Prehistoric languages and human self-domestication

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Abstract:

The comparative method in linguistics has enabled to trace phylogenetic relationship among distant languages and reconstruct extinct languages from the past. Nonetheless, it has limitations and shortcomings, which results, in part, from some of its methodological assumptions (particularly, its heavy reliance on the lexicon), but mostly, from the real nature of language change, as languages do not only change by divergence from a common ancestor, but also as a result of contact with non-related languages. At the same time, ongoing research suggests that language change depends not only of the internal dynamics of linguistic systems, but also of factors external to languages, particularly, aspects of human cognition and features of our physical and cultural environments. In this paper, it is argued that the limitations of historical linguistics can be partially alleviated by the consideration of the links between aspects of language structure and aspects of the biological underpinnings of human language, human cognition, and human behaviour. Specifically, it will be claimed that research on human self-domestication (that is, the existence in humans of features of domesticated mammals compared to wild extant primates), which seemingly entailed physical, cognitive, and behavioural changes in our species, can help illuminate facets of the languages spoken in remote Prehistory, the vast time period during which human beings have lived for longer. Overall, we can expect that the languages spoken in that epoch exhibit most of the features of the so-called esoteric languages, which are used by present-day, close-knit, small human communities that share a great amount of knowledge about their environment.

1. Introduction

As it is pretty obvious, we lack any physical record of the languages spoken in Prehistory. For centuries or millennia, we have had folktales and mythological accounts of the origins of peoples and their languages, and more recently, just-so stories about language origins and prehistoric languages, which can be more or less plausible, but that have usually lacked any solid empirical basis. In the XIX century comparative linguistics emerged as a robust tool for probing phylogenetic relationships among languages and for reconstructing the protolanguages from which they derive. At some point, it seemed sounded that all languages are related at some deep level and that all of them derive from one and the same mother tongue. Otto Jespersen, for instance, was convinced of this possibility; in particular, he believed that ancient languages had been more complicated than present-day languages (Jespersen, 1922). Nonetheless, in spite of its success in some domains, particularly, in the Indo-European context, historical linguistics has problems for tracing phylogenetic relationships (particularly, deep phylogenetic links among phyla), and more generally, for providing detailed accounts of the grammars and the lexicons of languages spoken in our remote past. In this paper, we discuss the possibility that these problems can be overcome if the effect of the environment of language structure is considered, particularly, the way in which modern cognition and behaviour evolved in our lineage. The paper is structured as follows. First we review the problems for tracing phylogenetic relationships and reconstructing prehistoric languages. Afterwards, we discuss current research on extralinguistic causes of language diversity, which might may help circumvent some of these caveats. Finally, we focus on human self-domestication (that is, the existence in humans of traits otherwise found in domesticated mammals) and discuss how it can help fix some of these problems and gain a more accurate picture of how languages were in the deep prehistory and how they changed gradually to acquire the features we find in most present-day languages. We will end with some conclusions and questions for future research.

2. The comparative linguistics approach: successes and limitations

The comparative method is a robust tool for refining our view of how languages were in the past and for reconstructing extinct languages (see Meillet, 1967; Anttila, 1989; Fox, 1995; Campbell, 2013 among many others). Nonetheless, it has limitations and shortcomings that seemingly preclude going back too distantly in time. To begin with, there is an intense discussion around the purported directionality and steadiness of language change. Biological change is both directional and constant. Biological order is imposed by the functional efficiency of the changes (adaptedness), whereas changes occur randomly as a consequence of environmental factors. These circumstances allow to draw exact trees of life and to infer precise rates and timescales of evolution based on molecular clocks (Luo and Ho, 2018). By contrast, although it has been claimed that language change (particularly, phonetic change and grammaticalization) is directional (see Ferguson, 2000; Haspelmath, 2004), it has been equally argued that it is not (Lightfoot, 1999; Janda, 2001; Lightfoot, 2002). Likewise, different families of languages, languages, or even parts of the grammar of a language change at different rates (Dixon, 1997; Nichols, 1997; 2008). Computer simulations of language change in the laboratory reinforce the view that the rate of linguistic change can be variable, being faster in small communities and for linguistically marked structures (Nettle, 1999). All this seemingly hinders to establish precise phylogenetic relationships among languages, reconstruct protolanguages, and assign confident dates to the observed or postulated changes, to the split event between languages, and to the time window when a particular protolanguage was spoken.

This problem worsens by the fact that historical linguistics has mostly relied on cognate words for its comparisons and reconstructions. But words are frequently borrowed from other languages and this undoubtedly contributes to blur phylogenetic relationships. It has been argued that the notion of genetic marker can be extended to structural features (Nichols, 1992), and that these grammatical markers might provide more stable and distant phylogenetic signals (Nichols, 1994). This is seemingly due to their tighter integration compared to words or phonological features, their greater resistance to change, and their reduced borrowability (Thomason and Kaufman, 1988; Nichols, 1992). In fact, some parts of the grammar might be more stable than others, in particular, morpho-syntactic features (specially, if they are inter-correlated) compared to pragmatic features (Wichmann and Holman, 2009). As a consequence, it has been claimed that syntactic properties (and specifically, abstract syntactic parameters) are reliable indicators of distant phylogenetic relations and allow to travel back in time up to 20 thousand years ago (kya) (Longobardi and Guardiano, 2009; 2017). Ultimately, typological stability has been argued to be a robust indicative of deep phylogenetic relationships (Dediu and Cysouw, 2013). That said, it is important to acknowledge that in some areas outside the Indo-European domain, grammatical features seem to change faster and have higher amounts of conflicting signal than basic vocabulary (Greenhill et al. 2017). As reviewed by Greenhill and colleagues (2017), grammatical features are not free of important shortcomings that reduce as well their utility in historical linguistics, particularly, their borrowability and (readily) diffusion, and their limited diversity because of how languages are designed, which increases the risk of chance similarity by convergence or parallel evolution. Moreover, as noted by Nichols (1994), the prolonged stability in time of grammatical traits can be due not only to genealogical connections, but also to stable and prolonged language contact and ultimately, to areal inheritance.

In truth, it is certainly language contact and borrowing which make linguistic reconstructions so complicate, particularly, regarding languages spoken in very distant times. In places where deep contact between languages and extensive borrowing have taken place, like Australia, phylogenetic relationships are blurred and it is very difficult to tease apart shared aspects due to a common genetic origin, from resemblances of an areal origin. According to Dixon (1997), we should expect this scenario to be the most frequent condition in our history, with linguistic change taking place mostly through borrowing and spreading and resulting in languages that share a grammar prototype, but that exhibit different lexicons because of sociological and historical reasons. As a

consequence, we should expect as well that language change and diversification resulting from divergence from a common (proto)language is exceptional in historical terms, being linked to particular dramatic events (natural disasters, the rise of dominant human groups, the colonization of new territories and continents, and the like) that Dixon calls *punctuations*. If this model is correct, historical linguistics might be just able to reconstruct linguistic phylogenies resulting from the last punctuation. Therefore, even in the optimum case, we should expect that descent and reconstruction are not traceable beyond 20 kya (see Nichols 1990; 1997 or Gray, 2005 for shorter dates, around 10 kya), making difficult (or impossible) to draw precise (and complete) trees of all the world languages, and particularly, to reconstruct in detail prehistoric languages from more distant epochs.

It is clear that we need to improve our methodology and to consider other kind of evidence if we want to refine deep language phylogenies and to know more about the nature of the languages spoken in our remote past. A well-known attempt has been using genetic data to support less clear or even controversial phylogenetic groupings. This approach was first adopted by Luigi Cavalli-Sforza (e.g. Cavalli-Sforza et al., 1988). Using polymorphic sites in selected human genes, as well as archaeological and linguistic data, Cavalli-Sforza concluded that main human subgroups defined according to genetic criteria match language phyla and (some) macro-phyla defined according to linguistic criteria. Certainly, human diversification and language diversification can overlap if population movements are involved (Barbujani and Pilastro, 1993; Rosser et al., 2000; Bert et al., 2001). However, once people becomes sedentary and migration only occurs at a small scale, geography emerges as the main factor accounting for human diversity; as a consequence, genetic diversity correlates less with linguistic diversity (e.g. Monsalve et al., 1999; Evsiukov et al., 2000; Zerjal et al. 2001). Hence, speakers of Armenian and Azerbaijani are genetically closer to the speakers of Caucasian languages, which belong to a different phylum, than to speakers of other Indo-European or Altaic languages, respectively (Nasidze and Stoneking, 2001). The same happens with speakers of Georgian and Kurdish, who exhibit a genetic profile similar to Europeans, although Georgian is not an Indo-European language (Comas et al. 2000). In some cases, this reduced correlation between genetic and linguistic diversity is explained because linguistic diversification has taken place in a genetic homogeneous population (Belledi et al. 2000). For instance, no genetic barrier exists between Northern and Southern Chinese populations, in spite of their different linguistic affiliations (Ding et al., 2000). Likewise, Inuit speakers of Eskimo-Aleut languages and of Na-Dene languages exhibit reduced genetic differences, which are mostly related to geographical distance (Saillard et al. 2000). Eventually, in some cases it is genetic drift, but not language barriers (or even geographic distance), what accounts for most of the observed genetic differences between close populations, as observed in the Caucasus (Nasidze et al. 2001). Still, in spite of the linguistic barriers, sporadic migration occurs and keeps isolated communities linked genetically (Cox et al., 2016). This suggests that the barrier effect of languages is limited. Finally, it may also happen that linguistic homogeneity is achieved in spite of significant underlying genetic diversity, if a language is culturally imposed by a dominant group to an otherwise diverse population, like Turkish in Anatolia (Di Benedetto et al. 2001). Importantly, there is no evidence of serial founder effects as far as languages are concerned, contrary to what is observed with genetic diversity (Hunley et al. 2012). In summary, the mapping of genes to languages is expected to be not totally exact, not just because, as it is pretty obvious, the languages we speak are not in our genes, but mostly because language features and the relationships among languages are affected not only by genealogy, but equally by geography, as a reflect of how isolation, contact, and drift fuel and modulate language change.

Again, syntactic data has been claimed to be able to overcome this problem and to improve the accuracy of these methods. According to Longobardi and colleagues (2015), the consideration of a universal inventory of grammatical polymorphisms (i.e. syntactic parameters in the Chomskyan tradition) reveals significant correlations between genomic and linguistic diversity in Europe, for both Indo-European and non-Indo-European speaking populations, suggesting that, at least in Europe, language features prove to be a better predictor of genomic differences than geography. A recent study by the same authors (Cordoni et al., 2018), which includes more language groups

(Indo-European, Altaic, Uralic, Sino-Tibetan, Dravidian, Afro-Asiatic, and the language isolate Basque) reinforces the view that syntactic parameters provides more accurate and reliable linguistic phylogenies (compared to phonetic data and cognates) and particularly, that language history is much more vertical and independent of geography than genetic history, and that it correlates with geography only as a byproduct of its correlation with genetics. Still, the matching between genes and languages is not perfect. In Europe, the gene-language mismatch of Hungarians (discussed in detail in Longobardi et al. 2015; 2016) reflects the fact that although languages can (and sometimes do) act as a barrier to gene flow, and although language contact can (and sometimes does) entail genetic admixture, in humans (contrary to bacteria) the DNA is inherited vertically only (that is, from parents to the offspring), whereas languages can be inherited also horizontally (that is, from neighbours by language shift). Accordingly, the correlation between languages and genes is greater when demic diffusion and demic replacement are involved (like in Eurasia). It would be interesting to see whether this approach based on syntactic features also works in areas where extensive language contact and borrowing have taken place, like Australia (see Bower and Atkinson, 2012 for previous attempts).

Finally, consider that the time depth achieved by these new methods is still not disproportionate, going back in time not beyond 20 kya. This figure is impressive, of course. But it means that nearly 90% of our linguistic history is still in the dark. The question is how to improve these and other related methods to clarify language relations in earlier periods (let's say, 30 or 40 kya in Europe, or 100 kya in Africa). Or if disentangling deep phylogenetic relationships proves to be eventually impossible, whether we can say anything reliable about the grammatical features of prehistoric languages spoken in our deep past.

3. Moving beyond: environmental effects on language features

One possible answer to the questions raised above is that, in fact, there is no problem at all. Agreed: we might be eventually unable to reconstruct in detail prehistoric languages from distant periods because of all the caveats and shortcomings reviewed (including the mismatch between genetic and linguistic trees, caused by the very nature of language change, and ultimately of human behaviour). Nonetheless, we can expect that their grammars do not differ in any significant way from the grammars of present-day languages. What is more: we should expect the same typological diversity than nowadays. This would be in line with the uniformitarian view of languages, which has been the twentieth century consensus, according to which all languages are roughly equal in terms of overall complexity, as a result of trade-offs between subparts of their grammars, and with differences resulting mostly from internally-driven processes (Dixon 1997; Fromkin et al. 2011: 375-374). This uniformitarian view of human languages is rooted in a uniformitarian view of the cognitive faculty that enables to learn and use them (the so-called *language-ready brain*), which is assumed to be the same in all human beings (pathologies aside) and to have remained unmodified since our inception as species (Moro, 2008; Bolhuis et al. 2014 among many others). This cognitive continuity would entail a similar continuity of the cognitive mechanisms involved in language change, this in turn implying that prehistoric languages would have been and would have changed similarly to historical and present-day languages. Putting it differently, there would be no significant reasons to believe that first modern humans spoke protolanguages that lacked key design features of present-day languages. A piece of evidence would be that we have not found languages lacking them among present-day human groups, even among the most isolated or with less sophisticated cultures, including hunter-gatherers which seemingly resemble prehistoric human groups. Although it seems that certain typological features are more frequent in the languages spoken by hunter-gatherers (see Cysow and Comrie, 2013 for discussion), these are just correlations, so no qualitative differences have been found with the languages spoken by agriculturalists or other groups.

In summary, the mainstream view of language evolution and language change in Prehistory has resulted in a very specific narrative, according to which, we can (and should) separate the

evolution of language from the evolution of languages. Language is construed as a human-specific cognitive faculty that resulted from biological changes mostly. As a consequence, we can (and should) trace its history essentially by searching for homologs of language in other extant species and by examining the fossil and the archaeological registers, looking for proxies of language that enable to infer it in extinct hominin species. In turn, languages are thought as by-products of that faculty, which accounts for most of their distinctive features, with the effect of external factors, like the physical environment or cultural practices, circumscribed to quite peripheral components, particularly, the lexicon. According to this view, once our language-ready brain emerged, modern languages emerged too. A different story is, of course, the precise phylogenetic relationships between languages, which, as discussed before, are ultimately shaped by historical events. Putting this roughly, the consensus has been that history (or more generally, factors external to language) can explain where Indo-European languages are spoken nowadays and why Indo-European languages are interrelated, but not why Indo-European languages are fusional languages and not isolating languages... beyond the plain reason that they derive from a fusional language.

Increasing evidence suggests, however, that language complexity might differ cross-linguistically (or even be an emergent property of linguistic systems), and that language features (even grammatical features) are sensitive to external factors. Likewise, human cognition seems to be not as uniform as commonly assumed and it might have changed during our recent history. In the last part of this section, we will discuss these three possibilities in more detail.

On the linguistic side, grammaticalization has been hypothesised to increase the complexity of languages over time, in terms of the number and kinds of irregularities, but also of the number and types of categories (Givón, 1975). Specifically, as discussed by Heine and Kuteva (2007), grammaticalization theory could help push linguistic reconstruction quite back to the past and formulate testable hypotheses about prehistoric languages. Although this possibility is sounded, this proposal is somehow unplugged from other accounts of the human history, like paleoanthropological or archaeological narratives. Accordingly, it is difficult to assign any of the developmental stages in a model like Heine and Kuteva's to some specific period of our history or to some other hominin species. Moreover, grammaticalization theory assumes that human cognition and behaviour have remained essentially unchanged from our inception, and this could be not the case, as we will discuss below (see Benítez-Burraco, 2017 for a more detailed discussion). Interestingly, studies addressing how grammaticalization takes place in sign languages suggest that some key design features of human language, like duality of pattern, or basic aspects of complex syntax, like embedding, can develop with time in response to environmental triggers (like the kind and amount of input, the size of the community, the degree of interaction among speakers, and the like) and ultimately, result from social transmission and cultural evolution (Aronoff et al., 2005; Sandler et al., 2005; see Benítez-Burraco, 2016 for review). In truth, this could be said as well of some oral languages. The celebrated Pirahã language, with its unique lacking of recursive embedding of sentences or noun phrases (Futrell et al., 2016), as well as its absence or its limited presence of many features commonly found in human languages (like numbers and terms for quantification, color terms, and relative tenses, or its very simple pronoun and kinship terms inventories) (Everett, 2005), seemingly parallels what we find in sign languages. Therefore, its striking features could be viewed as resulting from an extreme effect of cultural constraints on language structure. Notice, however, that a less complex grammar imposed by cultural constraints does not necessarily entail that cognition is so markedly constrained by culture, *contra* Everett (see also some of the replies to Everett's 2005 paper). It is important to elaborate this latter aspect (that is, the extent of the effect of the environment on language structure) in some more detail, because it might provide a robust way of attaching the history of languages to other accounts of the human history and ultimately, of achieving a more detailed view of the nature of prehistoric languages.

Recent research using extensive language databases has shown that some aspects of languages (particularly, their phonological features) seem to be influenced (and perhaps, explained) by the physical environment in which they are spoken. A familiar example is the effect of vegetation on

sound inventories (Maddieson and Coupé, 2015), which parallels what we can find in many vertebrates (Boncoraglio and Saino, 2006; although see Ey and Fischer, 2012 for the possibility that acoustic adaptation is not as widespread as expected across taxa). Another familiar example is the negative correlation between dry climates and tone usage (Everett et al. 2015). The global distribution of tonal languages, which are concentrated in tropical and subtropical regions, is seemingly explained by the perturbations of phonation caused by desiccated ambient air (Roberts, 2018). Interestingly, this effect is confirmed by historical linguistics: Eastern and Central-Western Bantu languages, that moved to drier climates, are known to have generally fewer tonal contrasts than other Bantu languages, but the tone systems of the languages within these sub-groups that re-entered wet areas has become more complex (see Roberts, 2018 for discussion). The effect of climate on language change and language diversity can be thus a direct one. However, more frequently, it is an indirect one, via its influence on aspects of human ecology (food supply, spread of diseases), but also of human sociology (demography, patterns of migration and contact, topology of social networks) (see Roberts 2018 for a detailed discussion).

In truth, the strongest and most interesting effects of the environment on the structure of languages are caused by social factors. We are familiar with the triggering effect of social factors on linguistic diversity within a language. Accordingly, structural and functional differences can be found between variants of the same language as they are spoken by different social groups, by children vs adults, by men vs women, or by diverse ethnic groups. Likewise, we know that the context in which conversational exchanges take place (who speak, whom he/she speaks to, what they speak about, what they speak for, and the like) also influences the structure and the pattern of usage of a language. Nonetheless, the effect of these factors on language features of interest from a typological perspective is more controversial. Most linguists agree that the lexicons of the world languages differ as a reflect of their role as a reservoir of relevant cultural features of the societies speaking each language. Nonetheless, the way and the degree in which world languages grammaticalize aspects of the environment (like the contrast between human beings, animate beings, and inanimate entities underlying many of the noun classes in Bantu languages) is more controversial. Certainly, linguistic variation at this level seems to be constrained as well, to the extent that it can be characterised as a mixture of common principles, or universal features, and dimensions of variation, like syntactic parameters. However, the causes of this variation are not clear. In fact, as noted earlier, the consensus has been that this variation mostly results from random drift or internally-motivated changes in language structure, and that it is substantially insensitive to the environment.

Recent typological surveys suggest, however, that also grammatical features can be influenced by social factors, like the number of speakers, the degree of bilingualism, the tightness or the looseness of the social networks, or the proportion of adult learners of the language. A familiar example is the negative correlation found between the index of agglutination and population size (Lupyan and Dale, 2010). Ultimately, these effects of the social environment on language structure are seemingly due to their impact on language acquisition. When one considers all the social factors with an impact on language structure together with the language features subject to variation, an interesting pattern emerges. On the one side, the languages spoken by isolated human groups living in small, close-knit communities with high proportions of native speakers (the so-called *esoteric languages*) usually exhibit larger sound inventories and complex phonotactics, opaque morphologies (with more irregularities and morpho-phonological constraints), limited semantic transparency (with abundance of idioms and idiosyncratic speech), reduced compositional structure, and less sophisticated syntactic devices (with limited embedding). On the contrary, large and complex social networks, involving greater rates of inter-group contacts and cultural exchanges, seemingly favour languages with expanded vocabularies and increased syntactic complexity (including greater reliance on recursion). These *exoteric languages* also exhibit greater compositionality and enhanced semantic transparency, as well as simpler sound combinations and more regular morphologies. Overall, the difference between esoteric and exoteric languages seemingly results from their differential context-dependency. Hence, esoteric communication takes place between people sharing considerable amounts of knowledge, whereas

in exoteric communication language use is usually decontextualized (see Benítez-Burraco and Kempe, 2018 and references herein for details). Ultimately, environmental factors of the sort highlighted here (from aspects of the physical environment to population size) affect the shape of language family trees, reinforcing the view that language diversification is also driven by adaptive pressures beyond the effect of neutral drift (Bentz et al., 2018)

The take-home message is that although the languages we speak are undoubtedly a product of our brains, their properties depend not only on how the brain works, but also on our way of life in a broad sense. Fortunately, ongoing research on paleogeography, paleoclimatology, paleoecology, paleoanthropology, and paleogenetics is refining our view of the physical and the social environments in which our ancestors lived at times that are far beyond the limits of the best (or the feasible) linguistic reconstructions. For example, the examination of fossil ice, tree-ring records of living and fossil trees, sedimentary contents, fossil pollen, and animal remains can provide accurate descriptions of the climate, the flora, and the fauna of the places inhabited by prehistoric peoples (see Bartlein and Hostetler, 2003; Eglinton and Eglinton, 2008; Sheldon and Tabor, 2009; Elias, 2010. Esper et al., 2018; see Elias, 2018 and Thomson, 2019 for review). Regarding the socio-cultural environment of Paleolithic humans, our knowledge has equally improved in the last years. Traditionally, we have been limited by what can be inferred from the archaeological record. Nonetheless, recent research based on ancient DNA have greatly refined our view of how human groups lived and socialized. For instance, in a recent paper, Sikora and colleagues (2017) have probed that humans from Sunghir, in Russia, who lived around 34 kya were organized in small groups with limited within-band kinship and inbreeding, and embedded in wide social, mating networks, similarly to present-day hunter-gatherers. Accordingly, we could expect that the languages they spoke exhibited most of the features of the so-called esoteric languages. At the same time, improving our knowledge of social dynamics in this period, and particularly, of kinship systems, should help refine our understanding of the interrelations between gene and language phylogenies in that epoch. Still, this social organization found in Sunghir contrasts, to some extent, with what can be inferred for Magdalenian peoples, who lived around 15 kya. Although they were also organized in small bands, these bands were part of quite elaborated social systems and where engaged in extensive long-distance contacts (Schwendler, 2012). Accordingly, it could be hypothesised that their languages might have exhibited some exoteric features. An interesting, but still unexplored question is how these changes in human socialization patterns contributed to push languages towards the exoteric pole of the esoteric-exoteric continuum, and whether this transition, which seemingly resulted in the emergence of languages optimized for conveying information and know-hows to non-akin and strangers, is related (or directly contributed) to the important changes in human behaviour and culture (including the technological forward leaps) occurred during the Upper Paleolithic, particularly in Europe (see below for further discussion).

Finally, it seems necessary to put into question as well the core assumption of the uniformitarian view of languages and of language change, namely, the uniformity of the faculty of language across populations and across time. To begin with, brain size can vary almost twofold among present-day humans, and these differences have proven to have an impact on brain organization and function (Reardon et al., 2018). Additionally, psycholinguistic measures are varied across the neurotypical population (Fenson et al. 2000). Likewise, the limits of the brain areas involved in language processing are rather changeable from one subject to another and thorough growth, to the extent that similar cognitive profiles can rely on different brain architectures (see Fedorenko and Kanwisher, 2009 and Karmiloff, 2010 for discussion). It might be hypothesised that there can be different ways of implementing a functional faculty of language at the term of growth (Hancock and Bever 2013).

From an evolutionary perspective, it is true that our split from Neanderthals seemingly brought about important changes in our cognitive abilities resulting from attested changes in our skull/brain, which is more globular in our species. In several related papers (Boeckx and Benítez-Burraco, 2014a; 2014b; Benítez-Burraco and Boeckx, 2015), we have argued that this

globularization of the human brain resulted in a rewiring that improved the connections between sub-cortical and cortical structures, habilitating the neuronal workspace needed for being able to transcend the signature limits of core knowledge systems and ultimately, to combine and unify conceptual units that belong to distinct core systems. We further argued that this ability can be conflated to the core combinatorial operation in natural language, which is called *merge* by linguists of Chomskyan persuasion, and which is at the core of our language-ready brain. In our research we made use of the available information about ancient genomes to also identify some of the genetic changes that may account for the observed differences between hominin species regarding globularization and cognitive abilities. The candidate genes include *RUNX2* (a master transcription factor during vertebrate development) and several of its effectors; components of two gene networks implicated in vocal learning, clustered around the famous “language gene” *FOXP2*, and the *ROBO* and *SLIT*s effectors; and finally, a set of genes clustered around *AUTS2*, a robust candidate for autism (what, incidentally, reinforces the intriguing parallelisms between the autistic mind and the Neanderthal mind [see Benítez-Burraco and Murphy, 2016 for discussion]).

That said, it would be inaccurate to claim that this brain configuration has remained the same from our inception as species. Recent research by Neubauer and colleagues (2018) suggests instead that our characteristic globularity evolved gradually, reaching present-day human variation between about 100 and 35 kya. Intriguingly, this process parallels the emergence of behavioural modernity (or at least, of marked technological and cultural changes in some parts of the world, particularly, in Europe), as attested by the archaeological record (see McBrearty and Brooks, 2000; Klein, 2008, among many others). This is also in line with genetic evidence that suggests that changes in genes important for brain development have occurred within our lineage well after our split from Neanderthals and Denisovans (Zhou et al., 2017). Among these genes, several are involved in brain function, like *SPONI* (important for brain connectivity), or are mutated in clinical conditions impacting on our mode of cognition, including language abilities, like *SORLI* or *MAPT* (see Benítez-Burraco, 2017 for discussion). Additionally, it is worth highlighting that the interbreeding between modern humans and extinct hominins (particularly, Neanderthals and Denisovans), which took place quite late in our history, might have contributed as well to the reshape of our skull/brain, to the extent that Neanderthal-derived genetic variation has been claimed to be neurologically functional in selected areas of the brains of contemporary populations (Gregory et al., 2017). Also, the examination of the genomes from peoples living as late as 6 kya suggests that biological pathways important for cognitive function (specifically, long-term potentiation and dopaminergic synapse) have changed very recently, at least in Europe (Chekalin et al., 2018). Finally, it is worth highlighting as well that likewise some language features can be an adaptation to our ecological, social, and cultural environment, as discussed above, language features can have in turn some sort of feed-back effect on our cognitive architecture. Pretty obviously, planning to talk bias our perception and the way in which we process data, because we need to accommodate the structural features of the language we are using. Still, this effect can be more profound, if the habitual encoding and use of such specific language features results in non-linguistic representational and even behavioural effects. Ultimately, aspects of languages that are more costly to process and learn might favour the creation of “cognitive gadgets” through modifications in learning and data-acquisition mechanisms (Heyes, 2018). This could be, specifically, the case of languages endowed with larger vocabularies and increased syntactic complexity, which are typically associated to exoteric communication: although their higher cognitive cost might be partially alleviated by their simpler sound combinations, more regular morphologies, greater compositionality, and enhanced semantic transparency, they could still demand some cognitive adaptation, because of the enhanced requirement of working memory capacity, executive control, and declarative knowledge needed to learn and master them (see Benítez-Burraco and Kempe, 2018 for detailed discussion).

If we summarize what we have discussed in this section, it seems that although our cognitive architecture does surely account for many aspects of the languages we speak, it is equally true

that some language features depend on environmental and cultural factors, and affect, more or less permanently, our cognitive architecture. These two aspects cannot be detached one from the other. Putting this differently, it is not just that language and cognition are intimately interwoven: it happens that biology and culture are intimately interconnected. And we need to consider both on a par if we want to understand how language evolved and how languages were in the past. One possibility is that the biological changes that brought about our species also favoured the creation of the niche that enabled the emergence of aspects of language complexity via cultural evolution. Such a view would be in line with eco-evo-devo theories in biology, according to which organisms evolve as a result of the interactions between their genes, their developmental paths, and the environments in which they live. In the last section of the paper we will argue that human self-domestication (remember, the presence in our species of features typically associated to domesticated strains of mammals) fulfils these requirements and can account for the two processes, namely, the emergence of a modern language-ready brain, mostly via a biological mechanism, and the emergence of modern languages, endowed with all the features that are familiar to linguists, mostly via a cultural mechanism.

4. Human self-domestication and (the evolution of) prehistoric languages

In mammals, domestication is usually triggered by selection for tameness and results in a constellation of distinctive traits that are physical, cognitive, and behavioural by nature (the so-called *domestication syndrome*), including reduced brain size, shorter muzzles, reduced tooth size, and more frequent oestrus cycles (observed in all species), as well as floppy ears, supernumerary toes, disproportionate dwarfism, depigmentation, increased skin area and/or skin folds, hairlessness, curly hair, and neotenus behaviour (occurring in some species or varieties) (see Wilkins et al., 2014; Sánchez-Villagra et al., 2016 for review). This common set of features might be explained by the fact that selection for tameness reduces the input to the neural crest, an embryonic structure that gives rise to many different body parts during development (Wilkins et al., 2014). Pretty obviously, as far as humans are concerned, there was no external factor triggering the domestication process. Probably, human self-domestication resulted from sexual selection, when our ancestors started to choose non-threatening and less emotionally reactive partners for mating, as a consequence of living in community, co-parenting, or other social factors (see Hare et al., 2012 for discussion). Signs of domestication are remarkable in our species, particularly, in recent specimens. On the biological side, there is paleoanthropological evidence of changes in the human skull/brain shape after our split from Neanderthals, as discussed in the previous section, and particularly, of a generalised brain shrinking during the last 30 ky (Liu et al., 2018), similarly to what is observed in domesticated mammals. On the cultural side, as also discussed in the previous section, there is ample archaeological evidence suggesting that modern behaviour did not appear on a par with our species, but developed gradually too. As we will hypothesise below, these physical and behavioural changes could be an adaptation to new socialization patterns, entailing denser social networks and increased knowledge exchange with strangers.

Interestingly, in animals, domestication modifies cognition. For instance, domestic pigeons and guinea pigs exhibit enhanced spatial learning abilities compared to their wild conspecifics (Rehkämper et al., 2008; Lewejohann et al., 2010). In dogs, domestication resulted in an enhanced ability to detect social cues and to solve problems relying on such cues (Hernádi et al., 2012; Udell, 2015). Interestingly too, in some birds, domestication gives rise to more complex communicative signals (Okanoya et al., 2017), in part through the alteration of the innate constraints for song learning from adult tutors (Kagawa et al., 2014), seemingly because domestication entails a relaxation of selection (Kagawa et al., 2012). Not surprisingly then, self-domestication has been repeatedly claimed to be extremely valuable in capturing key aspects of our behavioural modernity, and specifically, the aspects of language that are thought to emerge through a cultural mechanism (see Thomas and Kirby, 2018 for discussion). However, a detailed account of how self-domestication might have contributed to the evolution of language (and of languages) is still pending. Specifically, it is not clear how it could have contributed to the biological, behavioural, and cultural changes involved.

In a recent paper (Benítez-Burraco and Kempe, 2018) we have implemented a model that aims to account for the effect of human self-domestication on the emergence of modern languages and that could help illuminate aspects of how languages might have been in our remote past (Figure 1). In brief, we can confidently expect that our ability to learn and use languages (that is, our *language-readiness*) resulted in part from some genetic or epigenetic changes occurred after our split from Neanderthals. Interestingly, genes important for language-readiness are found among (and interact with) genes that have been positively selected in domesticated mammals (Benítez-Burraco et al., 2016a). This means that even though human self-domestication seemingly resulted from selection against aggression, it might be in part a by-product of the changes that brought about our language-readiness, because of these functional links between candidates for language-readiness and candidates for domestication. As noted above, we can expect that self-domestication also affected the development and the evolution of our typical brain hardware, specifically, our distinctive pattern of brain connectivity and our cognitive abilities resulting in our language-readiness. This effect might have increased in the last thousands of years. Next, self-domestication seemingly favoured the cultural transmission process that fuelled the sophistication of linguistic structures. We believe that this was possible because of two important physiological and behavioural consequences of domestication: a less aggressive behaviour and an extended juvenile period. This effect might have increased in the last thousands of years. Next, self-domestication seemingly favoured the cultural transmission process that fuelled the sophistication of linguistic structures. We believe that this was possible because of two important physiological and behavioural consequences of domestication: a less aggressive behaviour and an extended juvenile period.

Figure 1. A schematic outline of the genetic, physiological, and behavioural changes that might account for the evolutionary origins of our language-readiness and the emergence of complex, modern-like languages. Adapted from Langley et al. (submitted). The skulls from Neanderthals (left) and AMHs (right) are from Boeckx and Benítez-Burraco (2014). The silhouettes of the Neanderthal man (left) and of modern human men (middle and right) are from PhyloPic (<http://www.phylopic.org/>)

Reduced aggression was surely crucial for establishing larger and more complex social networks, involving greater rates of inter-group contacts and cultural exchanges (although other factors seemingly contributed to this, like population growth or climatic changes). As noted in the previous section, these networks seemingly favour expanded vocabularies and increased syntactic complexity, and ultimately, the emergence of exoteric languages. Although as also noted, the greater cognitive cost to language processing and learning incurred by exoteric languages might

partially be alleviated by their greater simplicity and regularity in other domains (like phonology and morphology), the path towards exoteric languages would have been not possible without the positive effect of self-domestication on two other important aspects of our socialization: language learning by children and language teaching by caregivers, and language play. Both aspects become seemingly improved by the reduced aggressiveness and the extended juvenile period brought about by domestication.

Enhanced language learning by children and improved language teaching by caregivers seemingly facilitated children's mastery of increasingly complex linguistic systems via the enhancement of the linguistic input and the scaffolding of language acquisition for their immature cognitive abilities. Regarding enhanced play behaviour, we believe that it equally helped improve aspects of language acquisition of these more complex languages. Play is linked to language through common ontogenetic roots, as already showed by Piaget (1962), and supports language acquisition in many different ways: it increases language exposure; it allows to exercise many of the learning mechanisms involved in language acquisition; it enables to explore new constructions and new uses of known constructions; and it favours language practice (Bruner, 1983; Levy, 1984; Bebout and Belke, 2017; Quinn et al., 2018). Rhymes and verbal games are outstanding examples. In fact, they are related to another interesting possible outcome of enhanced playing behaviour: the aesthetic aspects of language. Play catalyses innovation through artistic and aesthetic proclivities. Accordingly, it can be expected to contribute to the linguistic innovations that resulted in more complex languages. Moreover, there is cross-linguistic evidence showing that some aspects of language structure might be aesthetically motivated, like the so-called "decorative morphology" (see Haiman, 2010 for discussion). What is more, we cannot rule out the possibility that some aspects of languages, like the similar sounding of inflectional endings spread across many parts of the sentence, like in Russian, do not merely result from our pervasive proclivity for structure and order, like in rhymes, alliterations, sound plays, formal symmetry and the like (contra Haiman, 2010), but that also help language acquisition as a result of overspecification (see Langley et al., submitted for discussion). Importantly, archaeological remains of play behaviour exhibit a higher prevalence in modern humans compared to extinct hominins, and are more abundant in the Upper Paleolithic (see Gamble, 1999, but also Langley et al., submitted). Interestingly too, comparative evidence from domestic animals shows that domestication results in enhanced playing behaviour, to the extent that most domesticated animals exhibit some form of play in the adulthood (Hart, 1985; Himmler et al., 2013; Kaiser et al. 2015). Increased play behaviour is, in turn, expected to affect brain and cognition, particularly, to areas involved in language processing, like the cortico-cerebellar system (Kerney et al., 2017).

In summary, the full story might sound as follows. After our split from Neanderthals, our brain/cognition was not a fully modern one, and neither was our behaviour, in part, because we were not fully self-domesticated yet. Subsequent changes in our brain (increased globularization) and in our cognition (improvement of cognitive resources involved in our language-readiness) occurred gradually, and also did self-domestication, with one affecting the other. This process resulted in the emergence of a modern-like brain and cognition, and a modern-like behaviour, around 100-50 kya, and ultimately, of modern-like languages, around 20-15 kya, via a cultural process. In our view, the explanatory potential of this hypothesis is reinforced by the fact that clinical conditions entailing language deficits and abnormal socialization patterns also exhibit an abnormal presentation of domestication features. For instance, signs of domestication are attenuated in subjects with autism spectrum disorder, which involves reduced socialization and reduced language complexity (Benítez-Burraco et al., 2016b). On the contrary, people with Williams Syndrome, who exhibit an enhanced socialization and less problems with grammar, show exacerbated features of domestication (Niego and Benítez-Burraco, 2018).

Conclusions

Languages are a product of both our biological endowment and the environment in which we live, particularly, of our culture, which in turn interact in complex ways. Recent advances in our

knowledge of the biological, environmental, and cultural changes occurred in Prehistory are expected to improve our understanding of language dynamics in the past and particularly, the nature of the languages spoken at times which are beyond reach of comparative linguistics. Of particular interest are hypotheses that reconcile (aspects of) our biological evolution with (aspects of) our cultural evolution, like the human self-domestication hypothesis. We should be confident that improved accounts of how languages were in our remote past will be available soon.

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