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Research Article

The Archaeological Record Speaks: Bridging Anthropology and Linguistics

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This paper examines the origins of language, as treated within Evolutionary Anthropology, under the light offered by a biolinguistic approach. This perspective is presented first. Next we discuss how genetic, anatomical, and archaeological data, which are traditionally taken as evidence for the presence of language, are circumstantial as such from this perspective. We conclude by discussing ways in which to address these central issues, in an attempt to develop a collaborative approach to them.

1. Introduction

The emergence of human language is generally seen as one of the major transitions in the evolution of the organic world [1]: the defining characteristic of the human species [2–4] or at any rate a crucial twist within it [5–7]. The issue is not without controversy, as linguistic abilities have been argued to be present in other species of hominids. Relevant evidence ranges from genetic data [8, 9] to the presence/absence of some sort of "symbolic culture" [10–13]—and considerations concerning the anatomy of the organs of speech and hearing abound as well [14–22]. Far from attempting to settle the chronological issue, our goal is to put forth some theoretical considerations that may be useful in evaluating the existing evidence, suggesting new avenues of research. Our perspective, often referred to as biolinguistic, goes back to ideas by Eric Lenneberg, Noam Chomsky, Massimo Piattelli-Palmarini, and others [23–27], which extend from Linguistics to other areas of Cognitive Science [28, for an overview].

In Section 2, we present the biolinguistic conception of language. To avoid a dreadful terminological matter, we will refrain from using the common term "language" and will use instead the expression Faculty of Language when referring to the object that may have evolved, in roughly the sense that organs evolve within organisms. In Sections 2.1 through 2.3, we review what is customarily taken to be evidence for the presence of language, demonstrating how this is questionable when interpreted from the perspective of a mental faculty. We argue that the biolinguistic perspective, with its conception of the Faculty of Language, may help Evolutionary Anthropology in the quest for our origins—especially those of our unique cognitive capacities. More specifically, in Section 3 we offer an example of how the biolinguistic perspective may contribute to progress in research, showing how a shift in focus helps us make significant headway.

2. Language: The Biolinguistics' View

The Faculty of Language may be defined as a *natural system of computation that resides in the mind/brain of all members of the human species*. Our definition uses the term "human" simply because (so far) no conclusive evidence exists of the presence of the Faculty of Language in any other extant or extinct species. As a result, the Faculty of Language (as present in humans) provides the only frame of reference for us to test scientific hypotheses concerning one putative such faculty in Neanderthals, or any other species. Being *computational*, this faculty must be studied as an information processing system based on the application of certain symbol manipulating capabilities [29, 30]. Being *natural*, it should be understood as an organ that is part of a larger organ system—the nervous system [31]. This faculty is also contingently taken to interface other parts of the mind/brain, intuitively related to "meaning" and "sound" (or "gesture") [32].

To emphasize this point, we see as accidental properties of the Faculty of Language the fact that, in humans, it interfaces other cognitive systems, in particular a Conceptual-Intentional and a Vocal-Auditory component. This collection of systems (the Faculty of Language + Conceptual-Intentional components + Vocal-Auditory components) is often labeled as "the Faculty of Language in the broad sense," following Hauser et al.'s convention [33]. Factually, how central the Conceptual-Intentional interface may be to the human Faculty of Language is open to debate, but the interface with the Vocal-Auditory system is certainly contingent [34, 35]. As decades of research into human sign languages demonstrate, these share the structural properties of human vocal languages [36–38]. So the externalization of "linguistic thought" does not privilege the Vocal-Auditory system, and it can also interface Gestural-Visual components.

The fact that (some) Faculty of Language interfaces are contingent is important. Our definition does not exclude the (metaphysical) possibility of a Faculty of Language system that shares definitional properties as outlined above but only some of the contingent properties we normally associate to the faculty in the human sense. Our conception allows, also, for a natural computational system with powers analogous to the linguistic ones to be studied here, but which is interfaced with entirely different mental subsystems. In the hypothetical, the faculty in question might implement "functions" that are entirely different from those traditionally attributed to human language. Underlying these assumptions is Chomsky's distinction between "competence" and "performance" [32]: a system of knowledge (the Faculty of Language) versus the (various) ways in which this system may be put to use. Inasmuch as these properties of the Faculty of Language are contingent, the natural system of computation itself should be seen as functionally unspecific [31].

Those qualifications constrain the range of hypotheses to test with respect to the origins of the Faculty of Language. In particular, considerations about "systems of communication"—or comparable such "functions" ascribed to language in a vague sense—become orthogonal to the faculty itself. Language as humans experience it serves multiple purposes: to communicate thoughts, to be sure, but also to assert the mere presence of an interlocutor, to lie, to joke, to express beauty, to frighten into submission, to "talk to oneself," to call a distant star or a number that affects no imaginable communicative act, to describe instances of nondenumerable expressions in mathematics, and surely many other purposes that any reader can fathom. Any of those is a "function of language", though none of them seems more natural than the others. Importantly for our purposes, the idea that language is "tailored to communication" (or any of the other "functions" alluded to) has provided no particular insight into the Faculty of Language as understood by linguists of our persuasion.

The qualifications above also entail that language, when rigorously understood, is far from a skill to be learned by repetitive training, like skiing or scuba-diving. This is particularly the case for "first languages," as acquired by children up to puberty. It is an open question whether a "second language" acquired by an adult—often through explicit teaching and rarely to native fluency—may indeed be a skill, subject to variations in ease and rapidity of acquisition, final performance, improvement, decay without practice, and so forth. This unfortunately confounds the matter of interest here. For it may well be that English, definable in some abstract sense as a set of instructions one could (ideally) get in training school for immigrants, has relatively little to do with English in the mind of a native English-speaking preschooler. For perspective, one can train a human to hang glide, by taking advantages of the air currents a condor uses. However, it would seem unjustified to assimilate the mental faculty behind the condor's (natural) flight to the skills necessary to succeed at human (artificial) hang gliding (this is not to imply that learning a second language does not employ the Faculty of Language in some sense—after all, only humans learn second languages, even if they do not do it to perfection. The point is raised simply to emphasize the difference between an observable behavior and its underlying causes). If we are interested in the evolution of a natural entity like the Faculty of Language, we cannot satisfy ourselves with vague considerations about whatever mental capacity allows humans to learn languages as adults—we have to go after the natural system in children.

That said, it is also important to distinguish the process of acquiring English (any first language) from the innate developmental process leading to the Faculty of Language in an individual. To use another bird analogy, one thing is for a zebra finch to acquire his (paternal) song (as opposed to a different acquirable song by another conspecific) and a very different thing is for that same zebra finch to develop the mind/brain "circuitry" that makes the achievement possible. Now just as the development of acquisition and performance brain circuits is a well-understood prerequisite for successful bird-song behavior [39], so too the development of the Faculty of Language seems to be a precondition for the acquisition of a given human language.

Having set aside contingent properties of the Faculty of Language, it is worth emphasizing its intrinsic characteristic: *combinatory power*. In short, the Faculty of Language, as a natural computational system, appears to be roughly equivalent to the family of systems traditionally classified as (mildly) context-sensitive in the Chomsky Hierarchy of grammars [40–43]. In a nutshell, this means that the system is capable of constructing complex expressions with (i) a hierarchical structure and (ii) dependencies among nodes in the hierarchy that are not expressible as hierarchical nodes, thus requiring a more powerful computation (see Section 3 on this). It is commonly held that no other natural computational system has the same power of the Faculty of Language [33]. Hauser et al. refer to this system as "the Faculty of Language in the narrow sense," meaning both that it is the core component of the Faculty of Language in the Broad Sense and that it seems to be an evolutionary novelty [33, 44].

Given this set of assumptions, we would like to examine next the evidence that is customarily adduced for the presence of linguistic abilities in a given species. Our interpretation of the data differs substantially from the traditional one in Evolutionary Anthropology and suggests a slight shift in focus. We will concentrate on the sorts of evidence that are most often discussed in relation to language origins: genetic, anatomical, and archeological considerations, in that order.

2.1. Genes for Language?

Molecular biology currently benefits from methodological tools capable of elucidating the differences, at the molecular level, between human beings and other organisms. As a consequence, it can also establish a precise chronological dating of relevant evolutionary changes. Moreover, the progressive optimization of techniques devoted to the analysis of the so-called fossil DNA has opened the way to the possibility of directly measuring the molecular evolution of such genes, yielding a much more accurate temporal perspective of the nature, pace, and magnitude of changes [45, 46]. This extraordinary methodological turn has made it possible for the first fragments of nuclear genes from *Homo neanderthalensis* to be cloned and sequenced [8, 47–49].

At this molecular level, *FOXP2*, generally regarded as the "gene of language" [50–54], has been the focus of much attention. This is the case due to two crucial facts: (i) the occurrence of two nonsynonymous changes in the sequence of the protein encoded by it [55], and (ii) the almost certainty that the corresponding Neanderthal gene also contains both substitutions. This suggests that the two modifications in point were not selected in correspondence with the emergence of *Homo sapiens* (around 200,000 years before present [55]), but in fact much earlier: within a common ancestor of our species and *Homo neanderthalensis* (*c.* 500,000 years before present [8]). The latter scenario has led different authors to speculate about the presence of a fully human Faculty of Language—or rather "language" in some general sense—in the second species [9, 56].

Interest in such comparative analyses has extended to other genes whose mutations appear to cause specific language impairments (these are conditions disjoint from neurological dysfunctions, mental retardation, broad cognitive deficits, a hearing impairment, or an inadequate exposition to linguistic stimuli during development). For instance, different substitutions in both *DYX1C1* and *ROBO1*, two genes associated to dyslexia [57–59], have been positively selected in the human lineage: in the first case, after the separation of the evolutionary lines leading, respectively, to humans and the rest of higher primates [57] and, in the second case, between 12 and 16 million years ago [58]. As a complete genetic characterization of the Faculty of Language cannot be made with the exclusion of genes that, when mutated, impair other cognitive capacities besides language, the catalogue of genes of interest is expected to increase in the near future [60, 61].

All these findings point to new and exciting avenues of research concerning the evolution of the Faculty of Language. However, conclusions on this area are undermined by a very common, but unfortunately untenable, assumption that the existence of full-fledged linguistic abilities in other hominids can be automatically inferred from the presence of the human variant of any of these genes.

To begin with, even if many genes have presently been cloned from people affected by specific language disorders [60, 62, 63], paradoxical situations routinely arise. (i) Sometimes relevant genes are also expressed in brain regions not related to language processing, and even in tissues outside the nervous system. (ii) Sometimes such genes are mutated in people affected by other cognitive (i.e., non specifically linguistic) disorders or are simultaneously linked to diverse language impairments. (iii) In some individuals affected by a particular language disorder, the sequence of such "language genes" is normal (phenocopy), while (iv) the linguistic competence of some of the individuals endowed with an anomalous variant of one of these genes is not impaired at all (null-penetrance) or is just mildly impaired (reduced penetrance). Moreover, (v) the identity of such genes differs (to a certain extent) from one population to another or depending on the subtype of the disorder (for a review of different cases, see [60, 63]).

A second point of concern is how genes actually contribute to the regulation of the development and functioning of the neural substrate of the Faculty of Language. Several considerations are worth bearing in mind. (i) Genes do not directly determine language; they just synthesize biochemical products, which will be engaged in particular physiological functions. (ii) Ordinarily, the same gene plays different roles (i.e., contribute to different physiological functions) in diverse moments and body tissues during ontogeny (pleiotropy). Simultaneously, (iii) many genes usually contribute (each to a different extent) to the same biological process (polygenism). Finally, (iv) the extent to which a particular gene product contributes to such a biological process heavily depends on the precise balance it keeps, in a particular moment and place, with the biochemical products encoded by the remaining genes involved.

Other parameters besides genes themselves also contribute to the initial "wiring" of the neural substrate of the Faculty of Language. These include maternal factors (in essence, protein gradients inherited via the egg cytoplasm) and regulatory elements belonging to all levels of biological complexity between genes (and their products) and brain areas [64] (concretely, the metabolome, different subcellular organelles, the diverse brain cells, the synaptic activities, and diverse specific brain circuits). Furthermore, information relating to the structural features and functional properties of the neural substrate of language could plausibly be generated as a consequence of the developmental process itself [65, 66]. Plus they could depend on general laws that apparently regulate the self-organization of biological systems [67, 68]. All these additional nongenetic factors, robustly appearing and acting at certain developmental stages, can be plausibly regarded as innate. Consequently, what can be deemed "innate" clearly transcends what can be regarded as "genetic" [69].

A third concern relates to the fact that complex regulatory mechanisms probably determine just the basic interconnection patterns among the diverse types of differentiated neurons involved (and, thereafter, the basic histological organization of the main anatomic macrostructures which conform the neural substrate of language). In itself, however, this need not produce fully operative computational devices, understood in more or less customary cognitive terms [70]. Frankly, no one has a clear picture as to how such systems may arise in nature in general, let alone minds/brains [71]. Another way of stating this important issue, emphasizing the distance between what happens at measurable brain levels and what is understood in more abstract mind terms, is that any brain prewiring must be compulsorily implemented by the feedback effect exerted by neural activity during language processing. Only in such a way is the ultimate cytoarchitecture of the neural substrate of the Faculty of Language achieved, with fully operative neural structures somehow resulting.

A fourth and crucial point to consider is that an increasing body of evidence suggests that most of the molecular changes occurred along our speciation have affected the *transcriptome* rather than the genome (and, consequently, the relevant protein sequences) [72–76]. These changes would essentially have carried the following: (i) modifications in the expression levels of different genes (and generally in the corresponding protein stocks) [72] and (ii) modifications in the spatiotemporal expression profiles of others, with the subsequent creation of new combined expression patterns; these are probably the basis for the appearance of new structural and functional compartmentalisations at the brain level and eventually of new cognitive capacities [77].

At the same time, both kinds of changes would have fundamentally been the result of the modification of the following: (i) the *cis* regulatory regions of gene expression (i.e., noncoding regions located proximal to coding sequences on the same DNA strand), as witnessed by the high number of positive selection signals observed in noncoding regions of genes associated with brain development and function [78, 79], (ii) the levels and/or modulating properties of certain transcription factors, components of signal transduction pathways, and noncoding RNAs (ncRNAs) [80] and (iii) the splicing patterns of mRNA of certain genes [81, 82], which could have affected on average around 6 to 8 percent of human exons, as compared with the chimpanzee [82]. Indeed, alternative splicing (i.e., the synthesis of different functional RNAs from the same primary transcript) is more frequent in the brain tissue than in any other [83]. Finally, it is also worth bearing in mind that other innate information storage systems, including mitochondrial DNA and epigenetic mechanisms, appear to exhibit a number of significant differences between humans and higher primates [84].

The case of *FOXP2* leads to some particularly illustrative conclusions. The introduction of the human variant in mice produces interesting phenotypic alterations [85], while the human protein brings about *in vitro* and *in vivo* a variation in the transcriptional regulation pattern of the FOXP2 factor, as compared to what happens in the chimpanzee [86]. Nevertheless, we mostly lack information about the sequence (and evolutionary history) of the regulatory regions of the gene. Very probably, significant mutations in these regions have occurred throughout the evolution of our species, with effects on the biological activity of the *FOXP2* protein probably surpassing those caused by the mutations accumulated in the coding sequence of the gene. Moreover, we also lack enough information about the sequences targeted by the gene [87] in other hominids (including Neanderthals) which have also been subject to positive selection during our recent evolutionary history. In other words, presently we are in the dark even about the existence of alternative expression patterns relatively to that of our species.

Advances in the molecular understanding of language are certainly fast and promising—but still inconclusive and relatively informative (connections between molecular and linguistic data are generally indirect and rather unclear. E.g., the protocadherin 11 gene pair (*PCDH11X*/*PCDH11Y*) has been suggested as a putative determinant of language via its role in cerebral asymmetry [88]. Cerebral asymmetry and right-handedness have recently been attributed to Neanderthals and pointed out as an additional clue in favor of the existence of complex linguistic capabilities in this species [89]. However, the relation between cerebral lateralization and language is not an implicational one [90–92]. Furthermore, the relation between lateralization and the peculiarities of the Faculty of Language *qua* computational system is unclear, if it exists at all [93]). There is, however, one thing we can be sure of: we cannot simply infer the presence of the Faculty of Language from just the existence of the human variant of a group of interesting genes, given all other relevant uncertainties.

2.2. On Speech and Hearing. Since Lieberman and Crelin's analysis of the Neanderthal vocal tract [14], the debate on the speech capabilities of extinct hominid species has thrived, generally based on anatomical studies [15–19, 94]. This line of research has recently been complemented through the important finding, by the team working at Sierra de Atapuerca, of the ear ossicles of a *Homo heidelbergensis*. These have made possible to determine relevant features of this and other species' hearing capabilities [20–22]. In this section, we would like to review these matters, although not attempting to be exhaustive—for example, we set aside studies focusing on anatomical features like the neural canal. Right from the onset we want to say that, in our view, it is unfortunate that this interesting debate should have been twisted into one on the presence of full-fledged linguistic abilities. Given our discussion above, an inference from a modern speech and hearing apparatus to the Faculty of Language, as presently understood by linguists, is unwarranted. In what follows we unpack our arguments as explicitly as this context permits.

First, it is a contingent fact that some humans externalize their "linguistic thoughts" through a Vocal-Auditory interface; other humans achieve the same result through a Gestural-Visual interface. Thus the presence of a modern anatomy of the vocal tract and of the middle ear, *per se*, does not sanction an inference of the presence of the Faculty of Language (as they are soft organs, the outer and inner ear do not fossilize, so we can only extrapolate their structure in extinct species from comparative studies with other, closely related, extant species. Needless to say, the inner ear plays a determining role in the way the auditory signal is processed [95, 96]). On similar logical grounds, absence of the modern anatomy of the vocal tract would not allow us to infer absence of the Faculty of Language. For perspective, we would not conclude, if examining a human being who is incapable of gestural-visual abilities, a corresponding absence of linguistic abilities—on the basis of the fact that in other individuals the relevant interface does exist. Patently, correlations of this sort are weak. A being with a thoroughly modern Vocal-Auditory interface but no Faculty of Language is as easy to imagine as a being with archaic Vocal-Auditory interface but Faculty of Language "plugged" into some different externalization system (or none whatsoever). There is no a priori reason to dismiss these reasonable theoretical possibilities (see [97–99], for some evolutionary implications).

Secondly, one must carefully separate the perception of sounds as such from the categorization of such stimuli in linguistic terms. A given organism may be able to produce/perceive sounds like, say, [u] or [i], without this entailing that this sounds are interpreted as vowels by the organism in point (these are the sounds that, for a human subject, correspond to the vowels appearing in the English words "booed" and "bead", resp. Note that English [u] and [i] are always long vowels and thus with a slightly extended duration than the corresponding short vowels found in other languages like Spanish. However the linguistic quality of these sounds is the same in both languages), without this entailing that these sounds are interpreted as vowels by the organism in point. In essence, vowels are linguistic units that, together with consonants, constitute the building blocks of syllables. The latter, in turn, are the basic constituents in the phonological structure of words and phrases, the basis for their characteristic rhythmic structure (rhythmical feet being still higher-order units) and so on. Thus a linguistic symbol is not just a sound, but an element in an intricate system of values that satisfy the famous slogan (attributed both to Saussure and to Meillet) that "chaque fait linguistique fait partie d'un ensemble où *tout se tient*." The distinction is not just pedantic. Human babies in prelinguistic stages are able to perceive categorically vocalic sounds like [u] or [i] [100], but so are other mammals, primates included [101–105]. However, no one should attribute the category "vowel" to these nonlinguistic beings—unless one is ready to argue that, for these creatures too, relevant such percepts arrange themselves into a system of interrelated values.

From a biolinguistic perspective, the state of affairs just described means that human languages have their phonetic/phonological structure adjusted to production/perception capabilities of the species. However, perceptual capabilities as such are probably quite ancient. In all likelihood, they are associated to the evolution of the mammalian inner ear and its ability to perform the spectral analysis of complex waveforms in order to individuate their most intense harmonics. Moreover, the data on the perceptual capabilities of mammals are a clear indication that a perfect adjustment between production and perception is not something to be expected in all cases. It is observed in chimpanzees, whose vocalizations appear to contain sounds like human [a], [o], and [u], but nothing comparable to [i] or [e], which, given the sensitivity of their middle ear, are hard to discriminate for them [104]. That case contrasts with that of chinchillas, who perceive but do not produce a variety of the categories that enter the linguistic repertoire in some form [106]. More to the point of our concerns here, we simply do not know what may have happened in earlier hominid species and whether they could or could not discriminate sounds that they were not able to produce accurately [22, 61].

Lieberman [107] argued that if we were to find any evidence for the Faculty of Language in Neanderthals, and they externalized Faculty-of-Language expressions through the Vocal-Auditory interface, we would be able to predict that their phonetic inventory was smaller than ours. Lieberman furthermore suggested that this would be a phonetically less efficient system than ours. However, in point of fact anatomical evidence cannot tell us much about the Faculty of Language. All it can tell us is that human hearing capabilities antedate the apparition of *Homo sapiens*, whereas the modern configuration of the vocal tract seems to be a novelty of this species (note, moreover, that some of the features considered to be critical for the evolution of speech are not as uniquely human as has often been assumed. Thus, a descended larynx may be a human novelty as compared to other primates—but it is also observed in other mammals [108, 109]). Until we have additional, solid, evidence that this change might have had something to do with the emergence of a fully articulated language with a Faculty of Language interfacing a Vocal-Auditory system, the rest is sheer speculation (see [110, 111], for some interesting proposals about how research in this area might proceed).

2.3. An Archeological Approach to Language. Archaeologists studying the Paleolithic tend to agree that the transition to the Upper Paleolithic is one of the most complex, often elusive, research topics in this field [112]. Chronologically located at c. 40,000 years before present, it is a process that includes the demise of Neanderthals and not only the appearance of anatomically modern humans in Europe but their survival and their expansion into Eurasia—including areas that had never been inhabited before by older hominid species. Despite over forty years of studies and a few unquestionable advances, a clear and precise idea of how this phenomenon took place still escapes us. Predictably, language and other abilities considered modern are central to the debate of the demise of Neanderthals and the endurance of anatomically modern humans (who are assumed to have had the same type of cognitive development level and faculties as present-day humans [6]). Far too often, it has been presupposed that these qualities are what ultimately made the difference between the fates of the two species (see [113], among others).

Until a decade ago, a hypothetical revolution that would have taken place with the arrival of anatomically modern humans in Europe was seen as the spark lighting the intense changes the archaeological record of this period reveals [114]. A thorough revision of the African record [115] put an end to speculation, as it showed that every single "revolutionary characteristic" had been independently developed in that continent before being brought into Europe as part of a new-to-the-area "toolkit"—for over 100,000 years. With that result in mind, any analysis that attempts to shed light on the origins of language simply cannot be done on European data alone but must be based on much older remains, unearthed in African soil, where relevant traits first appeared. A simple linguistic argument for this view stems from the fact that the basic structure of natural languages (e.g., in their logical form) is roughly the same in all inhabited continents [116]. All existing evidence points to the direction that an underlying Faculty of Language, no matter how abstract, emerged in a focal African point and was subsequently carried to the confines of the planet.

Needless to say, the origins of the Faculty of Language cannot be directly studied by Archaeology as commonly understood, because of the lack of fossil evidence in this regard. At the same time, Archaeology aims at shedding light on how ancient humans lived and how they adapted to the environment and survived. Some of the ways in which this must have happened seem so intrinsically connected with the use of language that, no matter how invisible their fossil remains may have been, they ought to be taken into account when reconstructing the past. This is why a variety of archaeological projects have focused on this topic. We will concentrate now on the aforementioned set of innovations that left marks or remains in the record: a collection of traits also studied for other periods, involving economy, subsistence, technology, and so forth.

A word of clarification is relevant at this point. One traditional aspect in which archaeology may relate to linguistics, and vice versa, involves the sociocultural aspect of language, especially as encoded in lexical structures. What linguists call a lexicon—which can be defined as a repository of linguistic idiosyncrasies atomized into words—is undeniable a cultural artifact, aside from a fundamental cognitive component that the Faculty of Language interfaces with. Plainly, the way in which humans live affects how they record their living history through their words. In the process skills, traditions, instructions and other forms of "know how" repository may have been coded. It takes little reflection to realize that such explicit or implicit instructions would have such effects as cutting production time for tools or allowing for elaborate living dwellings, let alone artistic or metaphorical creations. In this regard, more or less sudden innovation in any of the latter—some of which do leave fossil records—can be seen as an indirect argument for a lexicon. Inasmuch as the lexicon presupposes a Faculty of Language, this then also constitutes indirect evidence for such a mental organ (see [117], where the argument is presented in a less meticulous fashion).

In the sections below we look into the traits that have been identified as "modernity indicators," all part of the archeological record. We will examine their relation to the Faculty of Language, as well as their implications for anatomically modern humans, their expansion out of Africa, and their survival.

2.3.1. Technology. Lithic industries constitute by far the largest corpus of remains in the archaeological record of the Paleolithic period. Accordingly, there is a large number of remains that can be grouped under the label of "technological markers". We will focus on three types that appeared at different moments during the Middle Stone Age. Among these are microliths (c. 70 ka), points (c. 250 ka), and blades (c. 280 ka) [115].

Middle Stone Age lithic industries represent a radical change from previous industries, both morphologically and technologically: relevant assemblages include smaller tools and new types, such as blades and microliths. Both were thought to have been part of composite tools, formed by a nonlithic section into which several lithic pieces would be inserted. Points were vastly represented across the African Continent during the Middle Stone Age; during that time they constitute a clear case of regional artifact style, a modernity indicator. These were also hafted to shafts, to be used as projectiles [118].

Composite tools imply aspects that cannot be related to older types of tools. These include forward planning (standardized microliths as replacement of similar older pieces broken during use) and the preparation and complementation of different types of materials that had to be worked in different ways and in separate stages, very likely well before needed. These traits are typically attributed to a stage of cognitive development that can perhaps be related to the Faculty of Language.

Complex bone technology appears in the African record at around 110 ka, during the Middle Stone Age. It contains impressive pieces like the Katanda harpoons and points from D. R. Congo [119]. These materials are dated well before the appearance of the split base points that signal the presence of the earliest Aurignacian in Western Europe. McBrearty and Brooks [115] consider that the African bone-working tradition has its origins much earlier in the Pleistocene. The Middle Stone Age levels show that its development was widespread in that continent.

Bone tools and artifacts manufactured using ivory, antler, and shell supports (organic technology) are considered modernity markers. Complex organic technology is one of the innovations that signal the onset of the Upper Paleolithic in Europe. It is at this point that we have the first evidence that relevant materials are worked using techniques that are different from those used to produce lithic tools. Previous attempts to use bone exist, but relevant artifacts are crudely worked [120, 121]. Of course, the innovation highlighted here relates not so much to the type of materials employed but to the way in which the materials were worked to make tools. Several techniques (polishing, sawing, and abrasion) started at that time to manufacture organic tools. Split-base bone points are an example of artifacts manufactured using such methods.

The abovementioned types of tools have implications within economic parameters. While some saw Middle Stone Age populations as mostly scavengers [122], it is now clear that they hunted. Moreover, their use of points indicates that they had no need to get close to game, which boosted survival rates at the same time that it improved productivity. Chase identifies a specific type of hunting practice as exclusive to anatomically modern humans [117], which is the driving of large game into enclosures or towards cliffs. European examples date from the Middle Pleistocene onwards, and some are related to Mousterian lithic assemblages [123, 124]. The latter would not even imply the use of projectiles, since the animal's fall would cause their certain death. According to this author, sophisticated language was needed to coordinate and organize this kind of hunting technique, though of course the argument remains indirect.

McBrearty and Brooks [115] also highlight the appearance of fishing and shell-fishing at around 110 and 140 ka, respectively, in the African record. These activities would have increased the number of resources available to human groups, at the same time that they opened marine coastal regions to exploitation and colonization.

The exodus of anatomically modern humans out of Africa, whatever its causes, can be traced back to the moment we see the introduction and systematic use of new resources into the Middle Stone Age diets. This was clear from the Lower Stone Age onwards. Once out of Africa, this expansion led anatomically modern humans to the colonization and occupation of Eurasian regions that had never before been explored. From early on this process witnessed the improved adaptability of relevant populations, who were able to survive in a broad array of environments and landscapes—on vastly improved resources. This prevented episodes of food crises leading to starvation and disease, which would have likely caused high mortality rates in previous periods.

The geographical expansion in turn brought the appearance of long distance networks, as well as new possibilities emerging from ties among groups living in different areas and exploiting different environments. Resources opened for those populations: not only in terms of alliances created by marriage—thus broadening the gene pool—but also arriving from foreign territories, as the case for new raw materials. More importantly, concepts and ideas, technologies and beliefs traveled too. Given the richness of what was shared, developed, and maintained, it seems unlikely that most of this sharing could have happened without lexical encoding, therefore presupposing the Faculty of Language [125]. We turn our attention to this in the next section.

2.3.2. Symbols and Culture. Material remains interpreted as symbolic, ritualistic, or nonfunctional have often been the focus of studies trying to shed light on the question of the origins of language—a highly complex system of symbolic combination. Some proposals have caused heated debates, as they revolved around objects of unclear use and significance, whose putative symbolic nature can only be presumed. Surely the use of bona-fide symbols implies a particular cognitive (or even neural) evolution—and perhaps this is related to some aspects of the Faculty of Language [117]. However material culture remains, especially those extremely rare ones, can only offer a very partial view of the minimum cognitive abilities of the people who made such objects [115, 126].

McBrearty and Brooks characterize symbolic behavior as "the ability to represent objects, people, and abstract concepts with arbitrary symbols, vocal or visual, and reify such symbols in cultural practice." We return shortly to the issue of whether such an ability entails or is presupposed by the Faculty of Language. The most commonly undisputed signs of symbolism in this sense, in the extant archaeological record, appear in Africa at around 250–300 ka. This is during the Acheulian-Middle Stone Age boundary, the latter being a period during which both *Homo helmei* and early *Homo sapiens* were present in Africa [115]. Within the extensive list of archaeological traits that start appearing at that time, the following are those classified as symbolic:

(i) regional artifact styles;

(ii) self-adornment objects (ornaments are defined by Mellars as "small objects for which [there is] no obvious functional explanation" [127]. Note that Chase [117] cautions against this direct relationship and offers an ethnographical list of perforated, grooved and serrated artefacts with practical functions), like beads (from c. 82 ka) and other perforated pieces;

(iii) use of pigment—processed (from c. 280 ka onwards);

(iv) notched and incised objects—organic and inorganic materials (from c. 105 ka);

(v) image and representation—also called "naturalistic art" (from c. 45 ka in Africa);

(vi) burials with grave goods, ochre, and ritual objects [128].

A cautionary note is due here. Although McBrearty and Brooks label the list above "modern human behaviors," so far very few anatomically human moderns remains have been found in association with symbolic artifacts. The same is true about any components of assemblages to which these remains are commonly assigned (Middle Stone Age in Africa and early Upper Paleolithic/Aurignacian in Europe) (physically, the makers of the early Aurignacian are poorly known [6], but fossils from Moravia and the Czech Republic link those to anatomically modern humans rather than to other, older, populations). Finally, there are cases of Neanderthal remains associated to Chatelperronian objects—for example, Saint-Césaire, Poitou-Charentes (France) [129, 130], some of which would qualify as symbolic artifacts according to some definitions.

It is also noteworthy that, in some instances where allegedly symbolic material has been found in relation with Neanderthal remains, bona-fide symbolism has been ruled out as a falsifiable explanation. For instance, while anatomically modern human burials can certainly be considered ritualistic, Neanderthal burials are often described as merely hygienic [131–133]. In a different instance, ochre was found in the latest Mousterian level and the earliest Upper Paleolithic level at l'Arbreda Cave in Serinyà, Banyoles (Spain): to its excavators for the last few decades, this ochre is a sign of symbolic behavior during the earliest Upper Paleolithic at the site. However, these researchers do not understand what the same type of remains mean in the Mousterian layer below [134]. Thus, curiously, the very same ochre found in that layer is not related to symbolic activities [135].

One more interesting debate concerns what happened at around 40 ka, when the aforementioned modern behaviors enter the European scene [136]. Then Neanderthals, who for over 200 ka had developed assemblages entirely devoid of symbolic artifacts, appear to start producing objects of the relevant kind. Did Neanderthals suddenly get the Faculty of Language, or some such symbolic engine? A large number of researchers have preferred to see this situation as a case of acculturation of Neanderthals at the hands of innovative and versatile anatomically modern humans [135].

To sum up, considerable disagreement exists among experts, and a lot of work still needs to take place before the fossil evidence yields more information about the Faculty of Language [117]. But a more serious cautionary note should be added from the perspective of linguistics, concerning the validity of taking the vestiges of symbolic behavior or "symbolic culture" as unquestionable evidence for the presence of the kinds of complex abilities commonly associated to the Faculty of Language.

Factually, a collection of cultural practices correlate with the presence of anatomically modern humans, and a number of these fall under the rubric of symbolic behavior or culture. Given this correlation, the following is often assumed as a valid inference:

(1) Symbolic Culture → the Faculty of Language.

This inference is often supplemented by its converse:

(2) the Faculty of Language → Symbolic Culture.

In essence, this presupposes that a Symbolic Culture is only possible with language and that a Symbolic Culture is a necessary consequence of language. Thus,

(3) the Faculty of Language ↔ Symbolic Culture.

However, these inferences are invalid, based as they are on a false premise that the use of linguistic symbols is a special case of symbolic behavior. We need to clarify this.

We do not question the idea that a Symbolic Culture may indeed be characterized as an instance of bona-fide symbolic behavior. This basically means that relevant practices partake of signification systems established between different entities, through the relations they stand in with respect to other entities within the system (the most explicit formulation of this idea is to be found in Renfrew [137] and Noble and Davidson [7]. It has never been challenged neither by evolutionary anthropologists nor by archaeologists). The problem is that the Faculty of Language does not respond to this characterization for two different reasons: first, the Faculty of Language is not a behavior, symbolic or otherwise, but a natural system of computation. Second, the semantics of natural languages does not seem to be the product of the kinds of relations that make cultural symbols meaningful.

As pointed out by Eco [138], cultures can only be understood as complex and opaque systems of significations. They are complex because the meaning of each particular component depends on the relations it establishes with the other components of the system. They are opaque because we will hardly be able to know the meaning of a particular symbol unless we know how it is used (this is, e.g., one of the arguments for what Renfrew [137] calls the cognitive-processual approach to archaeology and against what he calls the interpretive approach). So in order to properly understand the meaning of a particular element of the symbolic culture of a group of, say, early humans we should know how it was used in its context (how its use related to that of other elements of the same cultural set). It is highly doubtful that the same general conditions extend to natural languages, pace Wittgenstein [139] and Ryle [140] (although Wittgenstein's work is perhaps the main reference for Anthropology and Archaeology [141]).

The linguistic point is simple. Once we know the meaning of given words (DOG, UNICORN, BROWN, GREEN, etc.) we automatically gain access to the meanings of combinations thereof (BROWN DOG, BROWN UNICORN, GREEN DOG, etc.). This is so even without previous familiarity with the situations in which these symbols might be appropriate. In short, the semantics of natural languages possesses two well-established properties that no cultural system of symbols exhibits: *compositionality* and *productivity*. The only known explanation for these linguistic conditions is through the action of a computational system capable of dealing with hierarchical structures.

The contrast is thus clear. While the meanings of the elements making up a Symbolic Culture are opaque until we enter in contact with that Symbolic Culture (to participate in/observe/be informed of the practices in which these elements become meaningful), nothing of this sort applies to the meanings of linguistic complex expressions. These we naturally grasp as we hear them, even with no prior exposition and in the absence of corresponding entities or situations. Nothing of this comes as a surprise once we accept that Symbolic Culture and the Faculty of Language are very disparate entities: Symbolic Cultures are systems of complex and intricate culturally acquired behaviors, while the Faculty of Language is a natural component of the mind/brain of certain organisms (for detailed presentations of this argument see Fodor [30, 142–144]. Wittgenstein was aware of the consequences of the argument and, therefore, tried to show that the semantics of utterances is in fact not compositional [145]. Such a view has not been very influential in semantic studies [30, 146, 147]).

From all this it follows that "meaning" in a cultural system of symbols (or "meaning$_{SC}$") is probably quite different from "meaning" in a natural language (or "meaning$_{FL}$"). A crucial consequence of this is that the capacity of dealing with meaning$_{SC}$ does not presuppose or entail the capacity of dealing with meaning$_{FL}$. The putative connection between the two in humans is a contingent fact on which we cannot base reliable generalizations. The logic is corroborated by the fact that nonhuman apes appear to be able to acquire symbolic systems, at least under experimental conditions [148]—and perhaps even in the wild [149]. No primate, however, has ever been able to acquire/develop a full-fledged "language," or even rudimentary versions thereof involving some serious combinatorial syntax.

3. A Biolinguistic View on the Neanderthal/Modern Divide

3.1. Linguistic Complexity. Once again, the Faculty of Language is a natural computational system, capable of constructing complex expressions with a hierarchical structure and nuanced dependencies holding at arbitrarily long distances. The hierarchical structure of linguistic expressions is illustrated by the simple fact that the sentence "The boy says that he likes apples" contains the sentence "He likes apples", and could be contained within the sentence "Everybody knows that [...]." This means that linguistic utterances are not mere concatenations or linear arrangements of symbols but are instead hierarchically organized sets of units, as the following bracketing representation shows:

(4) [Everybody knows [that the boy says [that he likes apples]]].

As for long-distance dependencies, note for example that (4) contains a subject pronoun (he) optionally coreferring with the subject noun phrase (the boy) in the middle sentence. This preferred (though not obligatory) reading is captured by coindexation:

(5) [Everybody knows [that the boy$_i$ says [that he$_i$ likes apples]]].

Further dependences exist in this sentence under the form of subject/verb agreement ("everybody knows", "the boy says," and "he likes"). Arbitrarily large amounts of linguistic material can be introduced in between the verb and its subjects, without this having effect in the robustness of the dependency. Thus observe that

(6) **Everybody** in this (large (but still very (very...) charming...)) house **knows** that **the boy** with the red hat (that was a present form good old Santa...) **says** that **he** uncontrollably (and in fact even morbidly...) **likes** apples.

In addition, linguistic expressions can contain more subtle forms of long-distance dependences, technically known as "displacement" relations. This point can be illustrated with *Wh*-interrogative sentences, in which question words show up far away from the position where they receive interpretation as verbal arguments, as in (7) (where "e" represents the "empty position" left behind by question word after "moving"):

(7) [What$_i$ does everybody know [that the boy says [that he likes e$_i$]].

The ones just reviewed are well-established linguistic facts [28, 150]. They are, in a nutshell, the reasons behind the characterization of the Faculty of Language as a "Type 1" system in terms of its computational complexity, using as a reference point the Chomsky Hierarchy of formal grammar [40–43], which we review next.

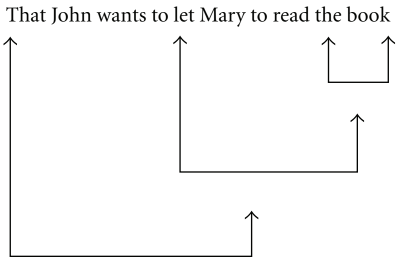
3.2. Formal Complexity. The said hierarchy defines different classes of "formal languages" (or corresponding grammars), arranged in an increasing scale of complexity. In these mathematical constructs, a "formal language" is understood as a set of strings of symbols generated under certain general admissibility conditions. Crucially, for a system of these characteristics to work, a finite collection of rules, describing the admissible strings in the language, can be produced and result in a computation that halts at some point (it should be easy to see, given the characterization of a "formal language" just introduced, that this mathematical notion is not synonymous to the biolinguistic notion of language defined at the outset of this paper. The notions are however related in some abstract sense [151]).

This ensures that, given the rules of a language (technically, its grammar), some computational device exists capable of mechanically generating any of the strings of the language in question. However, since the arrangement of symbols in a string may be more or less intricate, in definable ways, some languages may require more or less complex devices to generate them. The complexity of a language-generating device (an automaton) is essentially defined in terms of the amount and sophistication of its memory resources. Simply put, more complex languages can only be generated by automata with the appropriate memory resources. This distinction is what underlies the traditional classification of languages, grammars, and corresponding automata from Type 3 (or "finite-state", the simplest ones) to Type 0, the most complex.

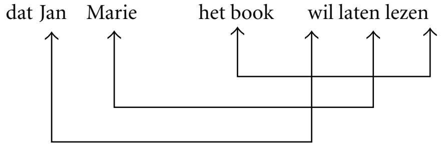
The Chomsky Hierarchy therefore provides a useful frame of reference to determine the complexity of Turing-computable problems (the architecture of relevant automata was defined by Alan Turing by theoretically imagining a logical processor writing operational steps on an infinite tape, one step at a time. When one speaks of "memory" within this system, one is basically referring to the ability to designate sections of the writing tape not so much for the purposes of carrying the computation forward but rather with the purpose of storing instructions to be used at later computational times. Different memory regimes determine, in the end, the overall complexity of the "formal languages" so characterized). Any such problem, inasmuch as it is computationally tractable, may be expressed by way of a "formal language" in the Hierarchy—success in this task being just a matter of identifying the critical properties of the problem. Type 3 languages are so simple that they can be described by an automaton with no memory (strings in this type of language are in fact like beads arranged in a linear fashion, with no further internal structuring).

Next up in the hierarchy, we find Type 2 or context-free languages. These need an automaton with enough memory to keep track of what structure is being built, while some embedded substructure is being further constructed. Context-free languages already provide a good measure of complexity for natural languages, since most of their structures fall within the computational capabilities of a "push-down" automaton. This is so called because it contains a simple memory "stack," such that the last item stored into the "stack" is the first one to come out, the top of said "stack" always being involved when recalling items from memory.

Push-down automata may actually describe some long-distance dependencies: those that happen to be "nested" within one another, as in the English example in (8a) (part of the sentence "Peter says that John wants to let Mary read the book"). However, natural language dependencies are known to also be "crossed-serial." One relevant example is the translation of (8a) into a language like Dutch:



(8a)



(8b)

Push-down automata are not equipped to deal with the sorts of dependencies in (8b). This is so because no simple "stack" regime can allow the computation to, at the same time, establish a dependency between two items in the computation and to continue holding an item in between those two in active memory—for subsequent computation. "Stacks" are too simple minded a memory: the entire set of stored items has to be active up to the very last item in storage, and this last item must be the first to be recalled.

A more powerful kind of automaton is needed to generate cross-serial dependencies, either with allowable manipulations within the "stack" (not just at the top) or a different sort of memory procedure. It is this property of natural languages that makes them characterizable as Type 1, or context-sensitive, within the scale of computational complexity defined by the Chomsky Hierarchy (see Table 1 for a summary). Indeed, most theoretical discussion in the last half century has ultimately centered around the issue of precisely how (and when) linguistic structures happen to be of this complex sort.

Table 1: The first three levels of complexity of the Chomsky Hierarchy, with a formal example of the kinds of structures each generates. A context-free grammar may keep track of the number of symbols in every subset so long as it deals with a maximum of two correlated subsets, If the same number of symbols in three (or more) correlated subsets is required within a given "formal language", a context-sensitive grammar is required to describe it [152].

Level of complexity	Language	Sample string
Type 3, finite-state	$a^*b^*c^*$	aabbbbccc
Type 2, context-free	$a^nb^nc^*$	aaabbbcc
Type 1, context-sensitive	$a^nb^nc^n$	aaabbbccc

3.3. *Is the Complexity of Knots Relevant to the Archaeology of Language?*

From our evolutionary perspective, an interesting question arises in light of the formal facts just reviewed. One way to determine whether a given hominid species had the Faculty of Language (as presently exhibited by us) would be to test their computational capabilities—in order to determine how high they were within the Chomsky Hierarchy. Obviously this is not doable in any direct fashion, since the fossil record does not contain direct linguistic evidence of the right sort. Nevertheless, there may well be an indirect manner to proceed that could take advantage of fossilized remains, by seeking traces of language in domains that, while not being directly defined as linguistic, may presuppose a "technical intelligence" that could well be, in some sense at least, parasitic on the Faculty of Language [153]. The prospect is realistic inasmuch as, as emphasized at the outset, this faculty interfaces with other cognitive systems and, through these, with general cognition and the mechanisms underlying behavior [33, 154].

From this perspective the key is to observe relevant aspects of the fossil record with a "grammatical lens," thus asking what sort of algorithm would computationally describe a given rule-governed behavior. If such an algorithm happens to be low within the Chomsky Hierarchy, not much can be surmised from the exercise, since behaviors thus described are common in animal cognition. But if the opposite is the case, and a hypothesized algorithm to describe a given behavior happens to fall high within the Chomsky Hierarchy, the result would potentially be significant. This is so because it is very rare to find bona-fide complex computational behaviors in the natural world. When or if such behaviors are isolated and properly described, three possibilities emerge for them: (i) that they correspond to a mental capacity that is totally unrelated to the Faculty of Language, (ii) that they depend, instead, on some interface with the computational procedure that the Faculty of Language presupposes, or (iii) that the said behaviors obey the conditions of a faculty that actually underlies both the Faculty of Language and whatever is responsible for the inferred behavior.

The idea of connecting artifactual properties with the presence of language (in some sense) is not new. But such exercises are rarely accompanied by rigorous criteria for evaluating the validity of underlying correspondences [155]. The foregoing discussion is aimed at addressing this methodological concern. A proposal originally made by Uriagereka et al. [156, 157], concerning the capacity to tie knots, is a model story of what we are arguing for. It involves a unique behavior within apes, whose computational description falls high within the Chomsky Hierarchy and whose results are inferable from the fossil record.

Particular knotting techniques (say, "clove hitch," "Eskimo bowline," and so on) are cultural practices. What interests us, instead, is the fact that, underlying these technical traditions, a certain natural capacity exists that, so it seems, is not accessible to other primates. One way to assess the complexity of knot tying is to resort to their mathematical characteristics. Knot-theory is the branch of topology that deals with the nature and properties of knots. From this perspective knots are conceptualized as elastic, closed, and tangled strings. The most basic knot (the unknot) is like a circle (i.e., a string joined by its two ends) lying on a single plane. More complex knots are constructed by crossings of the string, such that some parts thereof lie on more than one plane. The minimal knot is a string with three crossings (the so-called threefoil knot). An important area of knot-theory is to determine whether a complexly tangled string is the unknot, and if not what kind of knot it is (the "unkotting problem"). Formal details aside, the task of determining whether any given string is knotted is known to have a complexity comparable to the one needed to process an expression in a natural language (for given knots the computational complexity can be greater than that needed to process linguistic expressions, which moves us into obscure issues dealing with mathematical intuition in humans. Still, for our point to be relevant it is enough to think of simple knottings of the sort routinely used at work in human societies. For an introduction to knot-theory see [158], and [159] for complexity issues).

When actually making a knot, humans must, at a certain point in time, relate a portion in the knot with the background "figure". Intuitively, this is an operation in which both grouping and long distance-like relations are implied [156, 157, 160]. If so (un)tying knots (or determining whether a tangled string is knotted) seems to require an underlying computational system of Type 1 (or even a more powerful system). Once again, such a system is context-sensitive, which is to say capable of keeping track of the computational history until the overlapping(s) needed for knotting take(s) place. The process as a whole can be modeled by storing some (arbitrary) elements A, B, C, in that order, in some computational stack, to then proceed to relate element A at the bottom of the stack to some element D in the current state of the computation (the crossing). This could be represented as in (9a), which is to be compared to (9b):

(9a) $[D_1 \quad [C \quad [B \quad A_1]]]$

(9b) [What$_i$ does everybody know [that the boy says [that he likes e$_i$]].

Abstracting away semantically irrelevant symbols, the formal parallel with a long-distance dependency should be clear.

Again, the correspondence itself could signal the existence of a grammar for knots. However, these sorts of dependencies are exceedingly rare within the primate world. It seems more plausible to ascribe the parallelism in (9) either to the bona-fide Faculty of Language (extended in the appropriate cognitive direction [161]) or to a deeper cognitive system underlying both that faculty and some putative system specific to knots. If either of the latter conditions holds, finding structures of the sort in (9a) in the fossil record would argue for the Faculty of Language being in place by that time.

One last important clarification is in order: being able to learn a specific motor sequence to tie a knot is not sufficient evidence for inferring complex cognitive capacities. The scarce literature on knot-tying abilities in humans has only focused on how people learn to tie a knot either by instruction or by imitation [162, 163]. This may tell us something about how a cultural practice may have been transmitted, but it says nothing about the process of inventing new knots, which humans have been doing for millennia. Similar confusions often arise in the literature on animal behavior, for example when attempting to demonstrate whether birds can parse nested dependencies [164]. As has been noted by many [165, 166], training a bird to successfully identify a couple of such dependencies may tell us nothing about the ability involved in creating any new such expression. Full creativity has always been what is most puzzling about human language.

3.4. Setting the Record Straight.

Knots are not directly attested in Anatomically Modern Humans until 27 ka B.P., by means of weaving, both in clothing and clothing representations [167]. However, they can be inferred long before that, from purposefully perforated ornaments (beads, teeth, shells, etc.) and small projectile technology (arrow heads, arches, and harpoons), the oldest evidence of which is about 90–75 ka ([168–170], and [171] for an even earlier date). Those dates, of course, are tantalizingly close to what is presumed to be in the range of the emergence of the Faculty of Language.

From this perspective, a very intriguing issue is whether Neanderthals (or, for that matter, other hominids) were capable of knotting behaviors. Perforated shells dated at 50 ka and older, found at the Aviones site, Spain, have been presented as an indication that Neanderthals shared some of these practices with Anatomically Modern Humans [13]. The case merits serious examination, but the fact that the perforations in point are not deliberate (that is, they are indisputably due to natural causes) makes one wonder to what extent the relevant ornament was used in a deliberate way as a carefully crafted and prominently worn piece of jewelry, possibly a mark of social status.

Possibilities to interpret the relevant data, even from a biolinguistic point of view, are multiple. However, the most promising seem to be two. The first is that the Faculty of Language is an anatomically modern human evolutionary novelty among primates. By and large, this possibility fits well with the strong contrast between the material culture of anatomically modern humans and Neanderthals

[4, 6, 12, 128, 172–176]. The extremely diversified and dynamic character of the former could be a reflection of the open-endedness productivity of the Faculty of Language, a consequence of its computational properties [177]. Note that a computational system of Type 2 is enough for genuine "recursion" (or systematic and unlimited nested embedding) [33, 178]. This is the formal property that explains why sentences have no upper limit of components and, therefore, that there is no upper number of possible utterances a language allows [179]. However, recursion is still insufficient to deal with the real complexity of human languages. The qualification is in order because it could even be the case that Neanderthals had achieved one level of complexity without reaching the other see [180–183] for perspective. The second hypothesis is that the Faculty of Language is a feature shared by both anatomically modern humans and Neanderthals, already present in their common ancestor (i.e., a sapiens synapomorphy).

The latter position would rationalize Krause et al.'s finding concerning the antiquity of the *FOXP2* genetic variant [8]. It also would explain the abilities underlying the ornaments of Aviones site (see above; [13]) particularly if some independent proof is found of their use as beads tied together by some sort of thread. This hypothesis would be consistent with the possibility that there might exist other Type 1 computational systems in nature—beyond the human Faculty of Language. One case to examine seriously involves species of weaver birds that tie knots as a part of their nest construction techniques. Some of these knots are (near) equivalents of human knots [184, 185] (some apes in captivity have been reported to tie simple knots [186]). The jury is of course out on whether this means that the birds in point have the cognitive equivalent of a Faculty of Language, albeit with nest-building consequences instead of anything familiar to humans. Key to answering that question would be to determine the level of complexity the birds can attain in their knot-tying abilities. Patently, some of their relevant knots are more complex than others, and the question is whether any or all of them can be produced by the compilation of a motor skill (for example, the knots used in Michel and Harkins' experiment [162] are simple (the sheepshank, the butterfly knot, and the "magic" slip-knot), and yet only 37% of their subjects were able to learn to tie the three of them by just attending demonstrations, i.e., observing the necessary motor sequence to tie them).

Clarifying either position should also help us understand the late cultural achievements of Neanderthals: whether they constitute an acculturation effect from contacts with anatomically modern humans [12, 187], an independent cultural development [11, 130], an intraspecific "last minute" evolutionary event, or even the result of interbreeding [49]. It is good to have new tools to address such open questions.

4. Conclusions

In presenting the biolinguistic approach to the study of language, this paper has developed some ideas on how that approach may contribute to the study of human history. For the brand of linguistics we represent, the communicative or even symbolic aspects of language are not as central as its formal properties. Only by focusing on these properties are we able to draw a clear picture of the computational resources necessary to generate a human language. The natural cognitive computational system capable of deploying these resources—the Faculty of Language, an organ of our minds/brains—is thus our main subject of inquiry. Given this basic assumption, we have explored how research on Evolutionary Anthropology can be complemented: by qualifying or reassessing the interpretation of the existing data. It is our hope that future research will benefit from the perspective offered here, by strengthening the interdisciplinary stance that the inquiry into the origins of our species necessarily requires. When we need to date remains, we turn to Physics and Chemistry; when studying hominid remains, we ask palaeobiologists and geneticists—and experts on nutrition are consulted when palaeodiets are the focus. Similarly, when aiming at progress in the study of language and its origins, linguistics should prove to be useful. We hope it has been.

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