A FORMAL UNIVERSAL OF NATURAL LANGUAGE GRAMMAR

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This paper proposes that the possible word-orders for any natural language construction composed of n elements, each of which selects for the category headed by the next, are universally limited both across and within languages to a subclass of permutations on the "universal order of command" $1,\dots n$, as determined by their selectional restrictions. The permitted subclass is known as the "separable" permutations, and grows in n as the Large Schröder Series $\{1, 2, 6, 22, 90, 394, 1806, \dots\}$.

This universal is identified as formal because it follows directly from the assumptions of Combinatory Categorial Grammar (CCG)—in particular, from the fact that all CCG syntactic rules are subject to a Combinatory Projection Principle that limits them to binary rules applying to contiguous non-empty categories.

The paper presents quantitative empirical evidence in support of this claim from the linguistically attested orders of the four elements Dem(onstrative), Num(erator), A(djective), N(oun) that have been examined in connection with various versions of Greenberg's putative 20th Universal concerning their order. A universal restriction to separable permutation is also supported by word-order variation in the Germanic verb cluster, and in the Hungarian verb complex, among other constructions.*

1. INTRODUCTION. Discontinuous constituency, or the permutation of heads and their complements with those of other constituents, is a central problem for syntactic theory. Building in part on an observation by Williams (2003), the present paper proposes that the following formal universal of natural language grammars limits the permutations that they allow. The word-orders that are possible both across and within languages for any construction composed of n elements, each of which selects for the category headed by the next, are strictly limited intra- and cross-linguistically to a particular subclass of permutations on the Universal Order of Command $1,\dots,n$ determined by their selectional restrictions. The permitted subclass, known as the "separable" permutations (Bose et al., 1998), are those orders over which a "separating tree" can be constructed. A tree is separating when all leaves descending from any node form a continuous subset $i\dots j$ of the original ordered set $1,\dots,n$. An important property of separating trees for linguistic purposes is that *they cannot include any subtree in which no complement is string-adjacent to its selecting head.*

The number of separable permutations grows in n as the Large Schröder series $\{1, 2, 6, 22, 90, 394, 1806, \dots\}$. This series grows much more slowly than the factorial series $\{1, 2, 6, 24, 120, 720, 5040, \dots\}$ representing the total of all permutations of n elements, a fact of some interest for natural language processing to which we return briefly below.

After some preliminaries in section 2 concerning the nature of language universals, the paper begins in section 3 by reviewing evidence in support of this universal from the linguistically-attested orders of the four elements Dem(onstrative), Num(erator), A(djective), N(oun) that surface in English in their Universal Order of Command 1, 2, 3, 4. This construction has recently been examined by Cinque (2005, 2013b),

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Abels and Neeleman (2009, 2012), Nchare (2012), and others, in connection with a conjecture originating with Greenberg (1963), concerning their possible orders. For the case of four elements, there are 22 separable permutations, of which 21 have so far been attested by one or other of these these authors. The two non-separable permutation orders 2, 4, 1, 3 and its mirror-image 3, 1, 4, 2 are among the three unattested orders, as predicted.

Section 4 introduces Combinatory Categorial Grammar (CCG), and shows how this prediction follows as a formal universal from its assumptions, and in particular from the Combinatory Projection Principle, (11) below, which requires all rules of CCG to apply to strictly contiguous non-empty categories. It excludes both the above orders, because 1 cannot combine with 2 via such rules until 3 has combined with 4, and vice-versa. In general, CCG is incapable of recognising non-separable permutations on the Universal Order of Command.

Section 5 then shows in detail how the ensemble of NP permutations attested by these authors is predicted by CCG. The pattern of the very few orders still unattested allows a high confidence to be assigned to the correctness of this prediction in terms of the low probability of observing such a pattern by chance. Section 6 shows at greater length how each attested word-order, including patterns of word-order alternation in a free word-order language, can be specified in their respective language-specific lexicons. It is then shown in Section 7 that the same prediction is supported by word-order variation in the Germanic verb cluster, a parallel four-element construction subject to inter- and intra-linguistic variation, investigated by Wurmbrand (2004, 2006) and Abels (2016).

In order to generalize the predictions from this universal to more complex constructions, section 8 then introduces and motivates the treatment in CCG of arguments such as NPs via *type-raising*, a morpho-lexical process which exchanges the command relation of verbs and their arguments, which are subject thereafter to the same restriction of syntactic derivation to separable permutation. Section 9 then shows that word order-alternation in a number of more ramified Germanic verb-sequential constructions and in the Hungarian verb complex can be captured within the same degrees of freedom as the nominal construction. Section 10 then discusses the implications of the universal in its most general form, while section 11 draws some conclusions for linguistic theory.

2. FORMAL AND SUBSTANTIVE UNIVERSALS. The need to distinguish a number of different varieties of grammatical universal has been generally recognized since Chomsky, 1965.

Substantive universals, such as the availability in all languages of nouns and verbs, follow from the natural metaphysics required for our being in the world, as proposed by Hume, Kant, and Quine (Bach, 1989). Practical requirements for existence dictate a universal conceptual partition into "natural kinds", such as people, places, things, events, states, and relations over those types. The substantive universals include the functional universals, which reflect equally practically significant relations like agency, temporality, information status, and propositional attitude over those entities and relations.[1]

By contrast, *formal* universals follow as theorems from the theory of grammar itself, and intrinsic limitations in the expressive power of the grammar formalism we need in order to explain the attested phenomena of language. Those limitations follow in turn

[1] Unfortunately, we don't actually have access to the details of this metaphysics, at least as adults. Nor will any given language make all of its categories explicit in its morphology or syntax (Everett, 2005; Evans and Levinson, 2009).

from the compositional nature of the underlying meaning representations that human language expresses.[2]

The universal proposed here is of the latter formal kind. It follows from the fact that CCG as a theory of grammar is incapable of capturing non-separable permutation. As a corollary, if separability of permutation is *not* an empirical universal, then there is something wrong with the present form of CCG as a theory of grammar. To consider the evidence on this question, we begin with the NP.

3. ORDER IN THE NP. Cinque (2005) provides a careful survey of the attested orders for the four NP elements in those languages for which a single dominant order can be identified, including frequency counts. These counts are quantized to four ranks: "very many", "many", "few", and "very few", and cover 14 attested orders out of the 24 permutations of those four elements for fixed word-order languages.

A problem facing any such account is that the distribution of attested orders (at least, among languages in which a fixed or default order can be identified) appears to be Zipfian. That is, it is highly skewed according to a power law, so that a very few very frequent orders account for most of the languages surveyed, with a "long-tail" of doubly-exponentially rarer orders, with the rarest accounting for less than one percent of the data. It is therefore difficult to know whether the sample covers all the possibilities, or whether other word-orders that are in fact possible are missing, simply because of sampling bias. This problem is serious: it is in the nature of power laws that we would need to increase the size of our sample by at least an order of magnitude to have a reasonable chance of seeing even one more yet rarer order.[3]

More recently, Nchare (2012) has claimed that in the freer word order language Shupamem, nineteen of the twenty-four possible permutations are allowed, including seven not included in Cinque's fourteen. Nchare also proposes an account in terms of Kayne's (1994) Linear Correspondence Axiom (LCA), suggesting that these orders arise from the same varieties of movement as Cinque's.

3.1. THE DATA FOR NP. Greenberg (1963) originally claimed as his 20th generalization that only six of the twenty-four possible linear orderings were possible for the categories Dem(onstrative), Num(erator), A(djective), and N(oun) exhibited in English *These five young lads*. However, subsequent research by Hawkins (1983), Dryer (1992), and Cinque (2005) has added a further eight orders that are attested as the sole or dominant order in their languages.

Cinque is particularly strict in his definition of permutations that should be counted for the purpose at hand. Importantly, he stresses the importance of excluding from consideration orders that stem from *extraposition*, particularly that of adjectives, which arises from a process similar to relativization, and makes the adjective an NP modifier rather than an N modifier, changing the Universal Order of Command of the four elements. While Dryer's 2018 counts are broadly in line with Cinque's, he includes a

[2] Chomsky 1965: 27-30 (who may have adopted the terms from Max Weber's distinction between formal and substantive justice—cf. Sargentich, 2018) distinguishes only between substantive and formal universals. However, the specific instances of formal universal cited in *Aspects* include some that under the definition of Chomsky 1995b: 54-55 would be classified as substantive or functional. To the extent that formal universals are discussed at all in Chomsky 1995b: 16,222, it seems clear that the definition is the restricted one given here, and different from that in Lasnik and Uriagereka 2005: 12, where functional universals are referred to in passing as "formal," threatening to lose an important distinction.

[3] Cinque's original survey was based on about 700 languages. Since then, he has extended it to more than double that number without admitting any new orders (Cinque, 2013a), although the counts are much better, to the extent that some rankings have changed.

number of further attestations with very low counts which Cinque excludes as involving markers of relativization/extraposition.

3.1.1. NP WORD-ORDERS IN LANGUAGES WITH DOMINANT ORDER (CINQUE). Cinque (2005, 2013b) provides the summary shown in the second column of (1) for the fourteen possibilities attested in his survey for those languages that are claimed in the literature to have a dominant order for the four elements of the NP, giving an admirably detailed account of the sources and strength of the evidence, to which the reader is directed.[4]

(1)	Orders	Cinque 2005, 2013⋆	Nchare 2012
a.	These five young lads	Very many	√
b.	These five lads young	Many	√
c.	These lads five young	Very few	
d.	Lads these five young	Few	
e.	Five these young lads		√
f.	Five these lads young		√
g.	Five lads these young		
h.	Lads five these young		
i.	Young these five lads		√
j.	Young these lads five		
k.	Young lads these five	Very few	√
l.	Lads young these five	Few	√
m.	These young five lads		√
n.	These young lads five	Few⋆	√
o.	These lads young five	Many	√
p.	Lads these young five	Very few	√
q.	Five young these lads		√
r.	Five young lads these	Few⋆	√
s.	Five lads young these	Many⋆	√
t.	Lads five young these	Few	√
u.	Young five these lads		√
v.	Young five lads these		√
w.	Young lads five these	Very few	√
x.	Lads young five these	Very many	√

Cinque (2005) and Abels and Neeleman (2009, 2012) capture exactly the 14 possibilities attested in Cinque's survey, as shown in the second column of (1), in terms of the assumption of a Universal Order of Command (UOC) over the four elements, together with various more or less independently motivated constraints on movement which exclude all 10 orders unattested in his sample.[5]

[4] The ranked counts shown are based on the numbers in Cinque (2013b), as reported by Merlo and Ouwayda (2018)."Very many" means 200 or more, "Many" means 100 to 199, "Few" means 30 to 99, and "Very few" means 10 to 29, out of a total of more than 1400 languages examined. The ranks that are changed from Cinque, 2005 are marked ⋆. Cinque, 2007: n.13 notes the possibility that (m) constitutes a fifteenth order, attested for only one language so far, Dhivehi (Maldivian, Cain, 2000). Abels (2016: 185n.9) notes the possibility of a sixteenth order (f) for Somali, citing Adam (2012).

[5] Cinque refers to the UOC, slightly confusingly, as the "Universal Order of Merge".

Cinque's own analysis further assumes that the UOC is reflected in a single linear base order Dem Num A N, and that all other orders are derived by movement (including roll-up movement) subject to the Linear Correspondence Axiom (LCA) of Kayne (1994). However, Abels and Neeleman show that the 14 orders can be captured without roll-up or LCA, by base-generating the eight possible orders defined by the unaligned UOC, together with a number of constraints including a general prohibition against rightward movement. Stabler, 2011: 634-636 presents a related account in terms of Minimalist Grammar (MG), which allows 16 orders including the 14 attested by Cinque. (Stabler's two additional allowable orders are (j) and (v), a point to which we will return below.)

While the counts indicated above from Cinque are only approximated by four ranks "very many" to "very few", inspection of the relevant counts in Cinque, 2013b, Dryer, 2018, and Haspelmath et al., 2005 makes them appear, like most things in language, to have a Zipfian power-law distribution, with two highest-ranked orders (a) and (x) accounting for half of the sample, and a "long tail" of doubly exponentially rarer ranks, in which the rarest order, (k), is attested by only fourteen languages.[6]

This observation immediately raises the suspicion that some even rarer so far unattested orders are in fact possible, so that their assumed exclusion, and the stipulation of constraints to ensure their absence, are both premature.

In this connection it is interesting to ask whether languages with freer word-order for the relevant constructions are as constrained as Cinque's languages with a dominant order.

3.1.2. NP WORD-ORDER IN A LANGUAGE WITH MULTIPLE ORDERS (NCHARE). Nchare (2012: 134) claims the 19 possibilities shown in the third column of (1) as alternating orders of the same four elements of the NP shown in the first column for Shupamem, a Grassfields Bantu tone language with some 200,000 speakers. This study commands our attention because it was carried out in approximately the same theoretical framework as Cinque, with careful attention to his warnings about excluding orders resulting from extraposition.

Some of these possibilities are conditional on the presence of clitic agreement and definiteness markers not shown in (1), discussion of which is deferred until section 6.2, and certain of the orders shown are associated with contrast or focus effects—see Nchare, 2012: ch.3 and the later section for details.

Cinque argues that the alternate orders allowed in languages like Shupamem should not count for Greenbergian purposes, because they may achieve their focusing effects via movement to a COMP-like position external to the NP, as has been argued for Hungarian and certain Slavic languages (Szabolcsi, 1983, 1994; Giusti, 2006). However, such arguments are somewhat theory-internal, depending on the assumption that the said focus effects must arise analogously to adjective extraposition, by movement to a higher focus position, rather than by lexical specialization of the same head for different word-order. Specialization of the latter kind has been associated with the presence or absence of prosodic accent in languages like English, where NP order does not vary with NP-internal focus. Similar focusing effects can be captured in such languages by lexical specialization for prosodic accent within a fixed word-order, as in the contrast between "These five young LADS" and "These five YOUNG lads" (Steedman,

[6] Such power laws are even more evident when allowance is made for historical relatedness and contact of some of the languages involved (Evans and Levinson, 2009; Dryer, 2018), due to overrepresentation of European patterns in the sample.

2014). Accordingly, we will provisionally accept such alternations as syntactically non-extraposing,[7]

Since two of Cinque's attested orders, (1c,d), are not among Nchare's 19 orders for Shupamem, a total of 21 orders have arguably been attested out of the 24 permutations that unconstrained movement would allow. All 21 of the attested orders are among the separable permutations: the non-separable permutations (1g,j), "five lads these young" and "young these lads five" are not.

4. COMBINATORY CATEGORIAL GRAMMAR. Combinatory Categorial Grammar (CCG) is a radically lexicalized theory of grammar, in which all language-specific syntactic and semantic information concerning word-order and subcategorization or selection is specified in lexical entries or "categories", and is projected onto the sentences of the language by universal rules that are "combinatory" in the sense that they apply to strictly contiguous categories.[8]

4.1. ORDER OF COMMAND AS A SUBSTANTIVE UNIVERSAL. Hawkins (1983: 121-2) notes the possibility of a base-generative account of the generalization in terms of Categorial Grammar, based on the following universal schema for the relevant part of the lexicon, in which "$X|Y$" means "combines with Y, yielding X":[9]

(2) Dem = $NP|NumP$
Num = $NumP|N'$
Adj = $N'|N$
N = N

In the Minimalist notation of Chomsky (1995b, 2001), this lexicon would be written as follows:

(3) these :: { =Num D-case} ("yields D needing case; selects Num")
five :: { =N Num} "yields Num;selects N"
young :: { =N N} "yields N;selects N"
lads :: { N} "yields N"
walk :: { =D+case V} ("yields V; selects D, assigning case to it")

The lexical notation for Chomskyan Minimalism is thus essentially categorial (Chomsky, 1995a, 2000; Stabler, 2011; Adger, 2013). The main difference between CCG and Minimalism is then the use of combinatory rules rather than movement to handle discontinuity.

Chomsky's own notation omits directional alignment, like Hawkins's categorial version (2) with non-directional slashes $|Y$. Stabler (2011) also discusses a Directional Minimalist Grammar (DMG) which distinguishes language-specific directionality as =X and X=, equivalent to CCG directional slashes $/Y$ and $\backslash Y$ (see below).

[7] The reason that the additional permutations allowed in Shupamem do not show up in Cinque's sample of fixed orders is presumably that these orders require very specific contexts to be readily interpretable. Fixed word-order has by definition to be equally interpretable in *all* contexts.

[8] While there have over the years been slight variations in the detailed specification of CCG, all of them since at least Steedman, 2000a,b have explicitly embraced the principle stated below as (11), limiting combinatory rules to contiguous categories, and have restricted type-raising to the morpholexicon, as discussed below in section 8. In particular, the systems studied by Vijay-Shanker and Weir (1994); Baldridge and Kruijff (2003); Koller and Kuhlmann (2009); Kuhlmann et al. (2010), and Kuhlmann et al. (2015), some of which exhibit slight differences in expressive power, are restricted in both respects. Accordingly, the limitation to separable permutations applies to all these variants, and implicitly to earlier variants as well.

[9] Cinque and Chomsky follow the Minimalist convention for labeling categories whereby the noun phrase NP is categorized as DP or D and the adjectival phrase N′ as NP. The present notation is widely used in other linguistic frameworks, and is retained here for consistency with earlier work.

Although Cinque does not remark on the fact, such lexicons are closely related to his (2005: 315, 321, *passim*) assumption of a universal order of command Dem>Num>Adj>N over the relevant categories, since that is the order of dominance or command required by their semantic types, regardless of their linear order, as noted by Culbertson and Adger (2014), (although, as noted earlier, Cinque himself makes the stronger assumption that the UOC is reflected in a single underlying *linear* order). Moreover, the category schemata in (2) and (3) are homomorphic to their semantic types. For example, Dem is semantically something like a generalized quantifier determiner, taking a certain type of nominal property as its argument or restrictor, while Num is a function into the set of properties of that type. Thus the dominance order Dem>Num>A>N expressed in these categories is a substantive or functional universal stemming from their semantics. It is unnecessary to independently stipulate a universal order of command for these categories, or to assume that this linear order is separately stipulated in a universal base, other than as a universal requirement for homomorphism between syntactic and semantic types.

4.2. THE CATEGORIAL LEXICON. The lexical fragment for the the very common English NP order is a version of Hawkins's (2) in which all instances of | are instantiated as $/$, meaning that they have to combine with an element to their right, thus:[10]

(4) These $= NP/NumP$
five $= NumP/N'$
young $= N'/N$
lads $= N$

Slashes identify categories of the form X/Y and $X\backslash Y$ as *functions* taking an argument of syntactic type Y respectively to the right and left, and yielding a result of type X, specifying the order "These five young lads".

By contrast, the following lexical fragment defines the even more frequent mirror-image word-order glossed as "Lads young five these", as required for example for Yoruba (Hawkins, 1983: 119).

(5) "These" $= NP\backslash NumP$
"five" $= NumP\backslash N'$
"young" $= N'\backslash N$
"lads" $= N$

The distinction between forward categories X/Y and backward categories $X\backslash Y$ corresponds exactly in the terms of the Minimalist theory to lexical specification of Abels and Neeleman's initial- and final- headedness parameter for XP, and in the case of the latter to Cinque's iterated local leftward "roll-up" movement of Y to Spec of XP under the LCA. However, it does not make the same prediction that all pre-N elements must be linearized according to the Universal Order of Command. And indeed, some orders attested by Nchare and allowed by CCG do controvert this prediction.[11]

4.3. RULES OF FUNCTION APPLICATION. The universally available rules (6) of syntactic combination called *forward and backward application* (respectively labeled $>$ and $<$ in derivations) allow syntactic derivation from such lexicons.

[10] Of course, we need further lexical categories to allow e.g. *These young lads, Five lads, etc.* as NP. This might be done via underspecification using X-bar-theoretic features (Chomsky, 1970).

[11] I am grateful to the associate editor Lisa Travis for drawing my attention to this point.

(6) *The Application Rules*

a. $X/_{\star}Y \quad Y \quad \Rightarrow \quad X$ $\quad (>)$

b. $Y \quad X\backslash_{\star}Y \quad \Rightarrow \quad X$ $\quad (<)$

The type $\star$ of the slashes in $X/_{\star}Y$ and $X\backslash_{\star}Y$ limits the categories to which these rules can apply, and can be ignored for the moment, since bare $\backslash$ and $/$ slashes can combine by any rule, including these.

The forward rule (6a) allows the following derivation for the English lexicon (4):

(7)
$$\begin{array}{cccc}
\text{These} & \text{five} & \text{young} & \text{lads} \\
\overline{NP/NumP} & \overline{NumP/N'} & \overline{N'/N} & \overline{N} \\
 & & \multicolumn{2}{c}{\overline{\qquad\qquad}{>}} \\
 & & \multicolumn{2}{c}{N'} \\
 & \multicolumn{3}{c}{\overline{\qquad\qquad\qquad\qquad}{>}} \\
 & \multicolumn{3}{c}{NumP} \\
\multicolumn{4}{c}{\overline{\qquad\qquad\qquad\qquad\qquad\qquad}{>}} \\
\multicolumn{4}{c}{NP}
\end{array}$$

The rightward arrow $>$ on all combinations in (7) indicates that it is the rightward functional application rule (6a) that has applied in these cases.[12]

It will be obvious at this point that the two application rules (6) correspond in Minimalist terms to the simplest cases of (External) MERGE, including the "checking" of feature compatibility between function and argument.

Since there are two directional instances of the underspecified "|" slash in the category schema (2), as "/" and "\", it is obvious that all and only the following eight orders, all of which are among the sets attested by both Cinque and Nchare, are possible using application rules (6) alone (and hence, in Minimalist terms, without movement):[13]

(8)

a. $\begin{array}{cccc} \text{These} & \text{five} & \text{young} & \text{lads} \\ \overline{NP/NumP} & \overline{NumP/N'} & \overline{N'/N} & \overline{N} \end{array}$ Very many

b. $\begin{array}{cccc} \text{These} & \text{five} & \text{lads} & \text{young} \\ \overline{NP/NumP} & \overline{NumP/N'} & \overline{N} & \overline{N'\backslash N} \end{array}$ Many

n. $\begin{array}{cccc} \text{These} & \text{young} & \text{lads} & \text{five} \\ \overline{NP/NumP} & \overline{N'/N} & \overline{N} & \overline{NumP\backslash N'} \end{array}$ Few*

o. $\begin{array}{cccc} \text{These} & \text{lads} & \text{young} & \text{five} \\ \overline{NP/NumP} & \overline{N} & \overline{N'\backslash N} & \overline{NumP\backslash N'} \end{array}$ Many

r. $\begin{array}{cccc} \text{Five} & \text{young} & \text{lads} & \text{these} \\ \overline{NumP/N'} & \overline{N'/N} & \overline{N} & \overline{NP\backslash NumP} \end{array}$ Few*

s. $\begin{array}{cccc} \text{Five} & \text{lads} & \text{young} & \text{these} \\ \overline{NumP/N'} & \overline{N} & \overline{N'\backslash N} & \overline{NP\backslash NumP} \end{array}$ Many*

w. $\begin{array}{cccc} \text{Young} & \text{lads} & \text{five} & \text{these} \\ \overline{N'/N} & \overline{N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP} \end{array}$ Very few

x. $\begin{array}{cccc} \text{Lads} & \text{young} & \text{five} & \text{these} \\ \overline{N} & \overline{N'\backslash N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP} \end{array}$ Very many

These eight application-only orders are base-generated under the account of Abels and Neeleman, via headedness microparameters that are in present terms lexically defined

[12] Although compositional semantics and logical form are suppressed for the purposes of this article, the semantics of the rules in (6) is also the application of semantic functions such as *young'* to arguments such as *lads'* to yield logical forms such as *young' lads'*. In general, if the functor $X \mid Y$ has logical form f and the argument Y has logical form a, then the result X always has logical form $f\,a$ (read "f of a"). Thus, semantics is "surface compositional" in CCG.

[13] The discontinuous alpha-numeration reflects the place of these orders in Cinque's ordering of the twenty-four permutations of these elements introduced earlier at (1), which we will take as standard. Ranked counts that reflect changes from Cinque (2005) in Cinque (2013b) are again marked *.

by slash-directionality, corresponding to all configurations of a "mobile" that allows sister nodes to rotate freely around each other: These are also Culbertson and Adger's eight "scope-homomorphic" orders.

However, in order to capture the remaining attested orders, something more than rules of application are required. Cinque and others propose transformational movement subject to various constraints as that "something more" (see Merlo, 2015 and Merlo and Ouwayda, 2018 for regression analyses comparing the empirical fit of these approaches to these data). CCG offers base-generative alternatives to movement, or other syntactic operations over non-contiguous elements.

4.4. RULES THAT CHANGE WORD-ORDER IN CCG. Combinatory Categorial Grammars also include universally-available rules of functional composition, strictly limited in the first-order case to the following four rules:[14]

(9) *The harmonic composition rules*

a. $X/_{\diamond}Y \quad Y/Z \quad \Rightarrow_{\mathbf{B}} \quad X/Z$ $\qquad (>\mathbf{B}\ )$

b. $Y\backslash Z \quad X\backslash_{\diamond}Y \quad \Rightarrow_{\mathbf{B}} \quad X\backslash Z$ $\qquad (<\mathbf{B}\ )$

(10) *The crossing composition rules*

a. $X/_{\times}Y \quad Y\backslash Z \quad \Rightarrow_{\mathbf{B}_\times} \quad X\backslash Z$ $\qquad (>\mathbf{B}_\times)$

b. $Y/Z \quad X\backslash_{\times}Y \quad \Rightarrow_{\mathbf{B}_\times} \quad X/Z$ $\qquad (<\mathbf{B}_\times)$

All syntactic rules in CCG are subject to a generalization called the Combinatory Projection Principle (CPP), which says that rules must apply consistent with the directionality specified on the primary function $X|Y$, and must project unchanged onto their result $X|Z\ldots$ the directionality of any argument(s) $Z\ldots$ specified on the secondary function $Y|Z\ldots$:[15]

(11) *The Combinatory Projection Principle (CPP)*
Syntactic combinatory rules are binary rules that apply to contiguous non-empty categories of the specified syntactic types (**adjacency**), consistent with the rightward or leftward directionality of the principal functor X/Y or $X\backslash Y$ (**consistency**), such that the syntactic type and directionality of any argument in the inputs that also appears in the result are the same (**inheritance**).

The above Principle excludes rules like the following from CCG:

(12)
$$\begin{array}{llllll} Y & X/Y & & \not\Rightarrow & X & \\ X/Y & & & \not\Rightarrow & X\backslash Y & \\ X/Y & Y/Z & & \not\Rightarrow & X\backslash Z & \\ X/Y & Z & Y & \not\Rightarrow & X & Z \end{array}$$

The same principle excludes all movement, copying, deletion-under-identity, or other action-at-a-distance, all structure-changing operations such as "restructuring", "reanalysis", or "reconstruction", and all "traces" and other syntactic empty categories, making derivation strictly type-dependent, rather than structure-dependent.

In the full theory (Steedman, 2000b, *passim*), the harmonic and crossing composition rules (9) and (10) are generalized to four further "second order" cases, in which the

[14] While we continue to suppress explicit semantics for the purposes of the present paper, like the application rules (6) the composition rules (9) and (10) have an invariant surface-compositional semantics, such that if the meaning of the primary function $X|Y$ is a functor f and that of the secondary function $Y|Z$ is g, then the meaning of the result $X|Z$ is $\lambda z.f\,(g\,z)$, the *composition* of the two functors, which if applied to an argument of type Z and meaning a, yields an X meaning $f\,(g\,a)$.

[15] This Principle is defined more formally in Steedman (2000b, 2012) as the conjunction of three more elementary Principles of Adjacency, Consistency, and Inheritance. It also applies to the underspecified argument $|W$ in the second-order composition rule (13): *both* occurrences of $|W$ must be either $/W$ or $\backslash W$.

secondary function is of the form $(Y|Z)|W$ rather than $Y|Z$, of which the only instance that has any opportunity to apply in what follows is the following "forward crossing" instance, in which $|$ matches either / or \ in both input and output:

(13) *The forward crossing second-order composition rule*

$$X/_{\times}Y \quad (Y\backslash Z)|W \quad \Rightarrow_{\mathbf{B}_{\times}} \quad (X\backslash Z)|W \qquad (>\mathbf{B}^2_{\times})$$

The combination of crossing rules and second-order composition is the source of (slightly) greater than context-free (CF) expressive power in CCG, allowing analyses of trans-context-free constructions like Germanic crossed dependencies (Bresnan et al. 1982, Steedman 2000b, and below). However, this rule and the other three second-order rules, which are parallel to the first order rules (9a,b) and (10a), continue to exclude non-separable permutations under the CPP (11).[16]

The types $\diamond$ and $\times$ on the slashes on the primary function $X|Y$ in the composition rules (9) and (10), like the type $\star$ on the application rules (6), allows us to lexically restrict categories as to whether the rule in question can apply to them or to their projections. The absence of specific slash-typing on the secondary function $Y|Z$ is an abbreviation meaning that it schematizes over all slash-types. However, the Combinatory Projection Principle (11) requires that that corresponding slash-type(s) in the result $X|Z\ldots$ is the *same* slash-type.

The inclusion of the harmonic composition rules (9) allows some additional derivations, and supports a variety of "non-constituent" coordinations, of which the following is the simplest example:[17]

(14)

$$\begin{array}{ccccccc}
\text{These} & \text{five} & \text{fat} & \text{and} & \text{seven} & \text{lean} & \text{cows}\\
\overline{NP/_{\diamond\star}NumP} & \overline{NumP/_{\diamond\star}N'} & \overline{N'/_{\diamond\star}N} & \overline{(\mathrm{X}\backslash_{\star}\mathrm{X})/_{\star}\mathrm{X}} & \overline{NumP/_{\diamond\star}N'} & \overline{N'/_{\diamond\star}N} & \overline{N}\\
 & \multicolumn{2}{c}{\underline{\hphantom{NumP/_{\diamond\star}N'\ N'/_{\diamond\star}N}}{>}\mathbf{B}} & & \multicolumn{2}{c}{\underline{\hphantom{NumP/_{\diamond\star}N'\ N'/_{\diamond\star}N}}{>}\mathbf{B}} & \\
 & \multicolumn{2}{c}{NumP/_{\diamond\star}N} & & \multicolumn{2}{c}{NumP/_{\diamond\star}N} & \\
 & & & \multicolumn{3}{c}{\underline{\hphantom{(\mathrm{X}\backslash_{\star}\mathrm{X})/_{\star}\mathrm{X}\ NumP/_{\diamond\star}N}}{>}} & \\
 & & & \multicolumn{3}{c}{NumP/_{\diamond\star}N} & \\
 & \multicolumn{5}{c}{\underline{\hphantom{NumP/_{\diamond\star}N\ NumP/_{\diamond\star}N\ NumP/_{\diamond\star}N}}{<}} & \\
 & \multicolumn{5}{c}{NumP/_{\diamond\star}N} & \\
 & \multicolumn{6}{c}{\underline{\hphantom{NumP/_{\diamond\star}N\ NumP/_{\diamond\star}N\ NumP/_{\diamond\star}N\ N}}{>}}\\
 & \multicolumn{6}{c}{NumP}\\
\multicolumn{7}{c}{\underline{\hphantom{NP/_{\diamond\star}NumP\ NumP/_{\diamond\star}N\ NumP}}{>}}\\
\multicolumn{7}{c}{NP}
\end{array}$$

The crossing composition rules (10), unlike the harmonic rules (9), have a reordering effect that is relevant to the present discussion. For example, in English they allow a non-movement-based account of the Heavy NP Shift construction, thus:

(15)

$$\begin{array}{ccccc}
\text{I} & \text{will} & \text{buy} & \text{tomorrow} & \text{a very heavy book}\\
\overline{NP} & \overline{(S\backslash NP)/VP} & \overline{VP/NP} & \overline{VP\backslash VP} & \overline{NP}\\
 & & \multicolumn{2}{c}{\underline{\hphantom{VP/NP\ VP\backslash VP}}{<}\mathbf{B}_{\times}} & \\
 & & \multicolumn{2}{c}{VP/NP} & \\
 & & \multicolumn{3}{c}{\underline{\hphantom{VP/NP\ VP\backslash VP\ NP}}{>}}\\
 & & \multicolumn{3}{c}{VP}\\
 & \multicolumn{3}{c}{\underline{\hphantom{(S\backslash NP)/VP\ VP/NP}}{>}} & \\
 & \multicolumn{3}{c}{S\backslash NP} & \\
\multicolumn{3}{c}{\underline{\hphantom{NP\ (S\backslash NP)/VP}}{<}} & & \\
\multicolumn{3}{c}{S} & &
\end{array}$$

It will be obvious from the above derivation that allowing the crossing composition rules (10) to apply to unrestricted categories induces *alternation of word-order*, as here

[16] Steedman (2000b) and section 9.3, below, also consider the inclusion of higher-order rules such as $\mathbf{B}^3$ etc., with secondary functors of the form $((Y|Z)|W)|V$, etc. and results of the form $((X|Z)|W)|V$, up to some low bound. Such rules also are CPP- and separability-compliant.

[17] The scare quotes reflect the fact that, in CCG terms, sequences like *five fat* actually *are* typable constituents. The variable X in the conjunction category schematizes over over a bounded number of types. The category's $\star$ slash-types impose the across-the-board constraint on coordination (Steedman, 2012), and are a consequence of its semantics, which is assumed to follow Partee and Rooth (1983).

between the Heavy-Shifted order and the normal order. We shall see later that if we want to exclude such word-order alternations for a construction like the Greenberg NP in a language with one of the eight purely applicative orders (8) as a fixed order, then we can do so by lexically restricting the slash-type of the functor categories to either $\times$ ("only crossing-compose") or $\star$ ("only apply").

If (as is often the case) we want a category to combine by *both* forward harmonic composition *and* forward application, then we assign the category $X/_{\diamond\star}Y$, with the union of $\diamond$ and $\star$ types, as in derivation (14) for English. If we want all three rule-types to apply to a forward category, then we assign it the union of all three slash-types $X/_{\diamond\times\star}Y$, which to save space and maintain compatibility with earlier notations we write as the universal slash X/Y.[18]

In Minimalist terms, all of the composition rules correspond to further cases of ("External") MERGE, since they apply to string-adjacent categories. In the case of *crossing* composition, they have the same reordering effect as (bounded) MOVE, which they thereby reduce to external merger. (In the case of (14), the effects of multidominance and "parallel merge" (Citko, 2005, 2011) are to be found at the level of logical form—see Steedman (2000b), *passim*.) In a later section, we will see that this reduction extends to unbounded *wh*-movement and "internal" MERGE.

4.5. DISCUSSION (I). For the completely unconstrained NP lexicon schematized in (2), consisting of four types of the form $\{A|B,\ B|C,\ C|D,\ D\}$, intrinsically defining the Universal Order of command 1, 2, 3, 4, it follows that CCG allows just 22 of the 24 possible orderings of the four elements. The derivations for these orders are shown at (20) below. It is obvious by inspection that the two non-separable permutations 2,4,1,3 and 3,1,4,2 exhibited in the following mirror-image pair are impossible for these categories:[19]

(16) g.

Five	lads	these	young
$NumP|N'$	N	$NP|NumP$	$N'|N$
2	4	1	3

j.

Young	these	lads	five
$N'|N$	$NP|NumP$	N	$NumP|N'$
3	1	4	2

The Combinatory Projection Principle (11), and in particular the Principle of Adjacency that it subsumes, means that combinatory rules can only combine pairs of contiguous categories. No element $X|Y$ in (16) is adjacent to the thing of the form Y or $Y|Z$ with which it needs to combine, because $N'|N$ and N are *intercalated* with $NumP|N'$ and $NumP|N'$, so that any further derivation is blocked.[20]

The generalization that follows from these observations is that, under the combinatory projection principle (11) governing combinatory rules, an ordered set of n categories of the form $\{A|B,\ C|D,\ C|D,\ \ldots M|N,\ N\}$ can only give rise to permutations of

[18] The slash-typing convention used in this paper is slightly different from that in earlier work, in which the type written here as $X/_{\diamond\star}Y$ was written $X/_{\diamond}Y$ and $X/_{\times\star}Y$ was written $X/_{\times}Y$. Slash typing was introduced in CCG by Baldridge, 2002; Baldridge and Kruijff, 2003; Steedman and Baldridge, 2011, following Hepple (1990), and is independent of the restriction of all forms of CCG to separable permutation,

[19] The odd alphabetization is again to align them with the full set of 24 permutations (1).

[20] See Koller and Kuhlmann (2009) for discussion and a comparison with tree-adjoining grammars (TAG, Joshi (1988)), which are interestingly different in this respect.

that order that are *separable* in the sense defined in the introduction.[21]

It follows that an attestation in the free-order language Latin of the following NP word-orders as alternatives to *Hæ quinque puelæ pulchræ* ("These five beautiful girls") would be a strong counterexample to CCG in its present form as a theory of grammar:[22]

(17) a. *Quinque puellæ hæ pulchræ.
b. *Pulchræ hæ puellæ quinque.

Both seem very bad to this author's schoolboy Latin ear, but are offered as hostages to fortune.[23]

The forbidden word-orders (16g,j) are the only two orders in which no function is contiguous with either its argument or a function that will one day yield its argument. Neither order is attested by Cinque or Nchare (1), although, oddly enough, (16g) is allowed under Hawkins's revision of Greenberg's Universal 20 (Hawkins, 1983: 119-20), while (16j) is allowed under the Minimalist Grammar account of Stabler, 2011: 636, to which we will return below. It is also striking that the forbidden word orders (16g,j) are only excluded in Shupamem under Nchare's LCA-based account by his "freezing principle", which has been argued against by Koopman and Szabolcsi (2000) and Abels (2008) as overly restrictive, and which (as Nchare notes) threatens also to exclude (p), which *is* attested in Shupamem.

Cinque, 2005: 322n.26 notes that Senft, 1986: 105 at one point claims that (16g), is the default NP order for Kilivila. However, Kilivila is a very free-order language, with an elaborate classifier system and classifier agreement on all elements. While Shupamem also has a noun class system, we shall see below that class agreement is not obligatory. Nchare claims that the markers concerned combine with definiteness morphemes to limit word-order and mark contrast or focus, rather than adjunction. The examples that Senft cites in support of his claim involve adjectival adjuncts, and do not exclude the possibility of extraposition (cf. note 22). Cinque further notes that when Senft, 1986: 96 gives a citation example of exactly the construction to hand, as "These two beautiful girls", it is given in the order Dem Num A N.

Dryer (2018: 17,29) nevertheless claims that Kilivila and four other languages have (g) as their default order. While he argues against Cinque on the question of adjectival extraposition in Kilivila, he does not comment on Cinque's and Senft's 1986:96 example with order (a) in Kilivila. Of the other four languages, Dryer notes that the adjective in his example of this order in Yapese (Jensen, 1977) is marked as a relative clause including the copula, hence arguably extraposed from NP. Of the remaining three languages for which Dryer claims order (g), Katu (Costello, 1969: 22) does not lexically distinguish demonstratives from locatives, but the one example Costello gives (1969:34(87)) involving both an adjective and a demonstrative locative has the order N Adj Dem. The example given by (Tryon, 1967): 60 for Dehu/Drehu includes the copula with the adjective, so is arguably also extraposed.

The lexically multifunctional language Teop (Mosel, 2017), to which Dryer also attributes (g) as base order, is a slightly different case. The Teop equivalent of adjectives are expressed as adjoined adjectival phrases, with their own copies of the article or

[21] Stanojević and Steedman (2018) provide a formal proof for the general case of *n* elements.

[22] As noted above following Cinque, one needs to take care in considering such judgements that the words do indeed carry the categories of demonstrative, numerator, adjective and noun—for example, that the adjective is not read instead as an extraposed or adjunct NP modifier $NP|NP$, or a predicate $S|NP$, as opposed to $N|N$–see Cinque (2010) for further discussion.

[23] I am grateful to Rachel Hurley of Cardiff University for confirming (p.c.) that these two orders are indeed ungrammatical in Latin with the intended sense—that is, in the absence of adjective extraposition or NP adjunction.

agreement and numerator (2017:263):

(18) o bua naono o bua kikis
[ART2.SG two chief]$_{NP}$ [ART2.SG two strong]$_{AP}$
"two strong chiefs"

The Teop demonstrative determiner is distinct from the article, and is found in the post-head position in the NP (2017: 263, 275(58), 277(63)):

(19) o vuaba vai o kare tavus
[ART2.SG one DEM6]$_{NP}$ [ART2.SG recently come-out]$_{AP}$
"one that has just come out"

Mosel describes the DEM6 demonstrative *vai* as "often used with nouns that are modified by an adjectival phrase, a relative clause, or an appositional NP" (2017:290). In short, the possibility of extraposition or apposition clearly exists here also.[24]

In CCG terms, adjective extraposition requires the addition of a distinct category $NP|NP$, syntactically and semantically non-homomorphic to $N|N$, inducing a different Universal Order of Command. Thus, none of these languages constitutes a clear counterexample to the present claim that order (g) is universally excluded for the standard categories.

If we relabel the original category set schema $A|B$, $B|C$, $C|D$, and D as X, 1, 2, 3, then (16g) also corresponds to the *1-3-X-2 constraint on movement observed by Svenonius (2007) for adjuncts, which led him to complex stipulations of strong features and null functional heads to limit "roll-up" movement in a wide variety of languages and constructions, including Italian adverb orders, also investigated by Cinque (1999). In the next section, such constraints will be seen to be unnecessary in CCG, and the observed restrictions thereby explained.

5. ANALYSIS I: THE ENSEMBLE OF ATTESTED NP WORD-ORDERS. This section simply asks which permutations are allowed by CCG *at all*, regardless of whether they occur as a fixed default order or as alternations in a freer order language.

5.1. THE PERMUTATIONS. The combinatory projection principle (11) allows the following analyses of the twenty-four permutations, in which only essential compositions are indicated and all other combinations are application ("×" marks the two non-separable permutations (g) and (j) that are unanalysable in CCG as a consequence of the Combinatory Projection Principle (11), while "?" marks the only word order unattested by either author that CCG would allow.) For non-basic orders, the annotation "from *z*" indicates the basic pure-applicative order among those in (8) on whose lexicon a particular derived order is based:

(20) a. These five young lads — Both (basic: v.many)
$\overline{NP/NumP}$ $\overline{NumP/N'}$ $\overline{N'/N}$ $\overline{N}$

b. These five lads young — Both (basic: many)
$\overline{NP/NumP}$ $\overline{NumP/N'}$ $\overline{N}$ $\overline{N'\backslash N}$

c. These lads five young — Cinque (from b: few*)
$\overline{NP/NumP}$ $\overline{N}$ $\overline{NumP/N'}$ $\overline{N'\backslash N}$
$$\underline{NumP/N' \quad N'\backslash N}_{>\mathbf{B}_\times}$$
$NumP\backslash N$

[24] Verbs can also function as heads of adjectival phrases in Teop (2017:264), although these APs are apparently not relative clauses as such.

d. Cinque (from b: few)

$$\begin{array}{llll}
\text{Lads} & \text{these} & \text{five} & \text{young}\\
N & NP/NumP & NumP/N' & N'\backslash N\\
 & \multicolumn{2}{l}{NP/N' \quad >\mathbf{B}} & \\
 & \multicolumn{3}{l}{NP\backslash N \quad >\mathbf{B}_\times}
\end{array}$$

e. Nchare (from r)

$$\begin{array}{llll}
\text{Five} & \text{these} & \text{young} & \text{lads}\\
NumP/N' & NP\backslash NumP & N'/N & N\\
\multicolumn{2}{l}{NP/N' \quad <\mathbf{B}_\times} & &
\end{array}$$

f. Nchare (from s)

$$\begin{array}{llll}
\text{Five} & \text{these} & \text{lads} & \text{young}\\
NumP/N' & NP\backslash NumP & N & N'\backslash N\\
\multicolumn{2}{l}{NP/N' \quad <\mathbf{B}_\times} & &
\end{array}$$

g. × not attested (disallowed)

$$\begin{array}{llll}
\text{Five} & \text{lads} & \text{these} & \text{young}\\
NumP/N' & N & NP\backslash NumP & N'\backslash N\\
\multicolumn{2}{l}{*} & & \\
 & \multicolumn{2}{l}{*} & \\
 & & \multicolumn{2}{l}{*}
\end{array}$$

h. ? not attested (from s)

$$\begin{array}{llll}
\text{Lads} & \text{five} & \text{these} & \text{young}\\
N & NumP/N' & NP\backslash NumP & N'\backslash N\\
 & \multicolumn{2}{l}{NP/N' \quad <\mathbf{B}_\times} & \\
 & \multicolumn{3}{l}{NP\backslash N \quad >\mathbf{B}_\times}
\end{array}$$

i. Nchare (from n)

$$\begin{array}{llll}
\text{Young} & \text{these} & \text{five} & \text{lads}\\
N'/N & NP/NumP & NumP\backslash N' & N\\
 & \multicolumn{2}{l}{NP\backslash N' \quad >\mathbf{B}_\times} & \\
\multicolumn{3}{l}{NP/N \quad <\mathbf{B}_\times} &
\end{array}$$

j. × not attested (disallowed)

$$\begin{array}{llll}
\text{Young} & \text{these} & \text{lads} & \text{five}\\
N'/N & NP/NumP & N & NumP\backslash N'\\
\multicolumn{2}{l}{*} & & \\
 & \multicolumn{2}{l}{*} & \\
 & & \multicolumn{2}{l}{*}
\end{array}$$

k. Both (from n:v.few)

$$\begin{array}{llll}
\text{Young} & \text{lads} & \text{these} & \text{five}\\
N'/N & N & NP/NumP & NumP\backslash N'\\
 & & \multicolumn{2}{l}{NP\backslash N' \quad >\mathbf{B}_\times}
\end{array}$$

l. Both (from o: few)

$$\begin{array}{llll}
\text{Lads} & \text{young} & \text{these} & \text{five}\\
N & N'\backslash N & NP/NumP & NumP\backslash N'\\
 & & \multicolumn{2}{l}{NP\backslash N' \quad >\mathbf{B}_\times}
\end{array}$$

m. Nchare (from n)

$$\begin{array}{llll}
\text{These} & \text{young} & \text{five} & \text{lads}\\
NP/NumP & N'/N & NumP\backslash N' & N\\
 & \multicolumn{2}{l}{NumP/N \quad <\mathbf{B}_\times} &
\end{array}$$

n. Both (basic: few⋆)

$$\begin{array}{llll}
\text{These} & \text{young} & \text{lads} & \text{five}\\
NP/NumP & N'/N & N & NumP\backslash N'
\end{array}$$

o. Both (basic: many)

$$\begin{array}{llll}
\text{These} & \text{lads} & \text{young} & \text{five}\\
NP/NumP & N & N'\backslash N & NumP\backslash N'
\end{array}$$

p. Both (from o: v.few)

$$\begin{array}{cccc}
\text{Lads} & \text{these} & \text{young} & \text{five}\\
\overline{N} & \overline{NP/NumP} & \overline{N'\backslash N} & \overline{NumP\backslash N'}\\
 & & \multicolumn{2}{c}{\overline{\hspace{6em}}{<}\mathbf{B}}\\
 & & \multicolumn{2}{c}{NumP\backslash N}\\
 & \multicolumn{3}{c}{\overline{\hspace{10em}}{>}\mathbf{B}_{\times}}\\
 & \multicolumn{3}{c}{NP\backslash N}
\end{array}$$

q. Nchare (from r)

$$\begin{array}{cccc}
\text{Five} & \text{young} & \text{these} & \text{lads}\\
\overline{NumP/N'} & \overline{N'/N} & \overline{NP\backslash NumP} & \overline{N}\\
\multicolumn{2}{c}{\overline{\hspace{6em}}{>}\mathbf{B}} & & \\
\multicolumn{2}{c}{NumP/N} & & \\
\multicolumn{3}{c}{\overline{\hspace{10em}}{<}\mathbf{B}_{\times}} & \\
\multicolumn{3}{c}{NP/N} &
\end{array}$$

r. Both (basic: few*)

$$\begin{array}{cccc}
\text{Five} & \text{young} & \text{lads} & \text{these}\\
\overline{NumP/N'} & \overline{N'/N} & \overline{N} & \overline{NP\backslash NumP}
\end{array}$$

s. Both (basic: many*)

$$\begin{array}{cccc}
\text{Five} & \text{lads} & \text{young} & \text{these}\\
\overline{NumP/N'} & \overline{N} & \overline{N'\backslash N} & \overline{NP\backslash NumP}
\end{array}$$

t. Both (from s: few)

$$\begin{array}{cccc}
\text{Lads} & \text{five} & \text{young} & \text{these}\\
\overline{N} & \overline{NumP/N'} & \overline{N'\backslash N} & \overline{NP\backslash NumP}\\
 & \multicolumn{2}{c}{\overline{\hspace{6em}}{>}\mathbf{B}_{\times}} & \\
 & \multicolumn{2}{c}{NumP\backslash N} &
\end{array}$$

u. Nchare (from w)

$$\begin{array}{cccc}
\text{Young} & \text{five} & \text{these} & \text{lads}\\
\overline{N'/N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP} & \overline{N}\\
 & \multicolumn{2}{c}{\overline{\hspace{8em}}{<}\mathbf{B}} & \\
 & \multicolumn{2}{c}{NP\backslash N'} & \\
\multicolumn{3}{c}{\overline{\hspace{12em}}{<}\mathbf{B}_{\times}} & \\
\multicolumn{3}{c}{NP/N} &
\end{array}$$

v. Nchare (from w)

$$\begin{array}{cccc}
\text{Young} & \text{five} & \text{lads} & \text{these}\\
\overline{N'/N} & \overline{NumP\backslash N'} & \overline{N} & \overline{NP\backslash NumP}\\
\multicolumn{2}{c}{\overline{\hspace{6em}}{<}\mathbf{B}_{\times}} & & \\
\multicolumn{2}{c}{NumP/N} & &
\end{array}$$

w. Both (basic: v.few)

$$\begin{array}{cccc}
\text{Young} & \text{lads} & \text{five} & \text{these}\\
\overline{N'/N} & \overline{N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP}
\end{array}$$

x. Both (basic: v.many)

$$\begin{array}{cccc}
\text{Lads} & \text{young} & \text{five} & \text{these}\\
\overline{N} & \overline{N'\backslash N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP}
\end{array}$$

5.2. DISCUSSION (II). The derivations in (20) can be summarized as follows:

1. All of the eight orders (a, b, n, o, r, s, w, x) that are identified as "basic"—that is, as arising via application alone, or equivalently as following directly from the Universal Order of Command (UOC) determined by the four unordered categories (2)—are attested both by Cinque as primary or dominant orders, and by Nchare as available alternatives in the freer word-order language Shupamem. These eight orders include all of those identified in Cinque's 2013b sample as attested by "very many" or "many" languages.

2. Each of the six further orders attested by Cinque (c, d, k, l, p, t) and a seventh (m) on which he reserves judgement are obtainable by combinatory derivation involving crossing composition from the same lexicon as one of six basic orders (b, n, o, r, s, w). (Since the two other basic orders (a, x) are completely harmonic in slash directionality, they offer no opportunity for crossing composition, and hence give rise to no secondary orders.)

3. None of the derived orders attested by Cinque is higher in frequency rank than the basic order whose CCG lexicon it shares.

4. Another six derived orders which are only attested in the free word order language Shupamen are also obtainable by combinatory derivation from the same lexicon as one of the same set of basic orders.

5. One further order derivable in the same way, (h), is the sole order, apart from the two that are universally excluded by CCG, that is not attested by either author.

CCG itself is symmetric as a theory of grammar. It follows that the above asymmetries in the frequencies with which the permitted separable permutations are attested must arise from "soft" or violable constraints related to performance considerations and/or ease of acquisition. The fact that all of the five orders (a, b, o, s, and x) attested by "very many" or "many" exemplars in Cinque's 2013b sample are among the eight application-only orders suggests that one factor contributing to the skewed Zipfian distribution of counts is what Culbertson and Adger (2014) and Culbertson and Kirby (2016) identify as *isomorphism* between derivation and UOC. The fact that the only two orders (a, and x) among the homomorphic eight that give rise to "very many" exemplars are the only two orders that are also based on entirely directionally consistent lexicons, suggests that what Culbertson at al. call *harmony*, or consistent head-directionality, is a second factor. It is not clear what further factor(s) might be at work in determining the low counts of the remaining three homomorphic orders, except that where (b, o, and s), all ranked "Many", have the head-final adjective category $N'\backslash N$, the orders (n, r, and w), ranked "Few" or "Very few", require head-initial N'/N. (This factor also seems to be at work among the remaining separable permutations that are neither harmonic nor homomorphic—for example, (k) (derived from adjective-initial n) is much rarer than (l) (derived from adjective-final o).) Culbertson et al. and Dryer also note the apparent bias towards adjective-finality, which is the only one of their constraints that is asymmetric, suggesting an information-processing advantage to having the noun early in the construction. It is striking that all three of Culbertson's constraints apply in CCG terms at the level of the lexicon.

Such factors, which have been argued to relate to processing complexity and the related ease or difficulty of child language acquisition for the construction in question, are of considerable interest to psychologists and psycholinguistics, but they are not a direct concern for the theory of competence grammar, as Newmeyer 2005 has pointed out. To that extent, the soft-constraint-based optimality/harmony-theoretic approach advocated by Bresnan (1998), Steddy and Samek-Lodovici (2011), and Culbertson et al. (2013) and/or the Bayesian weighting approach of Merlo (2015) and Merlo and Ouwayda (2018), may be appropriate in explaining the skewed distribution of the 22 possibilities across and within the languages of the world, rather than the hard grammatical constraints proposed by Kayne, Stabler, Nchare, and Abels and Neeleman, as the latter authors concede.

Nevertheless, according to the present theory, the two permutations (g) and (j) are excluded by a hard constraint that follows as a formal universal from the CCG theory of grammar itself, a result whose strength it is possible to quantitatively assess, as follows.

5.3. STATISTICAL SIGNIFICANCE OF THE ENSEMBLE RESULT. Merely to have shown that the two permutations over the components of the NP that are predicted by CCG to be universally disallowed are among the ten orders that Cinque found to be unattested in his survey would be statistically uninteresting, because the chances of those two happening to fall among such a high proportion of unattested orders would be far too high to reject the null hypothesis that all 24 permutations were in fact possible.

However, the fact that the two orders that were *predicted* to be missing are among the three that are unattested in the union of Cinque's orders and Nchare's is a much stronger result. Assuming that permutations are sampled without replacement from a uniform distribution of 24 (since CCG makes no prediction concerning the actual distribution), the probability p of n excluded orders out of N permutations falling in a set of m undecided orders with zero counts is the reciprocal of the number of ways of choosing n specific orders out of all N possible permutations, multiplied by the number of ways of choosing n designated orders out of the m undecided—-that is:

(21)
$$p = \frac{\binom{m}{n}}{\binom{N}{n}}$$

In our case this can be instantiated as:

(22)
$$p = \frac{\binom{3}{2}}{\binom{24}{2}} = \frac{3}{276} \approx 0.01$$

In other the words, the probability of getting this result by chance is about one in a hundred.[25]

The remaining predicted NP order (h) remains unattested, and in the nature of Zipfian distributions, is likely to remain so. Nevertheless, if this prediction were to be confirmed, the probability of getting this stronger result by chance would drop to less than four in a thousand.[26]

6. Analysis II: Language-specific word-orders for NP.

In this section we ask how the lexicon of any language can either enforce a single word-order, or a specific set of word-order alternations.

6.1. Language-specific lexicons for Cinque's fixed NP orders.

According both to the movement-based theories of Cinque and Abels and Neeleman on the one hand and the present theory on the other, all orders other than the eight purely applicative orders (8) are derived either from the English order (a), or from one of those eight—in CCG terms, the one that has the same directionality in its lexical categories. Accordingly, in the absence of any further statement, each derived order might be expected to tend to *alternate* with its base order, and vice versa.

For example, from the same lexical categories as those in (8b), we can now also derive the following word-order via the forward crossing composition rule (10b):

[25] Stabler, 2011: 635 provides a Pearson rank correlation coefficient of the predictions of his constraint-based account with Cinque's ranks. CCG itself makes no prediction concerning ranked frequency, although we have noted its broad consistency with Culbertson's account.

[26] Dryer (2018: 29-30) does in fact claim the order (h) for a single language, Haya. However, his source Byarushengo (1977: 12) notes the possibility that the final adjective in his sole example is extraposed or even dislocated, on the grounds that it carries agreement with the demonstrative.

(23) c.
$$\begin{array}{cccc}
\text{These} & \text{lads} & \text{five} & \text{young} \\
\overline{NP/NumP} & \overline{N} & \overline{NumP/N'} & \overline{N'\backslash N} \\
 & & \multicolumn{2}{c}{\overline{\qquad NumP\backslash N \qquad}^{>\mathbf{B}_\times}} \\
 & \multicolumn{3}{c}{\overline{\qquad\qquad NumP \qquad\qquad}^{<}} \\
\multicolumn{4}{c}{\overline{\qquad\qquad\qquad NP \qquad\qquad\qquad}^{>}}
\end{array}$$

This is Cinque's attested order (1c).

Like the slash-type $\star$ on the application rules (6), the types $\diamond$ and $\times$ on the slashes on the primary functions $X \mid Y$ in rules (9) and (10) can be used in the language-specific lexicon to specify exactly which of the rules may apply to each category.

For example, we can capture a language like Maasai which limits its NPs to *only* allow the order in (23c) in the following more specific lexicon:

(24) "These" $= NP/_{\star}NumP$
"five" $= NumP/_{\times}N'$
"young" $= N'\backslash_{\star}N$
"lads" $= N$

Similarly, a language like French, where (1b) is the basic order allowed over the elements of the NP, can be captured by excluding crossing composition, limiting all function categories in the lexicon to $\star$ type:[27]

(25) "These" $= NP/_{\star}NumP$
"five" $= NumP/_{\star}N'$
"young" $= N'\backslash_{\star}N$
"lads" $= N$

In some cases like English and French, we could use either $\star$ or $\diamond\star$-typed slashes (the latter will allow such "non-constituent" coordinations as (14) in English). To keep things simple, in (26a,b,n,o,r,s,w,x) below, we show the more restrictive $\star$ modalities for the eight basic orders.

Cinque's six (or seven) further fixed derived orders, together with fixed orders for all the other permutations permitted by CCG can be obtained by similarly limiting the relevant function categories in the lexicon to combine *only* by harmonic or crossing composition, using $\diamond$ or $\times$ modality, as in (24) allowing the earlier derivation (23c) as the only derivation for (26c).[28]

(26) a.
$$\begin{array}{cccc}
\text{These} & \text{five} & \text{young} & \text{lads} \\
\overline{NP/_{\star}NumP} & \overline{NumP/_{\star}N'} & \overline{N'/_{\star}N} & \overline{N}
\end{array}$$
Cinque (basic)

b.
$$\begin{array}{cccc}
\text{These} & \text{five} & \text{lads} & \text{young} \\
\overline{NP/_{\star}NumP} & \overline{NumP/_{\star}N'} & \overline{N} & \overline{N'\backslash_{\star}N}
\end{array}$$
Cinque (basic)

c.
$$\begin{array}{cccc}
\text{These} & \text{lads} & \text{five} & \text{young} \\
\overline{NP/_{\star}NumP} & \overline{N} & \overline{NumP/_{\times}N'} & \overline{N'\backslash_{\star}N} \\
 & & \multicolumn{2}{c}{\overline{\qquad NumP\backslash_{\star}N \qquad}^{>\mathbf{B}_\times}}
\end{array}$$
Cinque (from b)

[27] Certain adjectives in French can also appear before the noun, as in "jeune fille/fille jeune". However, the meanings differ, and the prenominal forms where allowed are arguably separately lexicalized. In other Romance languages where AN order is genuinely free, we might want to use the non-directional slash $|_{\star}$ from (2) for the adjective category, allowing both forward and backward application.

[28] In a few cases, there is more than one way of specifying the same order. We will return to the orders attested in Shupamem later, since those orders *do* alternate with others.

d. Lads these five young — Cinque (from b)

$$\begin{array}{cccc}
\text{Lads} & \text{these} & \text{five} & \text{young} \\
\hline
N & NP/_{\diamond}NumP & NumP/_{\times}N' & N'\backslash_{\star}N \\
 & \multicolumn{2}{c}{NP/_{\times}N' \quad {>}\mathbf{B}} & \\
 & \multicolumn{3}{c}{NP\backslash_{\star}N \quad {>}\mathbf{B}_{\times}}
\end{array}$$

e. Five these young lads

$$\begin{array}{cccc}
\text{Five} & \text{these} & \text{young} & \text{lads} \\
\hline
NumP/_{\star}N' & NP\backslash_{\times}NumP & N'/_{\star}N & N \\
\multicolumn{2}{c}{NP/_{\star}N' \quad {<}\mathbf{B}_{\times}} & &
\end{array}$$

f. Five these lads young

$$\begin{array}{cccc}
\text{Five} & \text{these} & \text{lads} & \text{young} \\
\hline
NumP/_{\star}N' & NP\backslash_{\times}NumP & N & N'\backslash_{\star}N \\
\multicolumn{2}{c}{NP/_{\star}N' \quad {<}\mathbf{B}_{\times}} & &
\end{array}$$

g. × Five lads these young — (disallowed)

$$\begin{array}{cccc}
\text{Five} & \text{lads} & \text{these} & \text{young} \\
\hline
NumP/N' & N & NP\backslash NumP & N'\backslash N \\
\multicolumn{2}{c}{*} & & \\
 & \multicolumn{2}{c}{*} & \\
 & & \multicolumn{2}{c}{*}
\end{array}$$

h. ? Lads five these young

$$\begin{array}{cccc}
\text{Lads} & \text{five} & \text{these} & \text{young} \\
\hline
N & NumP/_{\times}N' & NP\backslash_{\times}NumP & N'\backslash_{\star}N \\
 & \multicolumn{2}{c}{NP/_{\times}N' \quad {<}\mathbf{B}_{\times}} & \\
 & \multicolumn{3}{c}{NP\backslash_{\star}N \quad {>}\mathbf{B}_{\times}}
\end{array}$$

i. Young these five lads

$$\begin{array}{cccc}
\text{Young} & \text{these} & \text{five} & \text{lads} \\
\hline
N'/_{\star}N & NP/_{\times}NumP & NumP\backslash_{\times}N' & N \\
 & \multicolumn{2}{c}{NP\backslash_{\times}N' \quad {>}\mathbf{B}_{\times}} & \\
\multicolumn{3}{c}{NP/_{\star}N \quad {<}\mathbf{B}_{\times}} &
\end{array}$$

j. × Young these lads five — (disallowed)

$$\begin{array}{cccc}
\text{Young} & \text{these} & \text{lads} & \text{five} \\
\hline
N'/N & NP/NumP & N & NumP\backslash N' \\
\multicolumn{2}{c}{*} & & \\
 & \multicolumn{2}{c}{*} & \\
 & & \multicolumn{2}{c}{*}
\end{array}$$

k. Young lads these five — Cinque (from n)

$$\begin{array}{cccc}
\text{Young} & \text{lads} & \text{these} & \text{five} \\
\hline
N'/_{\star}N & N & NP/_{\times}NumP & NumP\backslash_{\star}N' \\
 & & \multicolumn{2}{c}{NP\backslash_{\star}N' \quad {>}\mathbf{B}_{\times}}
\end{array}$$

l. Lads young these five — Cinque (from o)

$$\begin{array}{cccc}
\text{Lads} & \text{young} & \text{these} & \text{five} \\
\hline
N & N'\backslash_{\star}N & NP/_{\times}NumP & NumP\backslash_{\star}N' \\
 & & \multicolumn{2}{c}{NP\backslash_{\star}N' \quad {>}\mathbf{B}_{\times}}
\end{array}$$

m. These young five lads

$$\begin{array}{cccc}
\text{These} & \text{young} & \text{five} & \text{lads} \\
\hline
NP/_{\star}NumP & N'/_{\star}N & NumP\backslash_{\times}N' & N \\
 & \multicolumn{2}{c}{NumP/_{\star}N \quad {<}\mathbf{B}_{\times}} &
\end{array}$$

n. These young lads five — Cinque (basic)

$$\begin{array}{cccc}
\text{These} & \text{young} & \text{lads} & \text{five} \\
\hline
NP/_{\star}NumP & N'/_{\star}N & N & NumP\backslash_{\star}N'
\end{array}$$

o. These lads young five — Cinque (basic)

$$\begin{array}{cccc} \text{These} & \text{lads} & \text{young} & \text{five} \\ \hline NP/_{\star}NumP & N & N'\backslash_{\star}N & NumP\backslash_{\star}N' \end{array}$$

p. Lads these young five — Cinque (from o)

$$\begin{array}{cccc} \text{Lads} & \text{these} & \text{young} & \text{five} \\ \hline N & NP/_{\times}NumP & N'\backslash_{\star}N & NumP\backslash_{\diamond}N' \\ \cline{3-4} & & \multicolumn{2}{c}{NumP\backslash_{\star}N \quad {<}\mathbf{B}} \\ \cline{2-4} & \multicolumn{3}{c}{NP\backslash_{\star}N \quad {>}\mathbf{B}_{\times}} \end{array}$$

q. Five young these lads

$$\begin{array}{cccc} \text{Five} & \text{young} & \text{these} & \text{lads} \\ \hline NumP/_{\diamond}N' & N'/_{\star}N & NP\backslash_{\times}NumP & N \\ \cline{1-2} \multicolumn{2}{c}{NumP/_{\star}N \quad {>}\mathbf{B}} & & \\ \cline{1-3} \multicolumn{3}{c}{NP/_{\star}N \quad {<}\mathbf{B}_{\times}} & \end{array}$$

r. Five young lads these — Cinque (basic)

$$\begin{array}{cccc} \text{Five} & \text{young} & \text{lads} & \text{these} \\ \hline NumP/_{\star}N' & N'/_{\star}N & N & NP\backslash_{\star}NumP \end{array}$$

s. Five lads young these — Cinque (basic)

$$\begin{array}{cccc} \text{Five} & \text{lads} & \text{young} & \text{these} \\ \hline NumP/_{\star}N' & N & N'\backslash_{\star}N & NP\backslash_{\star}NumP \end{array}$$

t. Lads five young these — Cinque (from s)

$$\begin{array}{cccc} \text{Lads} & \text{five} & \text{young} & \text{these} \\ \hline N & NumP/_{\times}N' & N'\backslash_{\star}N & NP\backslash_{\star}NumP \\ \cline{2-3} & \multicolumn{2}{c}{NumP\backslash_{\star}N \quad {>}\mathbf{B}_{\times}} & \end{array}$$

u. Young five these lads

$$\begin{array}{cccc} \text{Young} & \text{five} & \text{these} & \text{lads} \\ \hline N'/_{\star}N & NumP\backslash_{\times}N' & NP\backslash_{\diamond}NumP & N \\ \cline{2-3} & \multicolumn{2}{c}{NP\backslash_{\times}N' \quad {<}\mathbf{B}} & \\ \cline{1-3} \multicolumn{3}{c}{NP/_{\star}N \quad {<}\mathbf{B}_{\times}} & \end{array}$$

v. Young five lads these

$$\begin{array}{cccc} \text{Young} & \text{five} & \text{lads} & \text{these} \\ \hline N'/_{\star}N & NumP\backslash_{\times}N' & N & NP\backslash_{\star}NumP \\ \cline{1-2} \multicolumn{2}{c}{NumP/_{\star}N \quad {<}\mathbf{B}_{\times}} & & \end{array}$$

w. Young lads five these — Cinque (basic)

$$\begin{array}{cccc} \text{Young} & \text{lads} & \text{five} & \text{these} \\ \hline N'/_{\star}N & N & NumP\backslash_{\star}N' & NP\backslash_{\star}NumP \end{array}$$

x. Lads young five these — Cinque (basic)

$$\begin{array}{cccc} \text{Lads} & \text{young} & \text{five} & \text{these} \\ \hline N & N'\backslash_{\star}N & NumP\backslash_{\star}N' & NP\backslash_{\star}NumP \end{array}$$

6.2. LANGUAGE-SPECIFIC LEXICON FOR NCHARE'S ALTERNATING NP ORDERS. It is not entirely clear exactly which combinations of alternating permutations are possible in CCG for freer-word-order languages.

Any of the 22 fixed-order NP lexicons in the last section elements can be made to alternate with any order simply by adding to the original lexicon any categories with different slash-directionality and/or slash-type that are in the alternate's fixed-order lexicon that are not already there. For example, adding $N'\backslash_{\star}N$ to (a) makes it alternate with (b). Adding $NumP/_{\times}N'$ and/or $NP\backslash_{\times}NumP$ to basic lexicon (s) makes it alternate with various combinations of (h), (t), and (f). (It may be possible to represent multiple categories for the same word with a non-directional and/or mixed slash type such as $\times\star$.

However, as soon as more than one such addition is made, a further order corresponding to the fixed-order lexicon with all such categories will be allowed as an alternate. (For example, it is possible in the above way to make (s) alternate with either (t) or (f), but it is not possible to have it alternate with both without it *also* alternating with (h), and vice versa.)

In the case of Shupamem, there is important further categorial information available from its morphology, which we have been able to ignore up until this point. In particular, Shupamem alternations like that of N A order in (b) with A N in (a) require the presence of a prefix “pí” on the final adjective in (b). Similarly, (x) requires the prefix on both Num and A. Nchare describes this prefix as a combined noun-class agreement (“p”) and definiteness marker (“í”) that appears to map N'/N to $N'\backslash N$ and $NumP/N'$ to $NumP\backslash N'$, reversing their default slash-directionality. This explains the exclusion of (c) and (d), and (even on the assumption that the demonstratives are bidirectional), also excludes (h) (Nchare, 2012: 192-4, 202-4).[29]

There appear from Nchare, 2012: 134 to be occasions on which unmarked “five” also has a backward category $NumP\backslash_{\times}N'$ restricted to combining by the backward crossing composition rule alone. (This category is crucial to accepting (28i, m, u, and v). Equally crucially, it continues to exclude (28c, d, and h).)

Thus, we can come close to capturing the variety of alternation in the Shupamem NP in the following lexicon:[30]

(27) these $:= NP/NumP$ **or** $NP\backslash NumP$
p-these $:= NP/_{\times}NumP$ **or** $NP\backslash_{\star}NumP$
five $:= NumP/_{\star}N'$ **or** $NumP\backslash_{\times}N'$
pí-five $:= NumP\backslash N'$
young $:= N'/N$
pí-young $:= N'\backslash N$
boys $:= N$

Crucially, none of the categories in (27), including the two adjectivals, is extraposing or preposing. That is to say that all of the lexical alternations, whether morphologically marked or not, are *homomorphic*, with the same Universal Order of Command.

The legal NP orders for Shupamem are then analysed as shown in (28) (cf. Nchare, 2012: 134) (case (28t) is discussed further below):

(28) a. Nchare (basic)

These	five	young	lads
$NP/NumP$	$NumP/N'$	N'/N	N

b. Nchare (basic)

These	five	lads	pí-young
$NP/NumP$	$NumP/N'$	N	$N'\backslash N$

c.

These	lads	pí-five	pí-young
$NP/NumP$	N	$NumP\backslash N'$	$N'\backslash N$

[29] The demonstrative also agrees in noun-class with the “pí”-marked Nump, via a prefix “p”, but this does not seem to determine the lexical slash-directionality of its category in the same way as “pí”-marking.

[30] In the interests of brevity, we pass over the semantic details of these categories, which Nchare (2012:Ch.3) shows should differ according to which element in the resulting logical form is marked for focus, or more specifically contrast. As noted earlier, these focusing effects seem to be susceptible to a lexical “Alternative Semantic” analysis similar to that used to account for the focus effects of prosodic accent in the English NP without autonomous rules of “focus projection” or movement (Steedman, 2014).

d.
$$\begin{array}{cccc}
\text{Lads} & \text{p-these} & \text{pí-five} & \text{pí-young} \\
\overline{N} & \overline{NP/_{\times}NumP} & \overline{NumP\backslash N'} & \overline{N'\backslash N} \\
 & \multicolumn{2}{c}{\hrulefill {>}\mathbf{B}_{\times}} & \\
 & \multicolumn{2}{c}{NP\backslash N'} & \\
 & \multicolumn{3}{c}{\hrulefill \star} \\
\end{array}$$

e. Nchare (from r)
$$\begin{array}{cccc}
\text{Five} & \text{these} & \text{young} & \text{lads} \\
\overline{NumP/N'} & \overline{NP\backslash NumP} & \overline{N'/N} & \overline{N} \\
\multicolumn{2}{c}{\hrulefill {<}\mathbf{B}_{\times}} & & \\
\multicolumn{2}{c}{NP/N'} & & \\
\end{array}$$

f. Nchare (from s)
$$\begin{array}{cccc}
\text{Five} & \text{these} & \text{lads} & \text{pí-young} \\
\overline{NumP/N'} & \overline{NP\backslash NumP} & \overline{N} & \overline{N'\backslash N} \\
\multicolumn{2}{c}{\hrulefill {<}\mathbf{B}_{\times}} & & \\
\multicolumn{2}{c}{NP/N'} & & \\
\end{array}$$

g. $\times$ (disallowed)
$$\begin{array}{cccc}
\text{Five} & \text{lads} & \text{p-these} & \text{pí-young} \\
\overline{NumP/N'} & \overline{N} & \overline{NP\backslash NumP} & \overline{N'\backslash N} \\
\hrulefill \ast & & & \\
 & \multicolumn{2}{c}{\hrulefill \ast} & \\
 & & \multicolumn{2}{c}{\hrulefill \ast} \\
\end{array}$$

h. ?
$$\begin{array}{cccc}
\text{Lads} & \text{pí-five} & \text{p-these} & \text{pí-young} \\
\overline{N} & \overline{NumP\backslash N'} & \overline{NP\backslash_{\star}NumP} & \overline{N'\backslash N} \\
 & \multicolumn{3}{c}{\hrulefill \star} \\
\end{array}$$

i. Nchare (from n)
$$\begin{array}{cccc}
\text{Young} & \text{these} & \text{five} & \text{lads} \\
\overline{N'/N} & \overline{NP/NumP} & \overline{NumP\backslash_{\times}N'} & \overline{N} \\
 & \multicolumn{2}{c}{\hrulefill {>}\mathbf{B}_{\times}} & \\
 & \multicolumn{2}{c}{NP\backslash_{\times}N'} & \\
\multicolumn{3}{c}{\hrulefill {<}\mathbf{B}_{\times}} & \\
\multicolumn{3}{c}{NP/N} & \\
\end{array}$$

j. $\times$ (disallowed)
$$\begin{array}{cccc}
\text{Young} & \text{these} & \text{lads} & \text{pí-five} \\
\overline{N'/N} & \overline{NP/NumP} & \overline{N} & \overline{NumP\backslash N'} \\
\multicolumn{2}{c}{\hrulefill \star} & & \\
 & \multicolumn{2}{c}{\hrulefill \star} & \\
 & & \multicolumn{2}{c}{\hrulefill \star} \\
\end{array}$$

k. Nchare (from n)
$$\begin{array}{cccc}
\text{Young} & \text{lads} & \text{p-these} & \text{pí-five} \\
\overline{N'/N} & \overline{N} & \overline{NP/_{\times}NumP} & \overline{NumP\backslash N'} \\
 & & \multicolumn{2}{c}{\hrulefill {>}\mathbf{B}_{\times}} \\
 & & \multicolumn{2}{c}{NP\backslash N'} \\
\end{array}$$

l. Nchare (from o)
$$\begin{array}{cccc}
\text{Lads} & \text{pí-young} & \text{p-these} & \text{pí-five} \\
\overline{N} & \overline{N'\backslash N} & \overline{NP/_{\times}NumP} & \overline{NumP\backslash N'} \\
 & & \multicolumn{2}{c}{\hrulefill {>}\mathbf{B}_{\times}} \\
 & & \multicolumn{2}{c}{NP\backslash N'} \\
\end{array}$$

m. Nchare (from n)
$$\begin{array}{cccc}
\text{These} & \text{young} & \text{five} & \text{lads} \\
\overline{NP/NumP} & \overline{N'/N} & \overline{NumP\backslash_{\times}N'} & \overline{N} \\
 & \multicolumn{2}{c}{\hrulefill {<}\mathbf{B}_{\times}} & \\
 & \multicolumn{2}{c}{NumP/N} & \\
\end{array}$$

n. Nchare (basic)
$$\begin{array}{cccc}
\text{These} & \text{young} & \text{lads} & \text{pí-five} \\
\overline{NP/NumP} & \overline{N'/N} & \overline{N} & \overline{NumP\backslash N'} \\
\end{array}$$

o. Nchare (basic)
$$\begin{array}{cccc}
\text{These} & \text{lads} & \text{pí-young} & \text{pí-five} \\
\overline{NP/NumP} & \overline{N} & \overline{N'\backslash N} & \overline{NumP\backslash N'} \\
\end{array}$$

p. Lads p-these pí-young pí-five — Nchare (from o)

$$\begin{array}{cccc} \text{Lads} & \text{p-these} & \text{pí-young} & \text{pí-five} \\ \overline{N} & \overline{NP/_{\times}NumP} & \overline{N'\backslash N} & \overline{NumP\backslash N'} \end{array}$$
$$N'\backslash N \quad NumP\backslash N' \Rightarrow_{<\mathbf{B}} NumP\backslash N$$
$$NP/_{\times}NumP \quad NumP\backslash N \Rightarrow_{>\mathbf{B}_{\times}} NP\backslash N$$

q. Five young these lads — Nchare (from r)

$$\begin{array}{cccc} \text{Five} & \text{young} & \text{these} & \text{lads} \\ \overline{NumP/N'} & \overline{N'/N} & \overline{NP\backslash NumP} & \overline{N} \end{array}$$
$$NumP/N' \quad N'/N \Rightarrow_{>\mathbf{B}} NumP/N$$
$$NumP/N \quad NP\backslash NumP \Rightarrow_{<\mathbf{B}_{\times}} NP/N$$

r. Five young lads p-these — Nchare (basic)

$$\begin{array}{cccc} \text{Five} & \text{young} & \text{lads} & \text{p-these} \\ \overline{NumP/N'} & \overline{N'/N} & \overline{N} & \overline{NP\backslash_{\star}NumP} \end{array}$$

s. Five lads pí-young p-these — Nchare (basic)

$$\begin{array}{cccc} \text{Five} & \text{lads} & \text{pí-young} & \text{p-these} \\ \overline{NumP/N'} & \overline{N} & \overline{N'\backslash N} & \overline{NP\backslash_{\star}NumP} \end{array}$$

t. ! Lads pí-five pí-young p-these — Nchare

$$\begin{array}{cccc} \text{Lads} & \text{pí-five} & \text{pí-young} & \text{p-these} \\ \overline{N} & \overline{NumP\backslash N'} & \overline{N'\backslash N} & \overline{NP\backslash_{\star}NumP} \end{array}$$
$$NumP\backslash N' \quad N'\backslash N \Rightarrow_{\star}$$

u. Young five these lads — Nchare (from w)

$$\begin{array}{cccc} \text{Young} & \text{five} & \text{these} & \text{lads} \\ \overline{N'/N} & \overline{NumP\backslash_{\times}N'} & \overline{NP\backslash NumP} & \overline{N} \end{array}$$
$$NumP\backslash_{\times}N' \quad NP\backslash NumP \Rightarrow_{<\mathbf{B}} NP\backslash_{\times}N'$$
$$N'/N \quad NP\backslash_{\times}N' \Rightarrow_{<\mathbf{B}_{\times}} NP/N$$

v. Young five lads p-these — Nchare (from w)

$$\begin{array}{cccc} \text{Young} & \text{five} & \text{lads} & \text{p-these} \\ \overline{N'/N} & \overline{NumP\backslash_{\times}N'} & \overline{N} & \overline{NP\backslash_{\star}NumP} \end{array}$$
$$N'/N \quad NumP\backslash_{\times}N' \Rightarrow_{<\mathbf{B}_{\times}} NumP/N$$

w. Young lads pí-five these — Nchare (basic)

$$\begin{array}{cccc} \text{Young} & \text{lads} & \text{pí-five} & \text{these} \\ \overline{N'/N} & \overline{N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP} \end{array}$$

x. Lads pí-young pí-five these — Nchare (basic)

$$\begin{array}{cccc} \text{Lads} & \text{pí-young} & \text{pí-five} & \text{these} \\ \overline{N} & \overline{N'\backslash N} & \overline{NumP\backslash N'} & \overline{NP\backslash NumP} \end{array}$$

As noted earlier, more needs to be said about (28t). The four sequences (i, m, u, and v) only go through on the assumption that the morphologically unmarked Shupamem Num "five" can combine backward by crossing composition *only*, as well as forward-combine, as shown in the Shupamem lexicon (27).

However, if we were to make the mirror-image assumption for the pí-marked Num, assigning an additional forward category $NumP/_{\times}N'$ so as to allow (28t) (marked) by crossing composition, then two further separable permutations (28c and d) would also be derivable, contrary to Nchare, 2012: 134.

We leave this loose end as an open problem to await further investigation. Clearly, more data is needed from Shupamem, not to mention other free NP-order languages. Although we have traded the undergeneration of (28t) for Nchare's own undergeneration of (28p) (as noted earlier, because of his freezing principle, 2012: 226), it is encouraging that such a range of word-order alternation can be captured with a comparatively small and unambiguous lexicon (27) in a non-movement account, without any constraints on syntactic derivation other than those specified in the lexical categories.

7. ANALYSIS III: WORD-ORDER ALTERNATION IN GERMANIC VERB COMPLEXES. For similar reasons to those just considered at length for the NP, two out of the twenty-four possible permutations of the four elements of the English VP "might$_{VP_1|VP_2}$ have$_{VP_2|VP_3}$ been$_{VP_3|VP_4}$ dancing$_{VP_4}$", namely those corresponding to "*have$_{VP_2|VP_3}$ dancing$_{VP_4}$ might$_{VP_1|VP_2}$ been$_{VP_3|VP_4}$" and "*been$_{VP_3|VP_4}$ might$_{VP_1|VP_2}$ dancing$_{VP_4}$ have$_{VP_2|VP_3}$", are predicted to be excluded by universal grammar. If either order were attested, say in a language with a similar lexical raising verb system but freer word order than English, such as Hungarian and the various Germanic languages, then CCG in the form presented here would be falsified.

7.1. THE ENSEMBLE OF GERMANIC VERB ORDERS. Abels (2016) examines word-order in a number of verb-cluster types in Germanic, including the permutations of (dominance-ordered) V(erb)$_1$ V$_2$ V$_3$ Part(icle)$_4$ and V$_1$ V$_2$ V$_3$ V$_4$. For the latter elements, Abels (206: 205) finds that, in Germanic alone, 13 of the 14 orders permitted by the constraints on movement in Abels and Neeleman's account of NP order are strongly attested. Their fourteenth order (29s) is more weakly supported as an alternate order in West Flemish, while three further non-predicted orders (29f,h,m) are also weakly supported, making 17 orders arguably attested.[31]

The examples below use the English words *will help teach swim* as proxy for a number of different sets of Germanic verbs V$_1$ V$_2$ V$_3$ V$_4$ of various types, inclusing auxiliaries, modals, raising/control verbs and participials nused in these studies. As in the case of the NP, there are eight application-only permutations (a, b, n, o, r, s, w, and x) that are accepted via derivations homomorphic to logical form, without composition. All of these orders are attested in Germanic, although as noted Abels regards the attestation of (s) as equivocal, because it only occurs as an alternate in his sample, despite being frequent as an NP order (1s).

When we consider the full set of verb-series permutations allowed by CCG, we see a similar picture to that for the elements of the NP (20). That is, only separable permutations are allowed:

(29) a. Abels: (basic)

$$\begin{array}{cccc} \text{will} & \text{help} & \text{teach} & \text{swim} \\ \hline VP_1/VP_2 & VP_2/VP_3 & VP_3/VP_4 & VP_4 \end{array}$$

b. Abels: (basic)

$$\begin{array}{cccc} \text{will} & \text{help} & \text{swim} & \text{teach} \\ \hline VP_1/VP_2 & VP_2/VP_3 & VP_4 & VP_3\backslash VP_4 \end{array}$$

c. Abels: (from b)

$$\begin{array}{cccc} \text{will} & \text{swim} & \text{help} & \text{teach} \\ \hline VP_1/VP_2 & VP_4 & VP_2/VP_3 & VP_3\backslash VP_4 \\ & & \multicolumn{2}{c}{\overline{\qquad\qquad\qquad}{>}\mathbf{B}_\times} \\ & & \multicolumn{2}{c}{VP_2\backslash VP_4} \end{array}$$

d. Abels: (from b)

$$\begin{array}{cccc} \text{swim} & \text{will} & \text{help} & \text{teach} \\ \hline VP_4 & VP_1/VP_2 & VP_2/VP_3 & VP_3\backslash VP_4 \\ & \multicolumn{2}{c}{\overline{\qquad\qquad\qquad}{>}\mathbf{B}} & \\ & \multicolumn{2}{c}{VP_1\backslash VP_3} & \\ & \multicolumn{3}{c}{\overline{\qquad\qquad\qquad\qquad\qquad}{>}\mathbf{B}_\times} \\ & \multicolumn{3}{c}{VP_1\backslash VP_4} \end{array}$$

e. (from r)

$$\begin{array}{cccc} \text{help} & \text{will} & \text{teach} & \text{swim} \\ \hline VP_2/VP_3 & VP_1\backslash VP_2 & VP_3/VP_4 & VP_4 \\ \multicolumn{2}{c}{\overline{\qquad\qquad\qquad}{<}\mathbf{B}_\times} & & \\ \multicolumn{2}{c}{VP_1/VP_3} & & \end{array}$$

[31] The verbal permutations are ordered to match Cinque's ordering for the NP construction used elsewhere in this paper. Abels's (2016) ordering of the permutations is different.

f. help will swim teach (Abels: from s)

$$\frac{\text{help}}{VP_2/VP_3}\quad\frac{\text{will}}{VP_1\backslash VP_2}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{teach}}{VP_3\backslash VP_4}$$
$$\frac{VP_2/VP_3\quad VP_1\backslash VP_2}{VP_1/VP_3}{<}\mathbf{B}_\times$$

g. × help swim will teach Not attested (disallowed)

$$\frac{\text{help}}{VP_2|VP_3}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{will}}{VP_1|VP_2}\quad\frac{\text{teach}}{VP_3|VP_4}$$
$$\frac{VP_2|VP_3\quad VP_4}{}{*}\qquad\frac{VP_4\quad VP_1|VP_2}{}{*}\qquad\frac{VP_1|VP_2\quad VP_3|VP_4}{}{*}$$

h. swim help will teach (Abels: from s)

$$\frac{\text{swim}}{VP_4}\quad\frac{\text{help}}{VP_2/VP_3}\quad\frac{\text{will}}{VP_1\backslash VP_2}\quad\frac{\text{teach}}{VP_3\backslash VP_4}$$
$$\frac{VP_2/VP_3\quad VP_1\backslash VP_2}{VP_1/VP_3}{<}\mathbf{B}_\times$$
$$\frac{VP_1/VP_3\quad VP_3\backslash VP_4}{VP_1\backslash VP_4}{>}\mathbf{B}_\times$$

i. teach will help swim (from n)

$$\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{help}}{VP_2\backslash VP_3}\quad\frac{\text{swim}}{VP_4}$$
$$\frac{VP_1/VP_2\quad VP_2\backslash VP_3}{VP_1\backslash VP_3}{>}\mathbf{B}_\times$$
$$\frac{VP_3/VP_4\quad VP_1\backslash VP_3}{VP_1/VP_4}{<}\mathbf{B}_\times$$

j. × teach will swim help Not attested (disallowed)

$$\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{will}}{VP_1|VP_2}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{help}}{VP_2|VP_3}$$
$$\frac{VP_3/VP_4\quad VP_1|VP_2}{}{*}\qquad\frac{VP_1|VP_2\quad VP_4}{}{*}\qquad\frac{VP_4\quad VP_2|VP_3}{}{*}$$

k. teach swim will help Abels: (from n)

$$\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{help}}{VP_2\backslash VP_3}$$
$$\frac{VP_1/VP_2\quad VP_2\backslash VP_3}{VP_1\backslash VP_3}{>}\mathbf{B}_\times$$

l. swim teach will help Abels: (from o)

$$\frac{\text{swim}}{VP_4}\quad\frac{\text{teach}}{VP_3\backslash VP_4}\quad\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{help}}{VP_2\backslash VP_3}$$
$$\frac{VP_1/VP_2\quad VP_2\backslash VP_3}{VP_2\backslash VP_3}{>}\mathbf{B}_\times$$

m. will teach help swim (Abels: from n)

$$\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{help}}{VP_2\backslash VP_3}\quad\frac{\text{swim}}{VP_4}$$
$$\frac{VP_3/VP_4\quad VP_2\backslash VP_3}{VP_2/VP_4}{<}\mathbf{B}_\times$$

n. will teach swim help Abels: (basic)

$$\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{help}}{VP_2\backslash VP_3}$$

o. will swim teach help Abels: (basic)

$$\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{teach}}{VP_3\backslash VP_4}\quad\frac{\text{help}}{VP_2\backslash VP_3}$$

p. swim will teach help Abels: (from o)

$$\frac{\text{swim}}{VP_4}\quad\frac{\text{will}}{VP_1/VP_2}\quad\frac{\text{teach}}{VP_3\backslash VP_4}\quad\frac{\text{help}}{VP_2\backslash VP_3}$$
$$\frac{VP_3\backslash VP_4\quad VP_2\backslash VP_3}{VP_2\backslash VP_4}{<}\mathbf{B}$$
$$\frac{VP_1/VP_2\quad VP_2\backslash VP_4}{VP_1\backslash VP_4}{>}\mathbf{B}_\times$$

q. Help teach will swim (from r)

$$\frac{\text{Help}}{VP_2/VP_3}\quad\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{will}}{VP_1\backslash VP_2}\quad\frac{\text{swim}}{VP_4}$$
$$\frac{VP_2/VP_3\quad VP_3/VP_4}{VP_2/VP_4}{>}\mathbf{B}$$
$$\frac{VP_2/VP_4\quad VP_1\backslash VP_2}{VP_1/VP_4}{<}\mathbf{B}_\times$$

r. help teach swim will Abels: basic

$$\frac{\text{help}}{VP_2/VP_3}\quad\frac{\text{teach}}{VP_3/VP_4}\quad\frac{\text{swim}}{VP_4}\quad\frac{\text{will}}{VP_1\backslash VP_2}$$

s. (Abels: basic)

$$\begin{array}{cccc}
\text{help} & \text{swim} & \text{teach} & \text{will}\\
\overline{VP_2/VP_3} & \overline{VP_4} & \overline{VP_3\backslash VP_4} & \overline{VP_1\backslash VP_2}
\end{array}$$

t. Abels: (from s)

$$\begin{array}{cccc}
\text{swim} & \text{help} & \text{teach} & \text{will}\\
\overline{VP_4} & \overline{VP_2/VP_3} & \overline{VP_3\backslash VP_4} & \overline{VP_1\backslash VP_2}\\
\cline{2-3}
 & \multicolumn{2}{c}{VP_2\backslash VP_4 \quad {>}\mathbf{B}_{\times}} &
\end{array}$$

u. (from w)

$$\begin{array}{cccc}
\text{teach} & \text{help} & \text{will} & \text{swim}\\
\overline{VP_3/VP_4} & \overline{VP_2\backslash VP_3} & \overline{VP_1\backslash VP_2} & \overline{VP_4}\\
\cline{2-3}
 & \multicolumn{2}{c}{VP_1\backslash VP_3 \quad {<}\mathbf{B}} & \\
\cline{1-3}
\multicolumn{3}{c}{VP_1/VP_4 \quad {<}\mathbf{B}_{\times}} &
\end{array}$$

v. (from w)

$$\begin{array}{cccc}
\text{teach} & \text{help} & \text{swim} & \text{will}\\
\overline{VP_3/VP_4} & \overline{VP_2\backslash VP_3} & \overline{VP_4} & \overline{VP_1\backslash VP_2}\\
\cline{1-2}
\multicolumn{2}{c}{VP_2/VP_4 \quad {<}\mathbf{B}_{\times}} & &
\end{array}$$

w. Abels: (basic)

$$\begin{array}{cccc}
\text{teach} & \text{swim} & \text{help} & \text{will}\\
\overline{VP_3/VP_4} & \overline{VP_4} & \overline{VP_2\backslash VP_3} & \overline{VP_1\backslash VP_2}
\end{array}$$

x. Abels: (basic)

$$\begin{array}{cccc}
\text{swim} & \text{teach} & \text{help} & \text{will}\\
\overline{VP_4} & \overline{VP_3\backslash VP_4} & \overline{VP_2\backslash VP_3} & \overline{VP_1\backslash VP_2}
\end{array}$$

7.2. DISCUSSION (III). Once again, the two non-separable permutations (g,j) are absent from the attested orders (29), including those that Abels is equivocal towards but for which attestation has been claimed.

Interestingly, the one order predicted under the present hypothesis that was not attested for the NP, namely (20h), is among the orders attested by Abels for the VP (albeit somewhat grudgingly, as "spontaneously, possibly as alternate", citing Wurmbrand, 2004: 59, who found it accepted by some Austrian German speakers). If taken at face value, this result would mean that all 22 separable permutations are attested at least as alternates for four elements of some construction of the form $A|B, B|C, C|D, D$, while the 2 non-separable permutations remain unattested in both the noun group and the verb group. As noted earlier, the probability of this result arising by chance would drop to $p < 0.004$.

We will pass over the intricate question of how lexicons can be specified for each of the West Germanic languages/dialects that compose this ensemble. It should be clear from the earlier discussions of fixed and variable word-order in the NP that: (a) restricting a language to a fixed verbal order requires restricting its lexicon by slash-typing; and (b) a language with freer word verbal order may require multiple lexical entries for individual words.

Instead, the next sections explore a few particularly well-documented further cases of word-order and word-order alternation for serial verbs and their arguments. First, however, we must reconsider the role of NPs in relation to verbs.

8. MORPHO-LEXICAL TYPE-RAISING AS CASE. In CCG, it is assumed that all NPs and other arguments of verbs are obligatorily type-raised, via a morpholexical rule that assigns them higher-order functional categories of the form

(30) a. $\mathrm{T}/(\mathrm{T}\backslash\mathrm{X})$
b. $\mathrm{T}\backslash(\mathrm{T}/\mathrm{X})$

—where X is an argument-type (such as *NP*), and T is any type such that $\mathrm{T}\backslash\mathrm{X}$ and T/X are existing lexical category types (such as verbs) subcategorizing for X. Thus, type raising is not a syntactic rule, and the raised type entirely replaces the base type in the lexicon.

Type-raised categories are in general *order-preserving* over the non-type-raised lexicon. For example, in English, type-raised *Egon* gives us back the following derivation, in which backward application is replaced by forward, and the resulting logical form is unchanged:

(31)

$$\begin{array}{cc}
\text{Egon} & \text{walks} \\
\hline
S/(S\backslash NP_{3sg}) & S\backslash NP_{3sg} \\
\hline
\multicolumn{2}{c}{S} \quad >
\end{array}$$

—but not **walks Egon*.

Because it limits the role that an NP can play in the VP, type-raising can be seen as corresponding to the linguistic notion of *case*, For example, the category for *Egon* above limits it to the role of subject, as if it bore *nominative* morphological case.

In English, noun phrases other than some pronouns are locally *ambiguous* as to the case they represent. However, in Latin, exactly the same kind of type-raising is typically disambiguated by morphologically-explicit case. For example:

(32) a.

$$\begin{array}{ccc}
\text{Balbus} & \text{amat} & \text{Liviam} \\
\text{Balbus.NOM.3sg} & \text{love.PRES.3sg} & \text{Livia.ACC.3sg} \\
\hline
S|(S|NP_{nom,3sg}) & (S|NP_{nom,3sg})|NP_{acc} & (S|NP_{nom})|((S|NP_{nom})|NP_{acc}) \\
\cline{2-3}
 & \multicolumn{2}{c}{S|NP_{nom} \quad <} \\
\hline
\multicolumn{3}{c}{S \quad >}
\end{array}$$

b.

$$\begin{array}{ccc}
\text{Balbus} & \text{Liviam} & \text{amat} \\
\text{Balbus.NOM.3sg} & \text{Livia.ACC} & \text{love.PRES.3sg} \\
\hline
S|(S|NP_{nom,3sg}) & (S|NP_{nom})|((S|NP_{nom})|NP_{acc}) & (S|NP_{nom,3sg})|NP_{acc} \\
\cline{2-3}
 & \multicolumn{2}{c}{S|NP_{nom} \quad >} \\
\hline
\multicolumn{3}{c}{S \quad >}
\end{array}$$

"Balbus loves Livia"

The fact that the categories of the nominative and the accusative are of the form $X|Y$ and $Y|Z$ means that the rule (9a) of composition can apply, "cancelling" $(S|NP)$ and supporting "argument/adjunct-cluster" coordination, sometimes subsumed to "gapping" (Ross, 1970), as follows:[32]

(33)

$$\begin{array}{cccccc}
\text{Balbus} & \text{Liviam} & \text{et} & \text{Livia} & \text{Balbum} & \text{amat} \\
\text{Balbus.NOM.3sg} & \text{Livia.ACC} & \text{and} & \text{Livia.NOM.3sg} & \text{Balbus.ACC} & \text{love.PRES.3sg} \\
\hline
S|(S|NP_{nom,3sg,m}) & (S|NP_{nom})|((S|NP_{nom})|NP_{acc}) & (X\backslash_{\star}X)/_{\star}X & \multicolumn{2}{c}{\vdots \quad >\mathbf{B}} & (S|NP_{nom,3sg})|NP_{acc} \\
\cline{1-2}
\multicolumn{2}{c}{S/((S|NP_{nom,3sg})|NP_{acc}) \quad >\mathbf{B}} & & \multicolumn{2}{c}{S/((S|NP_{nom,3sg})|NP_{acc})} & \\
\cline{1-5}
\multicolumn{5}{c}{S/((S|NP_{nom,3sg})|NP_{acc}) \quad <>} & \\
\hline
\multicolumn{6}{c}{S \quad >}
\end{array}$$

"Balbus loves Livia, and Livia Balbus."

The fact that such coordinate constructions can be obtained by purely adjacent combinatory operators provided the original motivation for including lexical type-raising in CCG (Dowty, 1985/1988; Steedman, 1985, 2000b)

Morpholexical type-raising of arguments, together with composition, also allows

[32] "$\vdots$" abbreviates a derivation parallel to that in the left conjunct. The combinatory annotation "$<>$" abbreviates the forward then backward combinations of the conjunction category. Of course, in the terms of CCG, this construction is simply coordination of *constituents*, albeit ones of a non-traditional type.

scrambling and extraction, as in free word-order in Latin (34) and topicalization (35) in English:[33]

(34)

Liviam	Balbus	amat
Livia.ACC.3sg	Balbus.NOM.3sg	love.PRES.3sg

$$\begin{array}{ccc}
\overline{S|(S|NP_{acc})} & \overline{S|(S|NP_{nom,3sg})} & \overline{(S|NP_{nom,3sg})|NP_{acc})} \\
 & \multicolumn{2}{c}{\underline{\hspace{12em}}{>}\mathbf{B}} \\
 & \multicolumn{2}{c}{S|NP_{acc}} \\
\multicolumn{3}{c}{\underline{\hspace{24em}}{>}} \\
\multicolumn{3}{c}{S}
\end{array}$$

(35)

$$\begin{array}{ccc}
\text{Movies,} & \text{I} & \text{like!} \\
\overline{S_{top}/(S/NP)} & \overline{S/(S\backslash NP)}{>}\mathbf{T} & \overline{(S\backslash NP)/NP} \\
 & \multicolumn{2}{c}{\underline{\hspace{10em}}{>}\mathbf{B}} \\
 & \multicolumn{2}{c}{S/NP} \\
\multicolumn{3}{c}{\underline{\hspace{20em}}{>}} \\
\multicolumn{3}{c}{S_{top}}
\end{array}$$

The fact that the latter extraction is unbounded in English follows from the fact that composition can apply across tensed clause boundaries, as in "Movies, [she thinks [(that) I like]]$_{S/(S\backslash NP)}$." That possibility in turn stems from the fact that in English and many other languages, the lexical category of verbs like "thinks" and complementizers like "that" are compatible with the $\diamond$ slash restriction on the forward harmonic composition rule (9a) (Steedman, 2000b, 2012).

In Minimalist terms, raised types can therefore also be thought of as *lexicalizing* MOVE *at the level of logical form*. That is to say that all of the raised NP categories in this section have a lexical logical form that can be schematized as follows (simplifying for purposes of exposition):

(36) nominal := $NP^{\uparrow} : \lambda p.p\,nominal$

—where $NP^{\uparrow}$ schematizes over a number of case-raised types, *nominal* corresponds to one of *balbus*, *livia*, *movies* etc., and p gets bound to adjacent *loves*, *loves livia*, $\lambda x.like\,x\,me$, etc.. Since raised categories including topics and *wh*-elements combine by combinatory rules, this too is a case of External Merge. It is only at the level of lexicalized logical form that it has the effect of (unbounded) MOVE, also known as "Internal Merge" (Epstein et al., 1998; Chomsky, 2001/2004), so that *Movies, I like!* ends up meaning *like movies me*.[34]

The inclusion of type-raising as a lexical operation for English then simply amounts to the claim that *all* languages have lexical case, whether or not they have case-morphology (cf. Vergnaud, 1977/2006; Sheehan and van der Wal, 2018; cf. Steedman, 2000b, 2012:81).[35]

For present purposes it is important to notice, first, that lexically-specified order-preserving case type-raising gives us some *additional derivations and types of conjunct*, and, second, that the non-order-preserving type-changing topicalized category in (35), coupled with composition, gives us some *additional word-orders*, of the kind that have

[33] Application of the function composition rules to directionally underspecified categories $Y|Z$, as in (34), remains subject to the Combinatory Projection Principle (11) (Steedman and Baldridge, 2011: 202-204).

[34] To put it another way, "movement" is the static reflex of case at the level of lexical logical form. It is therefore unsurprising that in many languages including Latin, *wh*-elements bear the case selected for by the verb they are extracted from, rather than that of the noun they modify:

(i)

Agricola	quem	Livia	amat
farmer.NOM.3sg	REL.ACC.3sg	Livia.NOM.3sg	loves

"the/a farmer that Livia loves"

[35] Of course, they may also mix lexical type-raising (structural or Vergnaud case) with "quirky" morphological case markers, as Icelandic notoriously does.

been attributed to movement.[36]

It is also important to understand that the availability of case as type-raising in CCG does not affect the earlier results concerning limitation of CCG derivability to the separable permutations. While type-raising can change word-order, it does so by *lexically inverting the order of command of function and argument in the lexicon*, thereby redefining the Universal Order of Command (UOC). It still cannot override the contiguity condition that is built into the Combinatory Projection Principle (11), although it will determine exactly which permutations are separable or otherwise.

For example, Haug (2017) analyses the following Latin example (Caesar *De Bello Gallico* V.i.i) as an instance of backward adjunct control of the subject of the participial adjunct *discedens ab hibernis in Italiam* ("departing from winter quarters to Italy") by the subject *Cæsar* of the main clause *Cæsar … imperat* ("Caesar ordered … "). That analysis seems to imply that the categories are as follows, where the PPs are adjuncts to *discedens*.

(37) discedens ab hibernis Cæsar in Italiam … … imperat …

$$\begin{array}{cccc} S|S & NP^{\uparrow}_{3sg,NOM} & S|S & S|NP_{3sg,NOM} \\ B|C & D & A|B & C|D \\ 2 & 4 & 1 & 3 \end{array}$$

If the nominative subject *Cæsar* were an unraised NP, the categories would be on the non-separable pattern (16g), and could not combine.

However, the subject in (37) is morpholexically *nominative*, and therefore necessarily type-raised as $S/(S\backslash NP)$, so the derivation goes through as follows:[37]

(38) discedens ab hibernis Cæsar in Italiam … … imperat …

$$\begin{array}{llll}
\underline{\text{discedens ab hibernis}} & \underline{\text{Cæsar}} & \underline{\text{in Italiam} \ldots} & \underline{\ldots \text{imperat} \ldots} \\
S/S & S/(S\backslash NP_{3sg,NOM}) & S\backslash S & S\backslash NP_{3sg,NOM} \\
\hline
\multicolumn{2}{c}{S/(S\backslash NP_{3sg,NOM})} & {>}\mathbf{B} & \\
\hline
\multicolumn{3}{c}{S/(S\backslash NP_{3sg,NOM})} & {<}\mathbf{B}_{\times} \\
\hline
\multicolumn{4}{c}{S} \quad {>}
\end{array}$$

The effect of nominative type-raising of the D in (37) to $C|(C|D)$ is to change the UOC of the four categories in (37) by exchanging the roles of *Cæsar* and the predicate headed by *imperat* as function and argument, making the former act as 3, in terms of the ordinal labels, and the latter as 4, and allowing the derivation shown as the separable permutation (p), or 4,1,3,2 in terms of the new categories. Since this lexicalized type-change is obligatory, it will be obvious that it is two *other* permutations 3,1,4,2 and 2,4,1,3 of these elements that are non-separable and therefore predicted to be disallowed with the intended meaning, namely the following and its mirror-image:

(39) g. *Discedens ab hibernis … imperat … in Italiam Cæsar

[36] The latter non-order-preserving type-raising is also lexicalized, and is required by the Combinatory Projection Principle (11) to have a distinct result category (here, S_{top}) from that of the function it applies to (here, S).

[37] The logical form is not shown, but I assume that the relation between *Cæsar* and the subject of absolutive *discedens* is mediated by paratactic anaphora (prodrop), rather than backward adjunct control as conjectured by Haeg. While the implicit subject of such participial adjuncts is frequently coreferential with the subject of the main clause, it can it can instead refer logophorically to the speaker or source of indirect discourse (Panhuis, 1982, 2006: §384), as in the following English absolute:

(i) Departing from winter quarters for Italy, the sun was shining.

De Bello Gallico is a self-promoting report intended to be read aloud by others, and written very much from Cæsar's point of view (Mueller, 2012: xxiii-v). A further possibility is that *imperat* is paratactically bound to *Cæsar* by prodrop.

9. ANALYSIS IV: VERBAL CONSTRUCTIONS INCLUDING NOMINAL ARGUMENTS. This section more briefly examines some more complex verbal constructions with larger numbers of elements.

9.1. GERMANIC VERB-PROJECTION RAISING. In view of the variety of word-orders allowed in the Germanic clause (29), it is interesting to examine in more detail the phenomenon of verb- and verb-projection- raising in specific versions of Germanic that allow variation in constituent ordering. Haegeman and van Riemsdijk, 1986: 432 discuss alternative orders for the following subordinate clause from Zürich German for a clause meaning "(that) he wants to let his children study medicine", for which the first (standard German-like) order (a) and the last order (g) are deprecated. This pattern of alternate derivations is allowed on the single assumption that *wil* ("wants") and *laa* ("to let") lexically subcategorize for their *VP* complement with $/_{\times\star}$ slash modality, allowing both (crossed-) composition and application. (In the derivations shown, the only effect of case or forward type-raising the NPs (abbreviated $NP^{\uparrow}$) is to require combination by forward application rather than backward.)[38]

(40) a. *

$$\begin{array}{ccccccc}
\text{(das)} & \text{er} & \text{sini chind} & \text{mediziin} & \text{studiere} & \text{laa} & \text{wil}\\
\text{(that)} & \text{he} & \text{his children} & \text{medicine} & \text{study} & \text{let} & \text{wants}\\
\overline{(S'/S')} & \overline{NP^{\uparrow}_{nom}} & \overline{NP^{\uparrow}_{acc}} & \overline{NP^{\uparrow}_{acc}} & \overline{VP\backslash NP_{acc}} & \overline{(VP\backslash NP_{acc})/_{\times\star}VP} & \overline{(S'\backslash NP_{nom})/_{\times\star}VP}\\
 & & & & \star & & \\
 & & & & \star & &
\end{array}$$

b.

$$\begin{array}{ccccccc}
\text{(das)} & \text{er} & \text{sini chind} & \text{mediziin} & \text{wil} & \text{laa} & \text{studiere}\\
\text{(that)} & \text{he} & \text{his children} & \text{medicine} & \text{wants} & \text{let} & \text{study}\\
\overline{} & \overline{NP^{\uparrow}_{nom}} & \overline{NP^{\uparrow}_{acc}} & \overline{NP^{\uparrow}_{acc}} & \overline{(S\backslash NP_{nom})/_{\times\star}VP} & \overline{(VP\backslash NP_{acc})/_{\times\star}VP} & \overline{VP\backslash NP_{acc}}
\end{array}$$

$$\begin{array}{l}
>\mathbf{B}_{\times}:\ ((VP\backslash NP_{acc})\backslash NP_{acc})\\
>\mathbf{B}^2_{\times}:\ ((S\backslash NP_{nom})\backslash NP_{acc})\backslash NP_{acc}\\
>:\ (S\backslash NP_{nom})\backslash NP_{acc}\\
>:\ S\backslash NP_{nom}\\
>:\ S
\end{array}$$

c.

$$\begin{array}{ccccccc}
\text{(das)} & \text{er} & \text{sini chind} & \text{wil} & \text{mediziin} & \text{laa} & \text{studiere}\\
\text{(that)} & \text{he} & \text{his children} & \text{wants} & \text{medicine} & \text{let} & \text{study}\\
\overline{} & \overline{NP^{\uparrow}_{nom}} & \overline{NP^{\uparrow}_{acc}} & \overline{(S\backslash NP_{nom})/_{\times\star}VP} & \overline{NP^{\uparrow}_{acc}} & \overline{(VP\backslash NP_{acc})/_{\times\star}VP} & \overline{VP\backslash NP_{acc}}
\end{array}$$

$$\begin{array}{l}
>\mathbf{B}_{\times}:\ ((VP\backslash NP_{acc})\backslash NP_{acc})\\
>:\ VP\backslash NP_{acc}\\
>\mathbf{B}_{\times}:\ (S\backslash NP_{nom})\backslash NP_{acc}\\
>:\ S\backslash NP_{nom}\\
>:\ S
\end{array}$$

d.

$$\begin{array}{ccccccc}
\text{(das)} & \text{er} & \text{sini chind} & \text{wil} & \text{laa} & \text{mediziin} & \text{studiere}\\
\text{(that)} & \text{he} & \text{his children} & \text{wants} & \text{let} & \text{medicine} & \text{study}\\
\overline{} & \overline{NP^{\uparrow}_{nom}} & \overline{NP^{\uparrow}_{acc}} & \overline{(S\backslash NP_{nom})/_{\times\star}VP} & \overline{(VP\backslash NP_{acc})/_{\times\star}VP} & \overline{NP^{\uparrow}_{acc}} & \overline{VP\backslash NP_{acc}}
\end{array}$$

$$\begin{array}{l}
>:\ VP\\
>:\ VP\backslash NP_{acc}\\
>\mathbf{B}_{\times}:\ (S\backslash NP_{nom})\backslash NP_{acc}\\
>:\ S\backslash NP_{nom}\\
>:\ S
\end{array}$$

[38] Cf: Wurmbrand (2006) and Abels (2016). The "restructuring" effect of these derivations on the verb group crucially involves the generalization of the composition rules to second-order rules—more specifically, the forward crossing rule shown there as (13), here indicated as $>\mathbf{B}^2_{\times}$.

e.

(das)	er	wil	sini chind	mediziin	laa	studiere
(that)	he	wants	his children	medicine	let	study
	$NP^{\uparrow}_{nom}$	$(S\backslash NP_{nom})/_{\times\star}VP$	$NP^{\uparrow}_{acc}$	$NP^{\uparrow}_{acc}$	$(VP\backslash NP_{acc})/_{\times\star}VP$	$VP\backslash NP_{acc}$

$$\text{laa studiere} \Rightarrow_{>\mathbf{B}_\times} ((VP\backslash NP_{acc})\backslash NP_{acc}$$
$$\text{mediziin laa studiere} \Rightarrow_{>} VP\backslash NP_{acc}$$
$$\text{sini chind mediziin laa studiere} \Rightarrow_{>} VP$$
$$\text{wil} \ldots \Rightarrow_{>} S\backslash NP_{nom}$$
$$\text{er} \ldots \Rightarrow_{>} S$$

f.

(das)	er	wil	sini chind	laa	mediziin	studiere
(that)	he	wants	his children	let	medicine	study
	$NP^{\uparrow}_{nom}$	$(S\backslash NP_{nom})/_{\times\star}VP$	$NP^{\uparrow}_{acc}$	$(VP\backslash NP_{acc})/_{\times\star}VP$	$NP^{\uparrow}_{acc}$	$VP\backslash NP_{acc}$

$$\text{mediziin studiere} \Rightarrow_{>} VP$$
$$\text{laa mediziin studiere} \Rightarrow_{>} VP\backslash NP_{acc}$$
$$\text{sini chind laa mediziin studiere} \Rightarrow_{>} VP$$
$$\text{wil} \ldots \Rightarrow_{>} S\backslash NP_{nom}$$
$$\text{er} \ldots \Rightarrow_{>} S$$

g. *

(das)	er	wil	laa	sini chind	mediziin	studiere
(that)	he	wants	let	his children	medicine	study
	$NP^{\uparrow}_{nom}$	$(S\backslash NP_{nom})/_{\times\star}VP$	$(VP\backslash NP_{acc})/_{\times\star}VP$	$NP^{\uparrow}_{acc}$	$NP^{\uparrow}_{acc}$	$VP\backslash NP_{acc}$

$$\text{wil laa} \Rightarrow_{\mathbf{B}^2_\times} ((S\backslash NP_{nom})\backslash NP_{acc})/_{\times\star}VP$$
$$\text{mediziin studiere} \Rightarrow_{>} VP$$
$$\text{sini chind mediziin studiere} \Rightarrow_{\star}$$
$$\text{laa sini chind} \Rightarrow_{\star}$$
$$\text{wil laa sini chind} \Rightarrow_{\star}$$

(In the latter case (g), type-raised "sini chind" cannot be lexicalized as $VP\backslash(VP\backslash NP_{acc})$ and compose by $<\mathbf{B}_\times$, because the necessary category-type is non-order-preserving, but also type-preserving over the result, and is therefore not available in CCG. See discussion of the topicalized object category in example 35.)

Many of the above alternates differ in the possibilities for positioning prosodic boundaries and information-structurally relevant properties such as the definiteness of NPs. All of the non-standard constituents constructed in the above derivations can be directly coordinated, analogously to (33) (Steedman, 1985, *passim*).

We noted earlier that the only location for language-specific information in CCG is the lexicon. It is striking that the variety of word-order found in Zürich German raising subordinate clauses, a construction that has provided the classic proofs of non-context-freedom in natural language (Huybregts, 1984; Shieber, 1985), can be captured in such a simple lexicon, with one directional category per verb, and that the complex process of "reanalysis" invoked by Haegeman and van Riemsdijk is an emergent property of the independently-motivated rules of composition—crucially, *crossing* composition.

In Minimalist terms, CCG thus reduces Reanalysis/Restructuring to Movement, and Movement in turn to contiguous adjacent combinatory merger.

The Zürich German alternation exemplified above is closely mirrored in West Flemish (Haegeman, 1992), and in German and Dutch by the *zu/te*-infinitival complement verbs such as *proberen/probeeren* ("try").[39]

9.2. DUTCH BARE-INFINITIVAL COMPLEMENT VERBS. A small set of German/Dutch bare-infinitival complement verbs like *sien/zien*, ("see") are more restricted, allowing only orders in which all NPs precede all verbs as in (40a,b) (the order of the

[39] The analysis of Haegeman, 1992: 193 in terms of "head adjunction" is in fact very similar to the present account in terms of serial verb composition.

verbs may vary), disallowing alternations like (40c,d,e,f, and g).[40]

(41)

dat	ik	*(Cecilia)	*(Henk)	*(de paarden)	zag	(*Cecilia)	helpen	(*Henk)	(*de paarden) voeren
that	I	*(Cecilia)	*(Harry)	*(the horses)	saw	(*Cecilia)	help	(*Harry)	(*the horses) feed

"that I saw Cecilia help Harry feed the horses"

The idiosyncracy of these verbs can be captured in the following lexical fragment, in which the crucial $/VP$ arguments are restricted by $\times$-only slash-type to only combining by crossing composition, while application to a complete VP is disallowed:[41]

(42) zag, etc. := $((S'\backslash NP)\backslash NP)/_{\times}VP$
helpen, leren, etc. := $(VP\backslash NP)/_{\times}VP$
voeren, etc. := $VP\backslash NP$

The derivation of (41) is the same as that given in Steedman, 2000b:141-142, and is suggested as an exercise.[42]

The Dutch/German infinitival verbs referred to in the last section like *probeeren/proberen*, which allow the alternate orders with the *te*-infinitival complement, have homomorphic categories subcategorizing for VP_{te} with various types of rightward slash. (The infinitival verbs in (42) must also bear such a category in addition to the ones shown there:)

(43) probeerde, etc. := $((S\backslash NP)\backslash NP)/_{\times\star}VP_{te}$
probeeren, leren, helpen, etc. := $(VP\backslash NP)/_{\star}VP_{te}$

These categories ensure that when the *te*-infinitival itself consists of serial infinitivals, the latter *cannot* carry the *te*-complementizer (Seuren, 1985):[43]:

(44) a. dat hij probeerde Jan *(te) leren het lied *(te) zingen.
b. dat hij probeerde Jan het lied *(te) leren (*te) zingen.
c. dat hij Jan het lied probeerde *(te) leren (*te) zingen.
"that he tried to teach Jan to sing the song"

9.3. CLUSTER COORDINATION AND SCRAMBLING IN THE GERMANIC SUBORDINATE CLAUSE. If lexically-determined order-preserving type-raised (cased) categories are allowed to compose, rather than simply applying as in the last section, then they induce new word orders. In particular, CCG supports exactly the same possibility of conjoining typable argument/adjunct clusters as Latin (33) and English (Dowty, 1985/1988; Steedman, 1985). For example:

(45)

(dat)	hij	zijn kinderen	medicijnen	en	zijn vrienden muziek	wil laten leren
(that)	he	his children	medicine	and	his friends music	wants let study
S'/S'	$S'/(S'\backslash NP)$	$(S'\backslash NP)/((S\backslash NP)\backslash NP)$	$((S'\backslash NP)\backslash NP)/(((S'\backslash NP)\backslash NP)\backslash NP)$	$(X\backslash_{\star}X)/_{\star}X$	⋮	$((S''\backslash NP)\backslash NP)\backslash NP$

zijn kinderen + medicijnen $\Rightarrow_{>\mathbf{B}}$ $(S'\backslash NP)/(((S'\backslash NP)\backslash NP)\backslash NP)$

zijn vrienden muziek: $(S'\backslash NP)/(((S'\backslash NP)\backslash NP)\backslash NP)$

coordination $\Rightarrow_{<>}$ $(S'\backslash NP)/(((S'\backslash NP)\backslash NP)\backslash NP)$

$\Rightarrow_{>}$ $S'\backslash NP$

$\Rightarrow_{>}$ S'

"that he wants his children to study medicine and his friends music"

Further examples such as the following are discussed in the earlier references, and are suggested as an exercise:

[40] Bech (1955); Evers (1975); Bresnan et al. (1982); Steedman (1985); Seuren (1985); see also van Craenenbroeck (2014); van Craenenbroeck et al. (2019).

[41] For reasons of space, we pass over the fact that tensed verbs and certain auxiliary infinitivals such as *hebben* support a greater variety of word-orders, requiring further categories specifying VP to the left—see Koopman, 2014: §3.

[42] Steedman, 2000b captures these restrictions in an earlier CCG formalism with type-restrictions on combinatory rules, rather than slashes, but the combinatory derivations are identical.

[43] The present account supersedes that in Steedman, 2000b: 144-146

(46) a. dat hij zijn kinderen en ze haar vrienden medicine wil laten leren
 b. dat hij zijn kinderen medicine en ze haar vrienden muziek wil laten leren

The availability of lexicalized order-preserving type-raising also allows a certain amount of (bounded) scrambling of arguments.

(47)

(daß)	seine Kinder	er	Medizin	studieren	lassen	will
(that)	his children	he	medicine	study	let	wants
S'/S'	$NP^{\uparrow}_{acc}$	$NP^{\uparrow}_{nom}$	$NP^{\uparrow}_{acc}$	$((S'\backslash NP_{nom})\backslash NP_{acc})\backslash NP_{acc}$		
			$(S'\backslash NP_{nom})\backslash NP_{acc}$ $>$			
		$S'\backslash NP_{acc}$ $>\mathbf{B}_{\times}$				
	S' $>$					

(48)

(daß)	seine Kinder	Medizin	er	studieren	lassen	will
(that)	his children	medicine	he	study	let	wants
S'/S'	$NP^{\uparrow}_{acc}$	$NP^{\uparrow}_{acc}$	$NP^{\uparrow}_{nom}$	$((S'\backslash NP_{nom})\backslash NP_{acc})\backslash NP_{acc}$		
			$(S'\backslash NP_{acc})\backslash NP_{acc}$ $>\mathbf{B}^{2}_{\times}$			
		$S'\backslash NP_{acc}$ $>$				
	S' $>$					

All permutations of the three arguments of such final verb clusters are allowed by the grammar.

More generally, it will be apparent from (48) that when all the other arguments are scrambled out past the nominative argument of the tensed verb, then in German the only way the derivation can proceed is to first compose all the verbs, and to then apply higher order composition of the subject with the composite serial verb. In general, for a sequence $NP^{\uparrow}_{2} \ldots NP^{\uparrow}_{n} NP^{\uparrow}_{1} (\ldots S\backslash NP_{1} \ldots)\backslash NP_{n}$, the first step of the derivation would require a rule $>\mathbf{B}^{n-1}_{\times}$. (For example, the sequence with four arguments followed by four verbs $NP^{\uparrow}_{2} NP^{\uparrow}_{3} NP^{\uparrow}_{4} NP^{\uparrow}_{1}\, V_4\, V_3\, V_2\, V_1$ would require a third order rule $>\mathbf{B}^{3}_{\times}$–Hockenmaier and Young, 2008)[44]

Native speaker judgements here are notoriously uncertain, but Joshi et al. (2000: 179) claim that German speakers are reluctant to accept scramblings on this pattern, suggesting that the generalization of the composition rules may not extend beyond the second-order case (cf. Joshi, 2014: 157, who notes that the corresponding limitation to tree locality in MC-TAG allows a Schröderian 22 out of the 24 possible scramblings).

The parallel limitation on NP scrambling does not apply to the corresponding Dutch construction (41b). Since in Dutch the basic order of the corresponding serial verbs is $V_1\, V_2\, V_3\, V_4$, with tensed verb initial, there is an alternative derivation where NP_1 composes with V_1 via the first-order rule, before V_1 composes with any other verb. It is striking that as the number of arguments rises, German shows a very strong tendency to adopt the Dutch tense-initial order of the verbal elements (Bech, 1955; Evers, 1975. See Steedman, 1985 for further discussion in an earlier CCG framework).

9.4. THE VERBAL COMPLEX IN HUNGARIAN. Williams (2003), following Koopman and Szabolcsi (2000), also analyses some related order effects for Hungarian verbal complexes in categorial terms. In its comparatively free word-order over these elements, Hungarian presents a similar problem to that of the Shupamem NP. The follow-

[44] The four third-order CCG composition rules are analogous to the second-order rules exemplified by (13), except for involving secondary functors of the form $(((Y|Z)|W)|V$ and results of the form $(((X|Z)|W)|V$. Such rules would be entirely CPP- and separability- compliant.

ing alternations are discussed by Koopman and Szabolcsi (2000: 15-17):

(49) a. (Nem) fogok kezdeni akarni be menni.
(Not) will-I begin want in go
b. (Nem) fogok kezdeni be menni akarni.
(Not) will-I begin in go want
c. (Nem) fogok be menni akarni kezdeni.
(Not) will-I in go want begin
"I will (not) begin to want to go in"

The permutations typified in (49) are the only ones that are grammatical: the following are all disallowed:

(50) a. *(Nem) fogok kezdeni be akarni menni.
(Not) will-I begin in want go
b. *(Nem) fogok akarni be menni kezdeni.
(Not) will-I want in go begin
c. *(Nem) fogok akarni kezdeni be menni.
(Not) will-I want begin in go

It is particularly noteworthy that (50b) is excluded, since the substring *[[akarni [be menni]] kezdeni] is a separable permutation that could potentially be obtained by allowing a single rotation of the topmost node of the basic order (49b), [kezdeni [akarni [be menni]]], "begin to want in go".

If the displaced main verb in this construction has a complement such as an object, the latter is stranded *in situ*:

(51) a. Nem fogom [szét szedni akarni] a rádiót
not will-I apart take want the radio
"I will not want to take apart the radio"
b. *Nem fogom [szét szedni a rádiót akarni]
not will-I apart take the radio want
"I will not want to take apart the radio"

The tensed first-person verb form *fogom* shows agreement with the definite accusative object *a radiot* ("the radio"), to which the intervening infinitivals are "transparent" (É. Kiss, 2002: 203). We pass over the complex details of exactly which accusative NPs license this agreement (Bartos, 1997, 1999; Coppock, 2013), except to note that this transparency suggests that the distant object and the finite verb stand in a scoping relationship.

9.4.1. BASIC WORD-ORDER. The above facts can be captured via the following (simplified) lexical fragment:

(52) *Simplified Hungarian Lexical Fragment*:
nem := S_{neg}/S_{fin}
fogok := $S_{fin}/_{\diamond\star}VP$
fogom := $S_{fin,acc}/_{\diamond\star}VP$
kezdeni, akarni, etc. := $VP_{+F}/_{\diamond\star}VP$ **or** $VP_{-F}\backslash_{\times\star}VP_{-F}$
menni := $VP\backslash_{\star}part_{be}$
szedni := $(VP/NP)\backslash_{\star}part_{szet}$
be := $part_{be}$
szét := $part_{szet}$

Crucially, the backward category $VP_{-F}\backslash_{\times\star}VP_{-F}$ of the raising infinitivals means that they can only combine to the left with VPs that are not marked $+F$, and that they yield a VP that is marked $-F$. (Crossed composition must be allowed, to permit 51a.) The other, rightward, category $VP_{+F}/_{\diamond\star}VP$ of the raising infinitivals means that they can combine to their right with any VP, and mark their result as $+F$. These alternating categories are homomorphic, and do not differ in UOC.[45]

This lexicon supports the following derivations for (49):

(53) a.

(Nem)	fogok	kezdeni	akarni	be	menni.
(Not)	will-I	begin	want	in	go
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$part_{be}$	$VP\backslash_{\star}part_{be}$

$$\text{be menni}: VP \;(<)$$
$$\text{akarni be menni}: VP_{+F} \;(>)$$
$$\text{kezdeni akarni be menni}: VP_{+F} \;(>)$$
$$\text{fogok} \ldots: S_{fin} \;(>)$$
$$\text{(Nem)} \ldots: S_{neg} \;(>)$$

b.

(Nem)	fogok	kezdeni	be	menni	akarni.
(Not)	will-I	begin	in	go	want
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$part_{be}$	$VP\backslash_{\star}part_{be}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$

$$\text{be menni}: VP \;(<)$$
$$\text{be menni akarni}: VP_{-F} \;(<)$$
$$\text{kezdeni be menni akarni}: VP_{+F} \;(>)$$
$$\text{fogok} \ldots: S_{fin} \;(>)$$
$$\text{(Nem)} \ldots: S_{neg} \;(>)$$

c.

(Nem)	fogok	be	menni	akarni	kezdeni.
(Not)	will-I	in	go	want	begin
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$part_{be}$	$VP\backslash_{\star}part_{be}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$

$$\text{be menni}: VP \;(<)$$
$$\text{be menni akarni}: VP_{-F} \;(<)$$
$$\text{be menni akarni kezdeni}: VP_{-F} \;(<)$$
$$\text{fogok} \ldots: S_{fin} \;(>)$$
$$\text{(Nem)} \ldots: S_{neg} \;(>)$$

However, the examples in (50) are blocked by the $-F$ feature of the inverting verbs:

(54) a.

*(Nem)	fogok	kezdeni	be	akarni	menni.
(Not)	will-I	begin	in	want	go
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$part_{be}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$	$VP\backslash_{\star}part_{be}$

$$\text{kezdeni be}: \star \qquad \text{be akarni}: \star \qquad \text{akarni menni}: \star$$

b.

*(Nem)	fogok	akarni	be	menni	kezdeni.
(Not)	will-I	want	in	go	begin
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$part_{be}$	$VP\backslash_{\diamond\star}part_{be}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$

$$\text{be menni}: VP \;(<)$$
$$\text{akarni be menni}: VP_{+F} \;(>)$$
$$\text{be menni kezdeni}: \star$$

[45] The feature-engineering with $\pm F$ fine-tunes the fragment to exclude (50b). Cf. Williams's related category alternation 2003:231-2. The question of the discourse-semantic interpretation of $VP_{\pm F}$ is not discussed here, but it appears related to the domain of what É. Kiss (1998) calls "informational focus", suggesting the two infinitival raising categories might be phonologically distinguished by deaccenting the latter.

c.

$*$(Nem)	fogok	akarni	kezdeni	be	menni.
(Not)	will-I	want	begin	in	go
S_{neg}/S_{fin}	$S_{fin}/_{\diamond\star}VP$	$VP_{+F}/_{\diamond\star}VP$	$VP_{-F}\backslash_{\times\star}VP_{-F}$	$part_{be}$	$VP\backslash_{\diamond\star}part_{be}$
		$\star$		$<$ VP	
		$\star$			

The object-stranding example (51a) is derived as follows:

(55)

(Nem)	fogom	szet	szdeni	akarni	a	radiot.
(Not)	will-I	apart	take	want	the	radio
S_{neg}/S_{fin}	$S_{fin,acc}/_{\diamond\star}VP$	$part_{szet}$	$(VP/NP_{acc})\backslash_{\star}part_{szet}$	$VP_{-F}\backslash_{\times\star}VP_{-F}$	$NP^{\uparrow}_{agr}/N_{agr}$	N_{acc}
		$<$ VP/NP_{acc}			$>$ $S_{fin}\backslash(S_{fin,acc}/NP_{acc})$	
		$<\mathbf{B}_{\times}$ VP_{-F}/NP_{acc}				
	$>\mathbf{B}$ $S_{fin,acc}/NP_{acc}$					
		$<$ S_{fin}				
$>$ S_{neg}						

Object agreement with *fogom* via the "right-node raised" category of accusative *a radot* does the work of Minimalist "movement to AgrO" (Bartos, 1999: 320). However, even if a similar raised category over infinitival were allowed, (51b) would be blocked by the lack of similar agreement on infinitivals:

(56)

$*$(Nem)	fogom	szet	szdeni	a	radiot	akarni.
(Not)	will-I	apart	take	the	radio	want
S_{neg}/S_{fin}	$S_{fin,acc}/_{\diamond\star}VP$	$part_{szet}$	$(VP/NP_{acc})\backslash_{\star}part_{szet}$	$NP^{\uparrow}_{agr}/N_{agr}$	N_{acc}	$VP_{-F}\backslash_{\times\star}VP_{-F}$
		$<$ VP/NP_{acc}		$>$ $VP\backslash(VP_{acc}/NP_{acc})$		
		$\star$				

9.4.2. VM FRONTING. The behavior in Hungarian of separable prefixes like "be" is more varied in the case of tensed verbs and verb-series. In "non-neutral" sentences (Koopman and Szabolcsi, 2000: 11-12)—that is, those with a fronted Focus Phrase or Negative Phrase—the particle is "stranded" post-verbally

(57) a. MARI ment be.
MARI went.3SG in
"It was MARY that went in"

b. Nem mentem be.
not went.1SG in
"I didn't go in"

By contrast, in "neutral" sentences, "be" is among a larger class of "verbal modifiers" (VM) which prepose to the position before the finite verb (Koopman and Szabolcsi, 2000: 11).

(58) a. Mari be ment.
Mari in went.3SG
"Mary went in"

b. Be ment.
in went.3SG
"He went in"

c. Be fogok akarni menni.
In will.1SG want go
"I will want to go in"

Fronting "be" in this way is incompatible with negation:

(59) a. *Nem be fogok akarni menni kezdeni.
Not in will-I want go begin

b. *be nem fogok akarni kezdeni menni.
In not will-I want begin go

It is also incompatible with verb orders other than the "English" order, where the infinitival verbs are all rightward-combining (Koopman and Szabolcsi, 2000: 91):

(60) a. *Be fogok kezdeni [menni akarni].
b. *Be fogok [menni akarni kezdeni]

Both Koopman and Szabolcsi and Williams conclude that fronting of "be" and other VMs patterns with *wh*-movement. In CCG, fronting elements are non-order-perserving higher-order categories, as in the English topicalized object $S_{top}/(S/NP)$ in (35), which takes a category S/NP and changes the type of its result form S to S_{top}, where the latter is a "root" type which no category in English subcategorizes for.

Thus, to follow these authors in CCG terms, we need the following expansion of the lexicon fragment (52), in which "menni" and "be" have one additional category each, including a non-order-preserving fronting category for the latter (this fragment remains incomplete with respect to topic- and focus-fronting categories):

(61) *Extended Hungarian Lexical Fragment*:
nem := S_{neg}/S_{fin}
ment := $S_{fin}/_{\star}part_{be}$
fogok := $S_{fin}/_{\diamond\star}VP$
fogom := $S_{fin,acc}/_{\diamond\star}VP$
kezdeni, akarni, etc. := $VP_{+F}/_{\diamond\star}VP$ **or** $VP_{-F}\backslash_{\times\star}VP_{-F}$
menni := $VP\backslash_{\star}part_{be}$ **or** $VP_{+F}/_{\diamond}part_{be}$
be := $part_{be}$ **or** $S_{neut}/(S_{fin}/part_{be})$

—where S_{neut} is the "neutral" clause type, $S_{neut}/(S_{fin}/part_{be})$ is the fronting *be*, and $VP_{+F}/_{\diamond}part_{be}$. is a forward-composing-only category for *menni* that marks its result like a raising verb as $+F$ and disallows *be in situ*. (The related lexical entries for *szét* and *szedni* are omitted.) The category alternation for *menni* is homomorphic. However, the new category or *be* is *non*-homomorphic, defining a distinct extraposing UOC, analogous to that of the English topic in (35b).

This lexicon yields the following derivation comparable to English topic fronting (35) for the particle/VM-fronting (58c).

(62)

$$
\begin{array}{cccc}
\text{Be} & \text{fogok} & \text{akarni} & \text{menni.} \\
\text{in} & \text{will.1SG} & \text{want} & \text{go} \\
\hline
S_{neut}/(S_{fin}/part_{be}) & S_{fin}/_{\diamond\star}VP & VP_{+F}/_{\diamond\star}VP & VP_{+F}/_{\diamond}part_{be} \\
 & & \multicolumn{2}{c}{\underline{\qquad\qquad\qquad\qquad}{>}\mathbf{B}} \\
 & & \multicolumn{2}{c}{VP_{+F}/_{\diamond}part_{be}} \\
 & \multicolumn{3}{c}{\underline{\qquad\qquad\qquad\qquad\qquad\qquad}{>}\mathbf{B}} \\
 & \multicolumn{3}{c}{S_{fin}/_{\diamond}part_{be}} \\
\multicolumn{4}{c}{\underline{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}{>}} \\
\multicolumn{4}{c}{S_{neut}}
\end{array}
$$

"I will want to go in"

It also yields the following analysis for (57b):

(63)

$$
\begin{array}{ccc}
\text{Nem} & \text{ment} & \text{be} \\
S_{neg}/S_{fin} & S_{fin}/_{\star}part_{be} & part_{be} \\
 & \multicolumn{2}{c}{\underline{\qquad\qquad\qquad}{>}} \\
 & \multicolumn{2}{c}{S_{fin}} \\
\multicolumn{3}{c}{\underline{\qquad\qquad\qquad\qquad\qquad}{>}} \\
\multicolumn{3}{c}{S_{neg}}
\end{array}
$$

By contrast, (59) and (60) remain excluded by the lexical types. The former are blocked because of mismatches between the types of clauses that *nem* and fronting *be* respectively require and provide. (Thus, type features do much the same work as functional projections in Koopman and Szabolcsi's account, and are doubtless equivalent at the level of logical form.) Example (60a) is excluded because fronted "be" requires a forward-looking $S_{fin}/part_{be}$, but the crucial composition of inverting *akarni* with *menni* that would allow this is blocked by a $\pm F$ feature mismatch on the latter:[46]

(64)

$$
\begin{array}{ccccc}
{*}\text{Be} & \text{fogok} & \text{kezdeni} & [\text{menni} & \text{akarni}] \\
\hline
S_{neut}/(S_{fin}/part_{be}) & S_{fin}/_{\diamond\star}VP & VP_{+F}/_{\diamond\star}VP & VP_{+F}/_{\diamond}part_{be} & VP_{-F}\backslash_{\times\star}VP_{-F} \\
 & & & \multicolumn{2}{c}{\underline{\qquad\qquad\qquad\qquad}{*}}
\end{array}
$$

It is correctly predicted on the basis of this analysis and the analogy to English topicalization (35) that such fronting of separable prefixes and other VMs, like topic-fronting or focus-movement (not covered here), will be unbounded, (É. Kiss, 1994: 33,42; Koopman and Szabolcsi, 2000: 211; Williams, 2003: 236). However, like Williams's CAT, CCG avoids the need for iterative pied-piping or roll-up movement of the kind invoked by Koopman and Szabolcsi, as it did in the earlier case of the NP construction.[47]

10. GENERAL DISCUSSION. Having examined in detail the permutations that are possible in natural grammars for the NP construction involving a spine of four elements, and shown the general applicability of CCG to the linearization of serial verb constructions involving larger numbers of spinal elements, we can consider the generalization that is implied by those observations, and the reason that it applies.

We have seen that for any ordered set of n categories of the form $\{A|B, B|C, \ldots, M|N, N\}$, the proportion of its $n!$ permutations that can be recognized by CCG is given by the nth in the Large Schröder series, of which the first few members are $\{1, 2, 6, 22, 90, 394, 1806, 8558, \ldots\}$. The fourth number in the series is 22, and applies to the four-element NP and VP complexes examined above.

The Large Schröder series corresponds to the number of separable permutations of the n categories (Bose et al., 1998), where separability is a property related to binary rebracketing and tree rotation of sister nodes around their mother over the original set of categories ordered according to the Universal Order of Command (UOC) defined by those categories. As we saw in the case of Latin and the Hungarian particles, determin-

[46] The other examples of fronted "be" are left as an exercise.

[47] Koopman and Szabolcsi refer to roll-up movement as as "recursive inversion".

ing the categories and the consequent UOC is complicated by the fact that arguments may be lexically type-raised, exchanging the UOC or command relations of functor and argument.[48]

The Large Schröder series grows much more slowly with n than the factorial number of permutations $n!$, so that the proportion of non-separable permutations that are disallowed by CCG grows rapidly with n, as $0,0,0,2,30,326,3234,31762,321244,\ldots$. For example, for a set of nine categories $\{X_1|X_2,\ldots,X_8|X_9,X_9\}$, nearly 90% of the possible permutations, and for fifteen categories, 99.9%, are excluded.[49]

This property was first noticed by Wu (1997) for Inversion Transduction Grammars (ITG), a form of synchronous CFG of rank 2 proposed for Machine Translation, and by Williams (2003: 203-211) for his categorial calculus CAT. CAT has a standard directional categorial lexicon and rule of application, with a combinatory operation REASSOCIATE equivalent to composition, and an operation FLIP, which reverses the directionality of a functor category, contrary to CCG's CPP (11)..

The reason that Williams's CAT makes the same prediction as CCG concerning the impossibility of non-separable permutation is that CAT, like CCG, is *combinatory*, restricted to the unary rules of associative rebracketing and FLIP, and in particular to combination of adjacent categories. Thus, it is subject to a version of CCG's combinatory projection principle (11).

However, the two theories are different, and make different predictions in other respects. Williams incorrectly claims (2003: 209) that CCG type-raising evades the constraints on movement that are corollaries of his FLIP, to such an extent that it rendered CCG permutation-complete, losing the above generalization.

As we have seen, for other choices of category-set, including those with categories such as verbs with valency > 1, including the Germanic and Hungarian verbal complexes, NP arguments with raised types do indeed allow derivations that are not otherwise allowed (such as (33) and (35)).

However, in further suggesting that type-raising renders CCG permutation-complete, Williams fails to notice that type-raising in CCG is a strictly lexical operation, replacing one lexical category by another (Steedman, 2000b: 47,70-85, and above), and merely exchanging the roles of arguments such as NPs and functors such as verbs. It is not a free syntactic combinatory rule, comparable to movement. As we saw in the discussion of Haug's example (37), type-raising, by changing arguments into functions, has the effect of *redefining the Universal Order of Command*, thereby changing the set of permutations that are separable. However, *once the lexical category set including raised types is chosen*, non-separable permutations of that UOC continue to be excluded.

Williams's CAT is therefore closely related to CCG. However, without the addition of raised lexical types, Williams's system CAT is unable to express the variety of constructions that CCG makes available via contiguous composition, including relativization, various coordinate constructions, and Hungarian VM fronting, except by invoking

[48] The Large Schröder numbers also correspond to the number of paths through an $n \times n$ diagonal half matrix in which the permitted transitions are $(0,1)$ to a right-horizontally adjacent node, $(1,0)$ to a vertically adjacent node, and $(1,1)$ to a right-diagonally adjacent node (Weisstein, 2018), an interpretation which is related to the problem of parsing with CCG. Stanojević and Steedman (2018) show that this model can also be interpreted as the derivations of a normal-form Shift-Reduce CCG parser for the separable permutations, limiting any given permutation to a single derivation via a single path.

[49] This sort of saving is important for applications in natural language processing. For example, machine translation programs need consider only a fraction of the possible alignments of words between source and target language sentences. Of course, if there are multiple categories for a given element, then the saving from the restriction to separable permutations will accrue *for each set/reading*.

powerful rules such as movement, copying, and/or deletion, some or all of which actually do risk permutation-completeness.

11. CONCLUSION. Descriptive adequacy in a linguistic theory stems from the possibility of capturing the considerable variation in linguistic constructions that we observe across the languages of the world.

There is no shortage of descriptively adequate theories of grammar. While it has sometimes been claimed that such theories can be compared on the basis of an "evaluation metric", such metrics have in practice depended on largely subjective claims for simplicity, based on a number of factors such as size of lexicon, number of rules, number of constraints on rules, etc., sometimes ignoring the nature and number of constructions actually covered, and the intrinsic expressiveness of the theory. Since we have no objective basis for any weighting of these factors, whether mathematical, psychological, computational, or evolutionary, simplicity has under these conditions proved to be very much in the eye of the beholder.

However, once descriptive adequacy has been attained, so that we can agree on what it is that we need to explain, the stronger criterion of explanatory adequacy depends on being able to explain why other things *don't* happen. If these have been captured by constraints at the level of the competence grammar, as in various ways they have been for the NP construction by Cinque, Abels and Neeleman, Nchare, and Stabler, then those constraints themselves have in turn to be explained.

The best explanation for a constraint was enunciated by Perlmutter (1971: 128) as the "No Conditions Principle": the best theory is one that needs no explicit constraints, because all and only the degrees of freedom observed in the data follow as theorems from a restricted underlying set of assumptions that are simply incapable of accomodating anything else. (Of course, there will be more to say, as we saw in the case of the NP construction, to explain the *distribution* that is observed over the alternatives that the theory does allow.)

The limitation on permutation of *n* elements in natural grammars to the separable permutations is in CCG a formal universal that follows as a corollary of the combinatory theory of grammar and the formally explicit reduction that it affords of all varieties of Minimalist movement to type-driven contiguous merger.

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