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**Citation for published version:**

Steedman, M 2020, 'A Formal Universal of Natural Language Grammar', *Language*, vol. 96, no. 3, pp. 618-660 . <https://doi.org/10.1353/lan.2020.0043>

**Digital Object Identifier (DOI):**

[10.1353/lan.2020.0043](https://doi.org/10.1353/lan.2020.0043)

**Link:**

[Link to publication record in Edinburgh Research Explorer](#)

**Document Version:**

Publisher's PDF, also known as Version of record

**Published In:**

Language

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## A formal universal of natural language grammar

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Language, Volume 96, Number 3, September 2020, pp. 618-660 (Article)

Published by Linguistic Society of America

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# A FORMAL UNIVERSAL OF NATURAL LANGUAGE GRAMMAR

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This article 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 combinatorial projection principle that limits them to binary rules applying to contiguous nonempty categories.

The article 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), which 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.\*

*Keywords:* word order, universal order of command, combinatorial categorial grammar, separable permutations

**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 article 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 crosslinguistically to a particular subclass of permutations on the UNIVERSAL ORDER OF COMMAND (UOC)  $1, \dots, n$ , 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 §2 concerning the nature of language universals, the article begins in §3 by reviewing evidence in support of this universal from the linguistically attested orders of the four elements Dem(onstrative), Num(erator), A(djective),

\* This article was originally inspired by a talk given by Ad Neeleman in 2006. A preliminary version was presented in that year at the University of Pennsylvania and circulated under a different title. I have benefited since then from discussions with Klaus Abels, Paul Atkinson, Keith Brown, Peter Buneman, Jennifer Culbertson, Mary Dalrymple, Dag Haug, Mark Hepple, Caroline Heycock, Rachel Hurley, Aravind Joshi, Frank Keller, Bob Ladd, Andrew McLeod, Geoff Pullum, Miloš Stanojević, and Bonnie Webber, and from comments by the editors Meghan Crowhurst and Lisa Travis and the referees for *Language*. The paper is dedicated to the memory of Aravind Joshi, 1929–2017, who first addressed this question. The work was supported in part by ERC Advanced Fellowship 742137 SEMANTAX.

N(oun), which surface in English in their UOC 1, 2, 3, 4. This construction has recently been examined by Cinque (2005, 2013b), 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 twenty-two separable permutations, of which twenty-one have so far been attested by one or another of these authors. The two nonseparable 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, given in 11 below, which requires all rules of CCG to apply to strictly contiguous nonempty categories. It excludes both of 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 recognizing nonseparable permutations on the UOC.

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 §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 intralinguistic variation, investigated by Wurmbrand (2004, 2006) and Abels (2016).

In order to generalize the predictions from this universal to more complex constructions, §8 then introduces and motivates the treatment in CCG of arguments such as NPs via TYPE-RAISING, a morpholexical process that 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 §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 David Hume, Immanuel Kant, and Willard Van Orman 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.<sup>1</sup>

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

<sup>1</sup> Unfortunately, we do not 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 & Levinson 2009).

order to explain the attested phenomena of language. Those limitations follow in turn from the compositional nature of the underlying meaning representations that human language expresses.<sup>2</sup>

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 nonseparable 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. THE NP.

**3.1. 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 fourteen attested orders out of the twenty-four 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 of 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.<sup>3</sup>

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.

**3.2. THE DATA FOR NP.** Greenberg (1963) originally claimed as his 20th generalization that only six of the twenty-four potential linear orderings were possible for the categories Dem, Num, A, and N 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 UOC of the four elements. While Dryer’s 2018 counts

<sup>2</sup> Chomsky (1965:27–30) (who may have adopted the terms from Max Weber’s (1978 [1925]) distinction between formal and substantive justice—cf. Sargentich 2018) distinguishes only between substantive and formal universals. However, the specific instances of formal universals 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 & Uriagereka 2005:12, where functional universals are referred to in passing as ‘formal’, threatening to lose an important distinction.

<sup>3</sup> 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.

are broadly in line with Cinque's, he includes a number of further attestations with very low counts which Cinque excludes as involving markers of relativization/extraposition.

NP WORD ORDERS IN LANGUAGES WITH DOMINANT ORDER (CINQUE). For those languages claimed in the literature to have a dominant order for the four elements of the NP, Cinque (2005, 2013b) provides the summary shown in the second column of 1 for the fourteen possibilities attested in his survey; he gives an admirably detailed account of the sources and strength of the evidence, to which the reader is directed.<sup>4</sup>

(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 fourteen possibilities attested in Cinque's survey (second column of 1) in terms of the assumption of a UOC over the four elements, together with various more or less independently motivated constraints on movement that exclude all ten orders unattested in his sample.<sup>5</sup>

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 LCA of Kayne (1994). However, Abels and Neeleman show that the fourteen orders can be captured without roll-up or the LCA by base-generating the eight possible orders defined by the unaligned UOC, together with a number

<sup>4</sup> 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 1,400 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 (2016:185, n. 9) notes the possibility of a sixteenth order (f) for Somali, citing Adam 2012.

<sup>5</sup> Cinque refers to the UOC, slightly confusingly, as the 'universal order of merge'.

of constraints including a general prohibition against rightward movement. Stabler (2011:634–36) presents a related account in terms of MINIMALIST GRAMMAR, which allows sixteen orders, including the fourteen attested by Cinque. (Stabler's two additional allowable orders are (j) and (v) in 1, a point to which we return below.)

While the counts indicated above from Cinque are approximated by only four ranks, 'very many' to 'very few', inspection of the relevant counts in Haspelmath et al. 2005, Cinque 2013b, and Dryer 2018 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.<sup>6</sup>

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.

NP WORD ORDER IN A LANGUAGE WITH MULTIPLE ORDERS (NCHARE). Nchare (2012: 134) claims for Shupamem, a Grassfields Bantu tone language with some 200,000 speakers, the nineteen possibilities marked in the third column of 1 as alternating orders of the four elements of the NP. This study commands our attention because it was carried out in approximately the same theoretical framework as that of 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 §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 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 2014). Accordingly, we provisionally accept such alternations as syntactically nonextraposing.<sup>7</sup>

Since two of Cinque's attested orders, 1c,d, are not among Nchare's nineteen orders for Shupamem, a total of twenty-one orders have arguably been attested out of the twenty-four permutations that unconstrained movement would allow. All twenty-one of the attested orders are among the separable permutations; the nonseparable permutations (1g,j) 'five lads these young' and 'young these lads five' are not attested.

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

<sup>7</sup> 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.



**4. COMBINATORY CATEGORIAL GRAMMAR.** Combinatory categorial grammar 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.<sup>8</sup>

**4.1. ORDER OF COMMAND AS A SUBSTANTIVE UNIVERSAL.** Hawkins (1983:121–22) 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  $X$ ’.<sup>9</sup>

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

In the minimalist notation of Chomsky (1995b, 2001), as interpreted by Stabler (2011), 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 nondirectional slashes ( $|Y$ ). Stabler (2011) also discusses a DIRECTIONAL MINIMALIST GRAMMAR, which distinguishes language-specific directionality as  $=X$  and  $X=$ , equivalent to CCG directional slashes  $/Y$  and  $\backslash Y$  (see below).

Although Cinque does not remark on the fact, such lexicons are closely related to his assumption of a universal order of command  $Dem > Num > Adj > N$  over the relevant categories (2005:315, 321, *passim*), 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

<sup>8</sup> 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 §8. In particular, the systems studied by Vijay-Shanker and Weir (1994), Baldrige and Kruijff (2003), Koller and Kuhlmann (2009), and Kuhlmann et al. (2010, 2015), some of which exhibit slight differences in expressive power, are restricted in both respects. Accordingly, the limitation to separable permutations applies to all of these variants, and implicitly to earlier variants as well.

<sup>9</sup> 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.



the set of properties of that type. Thus the dominance order  $\text{Dem} > \text{Num} > \text{A} > \text{N}$  expressed in these categories is a substantive or functional universal stemming from their semantics. It is unnecessary to independently stipulate a UOC 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 very common English NP order is a version of Hawkins's in 2 above in which all instances of  $|$  are instantiated as  $/$ , meaning that they have to combine with an element to their right, as in 4.<sup>10</sup>

- (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  $Y$  to the right and left, respectively, 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' =  $N$

In the terms of minimalist theory, the distinction between forward categories  $X/Y$  and backward categories  $X\backslash Y$  corresponds exactly 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 UOC. And indeed, some orders attested by Nchare and allowed by CCG do controvert this prediction.<sup>11</sup>

**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.

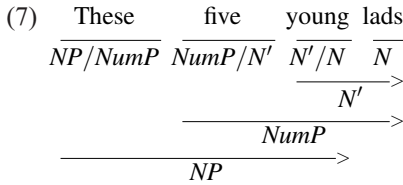
- (6) THE APPLICATION RULES  
 a.  $X/\star Y \ Y \Rightarrow X \quad (>)$   
 b.  $Y \ X\backslash\star Y \Rightarrow X \quad (<)$

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 it 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 given in 4 above.

<sup>10</sup> Of course, we need further lexical categories to allow, for example, *these young lads*, *five lads* as NP. This might be done via underspecification using X-bar-theoretic features (Chomsky 1970).

<sup>11</sup> I am grateful to associate editor Lisa Travis for drawing my attention to this point.



The rightward arrow > on all combinations in 7 indicates that it is the rightward functional application rule 6a that has applied in these cases.<sup>12</sup>

It will be obvious at this point that the two application rules in 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 in 2, ‘/’ 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 the application rules (6) alone (and hence, in minimalist terms, without movement).<sup>13</sup>

- (8) a.  $\overline{NP/NumP} \quad \overline{NumP/N'} \quad \overline{N'/N} \quad \overline{N}$  (very many)
- b.  $\overline{NP/NumP} \quad \overline{NumP/N'} \quad \overline{N} \quad \overline{N'\backslash N}$  (many)
- n.  $\overline{NP/NumP} \quad \overline{N'/N} \quad \overline{N} \quad \overline{NumP\backslash N'}$  (few\*)
- o.  $\overline{NP/NumP} \quad \overline{N} \quad \overline{N'\backslash N} \quad \overline{NumP\backslash N'}$  (many)
- r.  $\overline{NumP/N'} \quad \overline{N'/N} \quad \overline{N} \quad \overline{NP\backslash NumP}$  (few\*)
- s.  $\overline{NumP/N'} \quad \overline{N} \quad \overline{N'\backslash N} \quad \overline{NP\backslash NumP}$  (many\*)
- w.  $\overline{N'/N} \quad \overline{N} \quad \overline{NumP\backslash N'} \quad \overline{NP\backslash NumP}$  (very few)
- x.  $\overline{N} \quad \overline{N'\backslash N} \quad \overline{NumP\backslash N'} \quad \overline{NP\backslash NumP}$  (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 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.

In order to capture the remaining attested orders, however, 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 & Ouwayda 2018 for regression analyses comparing the empirical fit of these ap-

<sup>12</sup> 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  $X|Y$  has logical form  $f$  and the argument  $Y$  has logical form  $a$ , then the result  $X$  always has logical form  $fa$  (read ‘ $f$  of  $a$ ’). Thus, semantics is ‘surface compositional’ in CCG.

<sup>13</sup> The discontinuous alpha-numeration reflects Cinque’s ordering of the twenty-four permutations of these elements introduced earlier in 1, which we take as standard. Ranked counts that reflect changes from Cinque 2005 in Cinque 2013b are again marked \*.

proaches to these data). CCG offers base-generative alternatives to movement, or other syntactic operations over noncontiguous 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.<sup>14</sup>

(9) THE HARMONIC COMPOSITION RULES

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

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

(10) THE CROSSING COMPOSITION RULES

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

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

All syntactic rules in CCG are subject to a generalization called the COMBINATORY PROJECTION PRINCIPLE, which says that rules must apply consistent with the directionality specified on the primary function  $X|Y$ , and must project unchanged onto their result  $X|Z$ ... the directionality of any argument(s)  $Z$ ... specified on the secondary function  $Y|Z$ ...<sup>15</sup>

(11) THE COMBINATORY PROJECTION PRINCIPLE (CPP): Syntactic combinatory rules are binary rules that apply to contiguous nonempty 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.

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

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 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  $\backslash$  in both input and output.

(13) THE FORWARD CROSSING SECOND-ORDER COMPOSITION RULE

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

The combination of crossing rules and second-order composition is the source of (slightly) greater than context-free expressive power in CCG, allowing analyses of

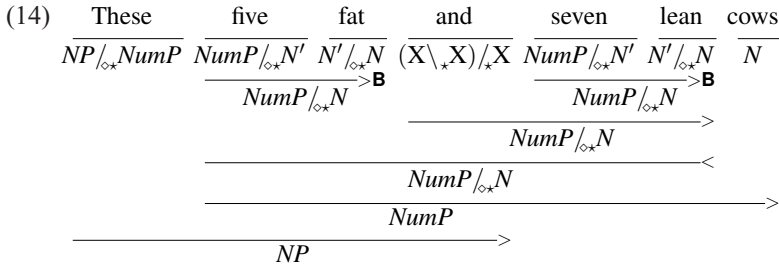
<sup>14</sup> While we continue to suppress explicit semantics for the purposes of the present article, like the application rules in 6, the composition rules in 9 and 10 have an invariant surface-compositional semantics, such that if the meaning of the primary function  $X|Y$  is a functor  $f$  and 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  $f(g a)$ .

<sup>15</sup> This principle is defined more formally in Steedman 2000b, 2012 as the conjunction of three more elementary principles of ADJACENCY, CONSISTENCY, and INHERITANCE.

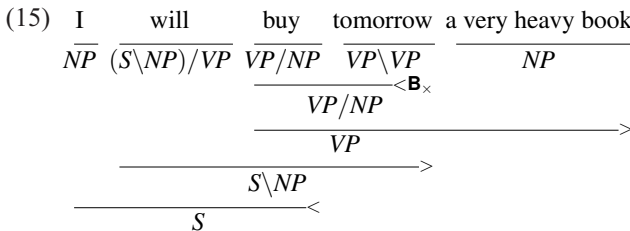
trans-context-free constructions like Germanic crossed dependencies (Bresnan et al. 1982, Steedman 2000b, and below). However, this rule and the other three second-order rules, which are parallel to the first-order rules 9a,b and 10a, continue to exclude non-separable permutations under the CPP (11).<sup>16</sup>

The types  $\diamond$  and  $\times$  on the slashes on the primary function  $X|Y$  in the composition rules in 9 and 10 above, like the type  $\star$  on the application rules in 6, allow 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 CPP (11) requires that the corresponding slash-type(s) in the result  $X|Z\dots$  is the SAME slash-type.

The inclusion of the harmonic composition rules (9) allows some additional derivations and supports a variety of ‘nonconstituent’ coordinations, of which the following is the simplest example.<sup>17</sup>



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, as in 15.



It will be obvious from the above derivation that allowing the crossing composition rules in 10 to apply to unrestricted categories induces ALTERNATION OF WORD ORDER, as here 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 in 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

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

<sup>17</sup> 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 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).

to apply to a forward category, then we assign it the union of all three slash-types  $X/\diamond_{\star}Y$ , which to save space and maintain compatibility with earlier notations I write as the universal slash  $X/Y$ .<sup>18</sup>

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 UOC 1, 2, 3, 4, it follows that CCG allows just twenty-two of the twenty-four possible orderings of the four elements. The derivations for these orders are shown in 20 below. It is obvious by inspection that the two nonseparable permutations 2, 4, 1, 3 and 3, 1, 4, 2 exhibited in the following mirror-image pair are impossible for these categories.<sup>19</sup>

(16) g.	Five	lads	these	young
	<i>NumP N'</i>	<i>N</i>	<i>NP NumP</i>	<i>N' N</i>
	2	4	1	3
j.	Young	these	lads	five
	<i>N' N</i>	<i>NP NumP</i>	<i>N</i>	<i>NumP N'</i>
	3	1	4	2

The CPP (11), and in particular the PRINCIPLE OF ADJACENCY that it subsumes, means that combinatory rules can combine only 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  $NP|NumP$  and  $NumP|N'$ , so that any further derivation is blocked.<sup>20</sup>

The generalization that follows from these observations is that, under the CPP (11) governing combinatory rules, an ordered set of  $n$  categories of the form  $\{A|B, B|C, C|D, \dots M|N, N\}$  can only give rise to permutations of that order that are SEPARABLE in the sense defined in the introduction.<sup>21</sup>

It follows that an attestation in the free-order language Latin of the following NP word orders as alternatives to *hæ quinque puellæ pulchræ* ‘these five beautiful girls’ would be a strong counterexample to CCG in its present form as a theory of grammar.<sup>22</sup>

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

<sup>18</sup> The slash-typing convention used in this article 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  $X/\star Y$  was written  $X/\star Y$ . 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.

<sup>19</sup> The odd alphabetization is again to align them with the full set of twenty-four permutations given in 1.

<sup>20</sup> See Koller & Kuhlmann 2009 for discussion and a comparison with tree-adjointing grammars (TAG; Joshi 1988), which are interestingly different in this respect.

<sup>21</sup> Stanojević and Steedman (2018) provide a formal proof for the general case of  $n$  elements.

<sup>22</sup> As noted above, following Cinque, one needs to take care in considering such judgments 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.

Both seem very bad to this author's schoolboy Latin ear, but are offered as hostages to fortune.<sup>23</sup>

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 (see 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 return below. It is also striking that these forbidden word orders are excluded in Shupamem under Nchare's LCA-based account only 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 (2005:322, n. 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. n. 22). Cinque further notes that when Senft (1986:96) gives a citation example of exactly the construction at 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, ex. 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 agreement and numerator (Mosel 2017:263).

- (18) o        bua naono    o        bua kikis  
       [ART2.SG two chief]<sub>NP</sub> [ART2.SG two strong]<sub>AP</sub>  
       'two strong chiefs'

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

- (19) o        vuaba vai        o        kare tavus  
       [ART2.SG one DEM6]<sub>NP</sub> [ART2.SG recently come.out]<sub>AP</sub>  
       'one that has just come out'

<sup>23</sup> 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.

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.<sup>24</sup>

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 UOC. 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 goes against 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 CPP (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 nonseparable permutations (g) and (j) that are unanalyzable in CCG as a consequence of the CPP, while ‘?’ marks the only word order unattested by either author that CCG would allow). For nonbasic 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: v.few)
$\overline{NP/NumP}$	$\overline{N}$	$\overline{NumP/N'}$	$\overline{N'\backslash N}$	
$\xrightarrow{>B_x}$				
- d. 

Lads	these	five	young	(Cinque; from b: few)
$\overline{N}$	$\overline{NP/NumP}$	$\overline{NumP/N'}$	$\overline{N'\backslash N}$	
$\xrightarrow{>B}$				
$\overline{NP/N'}$				
$\xrightarrow{>B_x}$				
$\overline{NP\backslash N}$				
- e. 

Five	these	young	lads	(Nchare; from r)
$\overline{NumP/N'}$	$\overline{NP\backslash NumP}$	$\overline{N'/N}$	$\overline{N}$	
$\xrightarrow{<B_x}$				
$\overline{NP/N'}$				
- f. 

Five	these	lads	young	(Nchare; from s)
$\overline{NumP/N'}$	$\overline{NP\backslash NumP}$	$\overline{N}$	$\overline{N'\backslash N}$	
$\xrightarrow{<B_x}$				
$\overline{NP/N'}$				

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



- g. × Five lads these young (not attested; disallowed)  

$$\frac{\frac{\frac{\text{NumP}/\text{N}'}{\text{N}}}{\text{NP}\backslash\text{NumP}}}{\text{N}'\backslash\text{N}}$$
- h. ? Lads five these young (not attested; from s)  

$$\frac{\frac{\frac{\frac{\text{N}}{\text{NumP}/\text{N}'}}{\text{NP}\backslash\text{NumP}}}{\text{N}'\backslash\text{N}}}{\text{NP}/\text{N}'}}{\text{NP}\backslash\text{N}} \rightarrow \mathbf{B}_\times$$
- i. Young these five lads (Nchare; from n)  

$$\frac{\frac{\frac{\frac{\text{N}'/\text{N}}{\text{NP}/\text{NumP}}}{\text{NumP}\backslash\text{N}'}}{\text{N}}}{\text{NP}\backslash\text{N}'}}{\text{NP}/\text{N}} \leftarrow \mathbf{B}_\times$$
- j. × Young these lads five (not attested; disallowed)  

$$\frac{\frac{\frac{\frac{\text{N}'/\text{N}}{\text{NP}/\text{NumP}}}{\text{N}}}{\text{NumP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}'}}{\text{NP}/\text{N}}$$
- k. Young lads these five (both; from n: v.few)  

$$\frac{\frac{\frac{\frac{\text{N}'/\text{N}}{\text{N}}}{\text{NP}/\text{NumP}}}{\text{NumP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}} \rightarrow \mathbf{B}_\times$$
- l. Lads young these five (both; from o: few)  

$$\frac{\frac{\frac{\frac{\text{N}}{\text{N}'\backslash\text{N}}}{\text{NP}/\text{NumP}}}{\text{NumP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}} \rightarrow \mathbf{B}_\times$$
- m. These young five lads (Nchare; from n)  

$$\frac{\frac{\frac{\frac{\text{NP}/\text{NumP}}{\text{N}'/\text{N}}}{\text{NumP}\backslash\text{N}'}}{\text{N}}}{\text{NumP}/\text{N}} \leftarrow \mathbf{B}_\times$$
- n. These young lads five (both; basic: few\*)  

$$\frac{\frac{\frac{\frac{\text{NP}/\text{NumP}}{\text{N}'/\text{N}}}{\text{N}}}{\text{NumP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}}$$
- o. These lads young five (both; basic: many)  

$$\frac{\frac{\frac{\frac{\text{NP}/\text{NumP}}{\text{N}}}{\text{N}'\backslash\text{N}}}{\text{NumP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}'}}{\text{NP}\backslash\text{N}}$$
- p. Lads these young five (both; from o: v.few)  

$$\frac{\frac{\frac{\frac{\frac{\text{N}}{\text{NP}/\text{NumP}}}{\text{N}'\backslash\text{N}}}{\text{NumP}\backslash\text{N}'}}{\text{NumP}\backslash\text{N}}}{\text{NP}\backslash\text{N}}} \leftarrow \mathbf{B}$$
- q. Five young these lads (Nchare; from r)  

$$\frac{\frac{\frac{\frac{\frac{\text{NumP}/\text{N}'}{\text{N}'/\text{N}}}{\text{NP}\backslash\text{NumP}}}{\text{N}}}{\text{NumP}/\text{N}}} \rightarrow \mathbf{B}$$
- r. Five young lads these (both; basic: few\*)  

$$\frac{\frac{\frac{\frac{\frac{\text{NumP}/\text{N}'}{\text{N}'/\text{N}}}{\text{N}}}{\text{NP}\backslash\text{NumP}}}{\text{NP}\backslash\text{N}}} \leftarrow \mathbf{B}_\times$$
- s. Five lads young these (both; basic: many\*)  

$$\frac{\frac{\frac{\frac{\frac{\text{NumP}/\text{N}'}{\text{N}}}{\text{N}'\backslash\text{N}}}{\text{NP}\backslash\text{NumP}}}{\text{NP}\backslash\text{N}}}{\text{NP}\backslash\text{N}}$$

t.	$\begin{array}{cccc} \text{Lads} & \text{five} & \text{young} & \text{these} \\ \hline N & \text{NumP}/N' & N'\backslash N & NP\backslash \text{NumP} \\ \hline \end{array}$ $\xrightarrow{\text{B}_\times}$ $\text{NumP}\backslash N$	(both; from s: few)
u.	$\begin{array}{cccc} \text{Young} & \text{five} & \text{these} & \text{lads} \\ \hline N'/N & \text{NumP}\backslash N' & NP\backslash \text{NumP} & N \\ \hline \end{array}$ $\xleftarrow{\text{B}}$ $NP\backslash N'$ $\xleftarrow{\text{B}_\times}$ $NP/N$	(Nchare; from w)
v.	$\begin{array}{cccc} \text{Young} & \text{five} & \text{lads} & \text{these} \\ \hline N'/N & \text{NumP}\backslash N' & N & NP\backslash \text{NumP} \\ \hline \end{array}$ $\xleftarrow{\text{B}_\times}$ $\text{NumP}/N$	(Nchare; from w)
w.	$\begin{array}{cccc} \text{Young} & \text{lads} & \text{five} & \text{these} \\ \hline N'/N & N & \text{NumP}\backslash N' & NP\backslash \text{NumP} \\ \hline \end{array}$	(both; basic: v.few)
x.	$\begin{array}{cccc} \text{Lads} & \text{young} & \text{five} & \text{these} \\ \hline N & N'\backslash N & \text{NumP}\backslash N' & NP\backslash \text{NumP} \\ \hline \end{array}$	(both; basic: v.many)

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

- (i) 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 UOC determined by the four unordered categories in 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.
- (ii) Each of the six further orders attested by Cinque (c, d, k, l, p, t) and a seventh (m) on which he reserves judgment 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.)
- (iii) None of the derived orders attested by Cinque is higher in frequency rank than the basic order whose CCG lexicon it shares.
- (iv) Another six derived orders that are attested only 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.
- (v) 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, 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 the 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 et 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 toward 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 twenty-two 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, 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 twenty-four 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 twenty-four (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:

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

In our case this can be instantiated as:

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

In other words, the probability of getting this result by chance is about one in a hundred.<sup>25</sup>

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.<sup>26</sup>

**6. ANALYSIS II: LANGUAGE-SPECIFIC WORD ORDERS FOR NP.** In this section we ask how the lexicon of any language can enforce either a single word order, or a specific set of word-order alternations.

**6.1. LANGUAGE-SPECIFIC LEXICONS FOR CINQUE'S FIXED NP ORDERS.** According to both 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 in 8 above 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.

$$\begin{array}{ccccccc}
 (23) \text{ c.} & \text{These} & \text{lads} & \text{five} & \text{young} & & \\
 & \overline{NP/NumP} & \overline{N} & \overline{NumP/N'} & \overline{N'\backslash N} & & \\
 & & & & \xrightarrow{\mathbf{B}^\times} & & \\
 & & & & \overline{NumP\backslash N} & & \\
 & & & & \xleftarrow{} & & \\
 & & & & \overline{NumP} & & \\
 & \xrightarrow{} & & & & & \\
 & \overline{NP} & & & & & \\
 & \xrightarrow{} & & & & & 
 \end{array}$$

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  $X|Y$  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.

$$\begin{array}{ll}
 (24) \text{ 'these'} & = NP/\star NumP \\
 \text{'five'} & = NumP/\times N' \\
 \text{'young'} & = N'\backslash\star N \\
 \text{'lads'} & = N
 \end{array}$$

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.<sup>27</sup>

<sup>25</sup> 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.

<sup>26</sup> 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.

<sup>27</sup> Certain adjectives in French can also appear before the noun, as in *jeune fille/fille jeune*. The meanings differ, however, and the pronominal forms, where allowed, are arguably separately lexicalized. In other Romance languages where AN order is genuinely free, we might want to use the nondirectional slash  $|_{\star}$  from 2 for the adjective category, allowing both forward and backward application.

- (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 ‘nonconstituent’ 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 of 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.<sup>28</sup>

- (26) a.  $\frac{\text{These} \quad \text{five} \quad \text{young} \quad \text{lads}}{NP/\star NumP \quad NumP/\star N' \quad N'\backslash\star N \quad N}$  (Cinque; basic)
- b.  $\frac{\text{These} \quad \text{five} \quad \text{lads} \quad \text{young}}{NP/\star NumP \quad NumP/\star N' \quad N \quad N'\backslash\star N}$  (Cinque; basic)
- c.  $\frac{\text{These} \quad \text{lads} \quad \text{five} \quad \text{young}}{NP/\star NumP \quad N \quad NumP/\times N' \quad N'\backslash\star N}$  (Cinque; from b)  
 $\frac{\hspace{10em}}{NumP\backslash\star N} >B_{\times}$
- d.  $\frac{\text{Lads} \quad \text{these} \quad \text{five} \quad \text{young}}{N \quad NP/\diamond NumP \quad NumP/\times N' \quad N'\backslash\star N}$  (Cinque; from b)  
 $\frac{\hspace{2em}}{NP/\times N'} >B$   
 $\frac{\hspace{10em}}{NP\backslash\star N} >B_{\times}$
- e.  $\frac{\text{Five} \quad \text{these} \quad \text{young} \quad \text{lads}}{NumP/\star N' \quad NP\backslash\star NumP \quad N'\backslash\star N \quad N}$   
 $\frac{\hspace{2em}}{NP/\star N'} <B_{\times}$
- f.  $\frac{\text{Five} \quad \text{these} \quad \text{lads} \quad \text{young}}{NumP/\star N' \quad NP\backslash\star NumP \quad N \quad N'\backslash\star N}$   
 $\frac{\hspace{2em}}{NP/\star N'} <B_{\times}$
- g.  $\times \frac{\text{Five} \quad \text{lads} \quad \text{these} \quad \text{young}}{NumP/N' \quad N \quad NP\backslash NumP \quad N'\backslash N}$  (disallowed)  
 $\frac{\hspace{10em}}{\hspace{10em}} *$
- h. ?  $\frac{\text{Lads} \quad \text{five} \quad \text{these} \quad \text{young}}{N \quad NumP/\times N' \quad NP\backslash\star NumP \quad N'\backslash\star N}$   
 $\frac{\hspace{2em}}{NP/\times N'} <B_{\times}$   
 $\frac{\hspace{10em}}{NP\backslash\star N} >B_{\times}$

<sup>28</sup> In a few cases, there is more than one way of specifying the same order. We return to the orders attested in Shupamem later, since those orders DO alternate with others.

- i.  $\frac{\text{Young}}{N'/_*N} \frac{\text{these}}{NP/_*NumP} \frac{\text{five}}{NumP\_*_N'} \frac{\text{lads}}{N}$   
 $\frac{NP\_*_N'}{>B_x}$   
 $\frac{NP/_*N}{<B_x}$
- j. ×  $\frac{\text{Young}}{N'/_*N} \frac{\text{these}}{NP/NumP} \frac{\text{lads}}{N} \frac{\text{five}}{NumP\_*_N'}$  (disallowed)  
 $\frac{*}{*}$
- k.  $\frac{\text{Young}}{N'/_*N} \frac{\text{lads}}{N} \frac{\text{these}}{NP/_*NumP} \frac{\text{five}}{NumP\_*_N'}$  (Cinque; from n)  
 $\frac{NP\_*_N'}{>B_x}$
- l.  $\frac{\text{Lads}}{N} \frac{\text{young}}{N'\_*_N} \frac{\text{these}}{NP/_*NumP} \frac{\text{five}}{NumP\_*_N'}$  (Cinque; from o)  
 $\frac{NP\_*_N'}{>B_x}$
- m.  $\frac{\text{These}}{NP/_*NumP} \frac{\text{young}}{N'/_*N} \frac{\text{five}}{NumP\_*_N'} \frac{\text{lads}}{N}$   
 $\frac{NumP\_*_N'}{<B_x}$
- n.  $\frac{\text{These}}{NP/_*NumP} \frac{\text{young}}{N'/_*N} \frac{\text{lads}}{N} \frac{\text{five}}{NumP\_*_N'}$  (Cinque; basic)
- o.  $\frac{\text{These}}{NP/_*NumP} \frac{\text{lads}}{N} \frac{\text{young}}{N'\_*_N} \frac{\text{five}}{NumP\_*_N'}$  (Cinque; basic)
- p.  $\frac{\text{Lads}}{N} \frac{\text{these}}{NP/_*NumP} \frac{\text{young}}{N'\_*_N} \frac{\text{five}}{NumP\_*_N'}$  (Cinque; from o)  
 $\frac{NumP\_*_N'}{<B}$   
 $\frac{NP\_*_N}{>B_x}$
- q.  $\frac{\text{Five}}{NumP/_*N'} \frac{\text{young}}{N'\_*_N} \frac{\text{these}}{NP\_*_NumP} \frac{\text{lads}}{N}$   
 $\frac{NumP/_*N'}{>B}$   
 $\frac{NP/_*N}{<B_x}$
- r.  $\frac{\text{Five}}{NumP/_*N'} \frac{\text{young}}{N'\_*_N} \frac{\text{lads}}{N} \frac{\text{these}}{NP\_*_NumP}$  (Cinque; basic)
- s.  $\frac{\text{Five}}{NumP/_*N'} \frac{\text{lads}}{N} \frac{\text{young}}{N'\_*_N} \frac{\text{these}}{NP\_*_NumP}$  (Cinque; basic)
- t.  $\frac{\text{Lads}}{N} \frac{\text{five}}{NumP/_*N'} \frac{\text{young}}{N'\_*_N} \frac{\text{these}}{NP\_*_NumP}$  (Cinque; from s)  
 $\frac{NumP\_*_N'}{>B_x}$
- u.  $\frac{\text{Young}}{N'/_*N} \frac{\text{five}}{NumP\_*_N'} \frac{\text{these}}{NP\_*_NumP} \frac{\text{lads}}{N}$   
 $\frac{NP\_*_N'}{<B}$   
 $\frac{NP/_*N}{<B_x}$

- v. 
$$\begin{array}{cccc} \text{Young} & \text{five} & \text{lads} & \text{these} \\ \hline N' / \star N & \text{NumP} \backslash \star N' & N & NP \backslash \star \text{NumP} \\ \hline & \text{NumP} / \star N & & \end{array} \left\langle \mathbf{B}_\times \right.$$
- w. 
$$\begin{array}{ccc} \text{Young} & \text{lads} & \text{five} & \text{these} \\ \hline N' / \star N & N & \text{NumP} \backslash \star N' & NP \backslash \star \text{NumP} \end{array}$$
 (Cinque; basic)
- x. 
$$\begin{array}{ccc} \text{Lads} & \text{young} & \text{five} & \text{these} \\ \hline N & N' \backslash \star N & \text{NumP} \backslash \star N' & NP \backslash \star \text{NumP} \end{array}$$
 (Cinque; basic)

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.

For any of the twenty-two 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 not already there but are in the alternate's fixed-order lexicon. For example, adding  $N' \backslash \star N$  to (a) makes it alternate with (b). Adding  $\text{NumP} / \star N'$  and/or  $NP \backslash \star \text{NumP}$  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 nondirectional 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 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 NA order in (b) with AN in (a) require the presence of a prefix *pi* 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 (*i*) that appears to map  $N'/N$  to  $N' \backslash N$  and  $\text{NumP}/N'$  to  $\text{NumP} \backslash N'$ , 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 2012:192–94, 202–4).<sup>29</sup>

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

Thus, we can come close to capturing the variety of alternation in the Shupamem NP in the following lexicon.<sup>30</sup>

<sup>29</sup> The demonstrative also agrees in noun class with the *pi*-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 *pi*-marking.

<sup>30</sup> 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).



- (27) ‘these’ :=  $NP/NumP$  or  $NP\backslash NumP$
- $p$ -‘these’ :=  $NP/_x NumP$  or  $NP\backslash_x NumP$
- ‘five’ :=  $NumP/_x N'$  or  $NumP\backslash_x N'$
- $pi$ -‘five’ :=  $NumP\backslash N'$
- ‘young’ :=  $N'/N$
- $pi$ -‘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, all of the lexical alternations, whether morphologically marked or not, are HOMOMORPHIC, with the same UOC.

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

- (28) a.  $\frac{\text{These} \quad \text{five} \quad \text{young} \quad \text{lads}}{NP/NumP \quad NumP/N' \quad N'/N \quad N}$  (Nchare; basic)
- b.  $\frac{\text{These} \quad \text{five} \quad \text{lads} \quad \text{pí-young}}{NP/NumP \quad NumP/N' \quad N \quad N'\backslash N}$  (Nchare; basic)
- c.  $\frac{\text{These} \quad \text{lads} \quad \text{pí-five} \quad \text{pí-young}}{NP/NumP \quad N \quad NumP\backslash N' \quad N'\backslash N}$
- d.  $\frac{\text{Lads} \quad \text{p-these} \quad \text{pí-five} \quad \text{pí-young}}{N \quad NP/_x NumP \quad NumP\backslash N' \quad N'\backslash N}$   
 $\frac{\hspace{10em}}{NP\backslash N'} >B_x$
- e.  $\frac{\text{Five} \quad \text{these} \quad \text{young} \quad \text{lads}}{NumP/N' \quad NP\backslash NumP \quad N'/N \quad N}$  (Nchare; from r)  
 $\frac{\hspace{10em}}{NP/N'} <B_x$
- f.  $\frac{\text{Five} \quad \text{these} \quad \text{lads} \quad \text{pí-young}}{NumP/N' \quad NP\backslash NumP \quad N \quad N'\backslash N}$  (Nchare; from s)  
 $\frac{\hspace{10em}}{NP/N'} <B_x$
- g.  $\times \frac{\text{Five} \quad \text{lads} \quad \text{p-these} \quad \text{pí-young}}{NumP/N' \quad N \quad NP\backslash NumP \quad N'\backslash N}$  (disallowed)  
 $\frac{\hspace{10em}}{\hspace{10em}}^*$
- h. ?  $\frac{\text{Lads} \quad \text{pí-five} \quad \text{p-these} \quad \text{pí-young}}{N \quad NumP\backslash N' \quad NP\backslash_x NumP \quad N'\backslash N}$
- i.  $\frac{\text{Young} \quad \text{these} \quad \text{five} \quad \text{lads}}{N'/N \quad NP/NumP \quad NumP\backslash_x N' \quad N}$  (Nchare; from n)  
 $\frac{\hspace{10em}}{NP\backslash_x N'} >B_x$   
 $\frac{\hspace{10em}}{NP/N} <B_x$
- j.  $\times \frac{\text{Young} \quad \text{these} \quad \text{lads} \quad \text{pí-five}}{N'/N \quad NP/NumP \quad N \quad NumP\backslash N'}$  (disallowed)  
 $\frac{\hspace{10em}}{\hspace{10em}}^*$
- k.  $\frac{\text{Young} \quad \text{lads} \quad \text{p-these} \quad \text{pí-five}}{N'/N \quad N \quad NP/_x NumP \quad NumP\backslash N'}$  (Nchare; from n)  
 $\frac{\hspace{10em}}{NP\backslash N'} >B_x$

- l.  $\frac{\text{Lads } \overline{\text{pí-young}} \quad \overline{\text{p-these}} \quad \overline{\text{pí-five}}}{\overline{N} \quad \overline{N' \setminus N} \quad \overline{NP / \times \text{NumP}} \quad \overline{\text{NumP} \setminus N'}}$  (Nchare; from o)  
 $\xrightarrow{\text{NumP} \setminus N'} \mathbf{B}_\times$
- m.  $\frac{\text{These } \overline{\text{young}} \quad \overline{\text{five}} \quad \overline{\text{lads}}}{\overline{NP / \text{NumP}} \quad \overline{N' / N} \quad \overline{\text{NumP} \setminus \times N'} \quad \overline{N}}$  (Nchare; from n)  
 $\xleftarrow{\text{NumP} / N} \mathbf{B}_\times$
- n.  $\frac{\text{These } \overline{\text{young}} \quad \overline{\text{lads}} \quad \overline{\text{pí-five}}}{\overline{NP / \text{NumP}} \quad \overline{N' / N} \quad \overline{N} \quad \overline{\text{NumP} \setminus N'}}$  (Nchare; basic)
- o.  $\frac{\text{These } \overline{\text{lads}} \quad \overline{\text{pí-young}} \quad \overline{\text{pí-five}}}{\overline{NP / \text{NumP}} \quad \overline{N} \quad \overline{N' \setminus N} \quad \overline{\text{NumP} \setminus N'}}$  (Nchare; basic)
- p.  $\frac{\text{Lads } \overline{\text{p-these}} \quad \overline{\text{pí-young}} \quad \overline{\text{pí-five}}}{\overline{N} \quad \overline{NP / \times \text{NumP}} \quad \overline{N' \setminus N} \quad \overline{\text{NumP} \setminus N'}}$  (Nchare; from o)  
 $\xleftarrow{\text{NumP} \setminus N} \mathbf{B}$   
 $\xrightarrow{\text{NP} \setminus N} \mathbf{B}_\times$
- q.  $\frac{\text{Five } \overline{\text{young}} \quad \overline{\text{these}} \quad \overline{\text{lads}}}{\overline{\text{NumP} / N'} \quad \overline{N' / N} \quad \overline{NP \setminus \text{NumP}} \quad \overline{N}}$  (Nchare; from r)  
 $\xrightarrow{\text{NumP} / N} \mathbf{B}$   
 $\xleftarrow{\text{NP} / N} \mathbf{B}_\times$
- r.  $\frac{\text{Five } \overline{\text{young}} \quad \overline{\text{lads}} \quad \overline{\text{p-these}}}{\overline{\text{NumP} / N'} \quad \overline{N' / N} \quad \overline{N} \quad \overline{NP \setminus \times \text{NumP}}}$  (Nchare; basic)
- s.  $\frac{\text{Five } \overline{\text{lads}} \quad \overline{\text{pí-young}} \quad \overline{\text{p-these}}}{\overline{\text{NumP} / N'} \quad \overline{N} \quad \overline{N' \setminus N} \quad \overline{NP \setminus \times \text{NumP}}}$  (Nchare; basic)
- t. !  $\frac{\text{Lads } \overline{\text{pí-five}} \quad \overline{\text{pí-young}} \quad \overline{\text{p-these}}}{\overline{N} \quad \overline{\text{NumP} \setminus N'} \quad \overline{N' \setminus N} \quad \overline{NP \setminus \times \text{NumP}}}$  (Nchare;  $\diamond$ )  
 $\xrightarrow{\times}$
- u.  $\frac{\text{Young } \overline{\text{five}} \quad \overline{\text{these}} \quad \overline{\text{lads}}}{\overline{N' / N} \quad \overline{\text{NumP} \setminus \times N'} \quad \overline{NP \setminus \text{NumP}} \quad \overline{N}}$  (Nchare; from u)  
 $\xleftarrow{\text{NP} \setminus \times N'} \mathbf{B}$   
 $\xleftarrow{\text{NP} / N} \mathbf{B}_\times$
- v.  $\frac{\text{Young } \overline{\text{five}} \quad \overline{\text{lads}} \quad \overline{\text{p-these}}}{\overline{N' / N} \quad \overline{\text{NumP} \setminus \times N'} \quad \overline{N} \quad \overline{NP \setminus \times \text{NumP}}}$  (Nchare; from u)  
 $\xleftarrow{\text{NumP} / N} \mathbf{B}_\times$
- w.  $\frac{\text{Young } \overline{\text{lads}} \quad \overline{\text{pí-five}} \quad \overline{\text{these}}}{\overline{N' / N} \quad \overline{N} \quad \overline{\text{NumP} \setminus N'} \quad \overline{NP \setminus \text{NumP}}}$  (Nchare; basic)
- x.  $\frac{\text{Lads } \overline{\text{pí-young}} \quad \overline{\text{pí-five}} \quad \overline{\text{these}}}{\overline{N} \quad \overline{N' \setminus N} \quad \overline{\text{NumP} \setminus N'} \quad \overline{NP \setminus \text{NumP}}}$  (Nchare; basic)

As noted above, 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  $\diamond$ ) by crossing composition, then two further separable permutations (28c,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 nonmovement 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 reasons similar 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*<sub>VP1|VP2</sub> *have*<sub>VP2|VP3</sub> *been*<sub>VP3|VP4</sub> *dancing*<sub>VP4</sub>, namely those corresponding to *\*have*<sub>VP2|VP3</sub> *dancing*<sub>VP4</sub> *might*<sub>VP1|VP2</sub> *been*<sub>VP3|VP4</sub> and *\*been*<sub>VP3|VP4</sub> *might*<sub>VP1|VP2</sub> *dancing*<sub>VP4</sub> *have*<sub>VP2|VP3</sub>, 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)<sub>1</sub> V<sub>2</sub> V<sub>3</sub> Part(icle)<sub>4</sub> and V<sub>1</sub> V<sub>2</sub> V<sub>3</sub> V<sub>4</sub>. For the latter elements, Abels (2016:205) finds that, in Germanic alone, thirteen of the fourteen 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 nonpredicted orders (29f,h,m) are also weakly supported, making seventeen orders arguably attested.<sup>31</sup>

The examples below use the English words *will help teach swim* as proxy for a number of different sets of Germanic verbs V<sub>1</sub> V<sub>2</sub> V<sub>3</sub> V<sub>4</sub> of various types, including auxiliaries, modals, raising/control verbs, and participials used in these studies. As in the case of the NP, there are eight application-only permutations (a, b, n, o, r, s, w, 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 occurs only 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 picture similar to that for the elements of the NP (20). That is, only separable permutations are allowed.

- (29) a.  $\frac{\text{will}}{VP_1/VP_2} \frac{\text{help}}{VP_2/VP_3} \frac{\text{teach}}{VP_3/VP_4} \frac{\text{swim}}{VP_4}$  (Abels; basic)
- b.  $\frac{\text{will}}{VP_1/VP_2} \frac{\text{help}}{VP_2/VP_3} \frac{\text{swim}}{VP_4} \frac{\text{teach}}{VP_3 \setminus VP_4}$  (Abels; basic)
- c.  $\frac{\text{will}}{VP_1/VP_2} \frac{\text{swim}}{VP_4} \frac{\text{help}}{VP_2/VP_3} \frac{\text{teach}}{VP_3 \setminus VP_4}$  (Abels; from b)  
 $\xrightarrow{B_x}$
- d.  $\frac{\text{swim}}{VP_4} \frac{\text{will}}{VP_1/VP_2} \frac{\text{help}}{VP_2/VP_3} \frac{\text{teach}}{VP_3 \setminus VP_4}$  (Abels; from b)  
 $\xrightarrow{B}$   
 $\frac{\text{will}}{VP_1 \setminus VP_3} \frac{\text{teach}}{VP_3 \setminus VP_4}$   
 $\xrightarrow{B_x}$   
 $\frac{\text{will}}{VP_1 \setminus VP_4}$

<sup>31</sup> The verbal permutations are ordered to match Cinque’s ordering for the NP construction used elsewhere in this article. Abels’s (2016) ordering of the permutations is different.

- e. 
$$\frac{\frac{\frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2} \quad \frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{swim}}{VP_4}}{VP_1/VP_3} \leftarrow \mathbf{B}_\times}{\text{(from r)}}$$
- f. 
$$\frac{\frac{\frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{teach}}{VP_3 \setminus VP_4}}{VP_1/VP_3} \leftarrow \mathbf{B}_\times}{\text{(Abels; from s)}}$$
- g. 
$$\frac{\frac{\frac{\text{help}}{VP_2|VP_3} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{will}}{VP_1|VP_2} \quad \frac{\text{teach}}{VP_3|VP_4}}{\text{---}^*} \leftarrow \mathbf{B}_\times}{\text{(not attested; disallowed)}}$$
- h. 
$$\frac{\frac{\frac{\frac{\text{swim}}{VP_4} \quad \frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2} \quad \frac{\text{teach}}{VP_3 \setminus VP_4}}{VP_1/VP_3} \leftarrow \mathbf{B}_\times}{\text{---}^*} \rightarrow \mathbf{B}_\times}{\text{(Abels; from s)}}$$
- i. 
$$\frac{\frac{\frac{\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{swim}}{VP_4}}{VP_1 \setminus VP_3} \rightarrow \mathbf{B}_\times}{\text{---}^*} \leftarrow \mathbf{B}_\times}{\text{(from n)}}$$
- j. 
$$\frac{\frac{\frac{\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{will}}{VP_1|VP_2} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{help}}{VP_2|VP_3}}{\text{---}^*} \leftarrow \mathbf{B}_\times}{\text{(not attested; disallowed)}}$$
- k. 
$$\frac{\frac{\frac{\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{help}}{VP_2 \setminus VP_3}}{VP_1 \setminus VP_3} \rightarrow \mathbf{B}_\times}{\text{(Abels; from n)}}$$
- l. 
$$\frac{\frac{\frac{\frac{\text{swim}}{VP_4} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{help}}{VP_2 \setminus VP_3}}{VP_2 \setminus VP_3} \rightarrow \mathbf{B}_\times}{\text{(Abels; from o)}}$$
- m. 
$$\frac{\frac{\frac{\frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{swim}}{VP_4}}{VP_2/VP_4} \leftarrow \mathbf{B}_\times}{\text{(Abels; from n)}}$$
- n. 
$$\frac{\frac{\frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3}}{\text{(Abels; basic)}}$$
- o. 
$$\frac{\frac{\frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3}}{\text{(Abels; basic)}}$$
- p. 
$$\frac{\frac{\frac{\frac{\text{swim}}{VP_4} \quad \frac{\text{will}}{VP_1/VP_2} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3}}{VP_2 \setminus VP_4} \leftarrow \mathbf{B}}{\text{---}^*} \rightarrow \mathbf{B}_\times}{\text{(Abels; from o)}}$$
- q. 
$$\frac{\frac{\frac{\frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{will}}{VP_1 \setminus VP_2} \quad \frac{\text{swim}}{VP_4}}{VP_2/VP_4} \rightarrow \mathbf{B}}{\text{---}^*} \leftarrow \mathbf{B}_\times}{\text{(from r)}}$$
- r. 
$$\frac{\frac{\frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{will}}{VP_1 \setminus VP_2}}{\text{(Abels; basic)}}$$

- |    |   |                |
|----|---|----------------|
| s. | $\frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{will}}{VP_1 \setminus VP_2}$ | (Abels; basic) |
|----|---|----------------|
- |                      |   |                 |
|----------------------|---|-----------------|
| t.                   | $\frac{\text{swim}}{VP_4} \quad \frac{\text{help}}{VP_2/VP_3} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{will}}{VP_1 \setminus VP_2}$ | (Abels; from s) |
| $\xrightarrow{>B_x}$ |   |                 |
- |                      |   |          |
|----------------------|---|----------|
| u.                   | $\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2} \quad \frac{\text{swim}}{VP_4}$ | (from w) |
| $\xrightarrow{<B}$   |   |          |
| $\xrightarrow{<B_x}$ |   |          |
- |                           |   |          |
|---------------------------|---|----------|
| v.                        | $\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{will}}{VP_1 \setminus VP_2}$ | (from w) |
| $\xrightarrow{<B_x}$      |   |          |
| $\xrightarrow{VP_1/VP_4}$ |   |          |
- |    |   |                |
|----|---|----------------|
| w. | $\frac{\text{teach}}{VP_3/VP_4} \quad \frac{\text{swim}}{VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2}$ | (Abels; basic) |
|----|---|----------------|
- |    |   |                |
|----|---|----------------|
| x. | $\frac{\text{swim}}{VP_4} \quad \frac{\text{teach}}{VP_3 \setminus VP_4} \quad \frac{\text{help}}{VP_2 \setminus VP_3} \quad \frac{\text{will}}{VP_1 \setminus VP_2}$ | (Abels; basic) |
|----|---|----------------|

7.2. DISCUSSION III. Once again, the two nonseparable permutations (g,j) are absent from the attested orders in 29, including those that Abels is equivocal toward 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 twenty-two 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 two nonseparable 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 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: (i) restricting a language to a fixed verbal order requires restricting its lexicon by slash-typing; and (ii) a language with freer verbal word 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. MORPHEXICAL 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 in 30.

- (30) a.  $T \setminus (TX)$
- b.  $T \setminus (T/X)$

Here X is an argument-type (such as NP), and T is any type such that  $T \setminus X$  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:

$$(31) \quad \frac{\text{Egon} \quad \text{walks}}{\frac{S/(S \backslash NP_{3sg}) \quad S \backslash NP_{3sg}}{S} \rightarrow}$$

—but correctly continues to exclude \*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. In Latin, however, exactly the same kind of type-raising is typically disambiguated by morphologically explicit case, as seen, for example, in 32.

(32) ‘Balbus loves Livia.’

$$\begin{array}{l} \text{a.} \quad \frac{\text{Balbus} \quad \text{amat} \quad \text{Liviam}}{\text{Balbus.NOM.3sg} \quad \text{love.PRES.3sg} \quad \text{Livia.ACC.3sg}} \\ \frac{S/(S \backslash NP_{nom,3sg}) \quad (S \backslash NP_{nom,3sg}) \backslash NP_{acc} \quad (S \backslash NP_{nom}) \backslash ((S \backslash NP_{nom}) \backslash NP_{acc})}{S \backslash NP_{nom}} \leftarrow \\ \hline \frac{S}{S} \rightarrow \\ \text{b.} \quad \frac{\text{Balbus} \quad \text{Liviam} \quad \text{amat}}{\text{Balbus.NOM.3sg} \quad \text{Livia.ACC} \quad \text{love.PRES.3sg}} \\ \frac{S/(S \backslash NP_{nom,3sg}) \quad (S \backslash NP_{nom}) \backslash ((S \backslash NP_{nom}) \backslash NP_{acc}) \quad (S \backslash NP_{nom,3sg}) \backslash NP_{acc}}{S \backslash NP_{nom}} \rightarrow \\ \hline \frac{S}{S} \rightarrow \end{array}$$

The fact that the categories of the nominative and the accusative are of the form  $X|Y$  and  $Y|Z$  means that rule 9a of composition can apply, ‘canceling’ ( $S|NP$ ) and supporting ‘argument/adjunct-cluster’ coordination, sometimes subsumed to ‘gapping’ (Ross 1970), as follows.<sup>32</sup>

(33) ‘Balbus loves Livia, and Livia Balbus.’

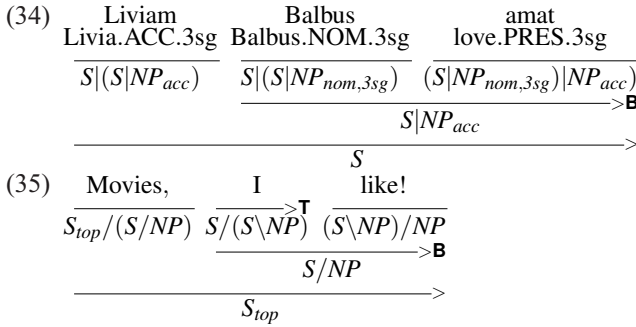
$$\frac{\frac{\text{Balbus} \quad \text{Liviam} \quad \text{et} \quad \text{Livia} \quad \text{Balbum} \quad \text{amat}}{\text{Balbus.NOM.3sg} \quad \text{Livia.ACC} \quad \text{and} \quad \text{Livia.NOM.3sg} \quad \text{Balbus.ACC} \quad \text{love.PRES.3sg}}}{\frac{S/(S \backslash NP_{nom,3sg,m}) \quad (S \backslash NP_{nom}) \backslash ((S \backslash NP_{nom}) \backslash NP_{acc}) \quad (X \backslash X) \backslash X \quad \vdots \quad (S \backslash NP_{nom,3sg}) \backslash NP_{acc}}{S/((S \backslash NP_{nom,3sg}) \backslash NP_{acc})} \rightarrow \mathbf{B}}{\frac{S/((S \backslash NP_{nom,3sg}) \backslash NP_{acc}) \quad S/((S \backslash NP_{nom,3sg}) \backslash NP_{acc})}{S/((S \backslash NP_{nom,3sg}) \backslash NP_{acc})} \rightarrow} \leftarrow \mathbf{B}$$

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 (Steedman 1985, 2000b, Dowty 1988 [1985]).

Morpholexical type-raising of arguments, together with composition, also allows scrambling and extraction, as in free word order in Latin (34) and topicalization (35) in English.<sup>33</sup>

<sup>32</sup> ‘:’ 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 nontraditional type.

<sup>33</sup> Application of the function composition rules to directionally underspecified categories  $Y|Z$ , as in 34, remains subject to the CPP (11) (Steedman & Baldrige 2011:202–4).



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]]<sub>S/(S\NP)</sub>*. 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, 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)  $\text{nominal} := NP^{\uparrow} : \lambda p.p\text{nominal}$

Here  $NP^{\uparrow}$  schematizes over a number of case-raised types, *nominal* corresponds to one of *Balbus*, *Livia*, *movies*, and so forth, and  $p$  gets bound to adjacent *loves*, *loves Livia*,  $\lambda x.like\ x\ me$ , and so on. 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 2004 [2001]), so that *Movies, I like!* ends up meaning *like movies me*.<sup>34</sup>

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 2006 [1977], Sheehan & van der Wal 2018; cf. Steedman 2000b, 2012:81).<sup>35</sup>

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 been attributed to movement.<sup>36</sup>

<sup>34</sup> 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’

<sup>35</sup> Of course, they may also mix lexical type-raising (structural or Vergnaud case) with ‘quirky’ morphological case markers, as Icelandic notoriously does.

<sup>36</sup> The latter non-order-preserving type-raising is also lexicalized, and is required by the CPP (11) to have a distinct result category (here,  $S_{top}$ ) from that of the function it applies to (here,  $S$ ).



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 UOC. It still cannot override the contiguity condition that is built into the CPP (11), although it will determine exactly which permutations are separable or otherwise.

For example, Haug (2017) analyzes 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 ...*

$S S$	$NP_{3sg,NOM}^\dagger$	$S S$	$S NP_{3sg,NOM}$
$B C$	$D$	$A B$	$C D$
2	4	1	3

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

However, the subject in 37 is morphologically NOMINATIVE, and therefore necessarily type-raised as  $S/(S\backslash NP)$ , so the derivation goes through as follows.<sup>37</sup>

(38) *discedens ab hibernis Cæsar in Italiam ... imperat ...*

$S/S$	$S/(S\backslash NP_{3sg,NOM})$	$S\backslash S$	$S\backslash NP_{3sg,NOM}$
> <b>B</b>			
$S/(S\backslash NP_{3sg,NOM})$		< <b>B</b> <sub>x</sub>	
$S/(S\backslash NP_{3sg,NOM})$			
$S$			
>			

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 nonseparable 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*

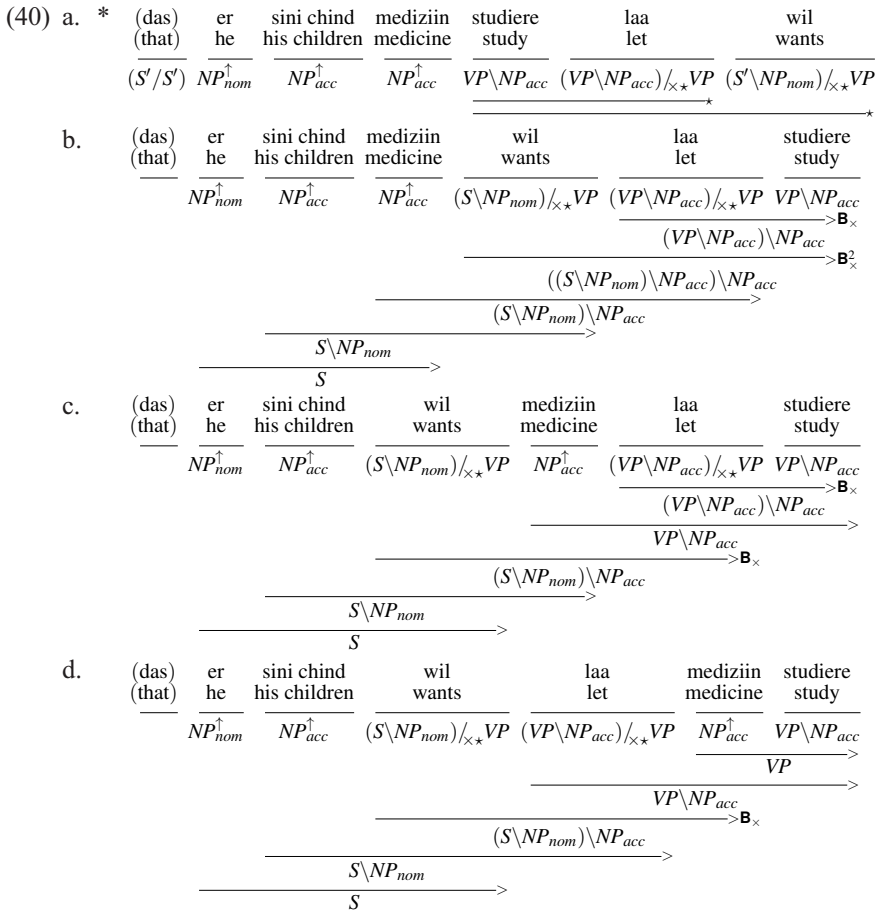
**9. ANALYSIS IV: VERBAL CONSTRUCTIONS INCLUDING NOMINAL ARGUMENTS.** This section more briefly examines some more complex verbal constructions with larger numbers of elements.

<sup>37</sup> The logical form is not shown, but I assume that the relation between *Cæsar* and the subject of absolute *discedens* is mediated by paratactic anaphora (pro-drop), 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 instead refer logophorically to the speaker or source of indirect discourse (Panhuis 1982, 2006:§384), as in the following English absolute.

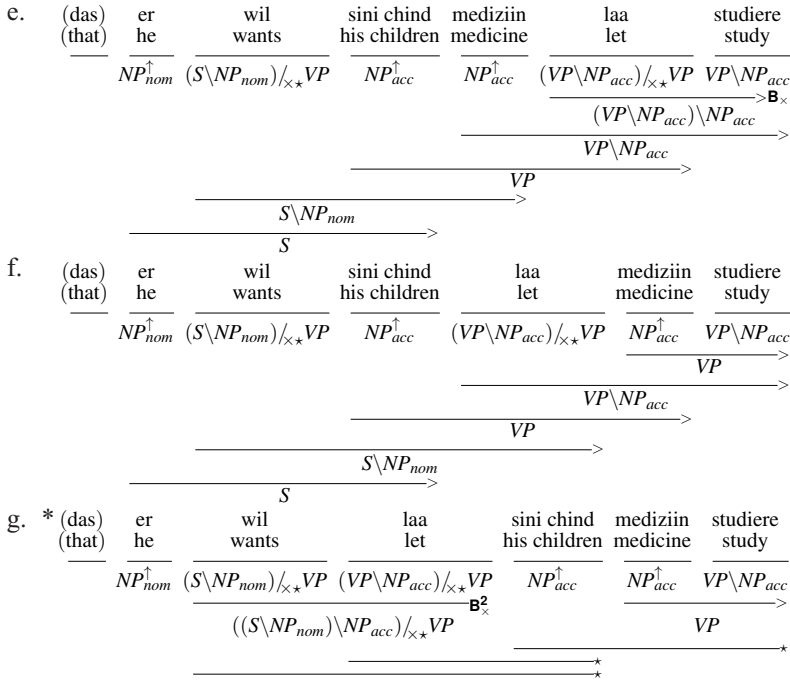
(i) Departing from winter quarters for Italy, the sun was shining.

*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–xxv). A further possibility is that *imperat* is paratactically bound to *Cæsar* by pro-drop.

**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 of the NPs (abbreviated  $NP^{\uparrow}$ ) is to require combination by forward application rather than backward.)<sup>38</sup>



<sup>38</sup> 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  $> \mathbf{B}_{\times}^2$ .



(In the latter case (g), type-raised *sini chind* cannot be lexicalized as  $VP(VP \setminus NP_{acc})$  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 nonstandard 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’.<sup>39</sup>

**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 verbs may vary), and disallowing alternations like 40c–g.<sup>40</sup>

<sup>39</sup> 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.

<sup>40</sup> Bech 1955, Evers 1975, Bresnan et al. 1982, Steedman 1985, Seuren 1985; see also van Craenenbroeck 2014, van Craenenbroeck et al. 2019.

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

The idiosyncrasy of these verbs can be captured in the following lexical fragment, in which the crucial /VP arguments are restricted by ×-only slash-type to combining only by crossing composition, while application to a complete VP is disallowed.<sup>41</sup>

- (42) zag, etc. := ((S\NP)\NP)/× VP  
 helpen, leren, etc. := (VP\NP)/× VP  
 voeren, etc. := VP\NP

The derivation of 41 is the same as that given in Steedman 2000b:141–42, and is suggested as an exercise.<sup>42</sup>

The Dutch/German infinitival verbs like *probeer**en/prober**en* referred to in the last section, 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\NP)\NP)/×  $VP_{te}$   
 probeeren, leren, helpen, etc. := (VP\NP)/★  $VP_{te}$

These categories ensure that when the *te*-infinitival itself consists of serial infinitivals, the latter CANNOT carry the *te*-complementizer (Seuren 1985).<sup>43</sup>

- (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 (Steedman 1985, Dowty 1988 [1985]), as in 45.

- (45) ‘that he wants his children to study medicine and his friends music’
- |                    |             |                           |                                |                               |                           |                  |
|--------------------|-------------|---------------------------|--------------------------------|-------------------------------|---------------------------|------------------|
| (dat)              | hij         | zijn kinderen             | medicijnen                     | en                            | zijn vrienden muziek      | wil laten leren  |
| (that)             | he          | his children              | medicine                       | and                           | his friends music         | wants let study  |
| $\overline{S'/S'}$ | $S'/(S\NP)$ | $(S\NP)/((S\NP)\NP)$      | $((S\NP)\NP)/(((S\NP)\NP)\NP)$ | $(X\backslash_X)\backslash_X$ | $(S\NP)/(((S\NP)\NP)\NP)$ | $((S\NP)\NP)\NP$ |
|                    |             | $\xrightarrow{B}$         |                                |                               | $\xrightarrow{>}$         |                  |
|                    |             | $(S\NP)/((S\NP)\NP)\NP$   |                                |                               | $(S\NP)/(((S\NP)\NP)\NP)$ |                  |
|                    |             | $\xrightarrow{>}$         |                                |                               |                           |                  |
|                    |             | $(S\NP)/(((S\NP)\NP)\NP)$ |                                |                               |                           |                  |
|                    |             | $\xrightarrow{>}$         |                                |                               |                           |                  |
|                    |             | $S\NP$                    |                                |                               |                           |                  |
|                    |             | $\xrightarrow{>}$         |                                |                               |                           |                  |
|                    |             | $S'$                      |                                |                               |                           |                  |

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

- (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

<sup>41</sup> 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.

<sup>42</sup> 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.

<sup>43</sup> The present account supersedes that in Steedman 2000b:144–46.

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
- $$\begin{array}{c} \frac{S'/S'}{NP_{acc}^\uparrow} \quad \frac{NP_{nom}^\uparrow}{NP_{acc}^\uparrow} \quad \frac{NP_{acc}^\uparrow}{((S' \setminus NP_{nom}) \setminus NP_{acc}) \setminus NP_{acc}}}{\frac{(S' \setminus NP_{nom}) \setminus NP_{acc}}{S' \setminus NP_{acc}} \rightarrow \mathbf{B}_\times} \\ \xrightarrow{S' \setminus NP_{acc}} \\ S' \end{array}$$
- (48) (daß) seine Kinder Medizin er studieren lassen will  
 (that) his children medicine he study let wants
- $$\begin{array}{c} \frac{S'/S'}{NP_{acc}^\uparrow} \quad \frac{NP_{acc}^\uparrow}{NP_{nom}^\uparrow} \quad \frac{NP_{nom}^\uparrow}{((S' \setminus NP_{nom}) \setminus NP_{acc}) \setminus NP_{acc}}}{\frac{(S' \setminus NP_{acc}) \setminus NP_{acc}}{S' \setminus NP_{acc}} \rightarrow \mathbf{B}_\times^2} \\ \xrightarrow{S' \setminus NP_{acc}} \\ S' \end{array}$$

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 of 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 of the verbs, and to then apply higher-order composition of the subject with the composite serial verb. In general, for a sequence  $NP_2^\uparrow \dots NP_n^\uparrow NP_1^\uparrow (\dots S' \setminus NP_1 \dots) \setminus NP_n$ , the first step of the derivation would require a rule  $\rightarrow \mathbf{B}_\times^{n-1}$ . (For example, the sequence with four arguments followed by four verbs— $NP_2^\uparrow NP_3^\uparrow NP_4^\uparrow NP_1^\uparrow V_4 V_3 V_2 V_1$ —would require a third-order rule  $\rightarrow \mathbf{B}_\times^3$ ; Hockenmaier & Young 2008.)<sup>44</sup>

Native-speaker judgments 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 twenty-two out of the twenty-four 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 analyzes some related order effects for Hungarian verbal complexes in categorial terms. In its comparatively free word order over these elements, Hungarian presents a problem similar to that of the Shupamem NP. The following alternations are discussed by Koopman and Szabolcsi (2000:15–17).

<sup>44</sup> 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.

- (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 rádiót* ‘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.

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

- (52) Simplified Hungarian lexical fragment
- |                       |   |
|-----------------------|---|
| nem                   | $\text{:= } S_{neg}/S_{fin}$  |
| fogok                 | $\text{:= } S_{fin}/\diamond\star VP$   |
| fogom                 | $\text{:= } S_{fin,acc}/\diamond\star VP$                                       |
| kezdeni, akarni, etc. | $\text{:= } VP_{+F}/\diamond\star VP \text{ or } VP_{-F}/\diamond\star VP_{-F}$ |
| menni                 | $\text{:= } VP \setminus \star part_{be}$                                       |
| szedni                | $\text{:= } (VP/NP) \setminus \star part_{szet}$                                |
| be                    | $\text{:= } part_{be}$  |
| szét                  | $\text{:= } part_{szet}$  |

Crucially, the backward category  $VP_{-F}/\diamond\star VP_{-F}$  of the raising infinitivals means that they can combine to the left only 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 the UOC.<sup>45</sup> This lexicon supports the following derivations for 49.

- (53) a. (Nem) fogok kezdeni akarni be menni.  
 (Not) will-I begin want in go  
 $\frac{S_{neg}/S_{fin}}{S_{fin}/\circ\star VP}$   $\frac{VP_{+F}/\circ\star VP}{VP_{+F}/\circ\star VP}$   $\frac{part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP \setminus_{\star} part_{be}}{VP}$   
 $\xrightarrow{VP_{+F}}$   
 $\xrightarrow{VP_{+F}}$   
 $\xrightarrow{S_{fin}}$   
 $\xrightarrow{S_{neg}}$
- b. (Nem) fogok kezdeni be menni akarni.  
 (Not) will-I begin in go want  
 $\frac{S_{neg}/S_{fin}}{S_{fin}/\circ\star VP}$   $\frac{VP_{+F}/\circ\star VP}{VP_{+F}/\circ\star VP}$   $\frac{part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP \setminus_{\star} part_{be}}{VP}$   $\frac{VP_{-F} \setminus_{\star} VP_{-F}}{VP_{-F} \setminus_{\star} VP_{-F}}$   
 $\xrightarrow{VP_{-F}}$   
 $\xrightarrow{VP_{+F}}$   
 $\xrightarrow{S_{fin}}$   
 $\xrightarrow{S_{neg}}$
- c. (Nem) fogok be menni akarni kezdeni.  
 (Not) will-I in go want begin  
 $\frac{S_{neg}/S_{fin}}{S_{fin}/\circ\star VP}$   $\frac{part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP_{-F} \setminus_{\star} VP_{-F}}{VP_{-F} \setminus_{\star} VP_{-F}}$   $\frac{VP_{-F} \setminus_{\star} VP_{-F}}{VP_{-F} \setminus_{\star} VP_{-F}}$   
 $\xrightarrow{VP_{-F}}$   
 $\xrightarrow{VP_{-F}}$   
 $\xrightarrow{S_{fin}}$   
 $\xrightarrow{S_{neg}}$

However, the examples in 50 are blocked by the  $-F$  feature of the inverting verb.

- (54) a. \*(Nem) fogok kezdeni be akarni menni.  
 (Not) will-I begin in want go  
 $\frac{S_{neg}/S_{fin}}{S_{fin}/\circ\star VP}$   $\frac{VP_{+F}/\circ\star VP}{VP_{+F}/\circ\star VP}$   $\frac{part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP_{-F} \setminus_{\star} VP_{-F}}{VP_{-F} \setminus_{\star} VP_{-F}}$   $\frac{VP \setminus_{\star} part_{be}}{VP \setminus_{\star} part_{be}}$   
 $\xrightarrow{VP_{-F}}$   
 $\xrightarrow{VP_{-F}}$   
 $\xrightarrow{VP_{-F}}$
- b. \*(Nem) fogok akarni be menni kezdeni.  
 (Not) will-I want in go begin  
 $\frac{S_{neg}/S_{fin}}{S_{fin}/\circ\star VP}$   $\frac{VP_{+F}/\circ\star VP}{VP_{+F}/\circ\star VP}$   $\frac{part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP \setminus_{\star} part_{be}}{VP \setminus_{\star} part_{be}}$   $\frac{VP_{-F} \setminus_{\star} VP_{-F}}{VP_{-F} \setminus_{\star} VP_{-F}}$   
 $\xrightarrow{VP_{+F}}$   
 $\xrightarrow{VP_{+F}}$

<sup>45</sup> The feature-engineering with  $\pm F$  fine-tunes the fragment to exclude 50b. Cf. Williams’s related category alternation (2003:231–32). 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) (Not)	fogok will-I	akarni want	kezdeni begin	be in	menni. go
	$S_{neg}/S_{fin}$	$S_{fin}/\circ^*VP$	$VP_{+F}/\circ^*VP$	$VP_{-F}\backslash\circ^*VP_{-F}$	$part_{be}$	$VP\backslash\circ^*part_{be}$
			*			<
					VP	
						*

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

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

Object agreement with *fogom* via the ‘right-node raised’ category of accusative *a radiot* 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) (Not)	fogom will-I	szet apart	szdeni take	a the	radiot radio	akarni. want
	$S_{neg}/S_{fin}$	$S_{fin,acc}/\circ^*VP$	$part_{szet}$	$(VP/NP_{acc})\backslash\circ^*part_{szet}$	$NP_{agr}^\uparrow/N_{agr}$	$N_{acc}$	$VP_{-F}\backslash\circ^*VP_{-F}$
				VP/NP <sub>acc</sub>			<
					$VP\backslash(VP_{acc}/NP_{acc})$		>
							*

VM FRONTING. The behavior in Hungarian of separable prefixes like *be* is more varied in the case of tensed verbs and verb series. In ‘nonneutral’ sentences (Koopman & 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.’

In ‘neutral’ sentences, by contrast, *be* is among a larger class of ‘verbal modifiers’ (VM) which prepose to the position before the finite verb (Koopman & 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 & 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-preserving 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 from  $S$  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 $VP_{-F}/\times \star VP_{-F}$
menni	:=	$VP_{\star} part_{be}$ or $VP_{+F}/\diamond part_{be}$
be	:=	$part_{be}$ or $S_{neut}/(S_{fin}/part_{be})$

Here  $S_{neut}$  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 for *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) ‘I will want to go in.’

Be	fogok	akarni	menni.	
in	will. 1SG	want	go	
$S_{neut}/(S_{fin}/part_{be})$	$S_{fin}/\diamond \star VP$	$VP_{+F}/\diamond \star VP$	$VP_{+F}/\diamond part_{be}$	
			$VP_{+F}/\diamond part_{be}$	>B
			$S_{fin}/\diamond part_{be}$	>B
$S_{neut}$			>	

It also yields the following analysis for 57b.

- (63) Nem ment be

$S_{neg}/S_{fin}$	$S_{fin}/\star part_{be}$	$part_{be}$	
		$S_{fin}$	>
$S_{neg}$		>	

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.<sup>46</sup>

$$(64) \quad \begin{array}{cccccc} *Be & fogok & kezdeni & [menni & akarni] \\ \hline S_{neut}/(S_{fin}/part_{be}) & S_{fin}/\circ^*VP & VP_{+F}/\circ^*VP & VP_{+F}/\circ^*part_{be} & VP_{-F}/\circ^*VP_{-F} \end{array}$$

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 & Szabolcsi 2000:211, Williams 2003:236). However, like Williams’s categorial calculus 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.<sup>47</sup>

**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 having 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  $\{A|B, B|C, \dots, M|N, N\}$ , the proportion of its  $n!$  permutations that can be recognized by CCG is given by the  $n$ th in the large Schröder series, of which the first few members are  $\{1, 2, 6, 22, 90, 394, 1806, 8558, \dots\}$ . The fourth number in the series is 22, and it 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 UOC defined by those categories. As we saw in the case of Latin and the Hungarian particles, determining 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.<sup>48</sup>

The large Schröder series grows much more slowly with  $n$  than the factorial number of permutations  $n!$ , so that the proportion of nonseparable permutations that are disallowed by CCG grows rapidly with  $n$ , as 0, 0, 0, 2, 30, 326, 3234, 31762, 321244, ... . For example, for a set of nine categories  $\{X_1|X_2, \dots, X_8|X_9, X_9\}$ , nearly 90% of the possible permutations—and for fifteen categories, 99.9%—are excluded.<sup>49</sup>

This property was first noticed by Wu (1997) for INVERSION TRANSDUCTION GRAMMARS (ITG), a form of synchronous context-free grammar of rank 2 proposed for ma-

<sup>46</sup> The other examples of fronted *be* are left as an exercise.

<sup>47</sup> Koopman and Szabolcsi refer to roll-up movement as ‘recursive inversion’.

<sup>48</sup> 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 that 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.

<sup>49</sup> 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.

chine translation, and by Williams (2003:203–11) 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 combinatory projection principle (11).

The reason that Williams's CAT makes the same prediction as CCG concerning the impossibility of nonseparable 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). The two theories are different, however, 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, nonseparable 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 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, and so forth, 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 DO NOT 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 constraints 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 accommodating 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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[Received 2 October 2018;  
revision invited 30 April 2019;  
revision received 22 July 2019;  
accepted pending revisions 19 November 2019;  
revision received 8 March 2020;  
accepted 30 March 2020]