of the metarules is limited to gap introduction.

Filler introduction is licensed by rules such as (46a) (for left extraction) and (46b) (for right extraction and RNR):

(46)   a. $S \rightarrow X\ S/X$

       b. $S \rightarrow S/X\ X$

London I liked receives the following analysis:

(47)

```
                    S
                  /   \
                 /    S/NP
                /    /    \
               /    /    VP/NP
              /    /     /    \
            NP    NP    TV   NP/NP
            |     |     |      |
          London  I   liked    e
```

In Gazdar et al (1985), the slash feature is restricted to taking as its value a single non-slash-valued category. It is immediately apparent from the examples in section 1 that such a restriction cannot be maintained, simply because a constituent can contain more than one gap. For example multiple slash values are needed to obtain double RNR.

In a GPSG context, Sag et al (1985) treat LNR such as (48) by a rule allowing an S or VP non-initial conjunct to consist of any number of maximal projections, provided the result is amenable to a certain interpretation rule.

(48)   I gave a book to John and a record to Sue

Hudson (1986) points out that this misplaces conjunct boundaries. In particular the proper structure cannot be assigned to (49).

(49)   Fred drinks [either sherry before dinner or brandy after dinner]

Also, the rule is in danger of allowing ATB violations.

Schachter and Mordechay (1983) provide a GPSG account in which LNR and RNR receive symmetrical (and in fact unified) treatments. One feature of their account is that 'sequence' categories are incorporated, e.g. for double RNR. Thus NP^PP means a noun phrase following by a prepositional phrase. More importantly, they introduce directionality superscripts: a RNRing conjunct has category X/Y^R, and a LNRing conjunct has category X/Y^L. For example a sentence conjunct from which an object has been RNRed (*I liked but Mary hated the second play*) will have category S/NP^R, and a verb phrase conjunct from which a prepositional ditransitive verb (PTV) has been LNRed (*I gave a book to John and a record to Sue*) will have category VP/PTV^L. Consider further (34) repeated below:
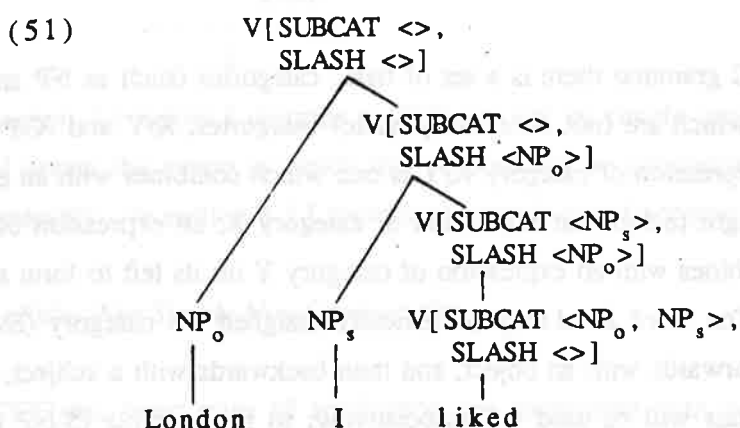
(50)   [Numerous statues]$_i$ [e_i e_j were erected [of the new president]$_j$ and
         e_i e_k were knocked down [of the old one]$_k$]

This has the unusual property that the LNRed subject contains a gap. This means that a slash-value must itself be able to carry a slash specification. Suppose the GPSG slash mechanism was augmented in the manner that I have suggested is necessary. Then there would be multiple slash values, directionality distinction, and slash-valued slash values. But then the GPSG slash-system would be identical to the slash-system of a directional categorial grammar (see below). If this machinary is needed anyway, the question arises as to whether the machinary alone suffices.

2.2. Head-Driven Phrase Structure Grammar

While GPSG has a slash feature which takes as value a single category, HPSG (Pollard 1985a,b) has features SUBCAT and SLASH which take as value a *stack* of categories. In general, a head has as its SUBCAT value a list of its complements (plus subject for verbs, and determiner for nouns). For example the verb *liked* may have a category V[SUBCAT $<NP_o$, $NP_s>$] in which NP_o and NP_s (abbreviations for object and subject noun phrase categories respectively) are on the SUBCAT stack. Combination rules state that an expression of category H[SUBCAT <C...>] can combine with an expression of category C to form an expression of category H[SUBCAT <...>]. The SLASH feature encodes gap information. A *Gap Introduction Principle* states, essentially, that an expression of category H[SUBCAT <C...>, SLASH <...>] is also of category H[SUBCAT <...>, SLASH <C...>], in which the top complement has been popped from the SUBCAT stack and pushed onto

the SLASH stack. Thus *liked*, of category $V[SUBCAT \langle NP_o, NP_s\rangle, SLASH \langle\rangle]$, is also of category $V[SUBCAT \langle NP_s\rangle, SLASH \langle NP_o\rangle]$. A *Binding Inheritance Principle* guides percolation of SLASH information; the analysis of *London I liked* is:

(51)

$$
\begin{array}{c}
V[SUBCAT \langle\rangle, \\
SLASH \langle\rangle]
\end{array}
$$

$$
\begin{array}{c}
V[SUBCAT \langle\rangle, \\
SLASH \langle NP_o\rangle]
\end{array}
$$

$$
\begin{array}{c}
V[SUBCAT \langle NP_s\rangle, \\
SLASH \langle NP_o\rangle]
\end{array}
$$

$$
NP_o \qquad NP_s \qquad
\begin{array}{c}
V[SUBCAT \langle NP_o, NP_s\rangle, \\
SLASH \langle\rangle]
\end{array}
$$

$$
London \qquad I \qquad liked
$$

This richer category-defining apparatus does not suffer from the same shortcomings as that of GPSG, since there may be multiple slash values, and slash values may themselves carry slash values. So the HPSG category system is in principle capable of characterising the constituents in section 1. However there are some shortcomings in the account of gap introduction. First, consider

(52)   a.   the man [with whom]$_i$ she arrived e_i

        b.   the woman [for whom]$_i$ he shopped e_i

        c.   the path [along which]$_i$ we ran e_i

Here adjuncts are being left extracted. According to the gap introduction principle, gaps arise by shifting from the SUBCAT stack to the SLASH stack, so the adjunct must have been on the SUBCAT stack. But if adjuncts are allowed to appear on the SUBCAT stack, the distinction between complements and adjuncts is lost. If another stack-valued feature, for adjuncts, is introduced on heads, there remains the problem of encoding the apparently indefinite number of adjuncts that a head can have.

LNR appears harder still. An appropriate category for a pair of complements would be one which seeks a verb subcategorized for them, to form what the verb would have formed. But it's unclear how principles and rules of the existing kinds could combine two complements, C_1 and C_2, to form a constituent with their head's category on the SLASH stack: $H[SUBCAT \langle...\rangle, SLASH \langle H[SUBCAT \langle C_1, C_2...\rangle]\rangle]$. Presumably rules could be devised, and any CG solution could be simulated because HPSG categories are richer than those of CG. In the absence of an HPSG account, I will turn now to consider LNR and

other phenomena from the perspective of CG, and return to consider the prospects for HPSG in the conclusion.

3. Categorial Grammar

In directional categorial grammar there is a set of basic categories (such as NP and S), and then for all X and Y which are (not necessarily basic) categories, X/Y and X\Y are complex categories. An expression of category X/Y is one which combines with an expression of category Y on its right to form an expression of category X; an expression of category X\Y is one which combines with an expression of category Y on its left to form an expression of category X. The word *liked* may be lexically assigned the category $(S \backslash NP_s)/NP_o$ whereby it combines forwards with an object, and then backwards with a subject, to finally form a sentence. Slashes will be used left-associatively, so for example $(S \backslash NP_s)/NP_o$ can be written $S \backslash NP_s/NP_o$.

In what can be called 'pure' directional categorial grammar, the following rules exhaust the possibilities for combination:

(53) a. *Forward Application*

$$[_f X/Y \ Y]_X$$

$$f =_{def} \lambda x \lambda y[xy]$$

b. *Backward Application*

$$[_b Y \ X \backslash Y]_X$$

$$b =_{def} \lambda x \lambda y[yx]$$

The rules are so-called in view of their semantics. The semantics of forward application is that the meaning of the mother expression is given by applying the meaning of the left-hand daughter expression to that of the right-hand daughter expression; the semantics of backward application is the converse. In the notation here, the names of rules are combinators denoting their semantics: functions which by convention apply to the daughter meanings in left-to-right order to yield the mother meanings.[8]

Derivations will be notated in the following manner (due to Steedman):

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[8] In λ-terms, application is indicated by juxtaposition, and is left-associative.

(54)   I   liked Fred
       -- -------- ----
       NP S\NP/NP   NP
           `-----------`f
                S\NP
       `----------`b
              S

In section 3.1 below I describe a CCG account of simple non-canonicality, and in section 3.2 I assess the extent to which this account can be generalised to handle compound non-canonicality. In section 3.3 I present a metarule-based account of non-canonicality.

3.1. Rules For Simple Non-Canonicality

In CCG the basic rules of application are augmented with a variety of additional rules.[9] Consider

(55)   I [read and will reference] [your paper]

The category of auxiliaries is VP/VP -- they combine with verb phrases on their right to form verb phrases.[10] The following rule will combine the auxiliary VP/VP and the transitive verb VP/NP in the right hand conjunct of (55) to form a constituent of category VP/NP, matching the transitive verb category on the left hand side.[11]

(56)   *Forward Composition*

$$[_{C_f} X/Y \quad Y/Z]_{X/Z}$$
$$C_f =_{def} \lambda x \lambda y \lambda z[x(yz)]$$

Another rule is *forward type-raising* (see Dowty 1985 section 2, and references therein):[12]

(57)   *Forward Type-Raising*

$$[_{R_f} X]_{Y/(Y\backslash X)}$$
$$R_f =_{def} \lambda x \lambda y[yx]$$

This has the form of Steedman's (1987, p39) 'subject type-raising'. The rule can be applied to a subject NP to yield S/(S\NP) where Y is instantiated to S. This is now of the right

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[9]One consequence of the augmentation is that expressions typically have many analyses which assign the same meaning; derivations presented are thus usually just one of many possible derivations. From a processing perspective, left-branching derivations are of interest, because they share the character of human left-to-right incremental processing.

[10]VP abbreviates S\NP.

[11]The rule is called *forward partial combination* in Ades and Steedman (1982, p527) and Steedman (1985, p533), and *forward composition* in Steedman (1987, p37), since its semantics is functional composition.

form to compose with a transitive verb S\NP/NP to yield S/NP, and this enables classical RNR:

(58)   [I liked but Mary disliked] the second play

(59)   I   liked
        - - - - - - -   - - - - - - -
            NP   S\NP/NP
        - - - - - - - -R_f
          S/(S\NP)
        - - - - - - - - - - - - - - - -C_f
              S/NP

Dowty (1985) shows how backward composition and backward type-raising counterparts to these rules provide an account of LNR:

(60)   *Backward Composition*

$[_{C_b} Y\backslash Z\ \ X\backslash Y]_{X\backslash Z}$

$C_b =_{def} \lambda y \lambda x \lambda z[x(yz)]$

(61)   *Backward Type-Raising*

$[_{R_b} X]_{Y\backslash(Y/X)}$

$R_b =_{def} \lambda x \lambda y[yx]$

Consider first the complement-adjunct case:

(62)   I met [John on Monday and Mary on Tuesday]

A suitable category for the conjuncts is VP\(VP/NP): they form verb phrases once they apply to transitive verbs on their left. The adverbials are VP\VP, and the NP objects can be backward type-raised to VP\(VP/NP), where Y in (61) is instantiated to VP. Then an object, VP\(VP/NP), and an adverbial, VP\VP, can combine by backward composition to form a constituent of category VP\(VP/NP), as desired:

(63)   John   on Monday
        - - - -   - - - - - - - - -
            NP   VP\VP
        - - - - - - - - - -R_b
         VP\(VP/NP)
        - - - - - - - - - - - - - - - -C_b
           VP\(VP/NP)

Next, consider the complement-complement case:

```
(54)    I     liked  Fred
        --  ---------  ----
        NP  S\NP/NP  NP
            -----------f
                S\NP
            -----------b
                S
```

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(58)   [I liked but Mary disliked] the second play

(59)   I   liked
        ---------   -------
           NP $S\backslash NP/NP$
        ---------R_f
         $S/(S\backslash NP)$
        ------------------C_f
              S/NP

Dowty (1985) shows how backward composition and backward type-raising counterparts to these rules provide an account of LNR:

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Consider first the complement-adjunct case:

(62)   I met [John on Monday and Mary on Tuesday]

A suitable category for the conjuncts is $VP\backslash(VP/NP)$: they form verb phrases once they apply to transitive verbs on their left. The adverbials are $VP\backslash VP$, and the NP objects can be backward type-raised to $VP\backslash(VP/NP)$, where Y in (61) is instantiated to VP. Then an object, $VP\backslash(VP/NP)$, and an adverbial, $VP\backslash VP$, can combine by backward composition to form a constituent of category $VP\backslash(VP/NP)$, as desired:

(63)   John   on Monday
         ----   ----------
           NP $VP\backslash VP$
        ----------R_b
         $VP\backslash(VP/NP)$
        ------------------C_b
         $VP\backslash(VP/NP)$

Next, consider the complement-complement case:

(54)   I   liked   Fred
          --   -------- ----
          NP   S\NP/NP NP
               -----------f
                  S\NP
          ----------b
               S

In section 3.1 below I describe a CCG account of simple non-canonicality, and in section 3.2 I assess the extent to which this account can be generalised to handle compound non-canonicality. In section 3.3 I present a metarule-based account of non-canonicality.

3.1. Rules For Simple Non-Canonicality

In CCG the basic rules of application are augmented with a variety of additional rules.[9] Consider

(55)   I [read and will reference] [your paper]

The category of auxiliaries is VP/VP -- they combine with verb phrases on their right to form verb phrases.[10] The following rule will combine the auxiliary VP/VP and the transitive verb VP/NP in the right hand conjunct of (55) to form a constituent of category VP/NP, matching the transitive verb category on the left hand side.[11]

(56)   *Forward Composition*

$[_{C_f} X/Y \quad Y/Z]_{X/Z}$

$C_f =_{def} \lambda x \lambda y \lambda z [x(yz)]$

Another rule is *forward type-raising* (see Dowty 1985 section 2, and references therein):[12]

(57)   *Forward Type-Raising*

$[_{R_f} X]_{Y/(Y\backslash X)}$

$R_f =_{def} \lambda x \lambda y [yx]$

This has the form of Steedman's (1987, p39) 'subject type-raising'. The rule can be applied to a subject NP to yield S/(S\NP) where Y is instantiated to S. This is now of the right

---

[9]One consequence of the augmentation is that expressions typically have many analyses which assign the same meaning; derivations presented are thus usually just one of many possible derivations. From a processing perspective, left-branching derivations are of interest, because they share the character of human left-to-right incremental processing.

[10]VP abbreviates S\NP.

[11]The rule is called *forward partial combination* in Ades and Steedman (1982, p527) and Steedman (1985, p533), and *forward composition* in Steedman (1987, p37), since its semantics is functional composition.

(64)   I gave [a book to John and a record to Sue]

The first complement, NP, can be backward type-raised to VP/PP\(VP/PP/NP): something seeking a prepositional phrase to its right once it combines with a prepositional ditransitive to its left.[13] The second complement can be backward type-raised to VP\(VP/PP), and now these can backward compose to form conjuncts of category VP\(VP/PP/NP):

(65)   a book   to John
          -------   -------
             NP   PP
        -------R_b -------R_b
    VP/PP\(VP/PP/NP)   VP\(VP/PP)
                     -------------------------------C_b
                         VP\(VP/PP/NP)

The following rule facilitates right extraction -- HNPS and right extraposition:

(66)   *Mixed Backward Composition*

$$[_{C_{bx}} \ Y/Z \quad X\backslash Y]_{X/Z}$$

$$C_{bx} =_{def} \lambda y \lambda x \lambda z [x(yz)]$$

Consider

(67)   I met e_i yesterday [an old school friend who has become a respected film critic]$_i$

Mixed backward composition combines $met_{VP/NP}$ and $yesterday_{VP\backslash VP}$ to form an expression of category VP/NP. The result can apply forward to a rightwardly displaced heavy noun phrase, so facilitating (67):

(68)   met   yesterday an old ...
        ----- ---------- ----------
        VP/NP   VP\VP   NP
        ----------------C_{bx}
            VP/NP
        ----------------------f
                VP

In a case like (69) the second, PP, complement can be backward type-raised to VP\(VP/PP), and this can combine by mixed backward composition with VP/PP/NP on its left to give VP/NP, again looking for the NP right of the second complement.
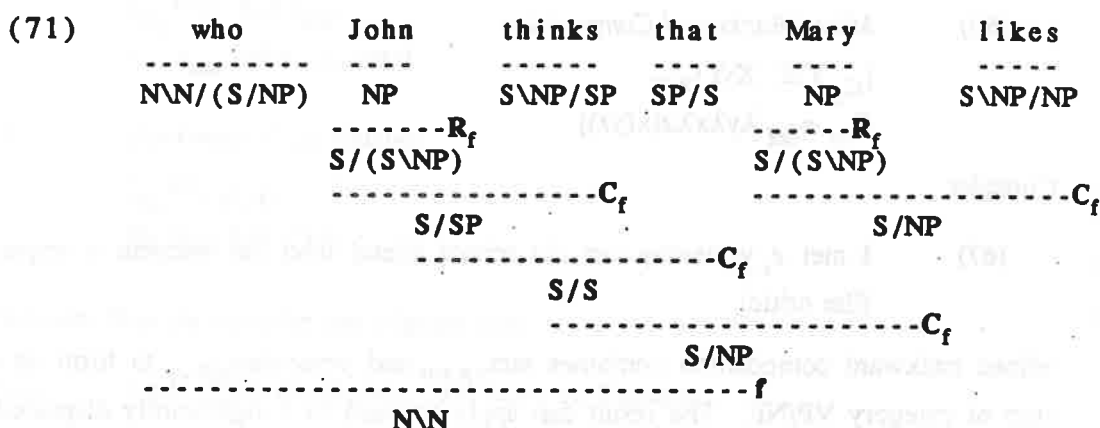
[13]PP abbreviates S\NP\(S\NP).

(69)   I gave e_i to John [a large red box]$_i$

Consider next right extraposition:

(70)   A man e_i arrived [who spoke Russian]$_i$

A noun like man_N can be forward type-raised to N/(N\N) -- a noun type-raised over an adnominal such as a relative clause. A determiner $a_{NP/N}$ can forward compose with this to give $a\ man_{NP/(N\N)}$. $Arrived_{S\NP}$ can combine with this by mixed backward composition, so that *a man arrived* seeks the relative clause beyond the verb phrase. Moortgat (1985) gives the corresponding treatment for right extraposition in Dutch.

The rules that have been presented also provide an account of left extraction. Repeated forward composition and type-raising builds the unboundedly long bridge between the gap and the filler:[14]

(71)   who   John   thinks   that   Mary   likes
        ----------- ----   ------   ----   ----   -----
    N\N/(S/NP)   NP   S\NP/SP   SP/S   NP   S\NP/NP
                    ------- R_f   ------ R_f
                    S/(S\NP)   S/(S\NP)
                    ---------------------- C_f   ------------------------- C_f
                         S/SP   S/NP
                         ---------------------- C_f
                              S/S
                              ------------------------- C_f
                                   S/NP
            -- f
                         N\N

In the case that extraction is from a clause non-final position, mixed composition is required to achieve the S/X 'clause-with-gap' category. For example the adjunct $yesterday_{VP\VP}$ will combine with $met_{VP/NP}$ by mixed backward composition to give VP/NP, from which derivation can proceed as above to yield

(72)   who$_i$ I met e_i yesterday

Similarly the complement *to John*, backward type-raised to VP\(VP/PP), can combine with $gave_{VP/PP/NP}$ by mixed backward composition to enable

(73)   which$_i$ I gave e_i to John

---

[14] In (71) the relative pronoun is lexically type-raised over S/NP, a sentence with a noun phrase gap. The lexical and syntactic possibilities for topic introduction need not concern us here.

Note the relation of this to the right extraction account. In general a fronted element combines with a clause of category S/X, which could have applied forwards to X, so elements which can left extract should be able to right extract. This is largely true, but not completely. The connection between left and right extraction is also expected in PSG since the categories of clauses with gaps are not distinguished as to whether the fillers are expected clause-initially or clause-finally.

Steedman (1987) proposes the following two rules for parasitic extraction:

(74)   a. *Forward Substitution*

$$[_{S_f} X/Y/Z \quad Y/Z]_{X/Z}$$
$$S_f =_{def} \lambda x \lambda y \lambda z[xz(yz)]$$

       b. *Backward Substitution*

$$[_{S_b} Y/Z \quad X\backslash Y/Z]_{X/Z}$$
$$S_b =_{def} \lambda y \lambda x \lambda z[xz(yz)]$$

Consider

(75)   who$_i$ I told the friends of e_i that Mary envied e_i

Forward composition (and possibly type-raising[15]) can analyse *told the friends of* as VP/SP/NP, and *that Mary envied* can be analysed as SP/NP. Then forward substitution combines these, identifying the NP arguments:

(76)   told   the   friends   of   that Mary envied

          S\NP/SP/NP NP/N N/(N\N) N\N/NP   SP/NP
          ----------------C$_f$ -------------C$_f$
              S\NP/SP/N   N/NP
              -----------------------C$_f$
                S\NP/SP/NP
              --S$_f$
                  S\NP/NP

In a case like (77), backward substitution combines *filed*$_{VP/NP}$ and *without reading*$_{VP\backslash VP/NP}$ to form an expression of category VP/NP.

(77)   which$_i$ I filed e_i without reading e_i

---

[15]The noun *friends* could be lexically type-raised over an *of*-prepositional phrase complement, or syntactically type-raised from N to N/(N\N).

3.2. Rules for Compound Non-Canonicality

The generalised version of forward composition in (78) enables double RNRing such as that in (79).

(78)   *Generalised Forward Composition*

$$[X/Y \quad Y.../Z]_{X.../Z}$$

(79)   [Mary gave e_i e_j or John sent e_i e_j] [a full report]$_i$ [to every student]$_j$

The particular instance required in this case combines a type-raised subject S/(S\NP) with a prepositional ditransitive verb S\NP/PP/NP to form a conjunct of category S/PP/NP.

In general there are two principles governing the rules of CCG:

(80)   *The Principle of Directional Consistency (PDC)*

All combinatory rules must be consistent with the directionality of the principle function. [Steedman 1987, p33]

(81)   *The Principle of Directional Inheritance (PDI)*

Every argument of a function resulting from the application of a combinatory rule will bear the same directionality as the corresponding argument(s) in the input function(s). [Steedman 1987, p36]

The *principle* daughter functor in a rule is the one the result category of which is the same as the result category of the mother; the other daughter functor is the subordinate one. The PDI tells us that the sequences denoted by the ellipses in the generalised rules must match on the mother and subordinate functors.

A generalisation of mixed backward composition allows two heavy verb complements to appear right of an adverbial:

(82)   *Generalised Mixed Backward Composition*

$$[Y.../Z \quad X\backslash Y]_{X.../Z}$$

Thus in (83), *posted*$_{VP/PP/NP}$ can combine with *yesterday*$_{VP\backslash VP}$ to form an expression of category VP/PP/NP.

(83)   I posted e_i e_j yesterday [a copy of the newsletter]$_i$ [to every student]$_j$

Consider now the following simultaneous extraction *of* a complement and *from* an adverbial:

(84)   He [met e_i during e_j and married e_i after e_j] [the great war]$_j$ [a woman whom I've always thought of as my Aunt]$_i$

It is necessary to combine met_{VP/NP_i} and $during_{VP\backslash VP/NP_j}$ to form an expression of category $VP/NP_i/NP_j$. In this case, gap arguments are to be 'inherited' from both subexpressions. Inspection of the generalised composition rules reveals that arguments inherited from principle functor must appear *after* the principle functor's top argument. Here however the top argument of $during_{VP\backslash VP/NP_j}$ is the gap category NP_j. There are a number of ways this problem could be tackled. One solution is to type-raise met_{VP/NP_i} into a suitable principle functor category seeking its gap category NP_i after the category it is type-raised over:

(85)   *Generalised Type-Raising I*

$[X/Y]_{Z/Y/(ZX)}$

Met_{VP/NP_i} can thus be type-raised to $VP/NP_i/(VP\backslash VP)$ and this can forward compose with $during_{VP\backslash VP/NP_j}$ to yield a conjunct category $VP/NP_i/NP_j$.

In (86) the subject's relative clause is right extraposed while the verb's object is left extracted.

(86)   a paper which$_i$ a woman e_j presented e_i [who has been studying computational linguistics for six years]$_j$

It is required to combine *a woman*$_{NP/(N\backslash N)}$ and *presented*$_{S\backslash NP/NP}$ to form $S/NP/(N\backslash N)$. As before, the problem is that the top argument of the principle functor $S\backslash NP/NP$ needs to be inherited. Again, Generalised type-raising I can map the $NP/(N\backslash N)$ subordinate functor into the principle functor $S/(N\backslash N)/(S\backslash NP)$, and this can forward compose with $S\backslash NP/NP$ to give $S/(N\backslash N)/NP$. This is almost right, except the arguments are being sought in the wrong order: $S/NP/(N\backslash N)$, which can apply forward to the right extraposed relative clause, was desired.

Consider the following double extraction from subject:

(87)   a woman [about whom]$_i$ an argument e_i e_j started [which went on all night]$_j$

Argument can be lexically assigned, or type-raised into, the category $N/(N\backslash N)$. Generalised type-raising I will transform this to $N/(N\backslash N)/(N\backslash N)$, and *an argument* can be derived as $NP/(N\backslash N)/(N\backslash N)$ by generalised forward composition. Then *an argument started* can be derived as $S/(N\backslash N)/(N\backslash N)$ by generalised mixed backward composition.

Next, consider

(88)   a paper which$_i$ he showed e_j e_i before submitting e_i [a good number of his colleagues]$_j$

This time $showed_{VP/NP_i/NP_j}$ should combine with $before\ submitting_{VP\backslash VP/NP_i}$ to form an expression of category $VP/NP_i/NP_j$. However, in the generalised substitution rules, it is the top arguments that become merged:

(89)   a.   *Generalised Forward Substitution*

$[X/Y/Z\ \ Y.../Z]_{X.../Z}$

b.   *Generalised Backward Substitution*

$[Y.../Z\ \ X\backslash Y/Z]_{X.../Z}$

The parasitic NP$_i$ is the second argument of $showed_{VP/NP_i/NP_j}$, and type-raising does not help here.

In (90) the gap in the adverbial is parasitically identified with the right extracted first complement as opposed to the left extracted second complement.

(90)   a picture which$_i$ he showed e_j e_i without forewarning e_j [the unsuspecting members of the jury]$_j$

$Showed_{VP/NP_i/NP_j}$ should combine with $without\ forewarning_{VP\backslash VP/NP_j}$ to form an expression of category $VP/NP_i/NP_j$. This time the parasitic argument *is* the top one, and generalised backward substitution achieves the desired combination.

In (91) there is left extraction from the verb phrase at the same time the subject determiner is LNRed:

(91)   a play which$_i$ each$_j$ [e_j boy liked e_i and e_j girl disliked e_i]

Boy_N should combine with $liked_{S\backslash NP/NP}$ to form $S/NP\backslash(NP/N)$. Boy_N can be backward type-raised to $NP\backslash(NP/N)$, but as before the top argument of the principle functor $S\backslash NP/NP$ needs to be inherited. $Boy_{NP\backslash(NP/N)}$ can be further type-raised as follows:

(92)   *Generalised Type-Raising II*

$[X\backslash Y]_{Z\backslash Y/(Z\backslash X)}$

Instantiating Z to S, this yields $S\backslash(NP/N)/(S\backslash NP)$ which can forward compose with $liked_{S\backslash NP/NP}$ to give a conjunct of category $S\backslash(NP/N)/NP$, which again seeks its arguments in the inappropriate order.

Recall that while LNRing, it is possible to extract from the left or the right modifier in the conjuncts, or to parasitically extract from both. First, extraction from the right modifier:

(93)   a topic [about which]$_i$ I lent$_j$ [e_j John a book e_i and e_j Mary a paper e_i]

A book$_{NP_2/(N\backslash N)}$ can be type-raised to VP/(N\N)\(VP/NP$_2$) by the following:

(94)   *Generalised Type-Raising III*

           $[X/Y]_{Z/Y\backslash(Z/X)}$

This can backward compose with *John*, backward type-raised to VP/NP$_2$\(VP/NP$_2$/NP$_1$), to give VP/(N\N)\(VP/NP$_2$/NP$_1$) as desired.

Second, extraction from the left modifier:

(95)   a topic [about which]$_i$ I lent$_j$ [e_j a paper e_i to John and e_j a book e_i to

           Mary]

A paper$_{NP/(N\backslash N)}$ can be mapped to VP/PP/(N\N)\(VP/PP/NP) by Generalised type-raising III, and *to John*$_{PP}$ can be backward type-raised to VP\(VP/PP) which combines with the first modifier by generalised mixed backward composition to give a conjunct of the appropriate category: VP/(N\N)\(VP/PP/NP).

The case with parasitic extraction from both modifiers while LNRing is not captured. Below, *a ticket to*$_{NP_1/NP_2}$ and *without wanting to visit*$_{VP\backslash VP/NP_2}$ should form VP/NP$_2$\(VP/NP$_1$). But type-raising will move the top arguments way from their top position, and the substitution rules require the arguments to be merged to be the top categories.

(96)   a town which$_i$ I bought$_j$ [e_j a ticket to e_i not wanting to visit e_i and e_j a
           ticket from e_i not wanting to leave e_i]

In (97) the object in the adverbial is parasitically left extracted with the first complement of the LNRed verb.

(97)   the subjects who$_i$ we gave$_j$ [e_j e_i stimulus A before drugging e_i and
           stimulus B after drugging e_i]

The category of the verb is VP/NP/NP$_i$. If the conjuncts could be analysed as VP\(VP/NP)/NP$_i$ then backward substitution could combine the verb and the coordinate structure to form VP/NP$_i$. In the category required for the conjuncts, NP$_i$, the adverbial's gap category, is the top argument. Since top arguments are inherited from the subordinate functors in combination rules, the adverbial would have to have been the subordinate

functor, and the complement the principle one. Accordingly, the NP complement, backward type-raised to VP\(VP/NP), needs to become VP\(VP/NP)/(VP\VP), which can forward compose with the adverbial, and this is achieved by Generalised type-raising II. But in (98), it is the *second* argument NP_i of the verb $VP/NP_i/NP$ which is parasitically left extracted. Because the substitution rules merge the top arguments, this cannot be appropriately combined with a $VP\(VP/NP)/NP_i$ coordinate structure.

(98)   a report which$_i$ he showed$_j$ [e_j John e_i before reading e_i and e_j Mary e_i after reading e_i]

In the last case to be considered here, a verb phrase S\NP, and a right extraposed adnominal N\N, need to be combined; a suitable result category would be S\(NP/(N\N)):

(99)   [Numerous statues]$_i$ [e_i e_j were erected [of the new president]$_j$ and e_i e_k were knocked down [of the old one]$_k$]

S\NP and N\N are entirely unrelated. N\N could be type-raised to NP\(NP/(N\N)), but the PDC prohibits S\NP from combining with this on its right, because its slash is leftward-looking.

More data could be considered, but I think it has been shown that even generalising the combination rules and adding another kind of type-raising does not suffice to extend the CCG account of non-canonicality to include all compound cases. Typically, inheritance of gap arguments from both subexpressions in a combination required Generalised type-raising; even then there can be complications with argument order. Several parasitic cases defied characterisation. Other rules could be tried -- perhaps, in view of the problems with order, including commutation -- but increasing the rule set does not in any case explain the existence of compound non-canonicality. The suggestion here is that the primitives underlying non-canonicality are not *rules*, but *metarules*, from which the kinds of rules considered above can be derived. This supports the intuition that compound non-canonicality is a hybridisation of simple non-canonicality. The interaction is modelled by the application of metarules to their own and each others' output, and the peripheral status of compound non-canonicality relative to simple non-canonicality is explained by the fact that the former requires more metarule application. In the next section I present one possible metarule account, and outline how it manages the kind of data on which ordinary rules flounder.

3.3. Metarules for Non-Canonicality

Consider the following:

(100)   *Right Abstraction*

$$[_\phi X \ [_\psi Y \ Z]]_V \ => \ [_{R\phi\psi} X \ Y]_{V/Z}$$

$$R =_{def} \lambda f \lambda g \lambda x \lambda y \lambda z [fx(gyz)]$$

The metarule states that if expressions of category Y and Z can be combined by rule ψ to form an expression which can combine by ϕ with an expression of category X on its left to form an expression of category V, then expressions of category X and Y can combine by $R\phi\psi$ to form an expression of category V/Z.[16] Consider the case when the combinations in the input are by forward application:

(101) $[_f X/Y \ [_f Y/Z \ Z]_Y]_X \ => \ [_{Rff} X/Y \ Y/Z]_{X/Z}$

The syntax (and semantics) of the derived rule is that of forward composition. Thus constructions captured by forward composition above are also captured in a system containing Right Abstraction. In the particular metarule account presented here all combinations are binary, since the basic rules of application are binary, and so are the outputs of metarules. RNR such as *I liked but Mary disliked the second play* is achieved by the following instantiation of Right Abstraction, which combines a subject and a transitive verb:

(102) $[_b NP \ [_f S\backslash NP/NP \ NP]_{S\backslash NP}]_S \ => \ [_{Rbf} NP \ S\backslash NP/NP]_{S/NP}$

Such effects of Right Abstraction also enable unbounded left extraction.

LNR is accomplished via

(103)   *Left Abstraction*

$$[_\phi [_\psi X \ Y] \ Z]_V \ => \ [_{L\phi\psi} Y \ Z]_{V\backslash X}$$

$$L =_{def} \lambda f \lambda g \lambda y \lambda z \lambda x [f(gxy)z]$$

The modifiers in complement-adjunct cases such as *I met John on Monday and Mary on Tuesday*, and complement-complement cases such as *I lent a book to John and a record to Sue*, are combined to form conjuncts by the instantiations (104) and (105) respectively.

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[16]The semantics of derived rules are denoted by their names interpreted as expressions of combinatory logic (CL). In CL-terms, application is indicated by juxtaposition and is left-associative, but space will prohibit full discussion of semantics here.

(104) $[_b[_fVP/NP\ NP]_{VP}\ VP\backslash VP]_{VP} => [_{Lbf}NP\ VP\backslash VP]_{VP\backslash(VP/NP)}$

(105) $[_f[_fVP/PP/NP\ NP]_{VP/PP}\ PP]_{VP} => [_{Lff}NP\ PP]_{VP\backslash(VP/PP/NP)}$

Another metarule underlies right extraction:

(106) *Middle Abstraction*

$[_\phi[_\psi X\ Y]\ Z]_V => [_{M\phi\psi}X\ Z]_{V/Y}$

$M =_{def} \lambda f\lambda g\lambda x\lambda z\lambda y[f(gxy)z]$

(107) combines a prepositional ditransitive with its second complement to form an expression seeking its HNPSed first complement; (108) shows that Mbf is mixed backward composition; as has been shown, this can combine a subject type-raised over an adnominal with a verb phrase to form an expression seeking a right extraposed adnominal, and it can combine a verb seeking a complement with an adverbial so that the complement is sought beyond the adverbial.

(107) $[_f[_fVP/PP/NP\ NP]_{VP/PP}\ PP]_{VP} => [_{Mff}VP/PP/NP\ PP]_{VP/NP}$

(108) $[_b[_fY/Z\ Z]_Y\ X\backslash Y]_X => [_{Mbf}Y/Z\ X\backslash Y]_{X/Z}$

The earlier account of parasitic extraction is achieved because, as the reader may check, Pfff is forward substitution, and Pbff is backward substitution:

(109) *Parasitic Abstraction*

$[_\phi[_\psi X\ Y]\ [_\xi Z\ Y]]_V => [_{P\phi\psi\xi}X\ Z]_{V/Y}$

$P =_{def} \lambda f\lambda g\lambda h\lambda x\lambda z\lambda y[f(gxy)(hzy)]$

Compound non-canonicality arises by recursion of metarules on themselves and each other. For example, in (110) part of the input to Right Abstraction is itself derived by Right Abstraction.

(110) $[_{Rbf}NP\ [_fS\backslash NP/PP/NP\ NP]_{S\backslash NP/PP}]_{S/PP} => [_{R(Rbf)f}NP\ S\backslash NP/PP/NP]_{S/PP/NP}$

The derived rule achieves double RNR. Similarly, recursion of Middle Abstraction on itself enables HNPS past an adverbial of both the complements of a two-complement verb:

(111) $[_{Mbf}[_fVP/PP/NP\ NP]_{VP/PP}\ VP\backslash VP]_{VP/PP} => [_{M(Mbf)f}VP/PP/NP\ VP\backslash VP]_{VP/PP/NP}$

Consider the following simultaneous extraction *of* a complement and *from* an adverbial:

(112)   He [met e_i during e_j and married e_i after e_j] [the great war]$_j$ [a woman whom I've always thought of as my Aunt]$_i$

Met$_{VP/NP_i}$ and *during*$_{VP\backslash VP/NP_j}$ are to be combined to form an expression of category VP/NP$_i$/NP$_j$. This is achieved by recursion of Right Abstraction on Middle Abstraction:

(113) $[_{Mbf}VP/NP_i \; [_f VP\backslash VP/NP_j \; NP_j]_{VP\backslash VP}]_{VP/NP_i} \Rightarrow$
         $[_{R(Mbf)f}VP/NP_i \; VP\backslash VP/NP_j]_{VP/NP_i/NP_j}$

Similarly, simultaneous right extraposition of a subject's relative clause and left extraction of a verb's object is achieved by recursion of Middle abstraction on Right Abstraction:

(114) $[_{Rbf}[_f NP/(N\backslash N) \; N\backslash N]_{NP} \; S\backslash NP/NP]_{S/NP} \Rightarrow [_{M(Rbf)f}NP/(N\backslash N) \; S\backslash NP/NP]_{S/NP/(N\backslash N)}$

Without going into the details, double extraction from subject, as in (115), arises thus: first, recursion of Right Abstraction on itself will combine a determiner and a noun into a noun phrase type-raised over two adnominals, NP/(N\N)/(N\N); second, recursion of Middle abstraction on itself will combine such a subject with a verb phrase S\NP to form S/(N\N)/(N\N).

(115)   a woman [about whom]$_i$ an argument $e_i \; e_j$ started [which went on all night]$_j$

Consider (116) where the verb's second complement is parasitically left extracted with the adverbial's object, and the first object is HNPSed.

(116)   a paper which$_i$ he showed $e_j \; e_i$ before submitting e_i [a good number of his colleagues]$_j$

This involves parasitic extraction and right extraction, and accordingly it is achieved by recursion of Middle Abstraction on Parasitic Abstraction:

(117) $[_{Pbf}[_f VP/NP_i/NP_j \; NP_j]_{VP/NP_i} \; VP\backslash VP/NP_i]_{VP/NP_i} \Rightarrow$
         $[_{M(Pbf)f}VP/NP_i/NP_j \; VP\backslash VP/NP_i]_{VP/NP_i/NP_j}$

As regards (118), *showed*$_{VP/NP_i/NP_j}$ combines with *without forewarning*$_{VP\backslash VP/NP_j}$ by P(Mbf)ff to form VP/NP$_i$/NP$_j$.

(118)   a picture which$_i$ he showed $e_j \; e_i$ without forewarning e_j [the unsuspecting members of the jury]$_j$

In (119) a noun N and a transitive verb S\NP/NP form a S/NP\(NP/N) conjunct.

(119) a. a play which$_i$ each$_j$ [e_j boy liked e_i and e_j girl disliked e_i]

b. $[_{Rbf}[_f NP/N\ N]_{NP}\ S\backslash NP/NP]_{S/NP} \Rightarrow [_{L(Rbf)}N\ S\backslash NP/NP]_{S/NP\backslash(NP/N)}$

Extraction from the right and left modifiers while left node raising is achieved by recursion of Left Abstraction on Middle Abstraction and Right Abstraction:

(120) a. a topic [about which]$_i$ I lent$_j$ [e_j John a book e_i and e_j Mary a paper e_i]

b. $[_{Rff}[_f VP/NP_2/NP_1\ NP_1]_{VP/NP_2}\ NP_2/(N\backslash N)]_{VP/(N\backslash N)} \Rightarrow$

$[_{L(Rff)}NP_1\ NP_2/(N\backslash N)]_{VP/(N\backslash N)\backslash(VP/NP_2/NP_1)}$

(121) a. a topic [about which]$_i$ I lent$_j$ [e_j a paper e_i to John and e_j a book e_i to Mary]

b. $[_{Mff}[_{Rff}VP/PP/NP\ NP/(N\backslash N)]_{VP/PP/(N\backslash N)}\ PP]_{VP/(N\backslash N)} \Rightarrow$

$[_{L(Mff)(Rff)}NP/(N\backslash N)\ PP]_{VP/(N\backslash N)\backslash(VP/PP/NP)}$

Parasitic extraction during LNR is captured thus:

(122) a. a town which$_i$ I bought$_j$ [e_j a ticket to e_i not wanting to visit e_i and e_j a ticket from e_i not wanting to leave e_i]

b. $[_{Pbff}[_{Rff}VP/NP\ NP/NP]_{VP/NP}\ VP\backslash VP/NP]_{VP/NP}\ VP\backslash VP/NP]_{VP/NP} \Rightarrow$

$[_{L(Pbff)(Rff)}NP/NP\ VP\backslash VP/NP]_{VP/NP\backslash(VP/NP)}$

(123) is another parasitic case captured by metarules.

(123) a. the subjects who$_i$ we gave$_j$ [e_j e_i stimulus A before drugging e_i and stimulus B after drugging e_i]

b. $[_{Pbff}[_f VP/NP_i/NP_k\ NP_k]_{VP/NP_i}\ VP\backslash VP/NP_i]_{VP/NP_i} \Rightarrow$

$[_{L(Pbff)}NP_k\ VP\backslash VP/NP_i]_{VP/NP_i\backslash(VP/NP_i/NP_k)}$

Finally, the formation of a conjunct out of a verb phrase and a right extraposed adnominal is achieved thus:

(124) a. [Numerous statues]$_i$ [e_i e_j were erected [of the new president]$_j$ and e_i e_k were knocked down [of the old one]$_k$]

b. $[_f[_{Mbf}NP/(N\backslash N)\ S\backslash NP]_{S/(N\backslash N)}\ N\backslash N]_S \Rightarrow [_{Lf(Mbf)}S\backslash NP\ N\backslash N]_{S\backslash(NP/(N\backslash N))}$

Conclusion

This paper has concerned itself with extraction and coordination in English from the point of view of theories which share a highly constrained character: they are *monostratal*, i.e. they make appeal to only one 'level' of syntactic representation; they are *rule-to-rule compositional*, i.e. semantic and syntactic analysis coincide; and they respect *adjacency*, by which I mean that the only syntactic operation is to concatenate subexpressions[17]. The question that has been of concern is: given these constraints on methodology, what approach does the data suggest? In particular, what category structures best characterise the properties relevant to linguistic classification, and what kind of generalisations, i.e. rules, characterise non-canonicality? In PSG canonical English can be crudely characterised using a category system containing just atomic symbols whose interpretation is separately provided by PS rules. But for non-canonicality categories must become structured symbols; I have argued that the range of non-canonicality data is such that this resulting category system is essentially that of directional categorial grammar.

The HPSG category system is more powerful than that of CG, but the richer symbols can in fact inhibit desiderata. I noted earlier that HPSG is weak in accounting for adjunct movement and LNR. Now these phenomena are notable for the fact that they involve extraction of functors rather than arguments. In CG, the treatment is to type-raise arguments over these functors, after which extraction of the functors-becomes-arguments proceeds along the same pattern as extraction of ordinary arguments. To type-raise, it is necessary to access what a functor category would have formed when it applied to its argument, because the type-raised argument must form the same result when it applies to the functor. In CG this is straightforward: the result of applying X/Y (or X\Y) is X: the category left of the slash. So Y is type-raised to X\(X/Y) (or X/(X\Y)). But in HPSG, the result of 'applying' X[SUBCAT <C...>, ...] is X[SUBCAT <...>, ...]: the same category except SUBCAT is popped. Whereas in CG, the result category is a subtree of the hierarchical functor category, in HPSG the result is not a subtree, and cannot be referenced so easily. To summarise, functor movement indicates a need to refer to the result of combination, but HPSG categories do not identify the result of combination as a unit of category structure.[18]

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[17]Other operations might include deletion or head-wrapping; some versions of HPSG do include the latter.

[18]It is a natural generalisation of CG, consistent with the CCG and metarule accounts of non-canonicality, to allow basic categories to actually be feature matrices. The implication of the above argument is that augmentation should fall short of allowing features on categories as a whole, because at that point the result of combination ceases to be a single unit in the functor category structure.

So far as rules are concerned, I have argued that the generalisations relating simple and compound non-canonicality are to be expressed by metarules. The metarule characterisation presented here is that described in Morrill (1987), but others are possible and this is one area requiring further investigation. An interesting point about metarules is that their existence potentially explains the PDC. This states that all combinations must be in accord with the directionality if the principle functor; now if the basis of metarule derivation of rules is always application, which respects the PDC, then so will all derived rules obey something like the PDC.

Here I have not been particularly concerned with constraints on non-canonicality; again, it is appropriate now to see to what extent these can be captured by stipulation of constraints. Two kinds of constraint may be expected: constraints on participating categories, and constraints on the contexts within which rules can apply. It then still remains to see whether these constraints can receive explanation in terms of such factors as processing and pragmatics.

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