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Stephen C. Levinson

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SHORT REPORT

Recursion in pragmatics

Stephen C. Levinson

Max Planck Institute for Psycholinguistics and *Radboud University, Nijmegen*

There has been a recent spate of work on recursion as a central design feature of language. This short report points out that there is little evidence that unlimited recursion, understood as center-embedding, is typical of natural language syntax. Nevertheless, embedded pragmatic construals seem available in every language. Further, much deeper center-embedding can be found in dialogue or conversation structure than can be found in syntax. Existing accounts for the 'performance' limitations on center-embedding are thus thrown into doubt. Dialogue materials suggest that center-embedding is perhaps a core part of the human interaction system, and is for some reason much more highly restricted in syntax than in other aspects of cognition.*

Keywords: recursion, center-embedding, dialogue, syntax, pragmatics

Recursion in pragmatics. In an article that has given rise to a great deal of commentary, Hauser, Chomsky, and Fitch (2002) suggested that the sole feature of language that may be domain-specific is the recursive nature of syntax, with the implication that it was the evolution of this syntactic ability that accounts for the species-unique character of human language. The aim of this short report is not to engage in further commentary, but rather to clarify that there is one central sense of the term recursion—namely embedding (see e.g. Larson et al. 2010)—that clearly is not exclusive to syntax, and that is exhibited in a much more fulsome way outside of sentential syntax.

1. Formal language theory and its limitations.[1] One of Chomsky's (1955, 1956, 1957) greatest (and undisputed) contributions to twentieth-century thinking is encapsulated in the so-called chomsky hierarchy of formal grammars, which set up a hierarchy of ever more powerful or unrestricted grammars, each with specific rule types, correlating with a hierarchy of automata and with the languages that each level could generate (as in Table 1).

CLASS	GRAMMAR	AUTOMATA	LANGUAGE	USEFUL DIAGNOSTIC PATTERNS
0	unrestricted	Turing machine	recursively enumerable	
1	context-sensitive	linear-bounded	context-sensitive	copy language: ABCABC (cross-serial dependencies)
2	context-free	pushdown-stack	context-free	mirror language: AABBAA counting language: $A^n B^n$
3	regular	finite	regular	$A^n B^m$

Table 1. The Chomsky hierarchy.

Thus, as every student of formal grammar or computation learns, regular languages pair with finite-state automata, context-free languages with nondeterministic pushdown-

* The ideas here were first presented at the International Conference on Language and Recursion, Mons, Belgium, March 14, 2011. I am grateful to the audience for discussion, and to colleagues at the Max Planck Institute for Psycholinguistics in Nijmegen after a short presentation there. I also thank my colleagues Penelope Brown, Nicholas Evans, Kobin Kendrick, Pim Levelt, and Karl-Magnus Petersson for very useful comments on an earlier draft, and the editor for suggestions; faults remaining are my own. This work was conducted within the framework of the ERC Advanced Grant INTERACT.

[1] This section owes a great deal to a talk delivered by Gerhard Jäger at the Max Planck Institute for Psycholinguistics, November 23, 2010, which clarified the essential issues for me (see Jäger & Rogers 2012).

stack automata, context-sensitive languages with linear-bounded automata, and so on (Levelt 1974, Partee et al. 1990). The proofs mostly rely on showing that languages with specific string types can or cannot be generated by the corresponding rule type. Thus strings of the form $A^n B^m$ (any number of As followed by any number of Bs) are the stigmata of regular languages; the $A^n B^n$ strings (any number of As followed by the same number of Bs—the 'counting language') or the string-sets AABBAA (the 'mirror language') belong to context-free languages; and strings of the type ABCABC (the 'copy language') belong to context-sensitive languages.

Chomsky (1957) argued cogently that English has strings (like the conditional) that are homomorphic with the mirror language, and thus can only be generated by a context-free (or higher-order) grammar.[2] The argument relies on the assumption that nested dependencies can be of unlimited depth, leading to unbounded dependencies, since any finite number of these patterns can be produced by a finite-state device producing a regular language. It is perhaps worth pointing out that this assumption is neurocognitively implausible (Petersson 2005). Most of these proofs of context-free properties rely on center-embedding, which thus plays a central role in formal linguistic theory.

There was then a minor industry in trying to find strings in natural languages that cannot be generated by a context-free grammar but would require the next level up, a context-sensitive device (Bar-Hillel & Shamir 1960, Huybregts 1976, 1984), but the examples proved undecisive since they relied on semantic construal (of e.g. stacked nouns corresponding to stacked verbs) rather than formal dependencies (Pullum & Gazdar 1982). A Swiss German dialect, however, finally provided what looks like a clearer example of formal dependencies beyond context-free power (Shieber 1985), namely strings with CROSS-SERIAL DEPENDENCIES of the form seen in 1.

(1) $A^n\ B^m\ C^n\ B^m$

The examples remain limited to only one or two languages (see also Culy 1985 on Bambara), so it remains anything but obvious that this is a general feature of natural languages.

Chomsky himself rapidly lost interest in the hierarchy that bears his name, because it is a formal theory of string-sets, and it quickly became evident to him that STRINGS of symbols are not the central object of study in linguistics. Instead, the focus is on the mapping of specific structures onto strings (for example, the familiar phrase structures), which are not determined by the strings themselves alone. A string like AAABBB, for example, might be psychologically construed as having a nested structure like $[A^3\ [A^2\ [A^1\ B^1]\ B^2]\ B^3]$ or a cross-serial dependency as in 2.

(2) $[A^1\ [A^2\ [A^3\ B^1]\ B^2\ ]\ B^3]$

It is the cognitive structure that is the object of study, not the formal properties of strings, and it is the construal of (unlimited) noncontiguous chunks as belonging together that is the central psychological phenomenon (Levelt 1974).

Formal grammar theory and its aftermath makes crystal clear that RECURSION per se is of little theoretical interest: strings like *a very very very … very big ship* can be produced by the simplest finite-state automata generating regular languages. In addition, the properties of strings themselves are of limited interest to linguistic theory, since there is generally no way to induce unequivocal phrase structure (or other syntactic or-

[2] His proof, however, was deficient, as Levelt (1974, vol. 2:23–26) pointed out.

ganization) from this information alone (Klein & Manning 2004).[3] What seem much more interesting are unbounded dependencies across center-embedded structures, which are the focus here.

2. Languages with limited center-embedding. Linguistic typologists are well aware of many languages that show little evidence of indefinite embedding.[4] Recently, Pirahã has been a focus of debate, with the original fieldworker (Everett 2005) claiming no evidence at all for recursive structures and generativist reanalysis suggesting that embedding may in fact be evidenced (Nevins et al. 2009). Analysis hinges on the distinction between embedding and parataxis, and on whether 3 should be analyzed as in 3a (Everett) or 3b (Nevins et al.).

(3) H xob-áaxáí. Hi kahaí kai-sai.
he see-well he arrow make-OLD.INFO
a. Everett: 'He is really smart. He makes arrows (as we were saying).'
b. Nevins et al.: 'He is really good [COMP at making arrows].'

What is not in doubt, however, is that embedding is very limited, and at most seems capped at one level deep.

As discussed in §1 above, it is the unlimited character of nested dependencies that is relevant for the theoretical issues. But in lacking evidence of indefinite recursion Pirahã is not unique at all. The Australian languages provide a wealth of better-documented cases. As Ken Hale (1976:78), sitting just down the corridor from Chomsky, pointed out:

> In a large number of Australian languages, the principal responsibility for productive recursion in syntax is shouldered by a structure which I will refer to as the *adjoined relative clause*. It is typically marked as subordinate in some way, but its surface position with respect to the main clause is marginal rather than embedded—hence the locution 'adjoined'. Typically, but not invariably, it is separated from the main clause by a pause.

A further property is that these juxtaposed sentences with the structure S1 + (particle) S2 function with a wide array of possible interpretations as relatives, temporal clauses, conditionals, and so forth. Hale pointed out (1976:80) that the Warlpiri sentence in 4 allows any of the indicated readings (the square brackets in the examples below indicate the putative embedded clause).

(4) Ngajulu-rlu kapi-rna maliki rluwa-rni, [kaji-ngki yarlki-rni nyuntu].
1-ERG AUX dog shoot-NP COMP?-AUX bite-NP you
a. 'I will shoot the dog, if/… when it bites you.'
b. 'I will shoot the dog that bites you/… that is going to bite you.'

Although Warlpiri has a particle that may be analyzed as a complementizer, many Australian languages do not. It then becomes a completely live issue as to whether we are dealing with structural dependence or parataxis with 'subordinate'-like construals. Consider the following Wambaya sentence (Nordlinger 2006).

(5) [Ilarri irri ngarabi] daguma irri-ngg-i.
grog.I(ACC) 3PL.A(NP) drink hit 3PL.A-RR-FUT
a. 'They'll drink grog (and then) they'll fight.' (coordinate construal)
b. 'When they drink grog, they'll fight.' (subordinate construal)

Nordlinger argues that the 'subordinate' construal may be forced by prosody, but as Hale noted, there is often a pause between clauses of these types in Australian lan-

[3] Instead, formal grammar theory has proved to be a central plank in computational theory, with a new lease on life in bioinformatics (Chiang 2012).

[4] See for example the discussion of Amele in Comrie & Kuteva 2008.

guages generally. It will not be easy then to come to a definitive conclusion either way, just as in the Pirahã case.

Many Australian languages nevertheless have some cases of relatively clear subordination. But in these cases indefinite embedding is hard to support, because the embedded verb typically takes a nominal case, for example a purposive. This often constrains further embedding. Consider Kayardild (Evans 1995), which adds an oblique case (COBL) to each of the subordinate constituents, as in 6. This case is terminal, so no further subordination is possible.

(6) Dan-da banga-a [kakuju-ntha ngijuwa raa-jarra-ntha
this-NOM turtle-NOM uncle-COBL 3.SUB.COBL spear-PST-COBL
walbu-nguni-nj].
raft-INSTR-COBL
'This is the turtle [uncle speared from the raft].'

It is therefore not possible to add, say, a relative clause to 'the raft'. Kayardild thus morphologically blocks recursion at one level deep. In general, polysynthetic languages show very restricted levels of embedding (see Evans & Levinson 2009). And, in the opposite direction, languages with very limited morphology often offer no clear evidence for subordination at all (see e.g. Englebretson 2003 on Indonesian). Pirahã is thus not an isolated case.

A frequent response to these sorts of findings is to invoke the metaphor of universal grammar as a 'toolkit' whose tools may not be all deployed (as in Jackendoff 2002):

> The putative absence of obvious recursion in one of these languages is no more relevant to the human ability to master recursion than the existence of three-vowel languages calls into doubt the human ability to master a five- or ten-vowel language. (Fitch et al. 2005:203)

But this fits ill with the claim (Hauser et al. 2002) with which we began, that 'recursion' (understood as embedding) may be the one crucial domain-specific feature of linguistic ability.

3. THE POWER OF PRAGMATICS. Recursive understandings do seem to be at the heart of human reasoning; for example, reasoning about other minds would seem to require propositional attitudes and embedded propositions. In special cases (like new sign languages) there is indeed some evidence that where linguistic systems are impoverished in this regard, there may be some hindrance in acquiring a sophisticated theory of mind (Pyers & Senghas 2009). But in general, speech communities suffer not at all from restricted means for direct coding of embedding, for the simple reason that parataxis is routinely construed in rich ways. Consider the verb string *veni, vidi, vici*, or the paratactic vs. subordinative alternatives in 7.

(7) a. John came in. Harry abruptly left.
b. As soon as John came in, Harry left.

The different possibilities are extensively exploited in normal language usage. Compare the following extract from a Hemingway short story ('The killers'), with the original version given in 8a and a more explicit version with multiple embeddings given in 8b. Nothing of interest is added by the more explicit version, but the famous style is lost.

(8) a. 'Give me bacon and eggs,' said the other man. He was about the same size as Al. Their faces were different, but they were dressed like twins. Both wore overcoats too tight for them. They sat leaning forward, their elbows on the counter. (original)
b. 'Give me bacon and eggs,' said the other man, who was about the same size as Al. Their faces were different, although they were dressed like

twins, wearing overcoats too tight for them. They sat leaning forward, putting their elbows on the counter. (embedded version)

When Australian languages choose to express relatives, conditionals, disjunctions, and temporal 'subordination' by means of parataxis, little may be lost, and concision gained. The pragmatic processes involved have been the subject of extensive investigation (see e.g. Sperber & Wilson 1986, Levinson 2000). They occur everywhere, of course, as illustrated in 9.

(9) a. The destroyer was hit amidships. The boat sank within minutes. (temporal, causal)
b. The man was uncouth. He came from the south. (nonrestrictive relative)
c. Buy a ticket. Win a thousand dollars. (conditional)
d. Perhaps John was involved. But Bill is certainly at fault. (concessive)

I once tongue-in-cheek coined the paradoxical slogan 'the less you say, the more you mean' (Levinson 1987) to draw attention to the inferential power of the principle that lies behind such interpretations—a principle that would cause communicative mayhem were it not hedged in by other pragmatic principles (see Levinson 2000). It is a consequence of this principle that Australian languages like Guugu Yimithirr can lack unequivocal encodings of conditionals or disjunctions: one can express a conditional by saying in effect 'uncertain X, Y', or a disjunction by saying 'perhaps X, perhaps Y' (Haviland 1979:149–50, and my own field notes).

4. Center-embedding in syntax. The discussion so far shows that parataxis can be hard to distinguish from embedding, especially since an embedding-like construal is likely to be driven by the pragmatics even when there is no syntactic motivation for it. This uncertainty arises, of course, where superficially the clauses are consecutive, as in *Mow the lawn and I'll give you six dollars*. But these difficulties are circumvented if instead of focusing on edge-recursion we focus on center-embedding, where one structure is included in another and flanked by material from the matrix clause.

It has long been noted, however, that there are comprehension problems associated with repeated center-embeddings. Chomsky and Miller (1963:286–87) wrote of 10 (here displayed so as to help comprehension) that it 'is surely confusing and improbable but it is perfectly grammatical and has a clear and unambiguous meaning'.

(10) The rat ate the malt.
the cat killed
the dog chased

They assumed that such sentences are licensed grammatically but run up against performance processing difficulties. There have been numerous theories since then about why exactly the processing is difficult, but all revolve around short-term memory limitations (Kimball 1973, Gibson 1991, 1998, Weckerly & Elman 1992, Perfors et al. 2010, Folia et al. 2011). Gibson (1998, Gibson & Thomas 1999), for example, suggested that the problem not only involves keeping track of a number of unfulfilled dependencies, but also follows a locality metric: hence nested dependencies three or more deep are more difficult than cross-serial dependencies (Bach et al. 1986), where the dependencies are serially and more locally discharged (see de Vries et al. 2012 for recent confirmation). These studies repeatedly show severe performance difficulties at three levels of embedding or higher (Marks 1968), allowing a connectionist account of performance (Christiansen & Chater 1999).

Karlsson (2007) examined corpora in seven European languages (English, German, Finnish, French, Latin, Swedish, Danish). He found that in the Brown corpus of English written texts, 57% of clauses have embeddings, of which 76% were final, 13% were initial, and 11% were center-embeddings (mostly relative clauses). This seems to be the general pattern at least for familiar languages of similar word order, but polysynthetic languages show a much lower incidence of embedding (e.g. 7% in Mohawk, 6% in Gunwinggu, and just 2% in Kathlamet; Mithun 1984). Center-embeddings can be classified as degree 1 (one embedding), degree 2 (embedding within an embedding), and degree 3 (embedding within an embedding within an embedding). A (simplified) example of Karlsson's coding is given in 11.

(11) Karlsson 2007:4

1 If	← degree 1 subordinate clause
2 as often happened	← degree 2 center-embedding
1 she asked him	
2 to tell her about it	← degree 2 complement
0 she thought	← matrix-clause (degree 0)
1 that he	← degree 1 complement
2 who had been so kind	← degree 2 center-embedding
1 would understand	

No examples of degree 3 embedding were found in corpora, although from hand-annotated historical texts from his and other earlier compilations, a total number of thirteen cases have been found in the whole of Western literature. He therefore observes that the maximal degree of multiple center-embedding is three in written language. For spoken language, no cases at all have been found, and only three cases of degree 2, from which he concludes that degree 2 is the upper bound for spoken language. These findings are of course interesting, since they undermine the idea that natural languages are not regular and necessarily context-free or higher—it remains an interesting question whether treating, say, English as regular (with large numbers of simple rules) is more complex than treating it as context-free (with fewer, more complex rules; see Perfors et al. 2010).

The psycholinguistic findings and the corpus findings converge: after degree 2 embedding, performance rapidly degrades to a point where degree 3 embeddings hardly occur.

5. Center-embedding in interactive discourse. We are now in a position to appreciate some very surprising facts.[5] There are embeddings in interactive discourse that have the same basic properties exhibited in sentential syntax, but that are distributed over two (or more speakers). But in this case there is no parallel limit on embedding—multiple embeddings seem in principle indefinite, certainly at least to degree 6.

The basic phenomenon can easily be illustrated, as in 12 (from Merritt 1976a:333). (Examples are drawn largely from interaction in service encounters, since these have a compact quality that lends them to brief exposition.)

(12)

A:	May I have a bottle of Mich?	
B:	Are you twenty one?	← degree 1 center-embedding
A:	No	← response at degree 1
B:	No	

[5] The observations are not new, but take on a new significance in the light of recent discussion. They were made early in conversation analysis (e.g. Sacks 1995 [1967]:324; see Schegloff 2007 for review), and I even pointed out their significance in terms of the Chomsky hierarchy thirty years ago (Levinson 1981), noting, however, a number of non-syntax-like properties. See also Koschmann 2010. Merritt 1976a,b also discussed a range of discourse structures in service encounters, including embeddings.

Clearly, in this interchange the second question leaves the first unanswered until a preliminary question is addressed, which then allows the answer to the first question to be subsequently provided. The question-answer pair in the middle forms an island over which a discontinuous dependency is maintained. In these kinds of insertion sequences, paired utterances are embedded at the same level together. We have here a nested dependency just as in *The boy the horse kicked has a broken leg*. Sequences of this type $Q_1Q_2A_2A_1$ belong squarely in the class of the counting or mirror languages, the prototypes of context-free languages. A context-free grammar that would generate strings like QQQAAA indefinitely might have the form in 13.

(13) Q&A → Q (Q&A) A
Q&A → Q A

It is true that, like nearly all the demonstrations of context-freeness in syntax, the assignment of structure to utterances in these cases is relative to a construal. In this case the construal depends not on the syntax and semantics so much as the speech act or illocutionary force: regardless of form or semantic content, the dependencies hold across utterances paired by function—across 'adjacency pairs' in the terminology of conversation analysis (Schegloff 2007).

How deep do such embeddings go? Consider 14, in which each action is bracketed and labeled, and given with its degree of embedding.

(14) Merritt 1976b:136

C: Do you have master carbons? (Q (prerequest): 0)
S: (pause) Yes, I think we do (A: 0)
What kind do you want? (Q: 1)
C: How many kinds do you have? (Q: 2)
S: Well, there are carbons for gelatin duplicators, and carbons for spirits (A: 2)
C: Well I'll take the carbons for spirits, please (A: 1)
S: ((goes to get)) (Action: 0)

This has the structure $[Q_0\ [Q_1\ [Q_2\ A_2]\ A_1]\ Action_0]$, where Q_0 is a conditional request leading eventually to the action requested ($Action_0$). This is an embedding of degree 2, which, recollect, occurs vanishingly rarely in spoken language syntax, but which in spoken discourse is routine. As the bracketing makes clear, this is a pushdown stack, responses climbing back up the stack. Conversation analysts note that some speech acts or actions (as they prefer) come in 'adjacency pairs'—thus questions expect an answer in the next turn; where the adjacency criterion is not met, an answer is nevertheless still due.

There are a range of reasons for these 'insert sequences', but typically the inserted adjacency pairs deal with a prerequisite for handling the initial action (Schegloff 2007). One prerequisite is hearing or understanding the prior turn. Thus 15 is an example of a different type involving other-initiation of repair, with a further repair-initiation on the first repair initiator.

(15) Schegloff 2007

Sig: Conservatives like to shoot people and (liberals don't) (Assertion: 0)
(2.0)
Dad: Conservatives like wha:t? (Repair initiator: 1)
Sig: Wha:t? (Repair initiator: 2)
Dad: What did you say about conservatives (Repair: 2)
Sig: Conservatives like to shoot people en liberals don't (Repair: 1)
Mom: N::no: (Reaction: 0)

Example 16 takes us one level deeper, to degree 3 embedding, well beyond the attested bound for recursive embedding in spoken language.

(16) Merritt 1976a:331

	S:	Next	(Request to order: 0)
0	C:	Roast beef on rye	(Order: 0)
1	S:	Mustard or mayonnaise?	(Q: 1)
2	C:	Excuse me?	(Repair initiator: 2)
3	S:	What?	(Repair: 3)
3	C:	Excuse me, I didn't hear what you said	(Repair: 3)
1	S:	Do you want mustard or mayonnaise?	(Repair: 2)
	C:	Mustard please.	(A: 1)
0	S:	((provides))	(Compliance with order: 0)

Examples of this depth or greater are not hard to find. Another is given in 17, arguably of degree 4 (as the examples become more complex, the room for different analyses increases, as Karlsson also found for complex written sentences).

(17) Abbreviated from Levinson 1983:305

C:	… I ordered some paint … some vermillion	
	And I wanted to order some more, the name's Boyd	(Preorder: 0)
R:	Yes how many tubes would you like sir?	(Q: 1)
C:	What's the price now with VAT?	(Q: 2)
R:	I'll just work that out for you	(Hold: 3)
C:	Thanks	(Accept hold: 3)
	(10.0)	
R:	Three pounds nineteen a tube sir	(A: 2)
C:	Three nineteen is it=	(Q: 3)
R:	Yeah	(A: 3)
C:	That's for the large tube?	(Q: 4)
R:	Well yeah it's the 37 ccs	(A: 4)
C:	I'll just eh ring you back I have to work out how many I'll need	(Hold: 2 for A: 1)
	((call-back with order and acceptance))	(0)

Human subjects performing psycholinguistic tests in an artificial-grammar learning paradigm show large degradation in performance at and after degree 3 embedding—'whereas two nested dependencies are still within our processing limits, three nested dependencies appear to be beyond what we can process' (de Vries et al. 2012:2073). In contrast, the deepest attested nesting of center-embedded insertion sequences seems to be of at least degree 6, as in the following highly abbreviated example (for the full transcript and discussion, see Schegloff 2007), where an unusual request leads to many subsidiary questions. After the request for permission to borrow a gun, eighty-odd turns at speaking intervene while the requestee works out the purpose of the request before he finally grants it. With any such complex example different analyses are possible, but a conservative analysis of the depth of embedding is shown in 18 by bracketing and labeling of actions and the degree of embedding, as elsewhere.

(18) Abbreviated and truncated from Schegloff 1990, 2007:111–13

1	B: I was wondering if you'd let me borrow your gun?	(Request: 0)
2	J: My gun?	(Repair initiator: 1)
3	B: Yeah	(Repair: 1)
4	J: What gun?	(Repair initiator on own repair initiator: 2)
5	B: Don't you have a beebee gun?	(Q: 3)
6	J: Yeah, I have a lotta guns	(A: 3)
7	B: You do?	(Q/Repair initiator: 4)
8	J: Yeah.	(A: 4)
9	J: What I meant was which gun?	(Redo Q: 2 (3rd position repair))
10	B: Well d'j' have a really long one?	(Q: 3)
11	J: A really long one?	(Q/Repair initiator: 4)
12	B: Yeah	(A: 4)
13	J: why would you like a really long one?	(Q: 4)
14	B: you don't have a really long one?	(Q: 5)
15	J: What?	(Q/Repair initiator: 6)
16	B: Donchuh have a really long one?	(6)
17	J: Yeah	(A: 5)
18	J: I want to know why you want a gun	(Redo Q: 5)
19	B: Well becuz…	(A: 5)
20	J: You're gonna shoot your mom?	(Q: 5)
...	*…((eventually c. 60 turns later))……*	
0	J: Yeah you can use it …	(Granting: 0)

6. Discussion. I have argued that recursive embedding in syntax is not necessarily a prominent feature of languages—in some large class of languages (yet to be exactly determined, but including for example many Australian languages) it is either not clearly evidenced or capped at a very shallow level. These languages provide no evidence, therefore, that a core element of language design is indefinite embedding of the kind produced by a context-free grammar. Whether or not languages have clear syntactic embedding, however, they always seem to make use of 'pragmatic embedding' as it were—that is, uncoded construals that understand clauses as if they were complements, relative clauses, or temporally subordinate. The two facts together suggest that 'recursion' understood propositionally (as relations between propositions) is not so much a universal property of grammar as a property of human psychology, most evident in language use.

We then went on to examine the patterning across turns in interactive discourse (dialogue in most of the cases examined). Here there is a curious analogue of the recursive embedding that has so much exercised linguists. Turns at talk are tied to each other as responses to prior speech acts, typically across adjacency pairs like question-answer, request-compliance, offer-acceptance, and so forth. When so construed we see that pairs of utterances may be embedded within other pairs of utterances, apparently with little effort and to a much greater depth than is exhibited in syntax. Once again, pragmatics outplays syntax.

This phenomenon raises a central question: How can we explain that what is apparently cognitively impossible in syntax (namely indefinite center-embedding) is so straightforward in the pragmatics of dialogue? The dialogue facts seem to rule out the idea that there is an absolute performance barrier due to short-term memory limitations; they also seem to undermine the idea that the difficulty found in syntax is based on holding dependencies over a lot of intermediate material (Gibson's 1998 locality effects). In the dialogue case, exactly the same pushdown-stack structure is involved, and the range over which these dependencies have to be held in memory can be immense (as shown by 16).

Perhaps the mystery can be partly dissolved in the following way. Note that our action-planning system in general needs to be able to hold a stack of subgoals, and check them off one by one—to make the coffee may require calling the water-getting subroutine, which may require the jug-finding subroutine, and so forth. Many aspects of language use are best explained in terms of joint-action planning (Clark 1996, Levinson 2013), so that language usage is able to draw directly on the cognition of our action systems in a way that syntax cannot. Note that the indefinite center-embedding in interactive discourse is construed over speech acts—actions in linguistic clothing. In addition, interactive language use is 'distributed cognition' par excellence, and this may somehow lower the processing load, although to participate effectively in such joint action each party must nevertheless model the whole emerging structure. If action, and specifically joint action, is indeed the root of this ability to parse embedded structures, then the more abstract and removed from this domain a mental task is, the more restricted human processing of this kind may be expected to be. That might explain our limited prowess in syntax. But this is speculation.

When an ability is much more developed in one arena than another, it seems reasonable to surmise that it is primarily adapted for the more developed arena. The inference then is that syntactic embedding may have evolved out of our capacities in the dialogue arena, which in turn draws directly on joint action abilities. There is just some general evidence for this in the discourse sources of complex constructions. First, discourse analysts have noticed that some complex syntactic dependencies are actually interactionally produced; for example, left-dislocations like 19a may have arisen from the interactional structure in 19b where the element is fronted to check recognition interactionally (Geluykens 1992).

(19) a. That last paragraph, I seem to remember it being different
  b. A: Now um, that last paragraph?
   B: Yes
   A: I seem to remember it being different …

Second, there is evidence that in the progression from pidgin to creole, paratactic constructions give rise to subordination—for example, paratactic clauses with deictics (with a similar recognition-checking function to 19b) can develop into relative clauses (Sankoff & Brown 1976). Third, in child language development, structures like conditionals (as in 20a) sometimes seem to arise from corresponding interchanges as in 20b (de Castro Campos 1981, following Jespersen's 1940 treatment of the grammaticalization of English conditionals).

(20) a. If it's late, then let's go
  b. A: Is it late?
   B: Yes
   A: Then let's go

There are thus at least three lines of evidence—from corpora, from creolization or language change, and from child language—that may suggest an origin of complex syntax in interactive language use.

7. BEYOND CONTEXT-FREE. As we have seen, the embedding of insertion sequences in interactive language use can have the $A^n B^n$ structure that is typical of context-free languages. But perhaps this is a chance homology across two domains, syntax and interaction structure. That is made unlikely by evidence elsewhere that suggests that interaction structure outperforms grammar in other respects too. Consider the quite esoteric evidence that seems to suggest that natural languages potentially lie higher on the Chomsky hierarchy, in the context-sensitive category. Sentential patterns homomorphic to the copy language (patterns like ABCABC) are enough to establish this. A Dutch subordinate sentence like that in 21 seems to have the necessary properties, where the coindexed objects align with corresponding predicates (Huybregts 1976).

(21) dat Jan Marie$_1$ Pieter$_2$ Arabisch$_3$ laat$_1$ zien$_2$ schrijven$_3$
that Jan Marie Pieter Arabic let see write
'that Jan let Marie see Pieter write Arabic'

These cross-serial dependencies are relative to a construal, of course (there is one unequivocal example of a language where this is formally marked, namely a Swiss German dialect; Shieber 1985). Now consider the analogue in interactive language use.

(22) Schegloff 2007:39 (after Schenkein)
A: Hey I got something that's wild
B: What
A: Y'know one of those great red fire alarm boxes thet're on the corner? I got one
B: (Wow!)

These 'presequences', as they have been called, have the same formal properties, linking constituent utterances in a cross-serial manner. They too are routinely extended to the level of interlocked triads of the ABCABC kind (see Schegloff 2007:44ff. on 'pre-pre-s'). Further examination of 18 will suggest that this pattern too can be of indefinite complexity. This seems to rule out the possibility of a chance homology in the case of context-free dependencies—whatever can be done in syntax seems to be outperformed in interaction.[6]

8. Conclusion. The idea that recursion, and especially recursive center-embedding, might be the core domain-specific property of language is rather directly undercut by the facts from interactive language use, which in turn seem to inherit their recursive properties from the action domain. The species-unique nature of human language is then not likely to find its explanation in a special syntactic prowess of this sort. For that, we will have to look elsewhere, and it is likely to involve many factors that may be uniquely human only in combination, like vocal learning, the predicate-argument and operator structure of clauses, and the powerful inferential pragmatics involved in construing utterances as actions that underlie embedded sequences within interactive language use (Levinson 2013).

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[6] For another kind of discourse, namely written texts, Wolf and Gibson (2005) show that some 12.5% of coherence relations have a cross-serial dependency, making tree structures for discourse relations impractical.

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[Stephen.Levinson@mpi.nl]

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