Recursion and the Language Faculty

On the Evolution of the Concept in Generative Grammar*

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Recursion has been a central feature of syntactic theory in generative grammar since its establishment in the 1950s (Bar-Hillel, 1953; Chomsky, 1956; 1957). Yet, since the highly influential 2002 paper by Hauser, Chomsky, and Fitch, and their strong hypothesis regarding the outstanding status of recursion in language, there has been a renewed interest in the subject. The ensuing debates, however, have been characterized by severe terminological confusion and thus been rendered futile at times. The aim of this article is to shed some light on different notions of recursion in general as well as in linguistic description and to provide a brief sketch of how these evolved in the development of generativism. We argue that two different perspectives need to be distinguished, which directly relate to distinct vantage points of earlier generative frameworks on the one hand and the *Minimalist program* on the other.

Keywords: *Recursion, History of Generative Grammar, Language Faculty*

1 Introduction

Recursion nowadays is a highly topical issue within certain linguistic frameworks; a fact that may strike one as rather surprising given that it is by no

* Many thanks to Marco Benincasa, Katja Böer, and Jan Kotowski for valuable comments and discussion.

means a new concept. It has been applied in linguistic theory for a long time and descriptions of what would be known as recursive rules today can be traced as far back as to Pānini's grammar of Sanskrit (Kadvany, 2007). As regards modern linguistics, recursion was formalized syntactically as a mode of sentence generation in the wake of the establishment of generative grammar in the 1950s and credited with being the grammatical building block of, e.g., sentence embeddings as in *Mary thinks that Paul believes that Kate is beautiful* (Bar-Hillel, 1953; Chomsky, 1957). In some form or the other, generativism thenceforth has understood it as the central combinatorial device of a finite repertoire of signs, accountable for the creativity in language: only if a grammar has "recursive devices of some sort, it will produce infinitely many sentences" (Chomsky, 1957: 24). Furthermore, recursion is oftentimes not only understood as the heart of creativity but, building on that, also ascribed the potency to create sentences of arbitrary length, i.e., the alleged "infinitude of language".[1]

While recursion initially—i.e. in the 1950s and 1960s—was treated merely descriptively as a formal device exhibited by human language, it was later on gradually reframed from a biologistic perspective. In light of the innateness hypothesis it "began to acquire [the] cognitive connotations [of] a genetically embedded computational procedure that is a central component of the human language faculty" (Tomalin, 2007: 1785).[2] In the following decades, the notion of recursivity as a core component of a biologically based *universal grammar* (UG) and as a necessary (absolute) universal responsible for creativity in language was taken as a given within generativism (Pullum/Scholz, 2010; Newmeyer, 2008).

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1 Claims on the infinitude of language are virtually ubiquitous in generative grammar—see e.g. Chomsky (1956; 1957, 1965); Hauser/Chomsky/Fitch (2002). For critiques of this very claim—on primarily mathematical grounds—see Pullum/Scholz (2010) and Sternefeld (2000).

2 See e.g. Chomsky (1965) for an example of this early development.

The recent revivification of the debate on the status of recursion[3] can be pinned down to general trends of the *Minimalist program* (MP) and, more specifically, to at least two particular scholarly exchanges of blows. First, the origins of the debate can doubtlessly be traced back to a 2002 article by Marc Hauser, Noam Chomsky, and Tecumseh Fitch (henceforth HCF) and the ensuing discussions with Steven Pinker and Ray Jackendoff (see Fitch/Hauser/Chomsy, 2005; Jackendoff/Pinker, 2005; Pinker/Jackendoff, 2005). HCF's essential claim is that the capacity for recursive syntactic procedures and how these map to peripheral systems are the only and decisive components that distinguish human language from non-human communication systems. Moreover, the authors hypothesize that recursion—which they unfortunately define implicitly at best—may well be the only feature of what they conceive of as the *faculty of language in the narrow sense* (FLN), i.e. the exclusive and single ingredient that is unique to human language and evolved therefor.[4]

Second, the debate has gained momentum via claims brought forward by Daniel Everett regarding the alleged lack of recursive structures in the syntax of the Amazonian Pirahã language—due to cultural restrictions—as well as by the critiques to this view (Everett, 2005; 2007; Nevins/Pesetsky/Rodrigues, 2007). Everett explicitly challenges the HCF hypothesis and assesses that by his findings in Pirahã grammar, in particular the absence of recursion, "the case for an autonomous, biologically determined module of language is seriously weakened" (Everett, 2005: 634). The better part of the criticism drawn by these

[3] The recency of which can easily be read off from the years of publication of the better part of the references to this article.

[4] By and large, Pinker and Jackendoff reject the hypothesis on the basis of their version of a language-specific UG, which they understand to be far more inclusive than HCF, as well as because they understand recursion to be a more general principle, which cannot be attributed primarily or even solely to human language (Jackendoff/Pinker, 2005; Pinker/Jackendoff, 2005).

statements concerns itself with disputing the accuracy of the author's data and—implicitly—his honesty.[5]

The article at hand will not introduce the two debates as such in detail; yet, their respective subject matters serve as the vantage point for its argument. The putative incompatibility of the HCF hypothesis with a recursion-less language is in fact ill-conceived precisely because a difference exists in these very subject matters, i.e. recursion is approached from fundamentally opposed perspectives. In this regard, Tomalin identifies a degree of confusion in the debate, stating "different linguists interpret the word recursion in different ways—an alarming state of affairs" (Tomalin, 2007: 1796). Following Heine/Kuteva (2007: 265), at least two versions need to be distinguished:

(1) a descriptive account of syntactic structure that uses phrase structure and rewrite rules as its categories
(2) a computational definition that regards the processing mechanism as such as recursive

These two definitions are not mutually exclusive, as the former even relies on a form of the latter as its structure assigning process. Yet, it will be argued that the MP that underlies the reasoning in HCF takes recursion to manifest itself along the lines of (2) in the structure building procedure called *Merge*. As will be seen, however, Merge is not necessarily recursive. Furthermore, it does

[5] In fact, this particular debate appears somewhat pointless, as all authors can refer to Everett's own sources only (he is quite unanimously considered the single scholarly authority on Pirahã). His earlier work (Everett, 1986), however, differs significantly from the more recent one, e.g. insofar as it identifies recursive elements in the Pirahã syntax.

not necessarily yield the recursive structures in definition (1), which most authors take as a basis when describing instances of recursion in language.[6]

The article will proceed as follows. After an introduction to recursion in general as well as the commonplace understanding of recursive structures within generative grammar, different stages in the generativist development will be reviewed by dint of relative clause constructions. In doing so, it will be shown that a noticeable reconceptualization of recursion in language has watered down certain basic notions of the initial concept and, more importantly, shifted the focus from the descriptive analysis of phrasal and sentential structure to the underlying, fundamental syntactic structure-building *processes*. These, in turn, no longer necessarily correlate with recursive structures readily identifiable on the syntactic surface. To that effect, Van der Hulst introduces the notions of *general* and *specific recursion* respectively (van der Hulst, 2010: xviii-xxiv).

2 What is recursion?

2.1 Recursion as a general principle

Examples of recursion or recursive structures can virtually be found everywhere. Versions of it occur as natural phenomena, in (visual) art, storytelling, music, etc. All of these instances have a core feature in common: they include some kind of self-embedding or can be described accordingly. Douglas R. Hofstadter, referring to the same principle, puts it slightly differently in his famous *Gödel, Escher, Bach: an Eternal Golden Braid*, stating that recursion always involves

[6] A typical and telling example of how these two notions are erroneously being lumped together can e.g. be found in Roeper (2007: ch.6), where the author explicitly seconds the HCF hypothesis (ibid.: 105-106), while he subsequently continues with an enumeration of self-embedding structures, which non-ambiguously relate to the structural version outlined in (1) above (see section 2.2 for an elaboration on structural recursion).

> nesting, and variations of nesting. The concept is very general. (Stories inside stories, movies inside movies, paintings inside paintings, Russian dolls inside Russian dolls (even parenthetical comments inside parenthetical comments!) – these are just a few of the charms of recursion.) […] One of the most common ways in which recursion appears in daily life is when you postpone completing a task in favor of a simpler task, often of the same type. (Hofstadter, 1979: 127)

Examples from visual art, literature, or natural phenomena[7] can usually not be captured in strict mathematical terms and are therefore oftentimes understood as occurrences of self-similarity. In each of these cases structures are made up from "smaller versions" of themselves, i.e., they rely on what I will call the *sameness condition* here. Thus, recursivity is attested only if we find structures that in a sense comprise themselves in the form of smaller, yet connatural instances. As Hazewinkel points out, mathematical forms of recursion differ in this respect, because these "have precise mathematical definitions, as opposed to the vague 'near mathematical' ideas about 'recursion in general'" (Hazewinkel, 1992: 16). In this sense, mathematicians do not conceive of recursion primarily from a structural, but rather from a computational or process-related perspective. This very difference also relates to the definitions (1) and (2) in the introduction and will be of crucial importance to the argument in the following sections.

General recursive definitions in mathematics (nearly) always feature at least two parts: a base case, which directly specifies the value for the bottom or smallest argument and a recursive or inductive case, which applies values of smaller arguments to define the result of a given argument. Applied to the

[7] Famous examples include the following: in visual art various works of Maurits Cornelis Escher (e.g. *Prententententoonstelling* [1956]) or Russian *matryoshka dolls*, in literature Giovanni Boccaccio's *Il Decamerone* (ca. 1349-1352), and as phenomena in nature ferns or Romanesco broccoli.

primitive recursive definition of the set of natural numbers *N*, the following two clauses a. and b. provide the basis, while c. ensures that computations in fact result in members of *N* only (ibid.: 16):

(3)	a. Base case:	$0 \in N$
	b. Inductive clause:	For any element *x* in *N*, $x + 1$ is in *N*
	c. Extremal clause:	Nothing is in *N* unless obtained from a. and b.[8]

Hence, by means of adding *1* to, e.g., *4*, we are able to generate *5* as the succeeding member of set *N*. The number *4* is known to be a member of *N*, because we know that *3* is, which is known because we know that *2* is, etc. This backward spiral will finally terminate when the base case *0* is reached—it therefore fulfills the condition of *well-foundedness*. Without a base case the spiral could not terminate, which means that the numbers preceding *4* could not be established (as it would lead to an infinite regress). However, to account for the infinity of the set of natural numbers we additionally rely on certain axiomatic terms.[9]

As can be illustrated by means of comparing the descriptive notion of self-similar structures with precise mathematical formulae, we crucially need to distinguish between the two perspectives upon recursion. The former kind largely applies to the self-embedding of concepts, themes, or structural appearances, while the latter one develops functions which account for how a certain structure (or number in the case above) is being generated. It will be argued in the following sections that this difference is reflected in—or in fact even in the center of—the debate on the role of recursion in human language.

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[8] Note that it is down to definition whether *0* is considered to be part of the natural numbers. Its in- or exclusion does not, however, affect the presented reasoning.

[9] The Peano axioms stating that every number in the set has a successor and that two numbers may not share a successor. It is because of these additional (and necessary) presuppositions that the infinitude of language is questionable if understood in analogy to the set of the natural numbers (Pullum/Scholz, 2010: 119).

2.2 Recursive structures in linguistics

Few authors have provided even rudimentary itemizations of the actual occurrences of recursion in human language (for exceptions see Karlsson, 2010; Roeper, 2007). Recursive structures are commonly identified to feature in certain morphological word-formation processes[10] and—less undisputedly—in phonological sequences.[11] Due to the article's limited scope, however, I will focus on syntactic structures, as syntax is not only the core domain of generativism but also the framework's point of origin for linguistic creativity. More precisely, yet, the upcoming section will briefly introduce what Van der Hulst calls *specific recursion*, i.e., "what most linguists usually have in mind when they define recursion as embedding a constituent in a constituent of the same type" (van der Hulst, 2010: xix).[12]

In classic, formal description recursive syntax relies on constituency and phrase structure as the categories which embed in one another and upon which the *sameness condition* is based (see section 2.1; Parker, 2006). In all of these cases, a certain symbol A is replaceable by a string of symbols which contains another instance of A, such as [A → B (D) A] or the usual way of capturing it by means of two rules as in (4), where the recursive component is triggered by rule (4b.) (Bar-Hillel, 1953; Tomalin, 2007).

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[10] In particular multiple compounding as in *newspaper journalist* ($[[[\text{news}]_N\ [\text{paper}]_N]\ [\text{journalist}]_N]_N$). Some authors also include prefix sequences into their registers of examples of recursive instances (see e.g. Roeper, 2007).

[11] See Pinker/Jackendoff (2005), Schreuder (2006), and Van der Hulst (2010) for opposing views on this question.

[12] In fact, the dicussion here will be further restricted to tail-recursive structures, i.e., structures which embed instances of the same kind to either the left or the right side of themselves. As such, tail-recursion needs to be distinguished from center-embeddings such as *The mouse the cat the dog fought chased ran away*. For discussion (and especially for performance-related restrictions) see Bach/Brown/Marslen-Wislon (1986); Christiansen/Chater (1999); Karlsson (2007).

(4) a. A → B C

b. C → D A

Translated to a natural language example, we can formalize the build-up of sentence (5)—and its recursive step—by means of statements on its individual constituents in (6).

(5) *Peter believes that Kate knows the answer*.

(6)	a.	S	→	NP	VP
	b.	VP	→	V	S
	c.	VP	→	V	NP
	d.	NP	→	N	

The sentence in (5) can then be said to contain another sentence—in the form of a Complementizer Phrase, i.e., a subordinate clause, that typically follows verbs of speech or thought (here *believes*)—as its granddaughter. The recursive step is statement (6b.), which holds that a verb phrase (VP) can embed another sentence (S). Crucially, the interplay between rules (6a.&b.) is a potentially endless one and as such meets a further characteristic of *productive* recursion identified by most linguists, namely that in principle recursive rules need to be applicable infinitely.[13] Structures derived in this fashion are

[13] The question in how far "true"—i.e., productive—recursion is down to potentially endless rule application is a tricky one, as capping embedding to so-called level-one depth features in different constructions in many languages and is oftentimes understood as non-recursive or as an exception to the rule. Consider e.g. the apparent impossibility in English to stack non-restrictive relative clauses that modify the same NP, constructions that are perfectly fine in e.g. Japanese (Newmeyer, 2008: 62):
**John, who goes to MIT, who likes math, will get a job.*
or the ungrammaticality of multiple prenominal possessive constructions in German (Nevins/Pesetsky/Rodrigues, 2007: 11-13; Roeper, 2007: 112-113):
English: *John's car's motor* vs. German: **Johannes' Autos Motor*

hierarchical and differ from iterative sequences (e.g. *a very, very, very tall man*) insofar as "recursion builds structure by increasing embedding depth whereas iteration yields flat output structures, repetitive sequences on the same depth level as the first instance" (Karlsson, 2010: 43).

Typical examples of tail-recursion (cf. footnote 12) include the following: propositional complements after verbs of speech and thought as in (7a.), prepositional phrases ((7b.)), relative clauses ((7c.)), prenominal possessives ((7d.)).

(7) a. *Peter believes that Kate claims that John knows the answer*.
b. *There is a bird in the tree in the garden behind the house.*
c. *The man, who lives in a house, which is next to a street, is tall.*
d. *John's mother's friend's bike is broken*.

As can be gathered from the examples in (7) above, recursive structural depth is not singularly a syntactic phenomenon but can also be approached from a semantic perspective. In this sense, we e.g. cannot exchange, substitute, or leave out any of the prenominal possessives in (7d.) without (at least possibly) changing the overall meaning of the sentence, which—by means of recursion—"allows us to specify reference to an object to an arbitrary fine level of precision" (Parker, 2006: 241). A different, yet related claim on semantic grounds holds for (7a.), where we have to state that only the matrix sentence (*Peter believes that…*) has a truth value, while its sentential complements do

For discussion and opposing views on the distinction between and nature of *simple* and *productive* recursion see e.g. Evans/Levinson (2009), Heine/Kuteva (2007), Roeper (2007).

not.[14] In other words, truth value does not embed in truth value, while reference does not embed in reference, either (Arsenijević/Hinzen, 2010).[15] Accordingly, Hurford (2004) points out that “the conceptual structures expressed by the sentences of languages are themselves best characterized by recursive descriptions” (ibid.: 563). Despite the Chomskyan mantra of syntactic autonomy (see e.g. Chomsky, 1957: 17), the semantic motivation for recursive structures on the basis of (recursive) conceptual structures appears to be based on a

> fairly basic cognitive activity, namely taxonomy. […] Once there is a linguistic expression for relations such as between less inclusive and more inclusive, part and whole, one social role and another, or possessee and possessor, the way is cleared for recursion to enter. (Heine/Kuteva, 2007: 269)

As an intermediate conclusion, we can analyze recursive structures as instances of *specific* recursion along the lines of definition (1) above. Here, recursive structures rely on hierachical phrase structure and constituents (which tend to be described in top-down fashion), while embedding on different depth levels distinguishes them from mere iteration. Moreover, such structures appear to have clear-cut semantic and conceptual bases, which allow themselves to also be interpreted in recursive terms.

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[14] Note that this claim does not necessarily hold true for factive verbs such as *know* in the matrix or embedding sentences, which arguably imply the truth of X in sentences such as *Peter knows X*.

[15] Arsenijević/Hinzen (2010) argue recursion to not immediately feature in syntax at all. They claim it to be an epiphenomenon, which comes into being after spell-out of individual derivational cycles; therefore, overt recursive structures are always subdivided by intermediate elements (such as the complementizer *that* in (7a.) or the genitive ‘s in between the NPs in (7d.)).

3 A brief historical excursus

The aforementioned confusion in the recent debate on the status of recursion in linguistics directly relates to the notion of the term just outlined in 2.2. It was this conceptualization that delivered the sole interpretative basis in the earlier frameworks of generative grammar up until the MP. Therefore, I will provide a very brief historical sketch of the development, via which the notional shift of a descriptive account of *specific* recursion (definition (1) and section 2.2) to the computational perspective of *general* recursion (definition (2)) can be retraced. The developmental stages under scrutiny will follow a similar endeavor by Bickerton (2008) and roughly relate to the frameworks based on Chomsky (1956; 1957), Chomsky (1965), and Chomsky (1995).

3.1 Transformational grammar

The framework known as *Transformational Grammar* was initiated by Chomsky's early work (1956; 1957) and divided into two components. First, it featured phrase structure, by means of which simple sentences—i.e., *kernel* sentences (in Chomskyan terminology) that undergo only obligatory transformations due to contextual restrictions[16]—were built. Second, a transformational component ensured the derivation of complex sentences out of simple ones. Crucially, in case of hypotactic subordination, embedding did not feature in the phrase structure component but relied on prefabricating kernel sentences and adjoining them in a second step.

With regard to relative clauses such as (7c.), the idea at the time was that by dint of a certain transformational or embedding rule—the *relative clause transformation*—a full-fledged sentence could be adjoined to a noun phrase as

[16] E.g., the occurrence of certain auxiliaries and past tense marking at verbs in certain contexts; see Chomsky (1957: 38-40).

its modifier. Disregarding certain restrictions here,[17] the single prerequisite for embedding one kernel sentences to another was that the two share a noun phrase. The relative transformation was non-directional and “either [could] be embedded to the other as a relative clause” (Smith, 1964: 40). Therefore, the two simple sentences in (8a. & b.) could generate both (8c. & d.) via the same mechanism—including reordering of constituents and subsequent deletion of the shared NP in the embedded clause.[18]

(8) a. *The man is Harry’s brother.*
b. *You saw the man yesterday.*
c. *The man you saw yesterday is Harry’s brother.*
d. *You saw the man, who is Harry’s brother, yesterday.*

The recursive structures in (8c. & d.) lend themselves to the analysis of *specific* recursion in (1) as well as 2.2. This holds true for their phrase structural basis as well as their conceptual motivation. Importantly, again, we are dealing here with an insertion procedure of already established simple sentences. Thus, from a derivational perspective, “the *Syntactic Structures* model [i.e., Chomsky (1957); S.K./H.H.] involved recursion only in the transformational component, when one *prefabricated* S was inserted in another *prefabricated* S” (Bickerton, 2008: n.p.; first emphasis in the original, second and third added).

[17] Such as the impossibility of adjoining an appositive relative clause to noun phrases with certain determiners, as in **Any book, which is about linguistics, is interesting* (but *The book, which is about linguistics, is interesting*); see Smith (1964: 38).

[18] The examples in (8) have been adopted from Bickerton (2008) and extended to fit the argument. For a formal sketch of the relative clause transformation see Smith (1964: 40-41).

3.2 Generalized phrase markers

The concept of *generalized phrase markers* in Chomsky's *Aspects of the Theory of Syntax* (1965) marked a fundamental change to transformational grammar as outlined in 3.1. By the introduction of *deep structure* and a phrase structural *base component* the new version of generative grammar did away with the necessity of general transformations to account for the insertion of (simple) sentences within (simple) sentences. Chomsky (1965) comments on this evolution as follows:

> In the earlier version of the theory, the recursive property was assigned to the transformational component, in particular, to the generalized transformations and the rules for forming Transformation-markers. Now the recursive property is a feature of the base component, in particular, of the rules that introduce the initial symbol S in designated positions in strings of category symbols. There are, apparently, no other recursive rules in the base. (ibid.: 137)

Thus, relative clauses, to stay with our example domain, no longer relied on the prefabrication of kernel sentences and *a posteriori* adjoining of one of them as a modifier to a NP in the embedding one. In contrast, the complex example sentence (8c.) above (*The man you saw yesterday is Harry's brother.*) only had one underlying (yet expanded) phrase structural representation as its deep structure, illustrated in (9d.); constituents in brackets in (9b. & c.), then, stood for optional realizations (Bickerton, 2008; Chomsky, 1965).

(9)	a.	S	→	NP	VP				
	b.	NP	→	(Det)	N	(NP)	(PP)	(S)	
	c.	VP	→	V	(NP)	(PP)	(S)		
	d.	S	→	NP[Det N		S[NP VP]]		VP[V NP[N	NP[N]]]

The transformational component, in turn, was "solely interpretive" (Chomsky, 1965: 137) and matched surface structure M' (i.e., e.g. an actual sentence) to deep structure M (the generalized phrase marker)—"only if M' is well formed, then M was a deep structure" (ibid.: 140). Be that as it may, recursion as understood in Chomsky's (1965) *Aspects* theory still subscribed to the foundational ideas of hierarchical phrase structure. As shown in (9d.), we can even identify a total of three recursive instances: one S embedded within another S and NPs within NPs in two cases (Bickerton, 2008).

3.3 Minimalist Merge

The decades following *Aspects* saw a further reduction of the transformational component[19] in the *Government and Binding* theory and the *Principles and Parameters* approach, which eventually gave way to the introduction of the *Minimalist program* (MP) (Chomsky, 1995). The MP hypothesizes that only two processes are responsible for syntactic structure building, *Move* and *Merge*.[20] Importantly, this framework directly connects the infinitude of language—and hence linguistic creativity—to Merge, whereas recursive structures such as the ones identified by the early Chomsky (1956; 1957; 1965) are merely a non-obligatory possibility which can be achieved by the mechanism (van der Hulst, 2010: xviii-xxiv). Accordingly, Chomsky (2007) states that it is the unbounded application of Merge which "yields a discrete infinity of structured expressions" (ibid.: 5). In this vein, Merge builds structure in bottom-up fashion by combining individual elements to labeled ones, which in turn can be made subject to the same process again (Radford, 2004: 57-68).

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[19] E.g. the twofold arrangement of a deep-structure underlying a surface-structure began to be abandoned, while movement operations were concentrated in a single principle *Move alpha*.

[20] In fact, Move is oftentimes taken to be a special case of Merge, namely *internal* Merge.

However, if we maintain that phrase structure is the domain in which recursive loops are to be found, Merge *per se* is not in accordance with the *sameness condition* as introduced in 2.1 above as a necessary prerequisite for recursive structures. Yet, the MP reasoning appears to abandon phrase structure as this domain and HCF explicitly establish the recursivity of Merge analogously to the generation of the natural numbers (HCF: 1571). We are then confronted with a process-related case of *general* recursion in the sense of Van der Hulst (2010: xix) (see 2.1). Therefore, a reformulation of the category upon which sameness is based is required and introduced by the notion of *syntactic objects*. Chomsky (1995) straightforwardly defines syntactic objects and how they are combined locally and recursively, stating that “the simplest such operation takes a pair of syntactic objects (SO_i, SO_j) and replaces them by a new combined syntactic object SO_{ij}. Call this operation *Merge*” (ibid.: 226; emphasis in the original). He continues with a formalization of this definition:

> a. lexical items
> b. K = {γ, {α, β}}, where α, β are objects and γ is the label of K
> Objects of type [a.] are complexes of features, listed in the lexicon. The recursive step is [b.]. (ibid.: 243)

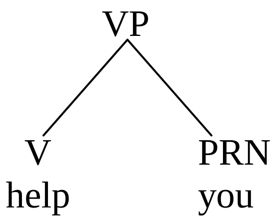
The analogy to the natural numbers (see (3) in 2.1), then, is fairly unambiguous. Chomsky defines a base case (a.) as well as an inductive clause (what he calls the recursive step in b.). The category *syntactic object* is—parallel to *natural number*—both input and simultaneously output of the recursive function.[21]

[21] Technically speaking, as Tomalin (2007) points out, the successor function used in deriving the sequence of the natural numbers can—just like Merge—be captured in terms of inductive definitions and does not require ‘full-fledged mathematical recursion’ (ibid.: 1797-1799); but see section 2.1.

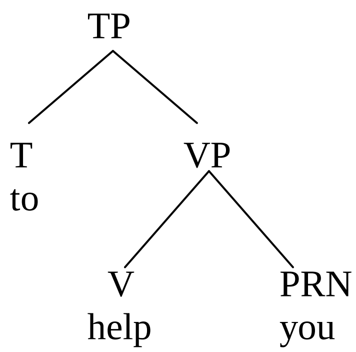
The crucial point for the discussion at hand, however, is that by means of the introduction of Merge recursive structure building has been decoupled from recursive structures. Multiple application of Merge does in fact account for the derivation of recursive structures—as conceived of traditionally and found e.g. in relative clauses such as in (8c.) above—in the long run.[22] Yet, the structure building process of any linguistic structure that runs through the Merge operation more than once (i.e., even fragments of sentences, clauses or phrases can do) has by definition already been a recursive. The fragmentary nature of 'recursive' Merge as well as its principle potential to create recursive structures can be illustrated with the help of the VP in (10a.) and its bottom-up derivation in form of tree structure representations in (10b.-d.) (Radford, 2004: 58-61).[23]

(10) a. *trying to help you*

b.



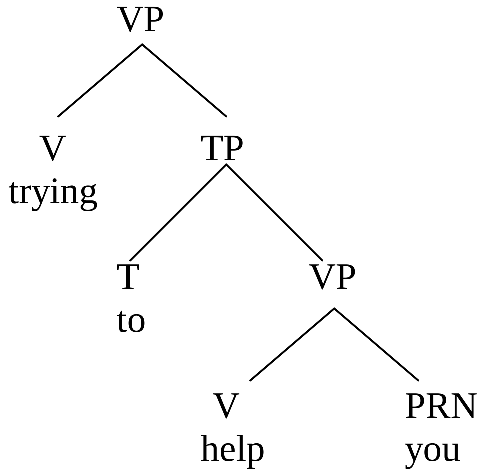
c.



[22] See Van der Hulst (2010: xviii-xxiv) for a discussion of how *general* recursion allows for *specific* recursion as a possible by-product.

[23] T and TP stand for a tense-marking constituent and a tense phrase or tense projection, respectively.

d.



The difference between the two structure fragments (10c.) and (10d.) sheds further light on the terminological confusion. While the derivations as well as the example sentence in (10) are taken from Radford's (2004) textbook on Minimalist syntax, in which the author states multiple applications of Merge, he does not identify the property of recursion until stage (10d.) is reached, in which we indeed find a recursive structure (a VP containing a VP) (ibid.: 61). However, substituting the phrase labels of all non-terminal nodes with the technical category *syntactic object* will lead to a structural representation of (10c.) that does display an instance of recursion, as well. Yet again, the expression *to help you* neither exhibits recursion on a conceptual or semantic level nor in its traditional phrase structural representation, but relies on the arguably arbitrary introduction of a derivational 'super category'.[24] For these reasons, the putative recursivity of Merge is oftentimes dismissed as merely "an **iterative** procedure, consisting of repeated applications of an identical process"

[24] The distinction can in particular be read off from different structural representations. While the conventional X' schemata—usually applied in the *Government and Binding* framework—make use of varying, phrase-dependent category labels, *bare phrase structure* uses unlabeled tree diagrams, in which sets of features are implicit in the lexical entries of the constituents in terminal node positions; see Radford (2004: 78-80).

(Bickerton, 2008: n.p.; bold type in the original). Everett's (2008) stance on Merge is even more pejorative:

> The newest definition of recursion to emerge from Chomsky's school makes recursion a form of compositionality. Simply put, it says that you can put parts together to make something new and you can do that endlessly. Under this novel notion of recursion, which is not accepted by any mathematical linguists or computer scientists that I know of, if I can put words together to form a sentence, that is recursion. (ibid.: 229)

4 Conclusion

The recent debate on recursion has been characterized by conceptual and terminological confusion. The better part of the linguists commenting on the hypotheses brought forth by HCF have argued on grounds of what has been called *specific* recursion here, i.e. instances of phrase structural representations in which a member of a certain category is embedded within a member of the same category. This notion also used to be the unanimously accepted version among generative grammarians up until the *Minimalist* assumption of Merge as the sole structure building procedure.

As has been shown, the differences between recursive structures relying on hierarchical phrase structure, on the one hand, and 'recursive' Merge, which builds any syntactic structure from bottom-up, on the other, can be traced back to two related, yet distinct concepts. First, self-similar structures are characterized by the self-embedding of themes or concepts and found virtually ubiquitously, e.g. in nature, visual art, or music. Recursive structures in human language seem to relate to these on grounds of their semantic and conceptual motivation. Second, a computational perspective defines structure-building processes as such as recursive and can be captured with mathematical formulae. Merge can, apparently, be interpreted to fulfill this condition and be defined in direct analogy to the generation of the natural numbers. Following the *Minimalist program*, it eventually generates all syntactic expressions, among them also recursive structures as traditionally conceived of.

Thus, challenging HCF on grounds of the alleged non-existence of recursive structures in a given language—as e.g. Everett (2005) does due to his findings in Pirahã grammar—appears ill-conceived, as recursivity in *Minimalism* does not presuppose the existence of structures of the kind. Nevertheless, several linguists regard multiple Merge to be an iterative, rather than a recursive process and therefore question the accuracy of the conflation of Merge, recursion, and linguistic infinitude. Even if 'recursive' Merge is considered technically sound in its build-up, however, the necessary introduction of a category independent from phrase structure, i.e. *syntactic object*, poses a more global problem: If any hierarchical combination of more than two items (of whatever kind, language-related or not) is recursive as long as an appropriate category is chosen that happens to comprise all subparts within the structure, is hierarchy then basically tantamount to recursion?

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