BETWEEN SKEPTICS AND ADAPTATIONISTS

NEW PROSPECTS FOR HUMAN LANGUAGE EVOLUTION

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The debate on human language evolution is crystallizing around a diatribe that is likely to be sterile, between skeptics (well represented by a provocative recent paper by Hauser *et al.*) and adaptationists convinced that language is just an instinct or a modulus gradually evolved by natural selection as an "adaptation for" general functions of communication. In this paper we will critically analyze both positions and we will propose two cases as examples of a possible "third way". In order to avoid this dichotomous impasse, we need to consider that now in the field we can count on an updated theory of evolution, an extended Neo-Darwinism more pluralistic in its explanatory patterns (ignored by both contenders), and on the enlargement of the empirical basis of evolutionary hypotheses, namely through the convergence of molecular, morphological, ecological and biogeographic data. With reference to the natural history of typically human language in strict sense, the "South African Final Wave" model and the "cascade of exaptations" model could be two promising applications of an updated theory of evolution. Such cases will be presented and discussed.

The mystery of language evolution?

The debate around the evolution of language has been recently fomented by the chronicle of an alleged failure, titled in a very eloquent way: "The mystery of language evolution"[1]. We will focus here on the category of "mystery", frequently adopted for human language in the history of evolutionary thought, but let us share briefly the contents of the paper before discussing them. The heaviest signer is certainly Noam Chomsky, but other very influential authors come together: the great Harvard geneticist Richard Lewontin, linguists Robert Berwick and Jeffrey Watumull, animal communication experts such as Michael J. Ryan and Marc D. Hauser, a well reputed scholar of language learning, Charles Yang, and Ian Tattersall, author of fundamental essays on human evolution. The scientific failure pointed by the article would have been that of those who have competed in the last four decades in any kind of evolutionary hypotheses on human language, but could not fill the gap that separates us from other animals.

"The richness of ideas is accompanied by a poverty of evidence"[2], this is the severe sentence. We do not have explanations of how and why our linguistic computations and representations arose in natural history yet. The alleged poverty of evidence is analytically described in four main areas: 1) studies of communication in nonhuman animals (with no relevant parallels to human linguistic communication and no insights about the underlying biological capacities); 2) paleontological and archaeological evidence (too fragmentary and unable to provide clues about past selective pressures); 3) genetics of language (no connections between genes and linguistic processes will be discovered any time soon); 4) evolutionary mathematic modelling (based on unfounded assumptions and without operational empirical tests).

This view of human linguistic discontinuity is not surprising. In the past of some authors we find some excess of anti-Darwinism, which could led them to exaggerate the pessimism. This is not the only weak point of the article. The harshness of the analysis of anything published so far in the field of language evolution is pivoted by the first signing of Marc Hauser, whose speculations on the natural history of a human universal moral grammar did not always have a happy ending. In some cases, the underestimation of current researches is clearly unfounded: for instance, it is unfair to write that from the paleontological and archaeolo-

[1] HAUSER, M. D. *et al.* The mystery of language evolution. *Frontiers of Psychology*, vol. 5, May 2014, article 401, doi: 10.3389/fpsyg.2014.00401, 2014

[2] HAUSER M. D. *et al. Op. cit.*

gical record is still impossible to deduce information about mental representations, cognitive and computational tasks in our ancestors (belonging to our species or not). The palaeo-neurological studies of human endocasts, the advanced geometric morphometry and the cognitive archeology applied to the patterns of stone tools production are supplying a growing literature related to the evolution of intelligence and language in the *Homo* genus.[3] We have archaeological evidence of computational processes (i. e. combinatorial and compositional skills), associated with neurological specificities (i. e. globularity in *Homo sapiens* skulls and evolution of language-related areas), able to support valid hypotheses about, as a case study, the computational differences between *Homo sapiens* and *Homo neanderthalensis*. As for genetics, recently we have seen the first data on the molecular changes that altered neural development and led to the evolution of the peculiar structure of the *Homo sapiens* brain, even after the split from the common ancestor with Neanderthals.[4]

The main weaknesses of the provocative article are anyway related to the argumentative structure. The initial standard case of túngara frog is too simplistic when compared to the dualistic definition of the human faculty of language "in the narrow sense" (FLN) that comes immediately after (as opposed to the language faculty in the broad sense, FLB). Setting the premises about the "language phenotype" along such a dramatic gulf with anything else in nature, it will seem to anyone that there is an evolutionary ocean in between. The discontinuity between FLN and FLB is strongly rooted in their respective *a priori* definitions. The described vast linguistic differences between birds, nonhuman primates and *Homo sapiens* often appear a matter of degree rather than a qualitative, unbridgeable Rubicon.

The conditions so far tested in nonhuman animals are just necessary but not sufficient for language (FLN sense), Hauser *et al.* say. Though, integrating more and more "necessary conditions" or enabling pre-conditions, we have no theoretical and experimental reasons to suppose that, at some point in the history of hominins, articulated language in modern sense could have evolved. Otherwise we should say, as a logic consequence, that the peculiar evolution of human language, as a qualitative dramatic jump, escapes the normal continuity (although with different rhythms) of any evolutionary process according to the core of the current Neo-Darwinian research programme.

[3] D'ERRICO, F. & STRINGER, C. Evolution, revolution or saltation scenario for the emergence of modern cultures. *Phil. Trans. Royal Soc.*, 366, p. 1.060-1.069, 2011.

[4] SOMEL, M.; LIU, X. & KHAITOVICH, P. Human brain evolution: transcripts, metabolites and their regulators. *Nature Neuroscience*, 14, p. 112-127, 2013.

Here we approach the basic fallacy of the paper: its implicit subjection to a polemic target that is an old fashioned view of the theory of evolution, intended as a straw man. The enemy is not mentioned but transpires between the lines for anyone who knows the history of the debate: the strong (and naïve) adaptationism of evolutionary psychology and other approaches.[5] Hauser *et al.*[6] consider the language phenotype as a single trait and challenge the functionalistic and gradualistic attempts to reconstruct its evolution. They are right with respect to the straw man they keep in mind, but the actual theory of evolution in the field today is not reducible to that caricature. Two examples of this fallacy follow.

When the "biological capacity for language" is repeatedly distinguished from "its many possible functions" (such as communication and internal thought), Hauser *et al.* should make explicit in which alternative ways it is possible to have the evolution of a complex trait or behaviour without considering just functions and selective pressures. They did not, and in the final suggestions for future researches (confined in just a table) they simply list some faint empirical and methodological possible advancements. Secondly, in a crucial point of the paper we can see directly this polemic bias against enemies not mentioned. Oddly, Hauser *et al.* consider a bankruptcy the discovery of recent evolutionary specificities in *Homo sapiens*: autapomorphic changes in our anatomy (in the shape of the vocal tract in the human head)[7] and autapomorphic changes in our genome (the first alleles associated with speech have been isolated). In other words, we are beginning to know what recently distinguished *Homo sapiens* from other species of the *Homo* genus strictly related phylogenetically to us. This great result is presented as a defeat. But who is to defeat? Just an evolutionary biologist strongly convinced that everything in nature must be explained through a slow, gradual, adaptively fine-tuned process. Why should the understanding of what constitutes the recent uniqueness of our species be evaluated as a negative proof or bad news? Evolution is not necessarily synonymous with exhausting graduality over millions of years.

Skeptics VS adaptationists: nothing else?

Are we doomed to choose between a mysterious mystical discontinuity of the "faculty of language in the narrow sense", in one hand, and a desperately long adaptive evolution whose functional beginnings are already present

[5] PLOTKIN, H. *Evolution in Mind*: An Introduction to Evolutionary Psychology. London: Allen Lane & Penguin, 1997.

[6] HAUSER, M. D. *et al. Op. cit.*

[7] LIEBERMAN, D. E. *The Evolution of the Human Head*. Cambridge (MA): Harvard University Press, 2011.

in frogs and sparrows? The paper tries to push us to take a position in a dichotomous conflict that does not exist in the facts: to be resigned to the mystery against the old glorious defenders of the orthodoxy. QED, while the *pars construens* of the paper (table 1) is quite nebulous (just a couple of interesting suggestions about neurological studies of animal communication in the wild). As expected, the reactions of the ultra-Darwinians in permanent service will be caustic and unrelated to the contents. Thus a perfect fight for the media is served.

How to escape this dichotomous setting and overcome the impasse? After all, Hauser *et al.*[8] make some good points. Methodologically, it is right to point out that the study of the remote causes of human behaviours should adhere to strict standards of experimental evolutionary biology *per se*, rather than relying on adaptationist "just-so stories" like much of evolutionary psychology (and evolutionary politics, evolutionary economy etc) has done so far (for two very effective and analytic critics of the evolutionary psychology literature: Buller[9] and Richardson[10]). The most advanced comparative studies analyzing the diffusion and history of different traits in primate phylogeny (according to the so-called "tree thinking") which integrate molecular, morphological and biogeographic data show, beyond any doubt, that it is a mistake to consider the adaptive hypotheses as the only plausible ones.[11] Tree thinking is missing in language and human psychology studies, and the authors are right to emphasize it.

Furthermore, we can just appreciate the correction [of direction] in the Chomskyan school. Instead of blaming Darwin himself and improvidently declaring defunct Neo-Darwinism itself (which, in the meantime, shows off excellent health and evolution), now Chomskyans and allies criticize the contents, aims and methodologies of current evolutionary hypotheses about language, with some biased bitterness and some piecemeal proposes for empirical alternatives to the naïve adaptationism that have prevailed for decades. Nevertheless, in their *pars construens* they have forgotten important lines of evolutionary research (among others, genes-cultures coevolution, evo-devo, epigenetics, quantitative human behavioral ecology)[12] that could be very useful for future researches on language evolution. But the overall attempt of provoking a scientific debate is welcome after all.

In order to avoid the dichotomous impasse we need much more. Those who surrender to the mystery of mystic

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[8] HAUSER M. D. *et al. Op. cit.*

[9] BULLER, D. J. *Adapting Minds:* Evolutionary Psychology and the Persistent Quest for Human Nature. Cambridge (MA): The MIT Press, 2005.

[10] RICHARDSON, R. C. *Evolutionary Psychology as Maladapted Psychology*, Cambridge (MA): The MIT Press, 2007.

[11] PIEVANI, T. *Evoluti e abbandonati. Sesso, politica, morale*: Darwin spiega proprio tutto? Torino: Einaudi, 2014.

[12] RICHERSON, P. J. & BOYD, R. *Not by Genes Alone*. Chicago: The University of Chicago Press, 2005. NETTLE, D. *et al*. Human behavioral ecology: current research and future prospects. *Behavioral Ecology*, 24(5):1.031-1.040, 2013. FISHER, S. E. & RIDLEY, M. Culture, genes, and the human revolution. *Science*, 340:929-930, 2013.

discontinuity of language (FLN) and those who believe in a gradual, adaptive, and functional piece by piece implementation of a instinct or module of language, share both the insensibility toward two recently emerging phenomena in evolutionary fields[13]:

a) We have an updated theory of evolution, a so-called extended Neo-Darwinism, more pluralistic in its explanatory patterns and methodologically advanced;
b) We have an enlargement of the empirical basis of evolutionary hypotheses, namely through the convergence of molecular, morphological, ecological and biogeographic data.

We will present in the following two cases of this possible new approach to evolutionary conundrums like language evolution (of course, without the ambition of being decisive). We would like to stress the methodological novelty of these researches, that could make obsolete the impasse between skeptics and adaptationists.

The "South African Final Wave" model

Considering recent data from different disciplines like molecular biology and palaeontology – handled as pieces of a puzzle and elements of a model intended as an inference towards the best explanation – some scholars are exploring the possibility that the development of a fully articulated language (with its computational costs in terms of combinatorial and compositional recursion) favoured the key cultural innovations which, in turn, pushed the last population wave of *Homo sapiens* out of Africa about 60 to 50K ago. So, there could have been a causal correlation between the evolution of the specific language of *Homo sapiens*, the so-called "symbolic behaviour", and the geographical globalisation of human populations.[14] Human biogeography could be the hidden side of a story that still needs to be completely disclosed by science.

The first signs of symbolic behaviour come from Africa, and not from Europe as thought for a long time: in Blombos Cave, south of Cape Town, there are 75.000 year old pieces of ochre with engravings organised in a combinatory pattern, as if representing a computation or a stylized figure[15]. In other South African sites, traces of ochre and decorative shells have been found, probably really ancient. Much later, in Europe, in Cro-Magnon *Homo sapiens* new and extremely innovative behaviours emerged. So it seems

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[13] PIEVANI, T. An evolving research programme: the structure of evolutionary theory from a Lakatosian perspective. *In*: FASOLO, A. (Ed.). *The Theory of Evolution and Its Impact*. New York: Springer-Verlag, 2012. p. 211-228.

[14] CAVALLI SFORZA, L. L. & PIEVANI, T. *Homo sapiens. The Great History of Human Diversity*. Turin: Codice Edizioni, 2012.

[15] D'ERRICO, F. & STRINGER, C. *Op. cit.*

that we have a first "burst" of innovation in South Africa (or several bursts there), and, much later, new innovations with the arrival of the first *Homo sapiens* in Europe and Australia.

Investigating the recent *Homo sapiens* uniqueness (200.000 years ago) among the hominins of the genus *Homo*, we see three clear marks of innovation: 1) a global anatomy uniquely derived, mostly in the structure of the skull (globularization) and postcranial skeleton[16]; 2) the maximum of neotenic trend observed in dental and skull development (also compared with Neanderthals: a study on teeth finished in 2011 has shown that their development was slightly faster than ours, although not all data are consistent)[17], associated with a supposedly extended genetic reorganisation; 3) and mainly, a very peculiar pattern of distribution of genetic diversity, a hint that was, until now, underestimated but has long-ranging bio-geographical consequences: genetic diversity inside our species is much less than in any other primate, and only an abrupt (or several abrupt) evolutionary "bottleneck" could explain this drop.[18] There are currently seven billion human beings on the planet and they have very limited genetic variance, proportionally less as one shifts away from the African continent.[19] This suggests that the entire human population could have descended from a small initial group which contained all our ancestors and which is currently thought to have numbered just a few thousand people.

Later, this original pioneering population which originated in the sub-Saharan region grew and spread, radiating new small founding groups which 60-50.000 years ago populated first the Old World, then Australia and the Americas, as inferred now from genome-wide patterns of variation.[20] The dynamics of expansion through subsequent shifts from the outer rim of the previous population generates a sequence of genetic drifts, an evolutionary step whereby the greater the distance from Africa, the fewer the average inner differences in any group of humans. This model, proposed by a network of geneticists led by Cavalli Sforza, is known as the "serial founder effect", originating in Africa.[21]

This means that we now have two main results from human genetics: 1) a positive and strong correlation between the decrease in genetic variability and the distance from Africa; 2) human genetic diversity has a geographical maximum. In 2010, a group of geneticists completed a project on the genome of four elderly Bushmen hunter-

[16] BRUNER, E.; MANZI, G. & ARSUAGA, J. -L. Encephalization and allometric trajectories in the genus *Homo*: Evidence from the Neandertal and modern lineages. *PNAS*, vol. 100, nº. 26, 15.335-15.340, 2003.

[17] SMITH, T. M. *et al.* Dental evidence for ontogenetic differences between modern humans and Neanderthals. *PNAS*, vol. 107, nº. 49, p. 20.923-20.928, 2010.

[18] KAESSMANN, H. *et al.* Great ape DNA sequences reveal a reduced diversity and an expansion in humans. *Nature Genetics*, vol. 27, p. 155-156, 2001.

[19] RAMACHANDRAN, S. *et al.* Support from the relationship of genetic and geographic distance in human populations for a serial founder effect originating in Africa. *PNAS*, vol. 102, n. 44, p. 15.942-15.947, 2005.

[20] LI, J. Z. *et al.* Worldwide human relationships inferred from genome-wide patterns of variations. *Science*, vol. 319, nº. 5.866, p. 1.100-1.104, 2008.

[21] DESHPANDE, O. *et al.* A serial founder effect model for human settlement out of Africa. *Proceedings of the Royal Society of London B*, vol. 276, p. 291-300, 2009.

gatherers, compared with a famous scion of Bantu farmers, Desmond Tutu.[22] The average individual variability among these South African genomes was extremely high. In particular, khoi-san languages speakers seem to be the closest to the initial phases of human diversification and spread: "Hunter-gatherer genomic diversity suggests a southern African origin for modern humans".[23] This highest degree of diversity in a specific region indicates that new genetic variations have been able to accumulate over a very long time there: "African hunter-gatherer populations, with a maximum in southern Africa, continue to maintain the highest levels of genetic diversity in the world"[24].

Where did the founders come from? Here archaeological data could join the molecular and biogeographic ones. According to Jacobs & Roberts[25] that used highly sophisticated methods of systematic dating of several sites in southern Africa, "two bursts of human innovation in southern Africa during the Middle Stone Age may be linked to population growth and early migration off the continent". Thanks to the analytic reconstruction of geography and timing of the two cultures of Still Bay Points (between 71 and 70K ago) and Howieson's Poort Points (between 65 and 60K ago), they outline the "ephemeral and punctuated nature of these bursts of technological and behavioural innovation"[26].

The study is really innovative, because Jacobs & Roberts integrate biogeography, systematic dating, ecology, climate science and molecular data in new kinds of regional survey.[27] They believe that repeated pulses of demographic expansions and contractions, produced by environmental local changes, influenced the social networks and the capacity of cultural innovation in small groups of *Homo sapiens* during the Middle Stone Age in southern Africa. The typically modern symbolic behaviour could have originated in such a complex scenario of evanescent cultures associated with small hunter-gatherer populations.

But what is even more interesting is that these data seem coherent with molecular ones. Their results "hint at the possible role of population expansions in Africa as a trigger for these Stone Age innovations, and, maybe, for early migrations from Africa about 60K ago".[28] In fact, "all mt-DNA lineages found outside Africa derive from just two haplogroups (M and N) that descend from the L3 haplogroup"[29], and the youngest major African L3 haplogroup corresponds to an increase in population size between 86K and 61K, so within a time span exactly including

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[22] SCHUSTER, S. C. *et al*. Complete Khoisan and Bantu genomes from southern Africa. *Nature*, vol. 463, p. 943-947, 2010.

[23] HENN, B. M. *et al*. Hunter-gatherer genomic diversity suggests a southern African origin for modern humans. *PNAS*, vol. 108, nº. 13, p. 5.154-5.162, 2011.

[24] HENN, B. M. *et al*. *Op. cit.*

[25] JACOBS, Z. & ROBERTS, R. G. Human history written in stone and blood. *American Scientist*, vol. 97, nº. 4, p. 302-309, 2009.

[26] JACOBS, Z. & ROBERTS, R. G. *Op. cit.*

[27] JACOBS, Z. *et al*. Ages for the Middle Stone Age of southern Africa: Implications for human behaviour and dispersal. *Science*, vol. 322, p. 733-735, 2008.

[28] JACOBS, Z. & ROBERTS, R. G. *Op. cit.*

[29] JACOBS, Z. & ROBERTS, R. G. *Op. cit.*

the Still Bay and Howieson's Poort cultures. Why did only one haplogroup (among the major four indigenous to Africa) show this success? According to Atkinson, Gray & Drummond,[30] forms of cultural innovation and increases in behavioural complexity by members of the L3 haplogroup gave them a competitive advantage in terms of group coordination, technological and communication efficiency, and mainly social cohesion[31].

Expansions were the trigger for innovations, and vice versa, because technological and behavioural innovations needed an extended network of social contacts and exchanges to spread. In other phases, population contractions isolated smaller and fragmented hunter-gatherer communities, breaking the social and economic networks: that is why we see several bursts of ephemeral and local innovations, lasting just a few millennia. So, the geographical dispersion and the population size of the groups are underestimated and crucial factors with threshold-effects on behavioural innovation. In this scenario, Jacobs & Roberts[32] suppose that "a spark of human ingenuity" inside the groups of L3 carriers in East Africa was the catalyst for the loop between cultural innovations and demographic expansions in a group with unprecedented success: "that innovation encouraged social cohesion and the more efficient use of natural resources, prompting rapid population growth among this group of people. This population expansion may have, in turn, promoted more innovations, including the Still Bay and Howieson's Poort in southern Africa, and the migration of people out of Africa to the north"[33].

A new model of modern human prehistory is emerging: it is possible that the "final wave" of people out of Africa, after the period of 60K, associated with the L3 haplogroup, was the bearer of the behavioural innovations that until now are associated with the so-called "symbolic revolution".[34] As it was already suggested by the Cambridge archaeologist Paul Mellars[35], after the first dispersals of anatomically modern populations to Asia between 110 and 90K ago, major technological, social and economic changes occurred in Africa between 80 and 70K ago, associated with clear symbolic expressions, in a period of climatic and environmental changes. Those changes were followed by major population expansions in Africa from small source areas (like in the Still Bay and Howieson's Poort cultures) between 70 and 60K ago, and then by the dispersal of modern populations from Africa to Eurasia around 60K

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[30] ATKINSON, Q. D.; GRAY, R. D. & DRUMMOND, A. J. Bayesian coalescent inference of major human mitochondrial DNA haplogroup expansions in Africa. *Proceedings of the Royal Society of London B*, vol. 276, p. 367-373, 2009.

[31] PIEVANI, T. Born to cooperate? Altruism as exaptation, and the evolution of human sociality. *In*: SUSSMAN, R. W. & CLONINGER, C. R. (Eds.). *Origins of Cooperation and Altruism*. New York: Springer, 2011. p. 41-61.

[32] JACOBS, Z. & ROBERTS, R. G. *Op. cit.*

[33] JACOBS, Z. & ROBERTS, R. G. *Op. cit.* p. 309.

[34] PIEVANI, T. The Final Wave. *Homo sapiens* biogeography and the evolution of language. *RIFL*, 203-216, 2012. Doi: 10.4396/20120618.

[35] MELLARS, P. A. Why did modern human populations disperse from Africa ca. 60.000 years ago? A new model. *PNAS*, vol. 103, p. 9.381-9.386, 2006.

ago. We can now add further substantiation to the interdisciplinary circumstantial evidence gathered so far.

When the "final wave" of *Homo sapiens* arrived, after 50-40K ago, the demographic balance with other recent human species (such as Neanderthals, *Homo floresiensis* and Denisova man) clearly favoured us. Neanderthals became extinct in the Iberian Peninsula around 30K ago, and *Homo floresiensis* 12K ago in the island of Flores. We know episodic expressions of symbolic behaviour in Neanderthals, but nothing compared with the systematic change in global behaviour and the cultural innovations observed in the later *Homo sapiens* populations during their diffusion into the Old World. The extinction of any other human species and the emergence of the complete modern human behaviour in *Homo sapiens*, with the trigger of the self-catalytic loop between expansion and cultural innovation, could be two causally related evolutionary phenomena: our species became more demographically invasive and increasingly competitive.[36]

As shown by the parallels in the tree of human genes and the tree of human languages,[37] the transmission of languages and genes are interestingly alike, but the analogy still remains highly disputed. According to the very controversial paper published in *Science* by Quentin Atkinson, "human genetic and phenotypic diversity declines with distance from Africa, as predicted by a serial founder effect in which successive population bottlenecks during range expansion progressively reduce diversity, underpinning support for an African origin of modern humans"[38]. Applying an analogous statistical analysis to the diversity of phonemes (the basic units of sound that differentiate words), it appears that a similar pattern may operate on human culture and language: "the number of phonemes used in a global sample of 504 languages is also clinal and fits a serial founder effect model of expansion from an inferred origin in Africa. This result, which is not explained by more recent demographic history, local language diversity, or statistical non-independence within language families, points to parallel mechanisms shaping genetic and linguistic diversity and supports an African origin of modern human languages"[39].

Quite surprisingly, the point of view of genes and the point of view of phonemes tell the same story of human diversification. Some linguistic caveats need attention: 1) the unique origin of modern languages is not established in this way; 2) phonemic diversity is a weak statistical basis

[36] TATTERSALL, I. *Masters of the Planet*. New York: Palgrave Macmillan, 2012.

[37] CAVALLI SFORZA, L. L.; MENOZZI, P. & PIAZZA, A. *The History and Geography of Human Genes*. Princeton (NJ): Princeton University Press, 1994.

[38] ATKINSON, Q. D. Phonemic diversity supports a serial founder effect model of language expansion from Africa. *Science*, vol. 332, p. 346-349, 2011.

[39] ATKINSON, Q. D. *Op. cit.*

because it varies inside the languages in a wide range of regional variants (other methodologies are expected: through regional variants, or units of syntax); 3) the differences between biological evolution and linguistic evolution cannot be underestimated. However, the provisional matching of the two patterns is impressive, mostly because the evolution of language is associated for the first time with *Homo sapiens* biogeography.

According to Atkinson, the connection between language and the global expansion of cognitively modern humans is clear: "Truly modern language, akin to languages spoken today, may thus have been the key cultural innovation that allowed the emergence of these and other hallmarks of behavioural modernity and ultimately led to our colonization of the globe"[40]. As Mark Pagel incisively pointed out in his comment to Atkinson in *The New York Times*: "Language was central to human expansion across the globe. It was our secret weapon, and as soon we got language we became a really dangerous species"[41].

The "cascade of exaptations" model

In this model, based on a pluralistic and extended version of the Neo-Darwinian theory of evolution[42]:

a) the evolutionary process is continuous (no qualitative and unsupported saltations), but with punctuated bursts of innovations in small populations, geographically located;

b) there is a direct liaison between biological evolution and cultural evolution (with the latter grafted onto the former, but the latter being able to modify the ecological niches and so the frame of selective pressures acting on *Homo sapiens* populations – according to the "niche construction" model[43];

c) a growing interdisciplinary collection of evidence is unified through an inference towards the best explanation, stressing the role of biogeography in the evolution of cognitively modern human behaviour.

This is a revised version of the "exaptive hypothesis" about the emergence of cognitively modern humans,[44] though not involving a discontinuous and very recent "great leap forward" without geographical reference. The alleged time gap between *Homo sapiens* anatomical appear-

[40] ATKINSON, Q. D. Phonemic diversity supports a serial founder effect model of language expansion from Africa. *Science*, vol. 332, p. 346-349, 2011. p. 348.

[41] WADE, N. Phonetic clues hint language is Africa-born. *The New York Times*, April 14, 2011.

[42] PIEVANI, T. An evolving research programme... *Op. cit.*

[43] ODLING-SMEE, J.; LALAND, K. N. & FELDMAN, M. W. *Niche Construction.* The Neglected Process in Evolution. Princeton (NJ): Princeton University Press, 2003.

[44] TATTERSALL, I. Human origins: Out of Africa. *PNAS*, vol. 106, nº. 38, p. 16.018-16.021, 2009.

ance (200.000 years ago in Eastern and Southern Africa) and the emergence of cognitively modern humans (75.000 years ago in Southern Africa) is possibly just an illusion due to a lack of evidence or to long periods during the Glaciations when human population shrunk in numbers. Other experts believe, instead, that our species always had the physical and cerebral potential to display such behaviours from the onset, but that a trigger was needed to release these resources (maybe related to the connection between the manipulation of stone-tools, social learning and the articulation of words)[45]. This process of "functional co-opting" is known by evolutionists as exaptation, whereby a structure evolved for a certain function (the former "pre-adaptation") or as a side-effect of others (a spandrel) is then re-used for new functions in subsequent contexts.[46]

The acknowledgment of the importance of exaptive processes, from palaeontology to biochemistry, has now entered in textbooks and has recently been consecrated in *Nature*[47], in a computational study carried out by the Zurich group of Andreas Wagner and Aditya Barve. They showed that considerable flexibility is hidden in metabolic networks, raising the idea that the functional nature of the co-optation of existing structures is widespread. Taking advantage of what you already have may be the secret of innovation.

Philip Lieberman[48] in 2006 had already suggested that functional co-optation and evolutionary by-products have played a role in language evolution. A very interesting "exaptational" theory for the evolution of syntax has been recently proposed by Tecumseh Fitch. Exaptation is frequently evoked in an anti-Darwinian Chomskyan sense, arguing that the most complex skills of human mind would have emerged as pure side-effects of other random modifications. This is a defensive interpretation (it admits some evolution, although not Darwinian) that trivializes the real meaning of the concept, which is not at all anti-Darwinian and does not entrust evolution to mere chance. Exaptive processes are divided into two categories, one quite moderate and one more radical: 1) the shift from a primary to a secondary function, through successive rearrangements, as described by Darwin in the sixth edition of *The Origin of Species* (and later defined as "pre-adaptation"); 2) the reuse and engagement of structures that evolved in the absence of a functional reason (spandrels), as initially side effects or structural effects.[49]

[45] DI VINCENZO, F. & MANZI, G. Social learning and origin of the language faculty by means of natural selection. *J. Anthropol. Sci.*, 91, p. 261-267, 2013.

[46] GOULD, S. J. & VRBA, E. S. Exaptation, a Missing Term in the Science of Form. *Paleobiology*, vol. 8, nº. 1, p. 4-15, 1982.
PIEVANI, T. Rhapsodic evolution: Essay on exaptation and evolutionary pluralism. *World Futures*, vol. 59, nº. 2, p. 63-81, 2003.
PIEVANI, T. & SERRELLI, E. Exaptation in human evolution: How to test adaptive vs exaptive evolutionary hypotheses. *Journal of Anthropological Sciences*, vol. 89, p. 1-15, 2011.

[47] BARVE, A. & WAGNER, A. A latent capacity for evolutionary innovation through exaptation in metabolic systems. *Nature*, 500, p. 203-213, 2013.

[48] LIEBERMAN, P. *Toward an Evolutionary Biology of Language*. Cambridge (MA): Harvard University Press. 2006.

[49] PIEVANI, T. Rhapsodic evolution... *Op. cit.*
PIEVANI, T. *Introdução à Filosofia da Biologia*. São Paulo: Edições Loyola, 2010.

In the first case, natural selection is always in action, not in the second. Through defined methodological criteria for the two categories, we must generate operationally testable hypotheses and avoid exaptive "just-so stories".[50] Despite some polemic misunderstandings, the concept of exaptation in nature does not exclude that countless structures and behaviours are direct adaptations shaped by natural selection, whose agency is not under discussion. We have to compare, in each case, alternative models and select those best suited to the empirical data, constantly updated. It is a pluralistic approach to evolutionary mechanisms, processes and patterns. Thus leaving Darwin in peace, and seizing different nuances of the concept of exaptation, it is possible to understand the peculiar functional, structural and historical features of human linguistic syntax wired in our brain through an updated evolutionary toolkit. As a somehow provocative example, linguist Andrea C. Moro proposed an evolutionary hypothesis for human language (FLN) based on an initial contingency (such as a frozen historical accident) and then inertial channelling, with or without a functional pressure at the beginning and no function at all now (a sort of reversed spandrel, or "kataptation").[51]

Then, how to use this new and rich toolbox to reconfigure the enigma of language evolution? An interesting proposal – methodologically at odds with the "pan-adaptationism" of evolutionary psychology – came out in 2012 from a seminal review written by Tecumseh Fitch, one of the leading experts in the field. An evolutionary biologist and cognitive scientist at the University of Vienna, he proposes to consider human language not as a monolithic trait, but as a collection of semi-independent components, each one having a possibly different evolutionary history.[52] Some structures might be very old and appeared before the genus *Homo*, being then re-adapted and "ex-apted" in new ecological niches during our phylogenetic trip. Others might be more recent and even typical of our species, namely the syntactic aspects of language.

In other words, language is not a trait, but a mosaic of traits. Some basic elements of universal grammar precede the language, while others have been integrated later. This is the classical "continuity with innovation" proposed by Darwin: evolution of complex traits in humans needs continuity of the process and triggers of innovation. Some parts of the "language mosaic" are common to other species and are candidates to be the natural precursors of the

[50] PIEVANI, T. & SERRELLI, E. *Op. cit.*

[51] MORO, A. C. 'Kataptation' or the QWERTY-effect in language evolution. *Frontiers in Psychology*, 2, p. 50. 2011.

[52] FITCH, W. T. Evolutionary developmental biology and human language evolution: Constraints on adaptation. *Evolutionary Biology*, 39, p. 613-637, 2012.

various forms of proto-languages that came before humanity (the building-blocks). It is clear that effective communication systems and proto-languages were already available to other species of genus *Homo*. The ecological and behavioral niche necessary to improve them perhaps was not only hunting, but also the (no longer physical) interactions between children and mothers through a musical and singsong proto-language.[53]

Other traits are species-specific and have marked human differences in our recent phylogeny, in terms of vocalization, syntax (combinatorial recursive operations) and semantics (sharing of meanings and theory of mind). A common feature of all these old and new components is to be the result – Fitch continues – of trade-offs between functional selective pressures on the one hand, and historical correlations and constraints (phylogenetic and development constraints) on the other. There are no more dichotomies between adaptations and constraints, continuity and discontinuity.[54] This is an example of the updated application of contemporary "evolutionary pluralism".

According to this model, language is not a gradual refinement of increasing complexity, as repeatedly pointed out in Steven Pinker's speculations, which stress only continuity. However, human language is not either the sudden emergence of a system already configured in its complexity and unusual near-optimality, as Chomsky and others still think, stressing only discontinuity. The third way assumes that the multiple factors of language may have evolved in different phylogenetic lines – some older, some newer – through gradual adaptations and exaptations, innovations and reconfigurations, until the current confluence of mechanisms that characterize the specific verbal language in *Homo sapiens*.

As for bipedalism, the search for a single ancestral function which the articulated language would be a specific "adaptation for" is likely to be illusory. Considering that bipedalism has more paleontological evidence due to anatomy, we have a wide range of different solutions adopted by various hominin species and not only one, with a number of morphological details to be compared. A similar feat for the language is prohibitive. Both bipedalism and language required anatomical reshaping, with structural constraints associated with. Both traits are costly and imperfect: as for bipedalism, abdomen is exposed in the front and many other ailments in the back are possible; as for language, the choking hazard. Their success, however, despite the cost, is

[53] FALK, D. *Finding Our Tongues*. New York: Basic Books, 2009.

[54] OKANOYA, K. Language, evolution and an emergent property. *Current Opinion in Neurobiology*, 17, p. 1-16, 2007.

a sign of the strong selective advantage they gave to our ancestors. The natural history of bipedalism is a "mosaic evolution".[55] Likely the same is true for language.

These clues suggest that language evolution has been produced by an interaction between functional adaptations, exaptations and structural/developmental constraints: a "cascade" of adaptations and exaptations.[56] The descent of the larynx is not typical of *Homo sapiens*, but is found in many mammals (deer, gazelles, cats). It has the function to lengthen the vocal tract necessary to produce lower sounds, so striking fear by exaggerating their prowess and size. Then it is not an "adaptation for" language, but an exaptation for phonetic and linguistic secondary uses. The further secondary descent of larynx that occurs in human males in puberty may be reminiscent of the primary adaptation and not related to linguistic functionality, additional evidence of the original independence of this trait from language. The same could be true for the vocal imitation of complex sounds, recorded in other mammals and birds. These preexisting traits contribute today – as constraints or phantoms of past adaptations – to typically human language. They are no "adaptations for" human language. As François Jacob metaphorically wrote, they are old staff which become available for new purposes.[57] In his view, human language is a new recombination of already existing traits (i.e. sensory-motor neural regions related to gestural and imitation skills), some of which may be coopted, implemented and refined.

In these two cases, we see the rising features of an updated theory of evolution, an extended synthesis or extended Neo-Darwinism, totally ignored in Hauser *et al.*[58]. Fitch proposes that language is not a trait but an integrated set of traits, adopting mosaic evolution, tree thinking (i.e. detailed phylogenetic analyses) and a plurality of processes (evo-devo constraints, adaptations/exaptations). He undermines the mutually exclusive duality between gradualism and novelty, continuity and innovation. In both cases, we see an enlargement of the empirical basis for testing evolutionary hypotheses, namely the consilience of molecular, morphological, ecological, biogeographic data. This is "the real thing" emerging from the field, despite the mass-media success of the fights between skeptics and adaptationists.

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[55] BERGER, L. The mosaic nature of *Australopithecus sediba*. *Science*, 340(6129), p. 163-165, 2013.

[56] FITCH, W. T. *Op. cit.*

[57] JACOB, F. Evolution and tinkering. *Science*, 196(4.295), p. 1.161-1.166, 1977.

[58] HAUSER M. D. *et al.* The mystery of language... *Op. cit.*