Recursion and the infinitude claim*

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Abstract

We address certain recent suggestions that the existence of infinitely many grammatical expressions in human languages (the infinitude claim) is a universal of human language. We examine the arguments given for the infinitude claim, and show that they tacitly depend on the unwarranted assumption that the only way to represent the structural properties of a language is by means of a generative grammar with a recursive rule system. We explore some of the reasons why linguists have been so willing to accept language infinitude despite its inadequate support and its paucity of linguistic consequences. We suggest that the infinitude claim is motivated chiefly by an inadvisable adherence to the notion that languages are sets. It is not motivated by considerations of the creative aspect of language use, or opposition to associationist psychology, or the putative universality of iterable linguistic structure such as recursive embedding or unbounded coordination (which are in any case probably not universal).

1 Infinitude as a linguistic universal

In a number of recent works, linguists have portrayed the infinitude of sentences in human languages as an established linguistic universal. Lasnik (2000) asserts, in the opening chapter of a textbook based on transcriptions of a series of introductory syntax lectures:

(1) Infinity is one of the most fundamental properties of human languages, maybe the most fundamental one. People debate what the true universals of language are, but indisputably, infinity is central. (Lasnik 2000:3)

This is not a statement about the appropriateness of using idealized infinitary mathematical models in theoretical linguistic science. It is about alleged "fundamental properties of human languages."

Epstein and Hornstein (2004), a letter originally submitted for publication in *Science* (ultimately printed in *Language*) gives an even bolder statement:

(2) This property of discrete infinity characterizes EVERY human language; none consists of a finite set of sentences. The unchanged central goal of linguistic theory over the last fifty years has been and remains to give a precise, formal characterization of this property and then to explain how humans develop (or grow) and use discretely infinite linguistic systems.

Here again, "discrete infinity" (by which we assume is meant denumerable infinity in sets of discrete elements such as symbol strings) is claimed to be a feature of "EVERY human language", as if one by one they had all been examined by scientists and checked for infinitude.

Yang (2006:103-104) takes up this theme, with somewhat confusing references to reproduction and recursion ("Language ... has the ability of self-reproduction, or *recursion*, to use a term from mathematics: a phrase may beget another phrase, then another, then yet another"), plus a comment that "There is no limit on the depth of embedding", and a comment that prepositional phrase modifiers may be added "... ad infinitum". He says:

(3) Recursion pops up all over language: many have argued that the property of recursive infinity is perhaps *the* defining feature of our gift for language.

A footnote at this point refers the reader to Hauser et al. (2002) (see Pinker and Jackendoff 2005 for a discussion of the widely repeated Hauser et al. remarks about recursion being the defining property of human language).

Such remarks represent infinitude as a fact about languages, which contrasts with views that were current fifty years ago. Chomsky (1957b:15) simply remarks that a grammar projects from a finite corpus to "a set (presumably infinite) of grammatical utterances", the infinite cardinality of the projected set being treated as a side consequence of the way the theory is set up. And this is precisely in line with the views of his doctoral supervisor. Zellig Harris (1957:208) remarks:

> Although the sample of the language out of which the grammar is derived is of course finite, the grammar which is made to generate all the sentences of that sample will be found to generate also many other sentences, and unboundedly many sentences of unbounded length. If we were to insist on a finite language, we would have to include in our grammar several highly arbitrary and numerical conditions—saying, for example, that in a given position there are not more than three occurrences of *and* between N.

His point is that a grammar should not include arbitrary numerical stipulations with no function other than to block coordinations from having unboundedly many coordinates. It is better, he proposes, to accept the consequence that the grammar generates unboundedly many sentences longer than any found in the corpus providing its evidential basis.

It is of course a familiar feature of science that idealizing assumptions are made, and that the idealized models have char-

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acteristics that are strictly false of the phenomena under study. Sometimes, for example, finite systems are modeled as infinite if that simplifies the mathematics. This is clearly what Harris is alluding to, and inasmuch as it does not result in distortion of the predictions of the theory in finite domains, and the idealizations permit greater elegance in theories, this is not problematic.

But contemporary linguists, particularly when writing for broader audiences such as beginning students, scientists in other fields, and the public at large, are treating infinitude as a property of languages themselves. This shift of view appears to stem from a kind of argument for infinitude that begins with observed facts about human language syntax and draws from them a conclusion concerning infinite cardinaliity.

2 The Standard Argument

The argument that linguists have most relied upon for support of the infinitude claim is actually a loose family of very similar arguments that we will group together and call *the Standard Argument*. Versions of it are rehearsed in, for example, Postal (1964), Bach (1964), Katz (1966), Langacker (1973), Bach (1974), Huddleston (1976), Pinker (1994), Stabler (1999), Lasnik (2000), Carnie (2002), and Hauser et al. (2002).

The Standard Argument starts with certain uncontested facts about the syntactic structure of certain classes of expressions. It draws from these the intermediate conclusion that there can be no longest expression. The infinitude claim then follows.

For concreteness, here as throughout much of the paper, we limit ourselves to English illustrations of the relevant kinds of syntactic facts. A few representative examples are given in (I).

(I) Syntactic facts
It is evident that *I exist* is a declarative clause, and so is *I know that I exist*, and so is *I know that I know that I exist*; that *came in and went out* is a verb phrase coordination, and so is *came in, turned round, and went out*, and so is *came in, saw us, turned round, and went out*; that *very nice* is an adjective phrase, and so is *very very nice*, and so is *very very very nice*; and so on for many other examples and types of example.

It is not controversial that a huge collection of facts of this sort, showing grammaticality-preserving extensibility of various types of expression, could be presented for many different languages. Our references to (I) are intended to refer to a suitably large collection of such facts.

The intermediate conclusion that purportedly follows from the facts in (I) is presented in (II):

(II) The No Maximal Length claim (NML)
For any English expression there is another expression that is longer. Equivalently: there is no English expression that has maximal length.

Some linguists give a stronger claim, which entails (II): they claim not just that for any expression a longer expression always exists, but that starting from any arbitrary grammatical expression you can always *construct* a longer one that will still be grammatical, simply by adding words. Since this is not necessary for the argument, we mostly ignore it.

The ultimate conclusion from the argument is then (III):

(III) The Infinitude Claim
The collection of all grammatical English expressions is an infinite set.

Presentations of the Standard Argument utilizing (I) – (III) in various forms can be found in large numbers of introductory texts on linguistics. Langacker (1973), for example, asserts (II) as applied to English, in both its weaker and its stronger form (the second apparently intended as an explication of why the former must be true), and concludes (III), with an additional claim appended:

(4) "There is no sentence to which we can point and say, 'Aha! This is the longest sentence of the language.' Given any sentence of English (or any other language), it is easy to find a longer sentence, no matter how long the original is . . . The set of well-formed sentences of English is infinite, and the same is true of every other language." (Langacker 1973:30)

The parenthetical remark "or any other language", claiming a universalization of (III) to all human languages, does not, of course, follow from the premises that he states (compare the similar remark by Epstein and Hornstein in (2)).

Bach (1974:24) states that if we assent to (II) — which he gives in its stronger form — then we must accept (III):

(5) "If we admit that, given any English sentence, we can concoct some way to add at least one word to the sentence and come up with a longer English sentence, then we are driven to the conclusion that the set of English sentences is (countably) infinite." (Bach 1974:24)

(The parenthesized addition "countably" does not follow from the premises supplied, but we ignore that.)

Huddleston (1976) (making reference to coordination rather than subordination facts) also asserts that if we accept (II) we must accept (III):[1]

(6) "... to accept that there are no linguistic limits on the number of clauses that can be coordinated within a sentence is to accept that there are no linguistic limits on the number of different sentences in the language, *ie* that there is a (literally) infinite set of well-formed sentences." (Huddleston 1976:7)

Stabler (1999:321) poses the question "*Is the set of linguistic structures finite?*" as one of the issues that arises in connection with applying formal grammars to human languages, and answers it by stating that (II) seems to be true, so we can conclude (III):

(7) "there seems to be no longest sentence, and consequently no maximally complex linguistic structure, and we can conclude that human languages are infinite."

[1]Huddleston is alluding to multiple coordination of the sort seen in *red, orange, yellow, green, blue, indigo, and violet*. Standard types of generative grammar cannot in fact describe this properly, because in standard formalisms every grammar has a longest rule, and this enforces an undesired numerical upper bound on the number of coordinate daughters one node can have. This presents difficulties for arguments in favor of generative grammatical theories of coordination, but the point irrelevant to our theme here, so we henceforth ignore it. Gazdar et al. (1985), ch. 8, attempts to describe multiple coordination in generative terms by means of infinite phrase structure rule schemata, and Rogers (1999) sketches a very interesting non-generative approach.

Hauser et al. (2002:1571), a more recent discussion, affirms that human languages have "a potentially infinite array of discrete expressions" because of a "capacity" that "yields discrete infinity (a property that also characterizes the natural numbers)." They proceed to the rather surprising claim that "The core property of discrete infinity is intuitively familiar to every language user", and then utter a coordination consisting of three different formulations of (II):

(8) "There is no longest sentence (any candidate sentence can be trumped by, for example, embedding it in 'Mary thinks that . . . '), and there is no non-arbitrary upper bound to sentence length."

Many other passages of a broadly similar character could be cited. We now proceed to critique the argument at which they all hint.

3 How the Standard Argument fails

All the linguists quoted in (4) – (8) seem to be concentrating on the step from (II) to (III). But this is basically trivial mathematics. If we assume the traditional informal definition of 'infinite', where it simply means 'not finite' (a collection being finite if and only if it we can count its elements and then stop[2]), then (II) and (III) are just paraphrases. The claim is that counting the expressions of a language like English could go on forever, which is all that 'infinite' means.

It is the inference from (I) to (II) that really needs to be explicated, and hardly any linguists discuss that step. What licenses the inference from the syntactic properties of individual English expressions to a claim about the lack of an upper bound on length of members in an entire collection of expressions?

3.1 Not inductive generalization, not mathematical induction

First, we can dismiss any suggestion that the inference from (I) to (II) is an inductive generalization — an inference from a statement about certain individuals to a statement about all the members of some collection.

An example of inductive generalization on English expressions — and a justifiable induction — would be reasoning from English adjective phrases like *very nice*, *very very nice*, *very very very nice*, and so on, to the generalization that repeatable adverb modifiers in adjective phrases always precede the head. But inferring that the collection of all possible English adjective phrases has no longest member is an entirely different matter. The conclusion is not about the properties of adjective phrases at all. It concerns a property of a different kind of object: it attributes a cardinality to a set of adjective phrases.

A different possibility would be that (II) can be concluded from (I) by means of a mathematical argument, rather than an inductive generalization from linguistic data. Pinker (1994:86) suggests this quite explicitly:

> By the same logic that shows that there are an infinite number of integers—if you ever think you have the largest integer, just add 1 to it and you will have another—there must be an infinite number of sentences.

This reference to a "logic that shows that there are an infinite number of integers" is apparently an allusion to reasoning by mathematical induction.

Arguments by mathematical induction use recursion to show that some property hold of all of the infinitely many positive integers. There are two components: a base case, in which some initial integer such as 0 or 1 is established as having a certain property P, and an inductive step in which it is established that if any number n has P then $n + 1$ must also have P. The conclusion that every positive integer has P then follows.

However, it follows only given certain substantive arithmetical assumptions. Specifically, we need two of Peano's axioms: the one that says every integer has a successor (so there is an integer $n + 1$ for every n), and the one that says the successor function is injective (so distinct numbers cannot share a successor).[3]

Pinker's suggestion seems to be that a mathematical induction on the set of lengths of English expressions will show that English is an infinite set. This is right, provided we assume that the analogs of the necessary Peano axioms hold on the set of English expressions. That is, we must *assume* both that every English expression length has a successor, and that no two English expression lengths share a successor. But to assume this is to assume the NML claim (II). (There cannot be a longest expression, because the length of any such expression would have to have a successor that was not the successor of any other expression length, and this is impossible.)

Thus we get from (I) to (II) only by assuming (II). The argument makes no use of any facts about the structure of English expressions, and simply assumes what it was supposed to show.

We take it to be clear, then, that neither inductive generalization nor mathematical induction can legitimate the inference from (I) to (II). A third alternative probably comes closest to reconstructing what the linguists quoted above had in mind. They assumed that facts like those in (I) inevitably demand representation in terms of generative rule systems with recursion, and they take infinitude to follow from that.

3.2 Arguing via generative grammars

There is a close connection between arguments by mathematical induction and the theory of recursive functions, which is the mathematics that underlies generative grammatical frameworks. A function is called recursive when its value at some arguments depends on values that it has at other arguments: the procedure for calculating its value invokes itself at certain points.

Generative grammars are not themselves recursive functions, but there is a conceptual connection: iterated function application (repeatedly applying a function to obtain some value and then giving the function that value as its next argument) is

[2] As Dretske (1965:100) remarks, to say that if a person continues counting forever he *will* count to infinity is coherent, but to say that at some point he *will have* counted to infinity is not.

[3] The Axiom of Mathematical Induction, despite its suggestive name, is not relevant here. It states that if a set contains 1, and contains the successor of every one of its members, then that set contains all the positive integers. This rules out non-standard models of arithmetic, where there are additional integers unreachable via successor. The two axioms mentioned in the text are sufficient to guarantee an infinity of integers.

analogous to repeatedly applying a rule to obtain some structure that offers a new opportunity for the rule to apply.

The enormous influence of generative grammatical frameworks over the past fifty years may have led some linguists to think that a generative grammar *must* be posited to represent the kind of data in (I) — there simply are no alternatives. Thus for data sets like *very nice*, *very very nice*, etc., it is assumed that the only possible finite representation is a generative grammar containing some rule such as the one in Chomsky (1957b:73): 'Adj $\rightarrow$ *very* Adj'. And for data sets like *I exist*, *I know I exist*, *I know I know I exist*, etc., it is assumed that the only possible representation is a generative grammar containing a rule embedding finite declarative clauses as complements of verbs of propositional attitude in larger declarative clauses (e.g., a rule 'Clause $\rightarrow$ NP VP', and a rule 'VP $\rightarrow$ V_k Clause' where *think* belongs to the category V_k — the subcategory of verbs of propositional attitude).

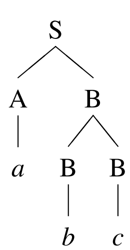
If data involving repetition of modifiers or iterated embedding of clauses actually *required* representation in terms of a generative grammar with recursive rules, linguists might infer (II) in this way: only generative grammars can represent the data, so we are forced to assume that a linguistically competent human being mentally represents "a recursive procedure that generates an infinity of expressions" (Chomsky 2002:86–87), and thus there is a sense in which a human language *has* infinitely many expressions.

There are two flaws in this argument. The less important one — worth noting in passing nonetheless — is that assuming a generative framework, and even requiring nontrivially recursive rules, does not entail NML, and thus does not guarantee infinitude. There are generative grammars (infinitely many of them) that make recursive use of non-useless symbols and yet fail to generate infinite sets. Consider for example the following simple context-sensitive grammar (suggested to us by András Kornai):

(9)
Nonterminals:	$\{S, A, B\}$
Terminals:	$\{a, b, c\}$
Start symbol:	S
Rules:	$\{S \rightarrow AB, \quad B \rightarrow BB,$ $A \rightarrow a, \quad B \rightarrow b \ /a\_\_,$ $B \rightarrow c \ /ab\_\_\}$

The second rule is non-trivially recursive — it generates the infinite set of all binary B-labelled trees. There are no nonterminals that are either unproductive (incapable of deriving terminal strings) or unreachable (incapable of figuring in a completed derivation from S). And there are no useless rules (in fact all rules participate in all derivations that terminate). Yet only a finite stringset is generated — the single string *abc*, which is the yield of this tree:

(10)



If more than one local subtree is rooted in B, the derivation cannot terminate. Recursion does not guarantee infinitude.

Lest anyone should think that this is just an unimportant anomaly, and that a proper theory of syntactic structure should simply rule out such failures of infinitude, note that for a wide range of grammars, including context-sensitive grammars and most varieties of transformational grammar, questions of the type 'Does the grammar generate an infinite set of strings?' are formally undecidable. No general algorithm can determine whether the goal of "a recursive procedure that generates an infinity of expressions" has been achieved or not. And although there could be a general linguistic theory allowing all and only those context-sensitive grammars that do generate infinite sets, it would have the strange property that whether a given grammar conformed to it would be an undecidable question.

The more important flaw, however, is the fact that generative grammars are *not* mandated by the necessity of representing data such as that given in (I). There are at least three alternatives — non-generative ways of formulating grammars that are mathematically explicit, in the sense that they distinguish unequivocally between grammatical and ungrammatical expressions, and model all of the structural properties required for well-formedness.

One would involve modeling grammars as transducers, i.e., formal systems that map between one representation and another. It is very common to find theoretical linguists speaking of grammars as mapping between sounds and meanings. They rarely seem to mean it, because they generally endorse some variety of what Seuren (2004) calls *random generation* grammars, and Seuren is quite right that these cannot be regarded as mapping meaning to sound. For example, as Manaster Ramer (1993) has pointed out, Chomsky's remark that a human being's internalized grammar "assigns a status to every relevant physical event, say, every sound wave" (Chomsky 1986:26) is false of the generative grammars he recognizes in the rest of that work: grammars of the sort he discusses assign a status only to strings that they generate. They do not take inputs; they merely generate a certain set of abstract objects, and they cannot assign linguistic properties to any object not in that set. However, it *could* follow if grammars were modeled as transducers: grammars could be mappings between representations (e.g., sounds and meanings) without regard to how many expressions there might be, thus making no commitment regarding infinitude.

Another possibility is suggested by an idea for formalizing the transformational theory of Zellig Harris. Given what Harris says in his various papers, he might be thought of as tacitly suggesting that grammars could be modeled in terms of category theory (Awodey 2006). There is a collection of objects (the utterances of the language, idealized in Harris 1968 as strings paired with acceptability scores), whose exact boundaries are not clear and do not really matter (Harris 1968:10–12 suggests that the collection of all utterances is "not well-defined and is not even a proper part of the set of word sequences"); and there is a set of morphisms defined on it, the transformations, which appear to meet the defining category-theoretic conditions of being associative and composable, and including an identity morphism for each object. In category theory the morphisms defined on a class can be studied without any commitment to the cardinality of the class; "a category is characterized by its morphisms, and not by its objects", as Marquis (2007) puts it. This seems very much in the spirit of Harris's view of language, at least in Harris (1968), where a transformation is "a pairing of sets ... preserving sentencehood" (p. 60).

Perhaps the best-developed kind of grammar that is neutral with respect to infinitude, however, is the purely constraint-based or model-theoretic approach that has flourished as a growing minority viewpoint in formal syntax over the past thirty years, exemplified first by Johnson and Postal (1980) but later in LFG as presented in Kaplan (1995), GPSG as reformalized by Rogers (1997), HPSG as presented in Pollard (1999) and Ginzburg and Sag (2000), and a variety of other proposed frameworks. The idea of constraints is familiar enough within generative linguistics. The statements of the binding theory in GB (Chomsky 1981), for example, entail nothing about expression length or set size: to say that every anaphor is bound in its governing category is to say something that could be true independently of how many expressions containing anaphors there might be. But Chomsky (1981) used such constraints only as filters on the output of an underlying generative grammar with an X-bar phrase structure base component and a movement transformation. In fully model-theoretic frameworks, grammars consist of constraints on syntactic structures and *nothing more* — there is no generative component at all.

Grammars of this sort are independent of the numerosity of expressions. For example, a grammar of English might include statements requiring (i) that adverb modifiers in adjective phrases precede the head adjective; (ii) that an internal complement of *know* must be a finite clause or NP or PP headed by *of* or *about*; (iii) that all content-clause complements follow the lexical heads of their immediately containing phrases; (iv) that the subject of a clause precedes the predicate. Such conditions are fully capable of representing facts like those in (I). But they are compatible with *any* answer to the question of how many repetitions of a modifier an adjective can have, or how deep embedding of content clauses can go, or how many sentences there are. The constraints are satisfied by expressions with the relevant structure whether there are infinitely many of them or only finitely many.

3.3 Interim conclusion

To summarize, in this section we have made four points. First, the inference from (I) to (II) is not a cogent inductive generalization. Second, it can be represented as a deductive argument (a mathematical induction on the integers) only by making it completely circular. Third, requiring that human languages be modeled by generative grammars with recursive rule systems does not in fact guarantee infinitude. And fourth, it is not necessary to employ generative grammars in order to model the data of (I) — there are at least three other kinds of fully explicit grammars that are independent of how many expressions there are.

Of course, the linguist could simply assume (III) (or equivalently (II)) as an axiom. But it would be an unmotivated axiom with no applications. It neither entails generative grammars with recursion nor is entailed thereby. It would have no consequences for linguistic structure, and thus no consequences for human knowledge of linguistic structure.

4 The stubborn seductiveness of the Standard Argument

If the Standard Argument for infinitude fails so clearly, the question arises of why its conclusion has been so seductive to so many linguists. We briefly consider four factors that seem to have contributed to linguists' eagerness to believe in language infinitude despite the singular inertness it displays in actual linguistic practice.

4.1 The notion that languages are collections

There can be no doubt that one factor tempting linguists to accept infinitude is the ubiquitous presupposition that a language is appropriately given a theoretical reconstruction as a collection of expressions. This is not an ordinary common-sense idea: speakers never seem to think of their language as the collection of all those word sequences that are grammatically well-formed. The idea of taking a language as a set of properly structured formulae stems from mathematical logic. Its appearance in generative grammar and theoretical computer science comes from that source. It is alien to the other disciplines that deal with language (anthropology, philology, sociolinguistics, and so on).[4]

The source of the idea seems to be that early generative grammar, with its emphasis on processes of derivation and its origins in the theory of recursively enumerable sets of symbol sequences, has placed an indelible stamp on the way linguists think about languages. It has even survived direct rejection by Chomsky (1986:20ff), where the term 'E-language' is introduced to cover any and all views about language that are "external" to the mind — not concerned with 'I-language' (languages construed as "internal", "individual", and "intensional"). 'E-language' covers all sorts of traditional views such as that a language is a socially shared system of conventions, but also the mathematical conception of a language as an infinite set of finite strings.

Chomsky's dismissal of the notion of infinite sets of sentences as irrelevant to modern linguistics leaves no place at all for claims about the infinitude of languages. Chomsky dismisses the study of sets of expressions for "its apparent uselessness for the theory of language." The cardinality issue only applies to the conception of language that Chomsky rejects as useless. Large numbers of linguists and philosophers have followed him, and adopted at least the terminological distinction between 'E-language' and 'I-language'. But the view of languages as collections has persisted anyway, even though it is atavistic, and harks back to conceptions that Chomsky (1986) rejects. And of course, if a language is a set of expressions, it has to be either finite or infinite; and if the former is unacceptable, then (if finitely describable) it can only be a computably enumerable infinite set.

One way to put this (and Chomsky comes close to saying this when he includes "intensional" in his characterization of 'I-language') is to say that the goal of a grammar is not to reconstruct a language extensionally, as a collection of containing all and only the well-formed expressions that happen to exist; rather, a grammar is about structure, which should be described intensionally, in terms of constraints representing the form that

[4]The notorious assertions that begin Montague (1970a) and Montague (1970b), to the effect that there are "no important theoretical difference between natural languages and the artificial languages of logicians", were shockingly at variance with the views of most linguists in 1970; and notice, even Montague does not appear to regard the mere availability of infinitely many expressions as significant.

expressions share. Linguists' continued attraction to the idea that languages are infinite is at least in part an unjustified hangover from the mathematical origins of generative grammar.

4.2 The phenomenon of linguistic creativity

A second factor that encourages linguists to believe that human languages are infinite sets stems from a presumed connection between linguistic creativity and the infinite cardinality of languages. Note, for example, this statement by Chomsky (1980:221–222):

> ... the rules of the grammar must iterate in some manner to generate an infinite number of sentences, each with its specific sound, structure, and meaning. We make use of this "recursive" property of grammar constantly in everyday life. We construct new sentences freely and use them on appropriate occasions...

He is suggesting that because we construct new sentences, we must be using recursion, so the grammar must generate infinitely many sentences. Note also the remark of Lasnik (2000:3) that "The ability to produce and understand new sentences is intuitively related to the notion of infinity."

No one will deny that human beings have a marvelous, highly flexible array of linguistic abilities. These abilities are not just a matter of being able to respond verbally to novel circumstances, but of being capable of expressing novel propositions, and of re-expressing familiar propositions in new ways. But infinitude of the set of all grammatical expressions is neither necessary nor sufficient to describe or explain linguistic creativity.

To see that infinitude is not necessary (and here we are endorsing a point made differently by Evans (1981)), it is enough to notice that creating a verse in the very tightly limited Japanese *haiku* form (which can be done in any language) involves creation within a strictly finite domain, but is highly creative nonetheless, seemingly (but not actually) to an unbounded degree. Over a fixed vocabulary, there are only finitely many haiku verses. Obviously, the precise cardinality does not matter: the range is vast. A haiku in Japanese is composed of 17 phonological units called morae, and Japanese has roughly 100 morae (Bill Poser, personal communication), so any haiku that is composed is being picked from a set of phonologically possible ones that is vastly smaller than $100^{17} = 10^{34}$ (given that phonotactic, morphological, lexical, syntactic, semantic, pragmatic, and esthetic considerations will rule out most of the pronounceable mora sequences). This set is large enough that competitions for haiku composition could proceed continuously throughout the entire future history of the human race, and much longer, without a single repetition coming up accidentally. That is what is crucial for making haiku construction creative. All that is needed for the experience of boundless creativity is that the range of allowable possibilities should be vast. It does not need to be infinite.

Not only is language infinitude not necesary, but it is also not sufficient for linguistic creativity. Mere iterable extension of expression length hardly seems to deserve to be called creative. Take the only recursive phrase structure rule in Chomsky's *Syntactic Structures* (where embedding of subordinate clauses was accomplished differently, by generalized transformations), which we quoted above. It says 'Adj → *very* Adj'. If that rule is included in a generative grammar that generates at least one string where some lexical item appears as an expansion of Adj, then the set of generated strings is infinite. Over the four-word vocabulary {*John*, *is*, *nice*, *very*}, for example, we get an infinite number of sentences like *John is very, very, very, very, ..., very nice*. Infinitude, yes, under the generative idealization. Creativity? Surely not.

Repetitiveness of this sort is widely found in aspects of nature where we would not dream of attributing creativity: a dog barking repeatedly into the night; a male cricket in late summer desperately repeating its stridulational mating call over and over again; even a trickle of water oozing through a cave roof and dripping off a stalactite has the same character. All of them could be described by means of formal systems involving recursion, but they provide no insight into or explication of the kind of phenomena in which human linguistic creativity is manifested.

4.3 The critique of associationist psychology

A prominent feature of the interdisciplinary literature that arose out of the early generative grammar community was a broad attack on such movements as associationism and Skinnerian behaviorism in 20th-century psychology. A key charge against such views was that they could never account for human linguistic abilities because they could never explain how humans could learn, use, or understand an infinite language. For example, Chomsky (1957b:1–2n) observes that the examples of axiomatic grammars provided by Harwood (1955) "could not generate an infinite language with a finite grammar".[5] Asserting the infinitude claim might thus have had a rhetorical purpose in the 1950s: the point would have been to stress that the dominant frameworks for psychological research at that time could not even hope to model human linguistic capacities. However, such a rhetorical strategy would be misguided.

Associationist psychology can be modeled by grammars generating sets of strings of behavioral units (represented by symbols), and the relevant grammars are the ones known as *strictly local*, or SL, grammars (see Rogers and Pullum 2007). SL grammars are nothing more than finite sets of n-tuples of terminal symbols.

The SL grammars that consist of n-tuples not longer than k, for some fixed $k \geq 2$, are called *strictly k-local* or SL_k grammars. Various contemporary connectionist systems and speech recognition programs are based on bigrams, and thus correspond to SL_2 grammars. Models using trigrams (the 'Wickelphones' of (Rumelhart and McClelland 1986) are SL_3. The SL class is the union of the SL_k classes of grammars for all $k \geq 2$.

Bever et al. (1968:563) claim to offer a formal refutation of associationist psychology by showing, in effect, that SL grammars are not adequate for the description of certain syntactic phenomena in English. They stress the issue of whether grammars have non-terminal symbols, and remark that association-

[5] The illustrative stochastic generative grammar given by Hockett (1955) in 'select one from each column' form also deals only with a finite set of sentences, and no mechanisms for recursive return to a previous column was mentioned. Oddly, the critical review by Chomsky (1957a) does not comment on that fact, but concentrates on critiquing the stochastic aspect of Hockett's proposals.

ism is limited to "rules defined over the 'terminal' vocabulary of a theory, i.e., over the vocabulary in which behavior is described", each rule specifying "an n-tuple of elements between which an association can hold", given in a vocabulary involving "description of the actual behavior". SL grammars have precisely this property of stating the whole of the grammar in the terminal vocabulary. They cite a remark by Lashley (1951) which in effect points out that SL_2 cannot even provide a basis for modeling the behavior seen in typing errors like typing 'Lalshey' for 'Lashley'.

However, no matter what defects SL grammars might have, an inability to represent infinite languages is not one of them, and Bever et al. tacitly acknowledge this, since they nowhere mention infinitude as a problem.

We raise this issue because Lasnik (2000:12) claims that the finite-state conception of grammar "is the simplest one that can capture infinity." This is not true. The infinite set alluded to above, containing strings of the form '*John is* (*very*)* *nice*', is easy to describe with an SL_2 grammar.[6]

In short, associationist psychology and connectionist models of cognition are entirely untouched by the infinitude claim. Infinitude has no more consequences for these research programs than it does for theories of grammar or linguistic creativity.

5 Concluding remarks

The quotations from Langacker (1973) and Epstein and Hornstein (2004) in (4) and (2) baldly assert that infinitude holds for every human language; and Lasnik (2000), Hauser et al. (2002), and Yang (2006) hold that infinitude, as a direct consequence of recursion in grammars, is a central and fundamental aspect of human language. We have argued that such claims are entirely unwarranted.

A side consequence of the recent stress on language infinitude and recursion has been a controversy about the Amazonian language Pirahã. The dispute documented in Everett (2006), Nevins et al. (2007), and Everett (2007) about this language has attributed great importance to such apparently fine-detail issues as whether the distribution of the *-sai* morpheme in Pirahã indicates the presence of clausal hypotaxis. Nevins et al. (2007) almost seem to suggest that assertions about Pirahã lacking clausal hypotaxis, and more generally infinitude, imply inferiority for the Pirahã and their linguistic abilities, or limitations on their linguistic creativity. We have argued, to the contrary, that there is no necessary connection between clausal hypotaxis and infinitude of the set of all expressions, and no discernible connection between infinitude and linguistic creativity.

Pirahã is in any case not the only language that might be claimed to have no true subordinate clause constructions. For example, it is clear from the careful descriptive work of Derbyshire (1979a) that the Amazonian language Hixkaryána (in the Cariban family, unrelated to Pirahã) does not have finite subordinate clauses as complements of verbs of propositional attitude like *know* or *think*. Derbyshire (1979a:21) states that "Subordination is restricted to nonfinite verbal forms, specifically derived nominals" or "pseudo-nominals that function as adverbials"; "There is no special form for indirect statements such as 'he said that he is going'…" The closest approach to subordination is the use of directly quoted main clauses followed by an inflected form of the verb meaning "say"; e.g., *àtehe kano* (I-go he-said-it) as the analog of English *"I'm going," he said*.

The topic needs closer study. Derbyshire's work was based on many years of residence among the people, daily use of the language, extensive translation experience, and syntactic research over more than two decades, and it is well documented. Derbyshire (1979b) is available as a resource for anyone seeking to examine the issue of subordination more minutely. There is a section (1979b:63ff) headed "Embedding of subordinate clauses", dealing with what Derbyshire refers to as "subordinate clauses embedded in other subordinate clauses". But it is important not to jump to conclusions from his informal characterization. Derbyshire is classifying sentences by reference to their English translations. The English free translations of the Hixkaryána sentences cited do have finite subordinate clauses, contained within main clause adjuncts, and those subordinate clauses have non-finite subordinate clauses inside them. But there are no finite subordinate clauses in the Hixkaryána, still less finite subordinate clauses inside finite subordinate clauses.

For example, the free translation "He went to Kasawa, because he was wanting to talk with Kaywerye" corresponds to this Hixkaryána utterance:[7]

(11)

Kasawa hona	*nteko,*	*Kaywerye*	*yakoro*
Kasawa to	he-went,	Kaywerye	with

tàrwonàmrà	*xe*	*tesnàr*	*ke*
his-talking	desirous-of	his-being	because

The verb *nteko* "went" is tensed, but the adjunct following it is composed of nominals and postpositions. The postposition *ke* "because" takes as complement a nominalized copular clause meaning literally "his being desirous of talking to Kaywerye". There is no verb corresponding to English *want*; *xe* is a desiderative postposition. There are also no verbs corresponding to English *talk* or *be*: *tàrwonàmrà* and *tesnàr* have nominal morphology. Whether such embedding of nominals might be indefinitely extensible is something Derbyshire did not address.

We take no stand here on whether indefinite extensibility of expressions through iterated embedding is possible in Hixkaryána or not. But it is not a matter to be settled either by reading English free translations or by a quick eyeballing of morpheme glosses. There is some careful theory-based interpretive work to be done here, followed perhaps by gathering of further data (Hixkaryána is by no means extinct). The point we are making is merely that the possibility of there being human languages with no iterable embedding did not suddenly emerge with Everett's work in 2005; it has been raised in earlier linguistic literature. Open questions remain, and those questions cannot be answered by dogmatic assertions that infinitude is a feature of every human language.

In the case of Hixkaryána, Derbyshire notes in addition the absence of any "formal means … for expressing coordination at either the sentence or the phrase level, i.e. no simple equivalents of 'and', 'but' and 'or'" ((Derbyshire 1979a:45)). This is not to say that the language cannot semantically express what English

[6]The strings in the set are all and only those that begin with *John*, and end with *nice*, and are otherwise composed entirely of the bigrams '*John is*', '*is very*', '*is nice*', '*very nice*', and (crucially for infinitude) '*very very*'.

[7]Notice that word order in the clause is essentially the reverse of what it would be in English; Hixkaryána is a postpositional OVS language.

syntactically expresses with clausal coordination: a Hixkaryána speaker can express the equivalent of *She was picking it and eating it* by saying *hohtyakon* (she-was-picking-it) and then saying *nenahyakon* (she-was-eating-it). There are particles that can be added to a sentence to suggest it implicitly contrasts with a preceding one, getting something like the semantic effect of *but* coordination in English (p. 46), but there is no syntactic coordination at all. Again, this is not unprecedented; Dixon (1972) finds no coordination devices in the Australian aboriginal language Dyirbal.

It is possible (though by no means certain) that there are no unboundedly extensible phrasal, clausal, or sentential constructions in Hixkaryana.

But if such recursive syntactic devices are absent from the grammar, this has no relevance to the possibility of expressing novel propositions, or expressing familiar propositions in novel ways. A translation of the entire New Testament into Hixkaryána (Derbyshire 1976), produced with the assistance of native speakers who approved every sentence, was completed without any inexpressible propositions being encountered. The Greek and English originals did have finite subordinate clause constructions, but their content did not cause work on the translation to grind to a halt. The propositions expressed were not incapable of being expressed in Hixkaryána.

And anyway, as anyone versed in the analysis of spontaneous conversation will attest, the use of subordination considered to be typical (and educationally approved of) in educated written Standard English is quite rare in real-life colloquial use of English in natural conversations. Pawley and Syder (2000) argues that clausal subordinate clause construction hardly occurs at all in spontaneous English speech, and quite a bit of what might be taken for on-the-fly construction of novel subordinative structures is in fact fill-in-the-blanks use of semi-customizable formulas containing subordinative patterns. It should not surprise us if we find no more subordination in colloquial speech in a small community with a preliterate culture than we find in colloquial English conversation.

If in areas like Amazonia, where hunter-gatherer cultures survive, some small human groups do use languages essentially devoid of resources for clausal subordination, that is just what one might expect.

Just as a claim about absence of a basis for infinitude claims about some languages should not be regarded as a demeaning allegation of inferiority concerning the speakers, which is apparently what the authors of Nevins et al. (2007) fear, it should by the same token not be seen as threatening the research program of transformational-generative grammar, as Everett (2006, 2007) appears to suggest. Generative linguistics does not stand or fall with the infinitude claim. Exposing the overstatements some linguists have made need not imply the collapse of a whole research progam. We have pointed out that it is not *necessary* to use generative rule systems with recursion in order to represent the syntax of languages that have iterable subordination, but it does not follow that it is a mistake to posit generative rule systems; that is an issue we do not take up here.

Our point is, rather, that the use of a rule-application analog of recursion in grammars does not entail infinitude for human languages, and infinitude does not offer independent evidence that a human language must have a recursive generative grammar. The remark of Lasnik (2000:3) that "We need to find a way of representing structure that allows for infinity" should be read, charitably, as a restatement of the claim of Harris (1957:208): "If we were to insist on a finite language, we would have to include in our grammar several highly arbitrary and numerical conditions." It should not be interpreted as a claim that languages have been found to be infinite so our theories have to represent them as such. Language infinitude is not a reason for adopting a generative grammatical framework. It is merely a theoretical consequence that will under some conditions emerge from adopting such a framework.

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