Dominance: Relation or Function?

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The formal difference between phrase structure grammars and categorial grammars can best be observed from an example. It demonstrates that the notion of dominance is functional, not relational.

The difference is critical. Looking from the top toward down, the parents of a phrase-structure may appear to denote relations because they may have many daughters. Looking at the same structure from the bottom shows that they are indeed functions, in the mathematical sense. If this shift of perspective shows promise for all dominance relations, then the early categorial grammarians' discovery that the verb alone can determine clausal structure gives one more edge to study the consequent sense of meaninfulness—consequent to grammaticality—because the verb determines the predicate and its participants, and we can add to that list event choice for the predicate; see Bozşahin (2025) for more of the story.

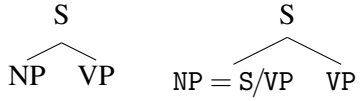
Consider the first phrase structure grammar in *Syntactic Structures* below. I kept the original sequence operator '+' for comparison on the same grounds.

(1)

S	$\rightarrow$	NP+VP	T	$\rightarrow$	the	Chomsky 1957:26
NP	$\rightarrow$	T+N	N	$\rightarrow$	man, ball, etc.	
VP	$\rightarrow$	Verb+NP	Verb	$\rightarrow$	hit, took, etc.	

The first rule can be interpreted from the perspective of either constituent of S. From the NP's perspective, it is a function that takes a VP to the right to yield S, in present terms $\texttt{NP} = \texttt{S}/\texttt{VP}$. We can see this functional behavior from the more structured notation below; these notations are equivalent.

(2)



From the VP's perspective, it is a function that takes an NP to the left and yield S, presently $\texttt{VP} = \texttt{S}\backslash\texttt{NP}$. We get the equivalences in the first row below if we apply the same logic to NP and VP rules. The second and third rows show the categories derived by further substitution (which is possible because this is essentially the algebra of concatenation as Lambek 1961 showed. Morrill 2000 points out the same property of Lambek calculus from a computational perspective).

(3)

$\mathtt{NP} = \mathtt{S}/\mathtt{VP}$ $\mathtt{VP} = \mathtt{S}\backslash\mathtt{NP}$	$\mathtt{T} = \mathtt{NP}/\mathtt{N}$ $\mathtt{N} = \mathtt{NP}\backslash\mathtt{T}$	Verb=$\mathtt{VP}/\mathtt{NP}$	$\mathtt{NP} = \mathtt{VP}\backslash\mathtt{Verb}$
$\mathtt{T} = (\mathtt{S}/\mathtt{VP})/\mathtt{N}$	$\mathtt{N} = \mathtt{NP}\backslash((\mathtt{S}/\mathtt{VP})/\mathtt{N})$	Verb=$(\mathtt{S}\backslash\mathtt{NP})/\mathtt{NP}$	$\mathtt{NP} = (\mathtt{S}\backslash\mathtt{NP})\backslash((\mathtt{S}\backslash\mathtt{NP})/\mathtt{NP})$
$\mathtt{NP} = \mathtt{S}/(\mathtt{S}\backslash\mathtt{NP})$	$\mathtt{N} = \mathtt{NP}\backslash(\mathtt{NP}/\mathtt{N})$	$\mathtt{T} = (\mathtt{S}/(\mathtt{S}\backslash\mathtt{NP}))/\mathtt{N}$	$\mathtt{N} = \mathtt{NP}\backslash((\mathtt{S}/(\mathtt{S}\backslash\mathtt{NP}))/\mathtt{N})$

We can find all substitutions for S, NP and VP of (1), and eliminate the entire first column in the grammar. What we cannot eliminate is the second column because that would change the empirical coverage of the grammar. The resulting grammar looks like (4), where the arrow notation is replaced by '::' because these are no longer rewrite rules. This notation is common in monads and category theory, the best mathematical niche we know of today for studying functions.

(4) the :: T = $(\mathtt{S}/(\mathtt{S}\backslash\mathtt{NP}))/\mathtt{N}$
man, ball, etc. :: N = $\mathtt{NP}\backslash((\mathtt{S}/(\mathtt{S}\backslash\mathtt{NP}))/\mathtt{N})$
hit, took, etc. :: Verb = $(\mathtt{S}\backslash\mathtt{NP})/\mathtt{NP}$

This process was called *radical lexicalization*. The term is due to Karttunen (1989), where he attempted to eliminate all phrase structure rules, leaving behind only 'lexical' elements with their (now complex) categories. This style of 'lexicalization' is explicitly endorsed earlier by Lambek (1961) as well. Nowadays we can think of it as the process of turning *all* linguistic dominance into functions and drop the 'lexical' designation; see Bozşahin (2025) for empirical reasons.

As it currently stands, it may appear to be a stylistic improvement in grammars, that is, a formal result. However, it does have empirical consequences. We can now study meaningfulness as a consequence of grammaticality so that we don't have to leave grammatical analysis at the determination of grammaticality. For example, we can take a verb in (4) and show what it means when it forms a clause:

(5) hit :: $(\mathtt{S}\backslash\mathtt{NP})/\mathtt{NP} : \lambda x \lambda y.hit' xy$

The connection is straigthforward in this example; but, consider the famous Chomsky example in (a) below, and shift of reference from activity (b) to accomplishment (c) *to the extent of affecting grammaticality* (say, mastery by a genius).

(6) a. Colorless green ideas sleep furiously.
b. She played the piano.
c. She played the piano in a year/*in an hour.

These we can think of as arising from making another choice for the verbal category, for example, paralelling above

(7) a. sleep :: $\mathtt{S\backslash NP}$: $\lambda x.torpid'\,x\,one'$

b. played :: $(\mathtt{S\backslash NP})/\mathtt{NP}$: $\lambda x\lambda y.play'xy$

c. played :: $(\mathtt{S\backslash NP})/\mathtt{PP}_{\mathrm{in}}/\mathtt{NP}$: $\lambda x\lambda z\lambda y.master'xy \wedge iter'(play'xy)zy$

Interestingly enough, these category shifts from ungrammaticality to grammaticality arise from conceiving events not just as external activities but human conceptions of activities such as achievements and accomplishments (Bozşahin, 2025). It is suggested there that not just so-called idiosyncrasies such as above but all structural functions of language such as case, agreement and grammatical relations can be studied this way.

With context-free substitutions, the process described here cannot break the phrase structure grammar barrier as Chomsky observed back in 1957. Breaking the barrier is a necessity because we know that human languages are provably not context-free (Shieber, 1985). There are no Dutch or Swiss German grammars[1] that can be radically lexicalized this way because of crossing dependencies. Enter function composition, the well-known controlled way to rise above context-freeness. This was in fact predicted by Harman (1963) very early on in the study of linguistic dominance. Linear-indexed grammars that come out of this idea are radically 'lexicalizable' too (Vijay-Shanker and Weir, 1994); one particular way to do it similar to current method is shown in Bozşahin 2012:74.

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[1] Swiss German results are stronger.