EVOLUTIONARY FRAMEWORK FOR THE LANGUAGE FACULTY

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Due to the nature of the subject, the field of language evolution has to rely largely on theoretical considerations. A coherent fundamental framework for approaching language evolution has to relate principles of evolution of complex traits with those governing the organization of cognitive processes, communication and natural language architecture. We suggest that by treating the language faculty as a complex trait with predefined functional interfaces, it is possible to delineate the evolutionary forces that have led to the emergence of natural language. We analyze embedding and recursion in communication, and propose a conceptual prerequisite for natural language and fully symbolic reference: a hierarchical way of conceptualization termed 'conceptual embedding' (the ability to nest concepts within concepts). We argue that parallel (multidimensional) interpretation and evolving abstract categories are the effects of conceptual embedding. We review and analyze relevant experiments in ethological literature and conclude that their results do not imply conceptual embedding in non-humans, which leads us to hypothesize that conceptual embedding may be a uniquely human trait. We go on to hypothesize that, initially, the selective force driving the development of the language faculty was towards enhanced conceptualization of reality that is functionally relevant in the absence of linguistic communication. According to this scenario, the invention of linguistic communication was a secondary event, dependent on conceptual embedding which supports the sophisticated conceptual underpinnings of linguistic meaning.

1. Introduction

We will start by proposing a general evolutionary framework that establishes the language faculty's functional interfaces and asymmetric dependencies between them. We continue by considering the theoretical foundations of recursion, followed by a discussion of relevant empirical data. Next, we propose the notion of conceptual embedding as a prerequisite for the invention of linguistic communication. A complex communication system cannot evolve until there is motivation to convey complex information (Bickerton, 2003; Nowak & Komarova, 2001). We hypothesize that such motivation requires the perception of reality in terms of independent, combinable concepts that can be embedded to form interdependent conceptual categories that provide the functional basis for the meaning of words. Accordingly, we suggest that the selective force that triggered the emergence of the language faculty's core components was towards an enhanced conceptualization of reality. Conceptualization is an associational level where immediate sensory experience is not needed to bring its target into attention. We assume that formation and embedding of concepts belong to a hierarchical continuum of higher order associational processes performed by the nervous system.

2. Functional interfaces and functional dependencies

We suggest that in order to create an evolutionary framework for a complex trait such as the faculty of language (FL), one has to start by defining its functional interfaces and their functional dependencies. Functional interfaces are defined as the functional outcomes of a complex trait that are most likely to contribute to the fitness of its bearer and

thus motivate natural selection. Functional dependencies, on the other hand, are required to create a continuously evolvable hierarchical structure that can acquire new functions by building on and modifying the structures already present. In our opinion, functional interfaces of FL should include thought (complex conceptualization) and linguistic communication. Since highly differentiated conceptual structure is a prerequisite for the development of a complex communication system like natural language (NL), there is an asymmetric dependence between them. This is based on the observations that (1) NL is very much centered around human conceptual structure, (2) elaborate conceptual structure would increase fitness without NL by enabling conceptualization of principles of reality.

3. Recursion and embedding

M.D. Hauser et al's paper posited FLN/FLB distinction[1] and hypothesized that "FLN comprises only the core computational mechanisms of recursion as they appear in narrow syntax and the mappings to the Sensory-Motor and Conceptual-Intentional interfaces" (Hauser et al., 2002, p. 1573). Lately, this hypothesis has been vigorously challenged (Jackendoff & Pinker, 2005; Parker, 2006; Pinker & Jackendoff, 2005). First, we will focus on the logical contingencies of embedding and recursion. Second, as the narrower claim of Hauser et al. that recursion is unique to our species has subsequently been questioned (Marcus, 2006; Okanoya, 2007; Watanabe & Huber, 2006), we will argue that recursion in non-human animal communication has so far not been attested.

3.1. *Recursion*

There is a confusion underlying the notion of recursion. In fact, there are two logically independent notions of recursion. In computer science and Chomsky's phrase structure grammar, recursion is a procedure or rule (Chomsky, 1956; Chomsky, 1964, 1975). For some other theorists, recursion is a type of structure: a situation where an instance of an item is embedded in another instance of the same item (Jackendoff & Pinker, 2005; Parker, 2006; Premack, 2004). For the sake of convenience, let us call the former procedural and the latter structural recursion. Procedural recursion implies infinity, whereas structural recursion does not. Thus, structural recursion does not imply procedural recursion, nor vice versa. For instance, the recursive center-embedding rule AB→AABB produces the strings AABB, AAABBB etc. It is impossible to tell by looking at these strings if their production procedure was recursion or concatenation. Furthermore, the strings do not exhibit structural recursion. The reason for this is that they comply with serial mode of communication, whereas structural recursion requires parallel communication. Speech, for instance, is parallel communication as a sequence of vocalizations is matched with sequential interpretation. This is not to deny that its *interface* – a sequence of vocalizations – is serial (Pinker & Bloom, 1990). For speech, sequential interpretation is, of course, an understatement. Linguistic interpretation is sequential *and* compounding, merging smaller units that are per se meaningful in the code (Chomsky, 1995; Hauser et al., 2002; Studdert-Kennedy, 1998). As far as we know, linguistic code is unique among species in stipulating parallel interpretation (semantic compositionality)[2]. "Not only is the syntax of human languages distinct from animal calls in being semantically compositional; it is also distinctively recursive" (Hurford, 2004). We note, however, that the argument about semantic compositionality is independent of the argument about recursion. Parallel communication does not have to be specified by a code or a mode of interpretation, but can be a direct consequence of a parallel interface. For instance, cephalopod skin displays are examples of a parallel interface, and hence, parallel communication in two space dimensions (cf. Mather, 2004). For an example of structural recursion in visual grouping in two-dimensional space, see Jackendoff & Pinker (2005). Cf. Parker: "/---/ 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 string alone" (Parker, 2006). We maintain that this "complex string" must comply with parallel communication in order for nested recursion to be evident. The definition of structural recursion was "an instance of

[1] The faculty of language in the narrow sense or FLN = unique aspects of the language faculty. The faculty of language in the broad sense or FLB = the whole language faculty, including the aspects shared with other species or faculties.

[2] Parallel interpretation may be closely related to multitasking (consciously managing two or more operations) – an ability admittedly unique to humans (Donald, 1998). Below we will demonstrate that parallel interpretation implies parallel communication but not vice versa.

an item is embedded in another instance of the same item". In serial communication, the condition 'the same' proves fatal, as the only interpretation of it would be 'identical', and in given conditions (identical items in serial communication) it is impossible to differentiate an item and structural recursion of the same item.

3.2. *Embedding. Recursion in non-human communication?*

Embedding is a situation where an item is embedded in any item (with infinity not implied). According to Chomsky, 'embedding' is logically independent from procedural recursion (i.e. there can be one without the other). Structural recursion, however, is a proper subset of embedding. Unlike structural recursion, embedding is possible in serial communication (pattern within pattern sequences is an example). Songs of ceateans and birds exhibit this property. The fact that embedding is hierarchical has frequently raised speculation about a putative underlying 'recursive' mechanism (or more unfortunately, resulted in confusing embedding with recursion). As Suzuki et al. correctly remark in discussing humpback whale song (in a paper that has attracted some misled attention as an evidence of recursion in non-human animals), "Hierarchical grammars may be efficiently represented using recursion, although recursion is not necessarily implied by hierarchy" (Suzuki, Buck, & Tyack, 2006, p. 1863). There have also been some claims as to the possibility of recursion in non-human communication in connection with Gentner et al's (2006) experiments with European starlings (Marcus, 2006; Okanoya, 2007; Watanabe & Huber, 2006) but, in this case, pattern recognition and/or counting are more simple and plausible explanations than learning a recursive rule. We submit two general points about attesting recursion in communication. First, it is much easier to attest structural than procedural recursion. Second, structural recursion can be attested in parallel communication systems only. This rules out species that, as far as we know, communicate serially (for instance, songbirds). To our knowledge, neither procedural nor structural recursion has been attested in non-human animal communication. This is in concordance with the observation by Fitch et al. (2005) that no non-human animal communication system known shows evidence of syntactic recursion.

4. Conceptual embedding

We propose another notion instead of syntactic recursion as an underlying feature of the many critical aspects of the language faculty. The notion is conceptual embedding – a type of embedding not to be confused with recursion. Conceptual embedding (CE) is a cognitive phenomenon directly related to conceptual structure. Reality is conceptualized in terms of independent and complex properties like form, texture, composition and kineasthetics that can be freely associated to construct an extensive number of conceptual categories. CE enables to develop a detailed, more highly differentiated conceptual structure by adding a new dimension to it. The ability to group aspects of sensory information into differentiated concepts that can be manipulated mentally and independently from situational context is presumably a product of higher-order associational mechanisms found in highly advanced nervous systems. For example, a concept of 'tree' in Estonia might consist of concepts like 'trunk', 'branches', 'leaves', 'bark', 'wood', 'can be cut', 'can be used to make fire', 'floats in water' etc. The utility of conceptual embedding is that for anything we might ever encounter and identify as falling into the category 'tree', we immediately recognize its properties and potential use. CE can be used to generate new meaning, and for any concept, embedding is literally limited by our imagination only. It is possible that CE (the capacity to nest concepts regardless of the presence of syntactic recursion in a language) is specific to humans. "If non-human animals know in some sense that things have parts that have subparts which have subparts, then again their mental representations, independent of language, have a recursive structure. It is not known whether animals are capable of such mental representations" (Hurford, 2004). We will generalize Hurford's point and submit that it is not known whether or to what extent non-human animals have CE. If they do then it is seemingly confined to limited aspects of reality. CE forms the basis of our capacity to operate on sets, construct categories and make categorical distinctions, and of our capacity to model possible worlds. The latter has been frequently cited as a uniquely human trait (Jacob, 1982). CE is evident in our conceptualization of predicate/argument (P/A) structure, and the conceptualization of grammar relies on CE even in its most rudimentary forms (Agent First, Focus Last, grouping and noun-noun compounds, as proposed by Jackendoff, 1999).

It is useful to think of CE as a hierarchical way of conceptualization. The fact that humans use CE to conceptualize, for instance, P/A structure, does not prevent other species from having access to P/A structure even if they conceptualize it differently from us. For example, it has been claimed that while apes may perhaps not be capable of storing such complex structures as humans, it seems certain that they have mental representations in predicate-argument form (Hurford, 2003). Hurford's claim, however, is about the mental P/A structure in perception and cognition, not about the conventional one(s) used in logic and descriptions of NL. In general, 'relation' and 'correspondence' are sufficiently vague concepts to be describable both in terms of CE (i.e. parallel interpretation – see 3.1) as well as conceptual concatenation (serial interpretation).

Still other concepts, e.g. 'possession', are hierarchic in nature, and thus, as far as we know (as there may be other ways of interpreting besides parallel and serial), accessible to CE only[3]. The linguistic correlate of 'possession' is grammatical or lexical possessive. Presumably all natural languages have constructions (e.g. *have*-constructions), affixes (e.g. genitive case) or words (e.g. *own*) indicating possession (Heine, 1997). Whether a non-human species has the concept of 'possession' or 'ownership' is highly dubious (see Fitch et al., 2005; Jackendoff & Pinker, 2005; Pinker & Jackendoff, 2005, for a discussion). Kummer and Cords' experiments have ascertained that priority of access, proximity and transporting, but not the value of the object are cues of ownership for long-tailed macaques (Kummer & Cords, 1991). The authors contend that ownership in macaques lacks several aspects of ownership in humans. As the human notion of 'ownership' is regularly associated with value, we hypothesize that the human conceptualization of notions 'value' and 'ownership' relies on CE. This concords with Pinker et al's argument that the human notion of ownership appears to be unique (Pinker & Jackendoff, 2005). More experiments are needed to prove this argument, but if proven correct, this uniqueness could be reducible to the uniqueness of CE (we will address this question in more detail in section 4.1). In Savage-Rumbaugh et al's experiments, bonobos were unable to grasp the notion of trash (Savage-Rumbaugh, Shanker, & Taylor, 1998). As the defining feature of trash is its lack of value, the concept of trash implies the concept of value. We suggest that the ability to conceptualize the abstract notion of value or trash (or, for that matter, any other properly abstract category, e.g. language, sign, thought, structure, function etc) is a fair indicator of the species' reliance on CE.

Obviously, then, CE is an indispensable building block in the development of the language faculty. Although conceptual embedding per se does not imply syntactic embedding, this core syntactic feature of NL is implemented by CE. In their article, Nowak and Komarova speak of 'compound signals', and define them as signals that consist of parts that have their own meaning (Nowak & Komarova, 2001). This definition makes use of CE to *conceptualize* 'compound signals' – whether compound signals are *implemented* by CE is a separate question. In this respect, Deacon's definition of 'non-degrading recursivity' is more telling: "The principle by which representational forms can be embedded within or collapsed into other forms without any loss of referential precision, allowing the same rules to apply repeatedly across different levels of structure" (Deacon, 2003, p. 126). Although referring to a property of symbolic forms (e.g. NL expressions), the definition of non-degrading recursivity sounds close to a definition of CE. A counterpart of CE is also present in the latest research program proposed by Chomsky (1995). Assuming that the procedure of Merge ("an operation that takes a pair of syntactic objects and replaces them by a new combined syntactic object" – Chomsky, 1995, p. 226) is not restricted to syntax, CE can be a manifestation of Merge on the cognitive level. As with CE, the product of Merge ("a new combined syntactic object") is hierarchical, as one of the two syntactic objects "projects" and is the "head" of the combined object. Recently, Hauser et al. have noted that "what non-human animals lack is not concepts to express /---/ but rather a mechanism for combining concepts" (Hauser et al., 2007, p. 110). Although we make no assumptions about the underlying neurobiological mechanisms, CE is a notion that stands for a hierarchical way of combining concepts.

In our estimate, CE is a necessary but not sufficient feature of FL, and CE could be unique to humans but is probably not specific to the language faculty. A clue as to its non-specificity to language is that CE must have preceded the development of protolanguage. As Fitch et al. have remarked, "Although it seems likely that some

[3] Some authors (e.g. lawyers) make a culture-specific distinction between possession and ownership (Heine, 1997). With respect to CE, this distinction is irrelevant. The distinction between possession and abstract relation, however, is CE-sensitive, as the former, but not the latter, is necessarily hierarchic.

aspects of human conceptual structure are unique to our species, the separate question of whether these are unique to language will require detailed research into non-linguistic cognition" (Fitch et al., 2005, p. 205).

4.1. *Conceptual embedding in non-human species?*

One of the most interesting questions is, of course, whether CE is empirically approachable in comparative studies in non-human species. This kind of inquiry is directly related to our ability to measure the degree of differentiation of conceptual structure possessed by the species. Until recently, comparative studies have focused primarily on the species' ability to accomplish feats of increasing complexity while the nature of cognitive processes that lie behind these achievements has received far less attention (see Hauser et al., 2007, for recent developments). We have reviewed experiments with grey parrots, bottlenose dolphins, bonobos, baboons and diana monkeys, and reanalyzed the results of these experiments with respect to the cognitive strategies used by the species. A few selected examples are presented below.

Louis Herman and colleagues (Herman et al., 1984) have provided a detailed account of the comprehension of novel sentences in bottlenose dolphins. In these experiments, various objects and actions were labeled with either sounds or gestural signs, and the comprehension was measured by the accuracy of response to the instructions given in these artificial languages. Different syntactic rules were used on two dolphins: direct object (DO) + action (AC) + indirect object (IO) on Phoenix (HOOP FETCH PIPE – interpreted as „take hoop to pipe“) and IO+DO+AC on Akeakamai (PIPE HOOP FETCH– interpreted as „take hoop to pipe“). Additionally, modifiers LEFT and RIGHT could be added to either DO or IO. In general, both dolphins showed nearly perfect syntactic knowledge, as only one reversal error occurred out of more than a hundred semantically reversible sentences (O+AC+O, interpreted as IO+AC+DO or DO+AC+IO depending on syntax). Whereas the dolphins performed well above chance levels for all sentence types (up to 4-word sentences for Akeakamai and 5-word sentences for Phoenix), comprehension of certain types of 3- and 4-word sentences showed marked differences. For 3-word sentences involving both the direct and indirect object, Phoenix's performance consistently exceeded that of Ake, both in the case of familiar and novel sentences. Phoenix's performance was also better for novel 4-word sentences involving the direct object with modifier. The authors suggest that these effects were purely related to memory demands, since the straightforwardly left to right syntax of Phoenix permitted execution of sentences while they were still unfolding. We find this unconvincing, as for novel 4-word sentences that included an indirect object with modifier, Ake’s performance exceeded that of Phoenix. Inferior performance on certain types of sentences suggests that the dolphins used predominantly a serial left-to-right interpretation strategy that was counter-acted by Ake’s syntax. In addition, and contrary to the claim of Herman et al., the fact that Ake ignored the first direct object in the anomalous DO+DO+AC sentences like WATER HOOP TAIL-TOUCH cannot be considered as a proof of reinterpretation of the first DO. As there was no alternative strategy of comparable complexity in the context of the established syntactic rules, omission of the first object is more plausible than reinterpretation.

We submit that a distinction between parallel (CE-based) vs. serial interpretation must be evoked to explain the results of these experiments (see 3.1). Logically, serial interpretation is more sensitive to word order than parallel interpretation. Human interpretation of speech is parallel. Correspondingly, different languages have (sometimes diametrically) different word order, and many have a relatively free word order. The fact that a certain word order is preferred in dolphins, suggests that their interpretation of strings is serial. If the dolphins had used parallel interpretation and CE, the memory demands for both types of syntax would have been the same.

Striking shortcomings in conceptualization were evidenced for Ake in sentence type IO+DO+FETCH, where the direct and indirect object were the same (e.g. BALL BALL FETCH – „take one ball to the other“). In interpreting such instructions, Ake consistently substituted the indirect object for an object of different type. The fact that the addition of modifiers facilitated dolphin's performance in spite of increased sentence length might indicate that their conceptualization does not allow ambiguity and is limited to one-to-one mappings between objects and object labels. Plausibly, one label (BALL) referring to two objects at the same time is inconceivable for dolphins. This concords with Ferrer i Cancho et al's observation that many non-human species are close to a perfect communication system where every object is mapped to a distinctive signal (Ferrer-i-Cancho, Riordan, & Bollobas,

2005). By Deacon's terminology, the labels acquired by the dolphins were indices not symbols: "Many indices can convergently point to one referent, but no one index points to many distinct referents" (Deacon, 2003, p. 128).

Further, Ake's failure to correctly interpret sentences where the same label represented DO and IO indicates that she did not acquire the abstracts concepts DO and IO (or their equivalents) but conceptualized, more primitively, the first and second object as qualitatively *different* objects instead. We suggest that this can be explained by the fact that the concepts DO and IO presuppose CE (minimally, the ability to embed an object-concept X in DO and IO), whereas conceptualizing the first and second object as qualitatively different objects requires only conceptual concatenation (the ability to discern X from Y by pattern recognition and the ability to concatenate the concepts of objects X and Y). From this, one could infer that bottlenose dolphins do not have CE but, of course, more experiments are needed to prove the validity of this inference.

Experiments have demonstrated that baboons are able to hierarchically classify conspecifics simultaneously with respect to their kinship and within-family dominance ranks (Bergman, Beehner, Cheney, & Seyfarth, 2003). The basic finding was that baboons spent more time looking at the speaker when between-family dominance rank reversal situations were presented as opposed to the within-family reversals. First, Bergman et al contend that baboons lack the ability to attribute mental states to each other (lack theory of mind). However, they maintain that, for baboons, the *significance* of a between-family rank reversal is higher than that of a within-family reversal, since the former signals a possible change in the dominance relations of two entire matrilines rather than just two individuals. We find this viewpoint problematic. If the monkeys lack theory of mind, how would they be able to attribute significance to the family rank reversals that occur outside of their own family and do not involve their own dominance rank? Furthemore, logically, there could be reversals with three types of consequences for each observer: increase in dominance (observer is involved in a kin that reversed its positions with a higher dominance rank kin), decrease in dominance (observer is involved in a kin that reversed its positions with a lower dominance rank kin), no effect (either two higher or lower dominance rank kins change their positions). While the kinship rank reversal occurs in each case, the result is very different for a given observer in each case. Note that in the „no effect“ case, the outcome would equal that of a within-family reversal not involving the observer. If baboons possessed the conceptual structure to make these inferences, they would be expected to react accordingly. We suggest that until there is no evidence that baboons reliably differentiate between the significance of various between-family rank changes involving their own dominance rank, implication of highly differentiated conceptual structure is not required to explain their behavior.

Since several properties characteristic of human language (e.g. representationality, hierarchical structure, open-endedness etc) are evident in nonhuman primates' social knowledge albeit on a rudimentary level, Cheney and Seyfarth (2005) hypothesize that "/---/ the internal representations of language meaning in the human brain initially emerged from our pre-linguistic ancestors' knowledge of social relations. /---/ The demands of social life create selective pressures for just the kind of complex, abstract conceptual abilities that are likely to have preceded the earliest forms of linguistic communication" (p 153). In our opinion, the lack of attribution of mental states is a dubious cause for not being able to form differentiated concepts of reality. Moreover, in order to attribute mental states the way humans do, one has to be aware that there are different *kinds* of mental states and that it is possible to link them to any individuals in the first place. We maintain that such process requires CE, as the concepts of mental states need to be embedded with the concepts of other living beings so that new meaning arises. Thus CE must predate the theory of mind. Since CE is also beneficial in situations not involving social relations, the hypothesis that social lifestyle created the selective pressure for the emergence of human-like conceptual structure might not be justified.

5. Conclusion

In the present article, we have proposed an evolutionary framework for the language faculty. We suggest that by defining the common functional interfaces of neurobiological traits involved in language-associated processes it is possible to delineate the selective forces that have acted upon them. Namely, we hypothesize that the common functional interfaces of the language faculty are thought (a sophisticated form of conceptualization) and linguistic communication. We argue that humans possess a hierarchical way of conceptualization termed as conceptual

embedding (the ability to nest concepts within concepts – see section 4 for details). Conceptual embedding (CE) is a pervasive feature of human conceptualization. For humans, it is hard to imagine abstract thought without CE, as a correct use of a properly abstract category (like trash, language, sign, value, thought, function etc) relies on CE. The major effects of CE are enabling parallel (or multidimensional – Hurford, 2002; Jackendoff & Pinker, 2005) interpretation and evolving abstract categories. We argue that CE is a prerequisite of human language and fully symbolic reference. We have discussed evidence that might imply CE in non-humans, and conclude that, to our knowledge, the existence of CE in non-human species has not been established. Previously it has been claimed that some species possess a rich conceptual structure despite the primitive content of their natural communication (Bickerton, 2003; Cheney & Seyfarth, 2005; Hauser et al., 2002; Hurford, 2006; Szamado & Szathmary, 2006). Drawing upon a wide range of experiments described in ethological literature, we have found these claims largely unsubstantiated. More experiments are needed to prove or refute CE in non-humans but we hypothesize that CE may turn out to be a uniquely human trait. We suggest that CE is at the top of the hierarchical continuum of associative processes performed by the nervous system. As the nervous system evolved, increasingly higher-order associative processes became available which resulted in the emergence of CE in human ancestors. By comparing it with theory of mind, we find that CE is more fundamental and evolutionarily salient explanation for the emergence of natural language. The advantages of CE include: (1) more fundamental and broadly applicable than theory of mind, (2) supports the principle of hierarchical organization of cognitive processes reflected in phylogenetic and ontogenetic development of the nervous system, (3) beneficial in the absence of natural language, (4) empirically approachable in humans and non-humans, (5) applicable to formation of categorical concepts as well as complex narratives, (6) a possible cognitive counterpart to Chomsky's (1995) Merge operation. We go on to hypothesize that, initially, the selective force driving the development of the language faculty was towards enhanced conceptualization of reality that is functionally relevant in the absence of linguistic communication. According to this scenario, the invention of linguistic communication was a secondary event, dependent on CE which supports the sophisticated conceptual underpinnings of linguistic meaning.

Abbreviations

AC action, CE conceptual embedding, DO direct object, FL the faculty of language, FLB the faculty of language in the broad sense, FLN the faculty of language in the narrow sense, IO indirect object, NL natural language, P/A predicate/argument

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