The Evolution of I-Language: Lexicalization as the Key Evolutionary Novelty

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Comparative psychological research suggests that human and non-human minds comprise an array of encapsulated cognitive systems ('core knowledge systems'). While most of these cognitive building blocks appear to be shared across species, the cognitive gap between human and non-human minds is nevertheless quite stunning (*Hauser's Paradox*). Following recent ideas concerning the crucial role of human word learning in cognitive development, it is here suggested that lexicalization — the association of concepts with words — is the key evolutionary novelty that allows linguistic minds to integrate the various encapsulated conceptual resources into a common mental language.

Keywords: comparative psychology; evolution; I-language; lexicalization

1. Introduction: The Object of Inquiry

In this contribution, I want to comment on the present stage of evolutionary linguistics and suggest some lines of research that seem plausible to me. I will neither review all the relevant literature to support my claims nor attempt to provide detailed justification. The tentative and speculative nature of the remarks that follow should be obvious.

When considering questions of 'language evolution', we should ask, first of all, whether the questions are put in the right way. What does it mean to ask how language evolved? Is *language* a well-defined object of inquiry, anyway?

A by-now traditional answer to the latter question is that it is not; 'Language' in the ordinary-language sense of the term is not the object of inquiry of theoretical linguistics. Concerning scientific realism about such common-sensical notions, Noam Chomsky (2000: 20ff.) comments:

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> The question is […] whether in studying the natural world […] we view it from the standpoint provided by such [common-sensical] concepts. Surely not. […] [I]n the context of the search for laws of nature, objects are not conceived from the peculiar perspectives provided by concepts of common-sense. […] The concepts of natural language, and common-sense generally, are not even candidates for naturalistic theories.

The argument applies with equal force to questions of 'language' and 'language evolution': If linguistics is a science, it must necessarily abandon a common-sensical understanding of its object of inquiry in favor of a scientific category. The investigation of *language* (the concept) and its conceptually necessary properties has no place in linguistics; it is part of lexicography or ethnoscience, if anything (Chomsky 1980: 29).

This basic tenet of Generative Grammar (or rather, of science in general) is, however, often ignored in professional discussions. The present topic is a dramatic illustration: It seems to me that a good deal of the literature on language evolution is in fact based on unnecessary confusion resulting from the term *language*. The result is aptly summarized by Derek Bickerton (2007: 510) when he concludes that "there is perhaps no other field of human inquiry which has been so vitiated by a failure to get priorities straight."

A necessary first step towards a resolution of the situation is the realization that there can be (as a matter of principle) no unitary answer to the question "How did language evolve?" The question is scientifically irrelevant, since it makes no reference to any scientific category. The alternative is, again, a traditional one, in linguistics and elsewhere — namely, "to try to isolate coherent systems that are amenable to naturalistic inquiry and that interact to yield some aspects of the full complexity" (Chomsky 2000: 29). Once this step is done, questions of evolution can be raised in a meaningful way.

The standard approach takes the object of inquiry to be *Universal Grammar*, a distinct component of human biological endowment. In the course of acquisition, Universal Grammar grows into an *I-language*, the system that yields the specifically linguistic knowledge of the competent speaker (Chomsky 1986). A theory of I-language explicitly characterizes this body of knowledge; it has no procedural implications and abstracts away from extraneous factors that enter into linguistic performance.[1]

Minimally, the I-language must comprise a *generative procedure* (syntax) that operates over a finite *lexicon* of atomic units or words (in the technical sense) and maps the resulting complex objects onto representations that are accessed by performance systems. Since syntactic operations apply recursively to atomic units and combinations thereof, the I-language yields an infinite array of structural descriptions linking 'sound and meaning', that is, representations encoding phonetic, semantic and structural properties (Chomsky 1965).

Selective impairments and developmental dissociations (cf. the Genie case) suggest that the I-language is distinct from the systems that enter into linguistic behavior (cf. Jenkins 2000); comparative evidence supports this distinction on

[1] By hypothesis, I-language is distinct from animal communication systems (bee dance and the like), which may well be associated with a common-sensical notion of 'language'.

phylogenetic grounds (more below). The complex of I-language and various performative systems enters into human action (linguistic thought and externalization).

With this sharpened understanding of what the object of inquiry is, let us now turn to questions of evolution, that is, the emergence of I-language in the human species.

2. I-Language and Related Systems — Evolution

2.1. Some Reasonable Assumptions

I think it fair to say that virtually nothing is known, in a strict sense of the term, about the evolution of I-language, understood as a distinctly human capacity, in the sense outlined above. In what follows, I will merely mention some of the suggestive observations that are frequently referred to in this connection.

Let us first consider some developments in the history of the species that can be taken to be plausible indications for the evolutionary emergence of I-language. Various lines of research suggest that humans arrived in Europe around 40–50,000 years ago (the transition from Middle to Upper Paleolithic), in a period that saw an explosive emergence of complex tools and art, burials and complex social organization, and symbolic behavior.[2]

As is often pointed out, it is hard to imagine how this extremely rapid development could have taken place in the absence of linguistic communication and complex symbolic thought. It therefore seems reasonable to assume that the human I-language trait is *at most* 100,000 years old (Hurford 2004: 552), its emergence having facilitated the 'Upper Paleolithic Revolution' (see also Berwick & Chomsky, to appear).

At the same time, however, it is known that brain capacity and vocal-tract anatomy of modern humans were in place much earlier (Holden 1998: 1455), predating, as it appears, the crucial cognitive innovations. Thus, by many estimates at least, there is an evolutionary mismatch between the phylogenetic development of anatomical prerequisites and the actual emergence of behavior indicating higher-order, presumably linguistic, cognition. In the words of evolutionary anthropologist Ian Tattersall (1998: 171):

> It is very hard to avoid the conclusion that articulate language is quite intimately tied up with all […] aspects of modern human behavior. Yet we know that effectively modern skull-base anatomy appeared long before we have any convincing archaeological evidence for complex sym-bolic behavior. […] Simultaneous acquisition of both the central and the peripheral apparatuses necessary for language would have been quite a developmental trick to pull off, and a multistage process is certainly easier to envisage in both developmental and evolutionary

[2] Juan Uriagereka (p.c.) points out that recent archaeological research casts some doubt on this traditional estimate; the actual cultural revolution may in fact have taken place tens of thousands of years earlier. Whatever the exact time frame, the crucial point is that the emergence of 'higher culture' took place within the blink of an eye, in evolutionary terms.

terms.

The idea of a 'multistage process' in both evolution and development has received ample support from comparative psychological research, to which I turn now.[3]

2.2. *The Comparative Approach and Hauser's Paradox*

What happened to the human species that enabled it to make the cognitive leap that was the foundation for the Upper Paleolithic Revolution?

There are essentially two kinds of approaches to explain the striking discrepancies between human and non-human cognitive capacity (cf. Spelke 2003). According to a long-standing view in psychology, the stock of domain-specific cognitive modules or 'core-knowledge systems' in humans is quite different from that found in non-human species. In this view, human and non-human minds are made up of radically different building blocks, and what made the human mind special was, essentially, the evolutionary accumulation of more cognitive systems (see, e.g., the papers collected in Barkow *et al*. 1992).

In the last 15 years, however, an alternative view has grown out of psychological research investigating humans (infant and adult) and animals in a directly comparative setting. Motivated in part by the tension described by Tattersall, this comparative approach has led to the emergence of a novel picture of the evolutionary origins of human cognitive function, according to which many of the building blocks of the human mind are in fact shared with other species, but tied up in a way that yields a cognitive quantum leap.

This is not the place to review the wealth of experimental research that has shaped this newly emerging consensus; for comprehensive surveys of the relevant evidence the reader is referred to Hauser *et al*. (2002), Fitch *et al.* (2005), Fitch (2005), Carruthers (2006), Hurford (2007), and sources cited there. Here, I want to address the relevant question in the context of I-language evolution, which is: "Which systems must be assumed to be part of this evolutionary novelty, and which systems can be assumed to have developed independently?"

It is useful at this point to adopt the terminology of Hauser *et al*. (2002), where those aspects of the human language faculty that are distinctly human innovations are labeled 'FLN', while the language faculty, construed broadly as a complex of FLN and interfacing performance systems, is termed 'FLB'.

As outlined above, a fairly conventional assumption is that the I-language (the generative system) interfaces with systems of sensorimotor control (which in

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3 The multistage process is a plausible scenario for FLN, too. Chomsky in particular has emphasized the asymmetry between the two mapping components (SEM and PHON), mapping to C-I and SM systems, respectively. First, PHON introduces a variety of features that are not present in the lexical items of the expression (e.g., stress and intonation contours) and erases information required for semantic interpretation (copy reduction). Second, island phenomena show that externalization of 'thinkable' thoughts can fail (consider a standard CNPC violation such as *Who did Mary believe the claim that John killed t*, which corresponds to a coherent thought but cannot be externalized as such), again indicating that computation to SM is ancillary (Chomsky 2008, Berwick & Chomsky, to appear). On this view, it is plausible (in fact, likely) that the I-language evolved as a thought system, which only later got adapted to the sensorimotor system.

turn provide instructions to the articulators), and with perceptual systems that process linguistic input. Hauser *et al*. (2002) review a wealth of comparative evidence suggesting that many if not all crucial aspects of articulatory and perceptual prerequisites relevant to phonetics are rather widely shared with other species. This includes basic vocal-tract anatomy and well-developed motor control on the physiological side, and categorical and rhythmic perception, and presumably even vocal imitation (in dolphins, whales, and seals), on the cognitive side (see Hauser & Fitch 2003 for detailed review; also the contribution by Samuels 2009). Consequently, Hauser *et al*. (2002) ascribe these systems to FLB, concluding that they are not plausible candidates for being part of the evolutionary innovation that yielded human I-language.

A mounting body of evidence suggests that the same is true with regard to conceptual-intentional systems, that is, those systems that enter into semantic interpretation of the outputs of the I-language. Here, too, many components appear to be shared between humans and other species. Experimental work suggests that many species have some (perhaps rudimentary) theory of mind and sophisticated knowledge in areas like planning, navigation, social relations, and spatial reasoning, among others (see Hurford 2007 and Boeckx 2009: chap. 11 for extensive review).

At least a good deal of the relevant conceptual resources, then, cannot have evolved as part of FLN in the human species. Most of our core-knowledge systems are found in other species and hence predate modern humans; in Hurford's (2007: 87) words, "some (not all) of a human system of common-sense understanding precedes a system of language, both ontogenetically and phylogenetically."

Hurford's claim is supported by developmental evidence as well. In experiment after experiment probing specific knowledge areas, pre-linguistic infants perform essentially like non-human animals, as Elizabeth Spelke and others have shown (see, e.g., Spelke 2003). The gist of this research is that pre-linguistic infants, like animals, exhibit sophisticated knowledge in specific domains, suggesting that the relevant cognitive systems predate the development of I-language. Nevertheless, like animals, infants fail at more complex tasks that require *conceptual connections across individual modules*.

Summarizing an extensive body of evidence, Spelke (2000: 1240) concludes that "although no young child or non-human animal possesses [the cognitive skills of adults], both exhibit many of the cognitive systems that serve as their building blocks." Concerning I-language, the natural conclusion is that "the early development of semantic categories [in pre-linguistic infants] parallels the development of phonological categories and suggests that natural language semantics, like natural language phonology, evolved so as to capitalize on pre-existing representational capacities" (Hespos & Spelke 2004: 455).

Synthesizing both the developmental and evolutionary evidence alluded to above, Hauser *et al*. (2002) conclude that conceptual systems are largely to be ascribed to FLB, part of the "peripheral apparatus" in Tattersall's terms.[4] In effect,

[4] Even on the neuro-functional level, certain areas (such as those accessed during the retrieval of word meanings) appear to be shared with non-human primates (Hurford 2007: 7, 57).

they equate I-language and FLN, speculating that the I-language (syntax and the lexicon) may indeed be the sole evolutionary novelty that allowed humans to cognitively outplay even their closest evolutionary relatives.

As the literature cited above demonstrates, the modular minds of non-linguistic creatures can be taken to comprise a variety of mental languages (or core-knowledge modules) that must allow for rudimentary predicate-argument structures (GIVE[X,Y,Z], SUPERIOR-TO[X,Y], etc.); for extensive arguments to this end, see Carruthers (2006), Hurford (2007). That is, non-human animals must have concepts and means of combining them into non-linguistic thoughts, within the limit of each core-knowledge system the animal possesses; these isolated cognitive systems can yield a high degree of task-specific sophistication, as described in the experimental literature (see the references above, and in particular Spelke 2003). The comparative approach strongly suggests that "Meanings existed in our pre-linguistic ancestors before the application of linguistic labels to them by humans" (Hurford 2007: 57) in just this rudimentary way (basic predicate–argument association). It is indeed hard to see how the relevant representations could be constructed without this fundamental mode of combination.

Overall, the comparative evidence suggests that we share a good deal of our non-linguistic cognitive capacities with other species (Fitch *et al*. 2005: 191). This suggests, in turn, that those systems that interact with the I-language were basically in place when the latter evolved, the scenario assumed by Hauser *et al*. (2002). The cognitive gap between human and non-human minds cannot be the result of the emergence of distinctive conceptual-intentional (let alone articulatory) systems in humans. It appears, then, that we end up with a *paradox*, as stated by Marc Hauser (2008, quoted in Boeckx 2009):

> [A]nimals share many of the building blocks that comprise human thought, but paradoxically, there is a great cognitive gap between humans and animals.

The way out of this paradoxical state of affairs that I will suggest below is based on a conjecture of Paul Bloom's (2000: 242): "Non-humans have no words and a relatively limited mental life; humans have many words and a much richer mental life. This might be no accident." I will elaborate on this idea in the remainder of the article.

3. Lexicalization as the Key Evolutionary Novelty

3.1. Words and Calls

The comparative approach suggests that while most cognitive building blocks predate the modern human mind, some rapidly-evolved novelty must have led to a dramatic change in overall cognitive capacity. This invites the hypothesis that it is indeed the human I-language that accounts (in large part at least) for the cognitive gap between linguistic and non-linguistic creatures (the evolution of FLN, as suggested by Hauser *et al*. 2002). But how could the emergence of I-language yield this dramatic change? To approach this question, let us consider a further domain of human uniqueness, namely the lexicon (a component of I-language). In general, animals calls are functionally referential, signaling food or danger to listeners. Alarm calls are unlearned and extremely limited in their application. Calls are not used for intentional acts of reference and usually stimulus-bound (see Hauser 1996 for extensive discussion).

None of these properties are true of human words. This is somewhat unexpected from a point of view that takes animal calls and human words to be stages of the same evolutionary continuum. But in fact, the human lexicon is *not* simply a memory system like those found in other species (its complexities go well beyond a memorized list of items, see below), and there is no evidence suggesting that animal calls are precursors to human words in any way (Fitch 2005: 205), or that human words have any real analogs or homologs in animal communication systems (Hauser *et al*. 2005: 1576). The two systems — calls and words — are radically different, suggesting that words are part of the evolutionary novelty that brought about the I-language.

Indeed, lexicalization — the process that associates concepts with words — is a rather stunning cognitive feat. Consider, for instance, the fact that the number of words that children acquire during the critical period is extremely large compared to anything non-human animals can achieve (Hauser & Fitch 2003, Bloom 2000). There is no evidence for comparable acquisition mechanisms in non-human animals. The rate of vocabulary acquisition clearly suggests that the concepts to which words are linked are already in place (Chomsky 1980: 139), at least to a substantial extent, suggesting again that conceptual resources precede I-language in development. The intricacy of semantic properties of lexical items is enormous (Pustejovsky 1995, Chomsky 2000), and there is no evidence for comparative complexities in animal calls. The same is true with regard to structure: at most, animal calls have linear-sequential structure, but no higher-order hierarchical structure as evidences in human syntax. Non-human primates have serial processing abilities, but seem to lack the capacity of perceiving phrase-structural representations and long-distance relationships between elements (Fitch & Hauser 2004).

Finally, there is no evidence for a complex compositional/propositional semantics in non-human communication systems (Hauser 1996) that would allow calls to be combined in a way that yields a meaningful syntactic object. By contrast, words are the building blocks of syntactic objects, which map onto conceptual representations. The absence of words in animals (and pre-linguistic infants) might be crucial for the limitations their cognitive capacity exhibits.

As reviewed in the previous section, although many animals have rich conceptual resources, they "cannot make the specifically *linguistic connections between concepts* that humans can make" (Hurford 2007: 85, emphasis mine — DO). According to recent ideas, it is lexicalization — the human capacity to turn domain-specific concepts into units of linguistic computation — that allows human minds to make these connections. To sharpen this hypothesis, let us consider the capacity of lexicalization in some more detail.

3.2. Lexicalization of Concepts in Humans

Lexicalization is the process that associates concepts with grammatical units, often in ambiguous ways. During acquisition, humans lexicalize a huge number of concepts within a very short period of time. Lexicalization appears to be largely automatic and independent of experience (cf. the acquisition of color and perception words in blind children discussed by Gleitman & Newport 1995).

A rather uncontroversial assumption is that concepts can be of various adicities; presumably, RUN is monadic, while GIVE is most likely polyadic. THE MAN does not have any adicity, since it is a referential expression. Adicities of predicates allow the formation of complex thoughts, via some kind of saturation: Concepts are 'interlocking' mental objects, and the formation of any meaningful thought requires at least the computation of minimal predicate-argument structure.

In a Fregean *Begriffsschrift*, each combination of two terms is an instance of function-application. This Fregean mode of combination is the minimal symbolic operation necessary for any mental language within a certain module, hence must be present in all animals. Without this kind of 'Fregean thought', it would indeed be inconceivable how animals can perform the intricate cognitive operations that underlie many kinds of behaviors, as argued at length by Hurford (2007) and others.[5]

According to the 'standard theory' in formal semantics (e.g. Heim & Kratzer 1998), the human I-language combines expressions in essentially this Fregean way. That is, combinations of predicates and arguments are interpreted as function-application/type-reduction, plus some theoretical tweaks to cover more complicated cases.

But some have argued that the human I-language does *not* work in this way, i.e. that it does not employ Fregean modes of combination to form complex expressions (Marantz 1997, Borer 2005, Pietroski 2005, forthcoming). Pietroski in particular has argued at length that on a plausible reformulation of semantics, all combination of lexical items signifies conjunction of monadic predicates. On this view, words are essentially adicity-free, while indicating (being linked to) the potentially polyadic concepts they lexicalize (see Pietroski 2005, forthcoming).

The starting point for such non-Fregean approaches to semantics is that once lexicalized, concepts (now words) appear to be extremely *promiscuous* (Pietroski's term). Words can be combined with other words to form expressions that are further combinable. I-languages do not impose any limits in this regard: All expressions are conjoinable, no matter how complex.

One observation that Pietroski capitalizes on is that the promiscuity of words makes it very hard to determine the adicity of a lexicalized concept. That is, words conceal the adicities of the concepts they indicate to a large extent. Consider some examples, borrowed from Pietroski (in press).

Is the concept GIVE triadic? That seems plausible: *X gave Y to Z*. But if the lexicalized counterpart of GIVE inherits this adicity, why are (1c–e) fine

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5 A reviewer rightly points out that inference from behavior to cognitive structures is not innocent, at least in the absence of a developed theory of conceptual/representational capacities. The evidence therefore has a 'best best' character; the conclusions drawn here are hard to avoid, however.

expressions of English?[6]

(1) a. John gave Peter the money.
    b. John gave the money to Peter.
    c. Barry gave the money away.
    d. Bill donated the painting and everybody gave something.
    e. Robin Hood steals from the rich and gives to the poor.

Are COOK or SING triadic? This seems unlikely. But once lexicalized, it seems like they can be:

(2) John cooked Bill an egg, while he sang the baby a lullaby.

What is the adicity of BUY? It seems rather implausible to assume that the concept BUY is, for example, triadic. But once lexicalized, it is free to occur in a ditransitive construction, as in (3c):

(3) a. Plum bought the knife.
    b. Plum bought the knife for Scarlet.
    c. Plum bought Scarlet the knife.
    d. Plum bought Scarlet the knife for ten dollars.

Further examples of this kind are all-too easy to find, and there is no need to go on here. What is relevant is that these examples are illustrations of the general case: Words do not have inherent adicities, but merely *indicate* (are associated with) concepts of certain adicities.

So, do words really 'take arguments', like concepts do? This is a traditional view in linguistics, but it is in fact all but obvious that argument structure (as a syntactically expressed property of predicates) really exists. There just seems to be no one-to-one relation between the grammatical behavior of a word and the adicity of the concept(s) it indicates, as shown above. But adicity-matching hypotheses assume just this one-to-one relation.

Pietroski's alternative is to deny that words have any adicities at all, and to take all words to be of the same semantic type. This requires demonstration that a single type is compatible with efficient semantic composition — a project that is pursued in Pietroski (2005, forthcoming), the details of which need not concern us here. Adicity effects in I-language expressions ('canonical' number of arguments and the like) must then be reflections of the associated concepts, that is, result from the interaction of the grammar with outside systems. In general, combination of words is so flexible, and the lexicalization process in infants so rapid, that words are apparently freed from any conceptually imposed adicities.

On this view, then, lexicalization is a distinctly human capacity (hence part

[6] A reviewer suggests that constructions like (1d) and (1e) might be elliptical, but it is hard to see what the elided object would be in these cases. A transparent example (from Chomsky 1986: 8) is *John ate*, which cannot mean *John ate something* (*something* elided), since *John ate a shoe* does not entail that *John ate*. It seems like the meaning of the predicate does indeed vary in subtle ways depending on the grammatical context, in this case as well as in those cited in the text.

of FLN; see below) that yields the unboundedness of (linguistic) thought without requiring significant changes in mental architecture. In the following section, I will elaborate on this more specific hypothesis.

3.3. The Universal-Currency Hypothesis

Non-human animals can no doubt compute elementary conceptual predicate-argument structures of the 'who did what to whom'-type; see Hurford (2007). As shown by the results in comparative psychology, we do find complex representations in many species, suggesting that (to put it informally), while certain conceptual capacities are present in the absence of I-language, there is comparatively little that nonhuman minds can do with them (Chomsky 2004: 47).

In particular, it seems like combinations of concepts cannot cross the bounds imposed by the various knowledge modules (such as social relations or spatial reasoning); that is, nonhuman conceptual structures are domain-specific in a rather strict way. As mentioned before, in order to generate thoughts, any conceptual system must be at least 'Fregean' in its combinatorial capacities (predicate-argument structure). But apparently, animals have no complex thought beyond that — the conclusion drawn by Hauser & Spelke (2004), Carruthers (2002, 2006), and many other researchers. Presumably, then, a Fregean mode of composition within the bounds of any particular core-knowledge system is all that is available to non-linguistic creatures:[7]

> [T]he cognitive functioning of [human infants, non-human primates, and human adults] can be understood, in part, in terms of the same systems of core knowledge. These systems serve to construct abstract representations of basic features of the world, including objects and numerosities, but they are limited in three respects: They are domain specific, task specific, and largely independent of one another.
> (Spelke 2000: 1240)

By contrast, (adult) human minds can integrate concepts from various sources by lexicalizing them, yielding unbounded cross-modular thought. Thus, higher apes may have complex Fregean conceptual structures in various mental domains while lacking the computational capacities provided by the I-language ('free thought'):

> When human adults form and use concepts that no other animal can attain, they do so by assembling a set of building blocks that are shared with other animals. These building blocks are part of core knowledge. Language may be a powerful device for assembling and coordinating the systems of core knowledge. (Hauser & Spelke 2004: 862)

When lexicalized, human concepts can freely and systematically compose, *regardless of the conceptual subsystem from which they are drawn*. I-language expressions can combine concepts of color, sound, space, time, self, other things, action, habitation, number, etc. as well as theoretical and fictitious concepts

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7 See already Chomsky (1980: 57) for similar speculations.

(Spelke 2000, Carruthers 20002, Pietroski, in press).[8] This fact about our linguistic ability is so natural to us that it is hard to appreciate its relevance; but in fact, there is no reason to take this ability of constructing *cross-modular concepts* for granted.

Consider science. Scientific concepts are very different from common-sense concepts, and given that only human minds are capable of naturalistic inquiry, we may well be led to posit a distinct conceptual system for science (the *Science-forming Faculty* of Chomsky 2000: 22). This particular cognitive system allows for the construction of concepts that are assigned determinate meanings, taken to refer to natural kinds, but open to modification as science progresses. Thus, other than common-sensical categories, these terms refer (by stipulation) and do not simply grow in the mind. As argued by Chomsky (2000), the resulting concepts abstract from all the semantic complexities of common-sense concepts, and their meaning is simply defined. *Hydrogen atom*, H_2O, *CP* are products of this particular conceptual capacity, and as such radically different from *language*, *person*, *table*, and other concepts drawn from the conceptual domain we call 'common sense' (Chomsky 2000: 23f.). Thus, both kinds of concepts belong to distinct mental conceptual resources.

However, "[t]he constructed systems [based on concepts of the science faculty] may use resources of the I-language (pronunciation, morphology, sentence structure, etc.)" (Chomsky 2000: 42f.). That is, "language makes science possible" (Hurford 2004: 552). This is because from the point of view of the grammatical system, radically different types of concepts are 'just words', once lexicalized.

Put in a different way, I-languages allow the generation of domain-general thoughts by extracting concepts from their modular bounds, by means of lexicalization. All comparative research suggests that animals and pre-linguistic infants are incapable of representing such multimodal thoughts (see especially Hauser & Spelke 2004, Spelke 2000, Carruthers 2002, 2006, and references cited). In the words of Spelke (2000: 1241):

> By combining representations from these systems, human children […] and adults may gain new abilities not by creating those abili-ties out of whole cloth, but by bringing together building-block representational systems that have existed in us since infancy.

If this is correct, then the distinctly human capacity of domain-general thought is a direct result of the distinctly human trait of I-language, comprising a lexicalization mechanism and syntax. I submit that this lexicalization mechanism of the I-language is indeed the most plausible candidate for the key evolutionary novelty that brought about the unity of human thought. It is lexicalization that allows a concept to be enter into the construction of syntactic structure, which in turn acts as an instruction to construct a complex concept/'thought' (Boeckx, to appear, Pietroski, in press, forthcoming).

A simple mechanism that associates words and concepts could thus

8 The resulting expressions may of course be awkward (*The unicorn swallowed the electron*), but that is immaterial to the point at hand.

account for both the unifying function of the I-language and its core computational property, discrete infinity:

> [A lexical item (LI)] has a feature that permits it to be merged. Call this the *edge feature* (EF) of the LI. … The fact that Merge iterates without limit is a property at least of LIs — *and optimally, only of LIs*, as I will assume. EF articulates the fact that Merge is unbounded, that language is a recursive infinite system of a particular kind.
> (Chomsky 2008: 139, emphasis mine — DO)

Evidently, if this were true, an evolutionary account of I-language would be significantly simplified, in that syntax itself would follow from lexicalization (assignment of an edge feature).

The proposal, then, is that the lexicalization of a concept effectively demodularizes it. Given this central role of lexicalization, it follows that humans (*qua* lexicalizers) can entertain an unbounded variety of thoughts, many of which are necessarily unavailable to non-linguistic minds. The idea is aptly phrased by Cedric Boeckx (to appear) in recent work:

> We can in fact think of lexicalization as the mental analog of the hypothetical creation of a truly universal currency, allowing transactions to cross formerly impenetrable boundaries.

In this way, humans can go beyond the limited combinatorial possibilities offered by the various encapsulated *Begriffsschriften* in all animal minds. Notice how neatly this proposal dovetails the emerging consensus in comparative psychology:

> [C]ore systems serve as building blocks for the development of new cognitive skills. When children or adults develop new abilities to use tools, to perform symbolic arithmetic calculations, to read, to navigate by maps and landmarks, or to reason about other people's mental states, they do so in large part by assembling in new ways the representations delivered by their core systems. (Spelke 2000: 1233)

This basic picture (see also Carruthers 2002) explains immediately why animals have striking capabilities in various core-knowledge domains, but why only humans appear to be able to unify all these domains via I-language (i.e., it resolves *Hauser's Paradox*). Bloom's conjecture is vindicated: *Words* are crucial.

Lexicalization is thus likely to have been the key innovation that yielded free, cross-modular thought, accounting for the difference between human and non-human mental life despite largely shared conceptual building blocks. A maximally radical version of this hypothesis holds that little more than the evolution of the edge feature (in Chomsky's sense) was necessary for this cognitive quantum leap.

3. Conclusion: Lexicalization as the Key Evolutionary Novelty

There is ample empirical evidence for the claim that basic semantic relations as part of shared conceptual systems predate (and provide a basis for) the emergence of human syntax (Bickerton 2003, Hurford 2007). Plausibly, animals have considerable conceptual capacities but are unable to integrate the various mental languages in the same way humans can. The comparative approach thus leads to *Hauser's Paradox*.

Lexicalization — the human capacity to associate concepts with words — appears to be more than merely a trivial attaching of phonetic labels to concepts. Lexicalized concepts become conjoinable beyond their modular bounds, yielding a recursive system that transcends the boundaries of core-knowledge domains. This suggests that the crucial evolutionary novelty was in fact the mechanism of lexicalization, leading to an increase in both computational and conceptual capacities. If these speculations are on the right track, the significant cognitive gap between humans and non-linguistic animals is not the result of a profound remodeling of the pre-linguistic mind. Rather, the sudden addition of recursive syntax, paired with a capacity for lexicalization, plausibly led to the explosive emergence of symbolic thought that paved the way for modern human behavior.

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