

EVOLVING THE NARROW LANGUAGE FACULTY: WAS RECURSION THE PIVOTAL STEP?

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A recent proposal (Hauser, Chomsky & Fitch, 2002) suggests that the crucial defining property of human language is recursion. In this paper, following a critical analysis of what is meant by the term, I examine three reasons why the recursion-only hypothesis^a cannot be correct: (i) recursion is neither unique to language in humans, nor unique to our species, (ii) human language consists of many properties which are unique to it, and independent of recursion, and (iii) recursion may not even be necessary to human communication. Consequently, if recursion is not the key defining property of human language, it should not be granted special status in an evolutionary account of the system.

1. Introduction

Hauser, Chomsky & Fitch (2002) (henceforth HCF) propose that the human language faculty (FL) consists of two types of property. Those which are found elsewhere in cognition (either human or non-human) form the broad language faculty (FLB), with those which are unique to language forming the narrow language faculty (FLN). This seems an uncontroversial delineation. What is more contentious, is where the dividing line is drawn. By placing only recursion in FLN, HCF suggest it is the single defining property of our linguistic abilities.

A number of interesting questions arise from this proposal. Firstly, what is meant by the term 'recursion'? HCF (and the ensuing rejoinders too) are strikingly vague. We must thus turn to the literature within and without our field to develop a clear definition. Secondly, is it true that there is nothing else in human language that is unique to it? Other unique properties would immediately invalidate HCF's argument. Thirdly, is recursion truly unique to human language? For HCF's recursion-only hypothesis to be upheld, this must be the case. Finally, is it the case that all languages exhibit recursion? A recursion-less human language would indicate that recursion cannot be *the* defining property of the system. Echoing Pinker & Jackendoff (2005) (henceforth PJ), this paper adds to their criticisms thorough analysis of recursion, examination of its uniqueness, and pinpointing of the crux of the recursion-less language argument.

^a The recursion-only hypothesis is just that – a hypothesis. The authors do not "...define FLN as recursion by theoretical fiat..." (Fitch, Hauser & Chomsky, 2005:183) (henceforth FHC), and indeed in places they seem to retreat to a weaker position. However, as the authors also note, "[t]he contents of FLN are to be empirically determined" (ibid: 182). That is precisely the aim of this paper – to use empirical data to assess the hypothesis that "...FLN only includes recursion..." (HCF: 1569).

2. Defining Recursion

A survey of the definitions of recursion available in the linguistics literature reveals a vagueness not conducive to our assessment. The computer science literature offers a little more formalisation, but in both cases there is little consensus on where to place the burden of explanation; certain definitions highlight the embedded nature of recursive structures, others use recursive phrase structure rules as their basis, others simply equate recursion with repetition. The most significant difficulty with definitions of recursion is their failure to make three important distinctions: recursion is not the same as iteration, recursion is not the same as phrase structure, and there are differing types of recursion.

One merit of the computer science definitions is that they draw our attention to an important feature of recursion – its memory requirements. In processing recursion we need to be able to keep track of where to return to once the embedded portion of the structure is complete. For this, we need a last-in-first-out type of storage device such as a pushdown stack.

2.1. Three Crucial Distinctions

Recursion versus iteration The first of three distinctions crucial in understanding recursion is the difference between recursion and the oft-confused iteration. This boils down to a distinction between embedding and repetition. While iteration simply involves repeating an action or object an arbitrary number of times, recursion involves embedding the action or object within another instance of itself.

When baking a cake, we might encounter a recipe instruction such as “*stir the mix until it becomes smooth*”. Following the instruction involves repeating some action over and over again until we reach the terminating condition. Importantly, each stirring action does not rely on the previous or the next. This is iteration. Once the cake has been baked, serving an equal-sized piece to each of sixteen guests involves repeating a cutting action over and over. We first cut the whole cake in half, then cut each half in half, then cut each quarter in half, and then cut each eighth in half. Here the process differs from the iterative example in that there is a dependency between actions; the output of each cutting action becomes the input to the next. Further, we cannot omit any intermediate action and end up with the same result; it is not possible to go from halves to eighths leaving out the step that gives us quarters. This is recursion.

Tail versus nested recursion The second distinction is between tail and nested recursion. The former is illustrated in possessive constructions - (1), and relative clause constructions - (2), the latter in centre embeddings - (3).

- (1) John’s brother’s teacher’s book is on the table.
- (2) The man that wrote the book that Pat read in the cafe that Mary owns.

(3) The mouse the cat the dog chased bit ran.

While tail recursion involves embedding at the edge of a phrase, nested recursion involves embedding in the centre, leaving material on both sides of the embedded component. The latter type of embedding produces long-distance dependencies. It is these dependencies that, in turn, necessitate a device for keeping track. In processing (3), we must store the subject noun phrases we encounter in memory (in the order we find them), retrieving them only (in the opposite order) when we reach the verbs with which they are associated.

Tail recursion might appear to be just a case of iteration, given that it looks like the simple repetition of identical phrases. However, consider (4):

(4) John's mother loves him.

This cannot be analysed as a simple proposition with another NP tacked on the front. Instead, it must be analysed as a sentence with a complex subject NP, containing within it another NP. This is exactly what Pinker and Bloom (1990) were referring to when they noted that recursion allows us to specify reference to an object to an arbitrarily fine level of precision. The iterative analysis of (4) is not true to the complex meaning it reflects. In other words, in natural language semantics forces us to analyse iteration and tail recursion differently.

Recursion versus phrase structure The final important distinction is between recursion and phrase structure, concepts which are often erroneously equated in the linguistics literature. Phrase structure is the hierarchical ordering of phrases within a sentence. Importantly, a structure may be hierarchical without being recursive. While hierarchy involves phrases embedded within other phrases, recursion involves *identical* phrases embedded inside each other. Phrase structure is thus required in language for recursion, because we need the capacity to embed before we can embed identical elements, but phrase structure does not guarantee recursion.

We are now in a position to define recursion (and iteration) as follows:

Iteration : the simple unembedded repetition of an action or object an arbitrary number of times.

Recursion: the embedding at the edge or in the centre of an action or object one of the same type. Further, nested recursion leads to long-distance dependencies and the need to keep track, or add to memory.

3. The Uniqueness of Recursion

Armed with a better understanding of recursion, we can turn to the next question: is recursion unique? HCF define FLN as that which is unique to language and unique to humans. If recursion fits this characterisation, there are three places we should not find it: human non-linguistic cognition, non-human non-communicative cognition, and non-human communicative cognition.

3.1. Human Non-Linguistic Cognition

Within the non-linguistic cognition of our species, a number of domains suggest themselves. Number is a reasonable possibility, but this should be ruled out as language and number may be evolutionarily linked (PJ, Chomsky, 1988, Hurford, 1987). In the visual domain, processes responsible for decomposition of complex objects and scenes may work in a recursive fashion, analogously to the earlier cake-cutting example. In social cognition, our theory of mind allows us to embed minds within minds - I can think that John thinks that Bill thinks that Mary thinks X. This is only possible with a complex conceptual structure capable of generating recursive propositions.

Music, like language, is organised hierarchically. However, ascertaining if a piece consisting of repeated phrases should be analysed iteratively or recursively will be very difficult. In language, semantics provides a pointer to structure, but in music there is no such pointer. Nevertheless, music offers more definitive evidence of recursion. Hofstadter (1980) suggests that on encountering a key change, the listener must store the tonic key in memory. Once the tonic key is resolved, the stack item can be popped off. In other words, there is a nesting of one musical key within another. Bach's "Little Harmonic Labyrinth", so called because its key modulations are so frequent and so complex that the listener is left confused as to where they are in relation to the tonic key, suggests a parallel with difficulties in processing nested recursion in language.

3.2. Non-Human Non-Communicative Cognition

In non-human non-communicative cognition, number can be ruled out as animals lack comprehension of the successor function, the basis of numerical recursion. Navigation studies within the travelling salesman paradigm point to a good place to look for recursion. Animals' complex action sequences, such as the food preparation techniques of mountain gorillas (Byrne & Russon, 1998), or the artificial fruit solving techniques of chimpanzees (Whiten, 2002), offer evidence of hierarchical reasoning, and may also provide an arena for future experimental testing for recursion.

Although attributing a full theory of mind to other species is controversial, it is less disputable that they have some degree of social cognition. Experiments (e.g. Tomasello *et al*, 2003) indicate that chimpanzees cannot embed minds within minds. However, the work of Bergman *et al* (2003) suggests that even with rudimentary aspects of a theory of mind, other species may be capable of recursive conceptual manipulation. Baboons classify themselves and their conspecifics both in a linear hierarchy of dominance, and in matrilineal kin groups. In other words, they are capable of forming conceptual structures such as [X is mother of Y [who is mother of Z [who is mother of me]]] or [X is more dominant than Y [who is more dominant than Z [who is more dominant than

me]]] – tail-recursively embedded associations, which (unlike the iterative counterparts) cannot be re-ordered while maintaining the correct relations.

3.3. *Non-Human Communicative Cognition*

Unfortunately, for non-human communication systems, the question of recursion turns out to be much more challenging. Animal communication systems can be divided into two types: (i) those with limited semantics, but a flat, non-hierarchical organisation, e.g. the dance of the honeybee (von Frisch, 1966), or the alarm calls of the Campbell's monkey (Zuberbühler, 2002), and (ii) those with a complex hierarchical organisation, but no semantics, e.g. bird song (Okanoya, 2002). While recursion will not be found in the first type, as hierarchy is required for recursion, the second type may have embeddings which could plausibly be recursive. The problem is that faced only with a string, and no pointer to its structure, we cannot distinguish tail recursion from simple iteration. Nested recursion, on the other hand, could be evidenced by a complex enough string alone. Although such strings are not currently attested in these systems, we can use this knowledge to narrow the scope of future research - to design experiments to test specifically for this type of recursion (nested) in this type of system (hierarchically organised).

In sum, recursion is not uniquely human or uniquely linguistic, and thus should not be characterised as a property of FLN. More interesting, however, is the fact that no hint of nested recursion is to be found in non-human domains, suggesting that the difference between human and non-human cognition may boil down to a difference in memory capabilities. Despite claims of methodological flaws (Perruchet & Rey (in press)), recent experimental work (Fitch & Hauser (2004)) may be interpreted as supporting this hypothesis. Tamarins, shown to be able to only learn strings of the form a^nb^n , might differ from humans, who can also learn those of the form $(ab)^n$, in being able to deal only with recursion of the tail variety^b. This would suggest that what was crucial in the evolution of human language was not recursion but the enhanced stack-type memory necessary to deal specifically with nested recursion.

4. The Contents of FLN

HCF's recursion-only hypothesis means that recursion should be the only aspect of language that is unique to language and unique to humans; as PJ put it, the only feature of language that makes it 'special'. The next question is whether there are other such properties of language which are independent of recursion.

From a wide-ranging literature in linguistics, we can discern a number of uniquely linguistic features which cannot be explained in terms of recursion. A non-exhaustive list would include the following (see also PJ for alternatives): (i)

^b A pointer to the structure involved would need to be incorporated to test the hypothesis.

structure dependence, (ii) the lexicon, (iii) movement, (iv) duality of patterning, (v) word order, and (vi) syntactic devices. All are to be found only in humans, and more specifically, only in human language. Moreover, none fall out of recursion either directly or indirectly.

Future research may, of course, uncover evidence of such properties in non-linguistic domains. This would mean re-assigning them to FLB, FLN then being the empty set. Yet the current state of play suggests expansion of FLN. Conceptually, the FLB/FLN distinction makes sense; empirically, HCF's division is in the wrong place.

5. Language without Recursion – the Case of Pirahã

The claim of HCF implies that a lack of recursion would reduce human language to something more like an animal communication system: "...animal communication systems lack the rich expressive and open-ended power of human language (based on humans' capacity for recursion)" (HCF: 1570). The question is: do languages without recursion exist? If they do, are they as expressive as languages which do make use of recursion? And importantly, would a language without recursion still look like a human language, or would we wish to class it as closer to non-human communication?

Everett (1986, 2005) has argued that the Amazonian language Pirahã does not make use of recursion. Pirahã uses alternate means to express what would be expressed in English-type languages using recursive subordinate embedding.

(5) ti baósa -ápisí 7ogabagaí. Chico hi goó bag -áob.

I cloth -arm want. name 3 what sell -completive
'I want the hammock. Chico what sold'

(6) hi gáí- sai xahóápáti ti xi aagá-hóág-a
3 say NOMLZR name 1 hunger have-INGR-REM
(i) 'Xahóápáti said, "I am hungry"'

or (ii) 'Xahóápáti said (that) I am hungry' (Everett 1986, 2005)

(5) shows juxtaposition used to express a clausal modification of the noun, while (6) shows that indirect speech is expressed in the same way as direct speech, leaving it up to the pragmatics to determine the referent of the pronoun.

Pirahã permits only one possessor - (7). Again, juxtaposition is used to express recursive possession - (8).

(7)a. *kó7oí hoagí kai gáihíí 7íga name son daughter that true 'That is Kó7oí's son's daughter'	b. kó7oí kai gáihíí 7íga name daughter that true 'That is Kó7oí's daughter'
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(8) 7ísaabi kai gáihíí 7íga. Kó7oí hoagí 7aisigí -ai
name daughter that true. name son the same be
'That is 7ísaabi's daughter. Kó7oí's son being the same' (Everett, 2005)

If the criterion for syntactic recursion is that there must be embedded inside a phrase one of the same type, the Pirahã data cannot be analysed as recursive.

This data tells us that human language without recursion is indeed possible. It also tells us that Pirahã speakers are perfectly capable of expressing the same underlying conceptual structures as English speakers (although arguably in a somewhat less efficient or less compressed way): "...Pirahã most certainly has the communicative resources to express clauses that in other languages are embedded..." (Everett, 2005: 631). The crucial point missed in the later installments in the recursion-only debate is that Pirahã is a full human language, not a system akin to the communication systems of other species. It is a language that exhibits uniquely human, uniquely linguistic properties, and that can only be acquired by those in possession of a human LAD.

So, here we appear to be faced with a human language lacking the one property HCF set out as the defining characteristic of human language. FHC's invocation of Jackendoff's (2002) toolkit hypothesis: that "...our language faculty provides us with a toolkit for building languages, but not all the languages use all the tools" (FHC: 204), just will not wash. For HCF, recursion is the one tool which defines human language. But, if a language can get on just as well without recursion, surely it must be only one of a number of tools in the set which makes language unique. And, if recursion is not the crucial defining property of human language, then its place in an evolutionary account of the system becomes far less important.

6. Conclusion

The initial question posed - is recursion the pivotal step in the evolution of FLN? - must be answered with a resounding no. Three arguments support this answer. Firstly, recursion exists in domains outside language. In other words, it is not unique to human language, and so should not be placed in FLN. Secondly, many properties of human language, which are entirely independent of recursion, are absent from non-linguistic domains. That is, FLN consists of much more. Finally, data from a full human language without recursion suggests that it is not crucial to the communication system of our species. Therefore, I submit that the recursion-only hypothesis of HCF is flawed.

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