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THE ROOTS OF CREATIVITY: INVESTING IN CULTURAL TRANSMISSION

Ivan Colagè* and Francesco d’Errico

Summary: 1. *Creativity: Individual or Social?* – 2. *From Biological to Cultural Evolution* – 3. *The Mechanisms of Cultural Evolution*; 3.1. Cultural Exaptation, 3.2. Cultural Neural Reuse, 3.3. Transmission Strategies – 4. *Exaptation, Transmission and Creativity* – 5. *Conclusion*

1. CREATIVITY: INDIVIDUAL OR SOCIAL?

The history and prehistory of humanity is full of novelties. Human cultural evolution can be regarded as the “theatre” where such novelties emerge, stabilize and spread. If one looks at very recent or contemporary times, one can get the impression that creativity finds its roots in individual ingenuity, and that history of novelties turns out to be a series of “strokes of genius”. Such an impression increases by considering that many important findings and products are linked with the names of their inventors or discoverers. How many technological advances, scientific theories or even pathogens and diseases do bear the name of those who designed, devised or discovered them? Not to speak of the works of art or of music. The impression is further strengthened by the establishment of the many prizes, medals, honours, and various kinds of acknowledgments to people who have given key contributions to humanity.

The issue of creativity has been a focus of psychological research since at least 1950¹. For about the following three decades, creativity has been, indeed, inquired as a feature of the individual²: how it is related to general intelligence (as measured by IQ) and personality aspects (like aesthetical sensitivity, autonomy, broadness of interests, self-confidence, etc.); how it can be the outcome of a variety of cognitive faculties and intellectual skills³ (such as memory, attention, and knowledge, or divergent thinking, flexibility, and conceptual combination). With the 1990s, and even more so after the year 2000, research on creativity acknowledged the relevance of the social dimension. Indeed, scholars engaged in social

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¹ J.P. Guilford, *Creativity*, “American Psychologist” 5 (1950), pp. 444-454

² F. Barron, D.M. Harrington, *Creativity, intelligence and personality*, “Annual Reviews in Psychology” 32 (1981), pp. 439-76.

³ M.A. Runco, *Creativity*, “Annual Reviews in Psychology” 55 (2004), pp. 657–87.

psychology has inquired extensively into the topic⁴. Here, the focus is in understanding how various levels and kinds of social environment affect individuals' creativity. Though the need to elaborate a "systems view" of creativity (capable of integrating the variety of relevant factors, including social ones) is acknowledged⁵, social psychologists do not really consider creativity as a genuinely social phenomenon: "Although this often remains implicit, in the psychology literature, creativity is essentially conceived as an individual ability"⁶.

It is only with the development of so-called sociology of creativity that creativity is considered as a truly social phenomenon. Interestingly for us, the following definition of creativity has been proposed in the field of sociology: "an intentional configuration of material and cultural elements that is unexpected for a given audience"⁷. We will come back to this definition in what follows; however, it is worth stressing from the beginning that it constitutes a good conceptual starting point for our contribution. Indeed, we will inquiry into the *roots* of creativity from the viewpoint of cultural evolution, thus taking a "deep-time perspective". On this level of analysis, access to the strictly individual dimension is, of course, precluded, whereas addressing the issue of creativity through the lenses of cultural evolution dovetails with the idea that emergence of cultural novelties is basically the emergence of novel *combinations* (or "configurations") of previously devised solutions (or "material and cultural elements").

Our focus in the social dimension of creativity is not meant to deny the importance of the individual one. Even in the deep-time perspective, it should be maintained that certain key cultural innovations – i.e. innovations that are so momentous that they spawn an array of secondary products or behaviours⁸ – most likely involved kinds of "strokes of genius" by some members of the populations introducing them. In other words, it is quite probable that the aspects of personality, cognitive faculties and intellectual skills mentioned above indeed played a role in the deep time as much as they can be shown to play a role in recent history and present times. It can even be argued that cultural evolution as such finds one of its fundamental driving forces in deep personal motivations⁹, consistently with the so-called "intrinsic motivation principle of creativity"¹⁰ proposed by Teresa Amabile and central to contemporary psychology of creativity.

⁴ B.A. Hennessey, T.M. Amabile, *Creativity*, "Annual Reviews in Psychology" 61 (2010), pp. 569–98.

⁵ B.A. Hennessey, T.M. Amabile, *Creativity*, cit., p. 571.

⁶ F. Godart, S. Seong, D. Phillips, *The Sociology of Creativity: Elements, Structures, and Audiences*, "Annual Review of Sociology" 46 (2020), pp. 14.1–14.22, p. 14.9.

⁷ F. Godart, S. Seong, D. Phillips, *The Sociology of Creativity*, cit., p. 14.2

⁸ S. Reader, K.N. Laland, *Animal innovation: An introduction*, in Id. (eds.), *Animal Innovation*, Oxford University Press, Oxford, UK 2003, pp. 1–9.

⁹ I. Colagè, *I motivi della cultura dalla preistoria alle scoperte scientifiche*, in Id. (ed.), *Allargare gli orizzonti del pensiero. Scommettere sulla cultura tra specializzazione e interdisciplinarietà*, Orthotes, Napoli-Salerno 2020, pp. 85-111.

¹⁰ According to Teresa Amabile, intrinsic motivation is "the drive to engage in a task because it is interesting, enjoyable or positively challenging": B.A Hennessey, T.M. Amabile, *Creativity*, cit., p. 574. It is usually opposed to extrinsic motivations, "which arises from the desire to obtain some outcomes (such as rewards) that are apart from the work itself": T.M. Amabile, *Motivational synergy: Towards new conceptualizations of intrinsic and extrinsic the workplace*, "Human Resource Management Review" 3 (1993), pp. 185-201, p. 186.

However, there are two reasons why we will mainly focus on the social dimension in what follows. First, as a matter of fact, it is practically impossible to inquire into the individual dimension of creativity as far as the deep-time perspective of cultural evolution is taken into account: no data can be available on individuals' creative attitudes on this level. On the other hand, inquiring into the *roots* of creativity seems to require reference to such a deep-time perspective. Indeed, in spite of the fact that the term "creativity" has spread quite recently¹¹, the phenomenon of creativity can be certainly traced back to prehistoric times, even before the emergence of our biological species *Homo sapiens*¹². Secondly, and most importantly, we are convinced that the *roots* of creativity lay precisely in the social dimension. Specifically, as we will deepen below, creativity first and foremost stems from the human attitude to develop fine *transmission strategies* (along with the suite of cognitive faculties it involves) which is – so we would argue – one of the necessary conditions to have cultural evolution at all.

Transmission strategies are social processes, and it is in this sense that we address the issue of creativity primarily in the social dimension (and on the cultural evolution level).

As a further way of introducing our contribution, and of clarifying what we will specifically address, let us also discuss briefly the relations among the notions of "creativity", "invention" and "innovation". These are tightly related but, though often confused, they are not perfect synonyms. Strictly speaking, creativity is a capacity of an individual and it is in this sense that it is mainly conceived in psychology, as we have seen. We might think of it as the capability to conceive something original, unique, unexpected. From the viewpoint of social psychology it has been defined as "the generation of products and ideas that are both novel and appropriate"¹³. Here, the emphasis is on the process more than on the capability, but the horizon remains that of the individual subject (though immersed in social contexts that may facilitate, hinder or anyway affect creative generation). An invention would be the potential but not necessary outcome of a creative process. This, however, should be carefully understood since we see an invention as a kind of subjective (but not yet truly social) outcome of the creative process. In other words, we have an invention when an individual really gets something novel or original, but this outcome remains – so to speak – at a private level without reaching any kind of social diffusion. A parallel may perhaps be established with what is labelled "little c creativity", i.e., "daily problem solving and the ability to adapt to change"¹⁴. Accordingly, both human history and every one's personal life are full of inventions – in the first case, all those novelties excogitated and implemented by some "inventor" which, for whatever reason, never reached social adoption and diffusion; in the second case, all those creative solutions to daily issues people creatively introduce in their lives but remain "private". Innovation, instead, should denote a creatively devised novelty that has also reached social diffusion, adoption, stabilization and perpetuation. Innovations has been defined as "the successful implementation of creative ideas"¹⁵. As this definition comes from the field of social *psychology*, it misses – at least in part – the genuinely social

¹¹ After Renaissance as a plainly human phenomenon, and in the late 19th century as a research topic.

¹² For some insight into this point, see F. d'Errico, I. Colagè, *I meccanismi che hanno permesso lo sviluppo della creatività umana*, in Accademia Nazionale dei Lincei (ed.), *La creatività: biologia, psicologia, struttura del processo creativo*. Atti dei Convegni Lincei 336, Bardi, Roma 2020, pp. 57-67.

¹³ B.A. Hennessey, T.M. Amabile, *Creativity*, cit., p. 570.

¹⁴ B.A. Hennessey, T.M. Amabile, *Creativity*, cit., p. 572.

¹⁵ B.A. Hennessey, T.M. Amabile, *Creativity*, cit., p. 585.

dimension. Our understanding of innovation, on the contrary, stresses the need for social reception and spreading. Specifically, our understanding stresses that a novelty becomes an innovation once a social group “invests” in it – and the primary form of such a “social investment” is devising means to *transmit* it. Hence, our emphasis on transmission strategies. To sum up, therefore, we will address the issue of the roots of creativity from the viewpoint of cultural evolution. This implies an emphasis on the *social* side of creativity, and a kind of bracketing of the individual one. Focusing on the cultural-evolution standpoint is functional to inquiring into the *roots* of creativity. This, in a sense, forces us to engage with the social dimension and to overlook the individual one. However, a positive reason to take the social stance on creativity is the idea that truly creative outcomes – i.e., *innovations* – actually require investing in their *transmission*, which patently is a social process.

2. FROM BIOLOGICAL TO CULTURAL EVOLUTION

As it is well known, evolutionary biology broke fourth in the 19th century as a fundamental approach to life explicitly acknowledging that *life forms change in time*. It can thus be claimed that the central problem to evolutionary biology was to explain the emergence of *novelty* in life’s history. The first accomplished and unified explanatory theory of biological evolution has been elaborated in the mid-20th century integrating Darwin’s theory of natural selection and Mendel’s original insights on genetics. This is the so-called Modern Evolutionary Synthesis.

Evolutionary biology sees biological evolution as proceeding through three key steps: production of variation, transmission of variation, selection of variation. With the elaboration of the Modern Synthesis these three steps came to be strongly based on genetic grounds – Modern Synthesis is considerably gene-centric. Variation production was essentially attributed to *genetic* mutation; variation transmission was generally assigned to *genetic* inheritance; variation selection was seen as operated by natural selection – with the important proviso that the eventual outcome of the selection process was regarded as the selection of organisms with *genomes* endowing them with fit traits.

Against this background, it is not surprising that *human* evolution was interpreted according to this general framework – which, from a methodological viewpoint, is an absolutely undisputable move, of course. Expanding further the picture, human *cultural* evolution has often been considered as fully reducible – indeed, as an epiphenomenon – of biological evolution, and specifically to the just-sketched gene-centred interpretation. Even in this case, it has been methodologically wise to walk this path at first.

If such a perspective were really able to provide a suitable understanding of cultural evolution, it would likely also offer insights into “the roots of creativity” – especially if the latter is considered as an individual capability so to be easily conceptualized as a “fit trait”. To be a bit more specific, if a gene-centred biological-evolution perspective were fully able to explain cultural evolution – and the plethora of *innovations* it is bringing about since “the deep-time” – it would likely explain: a) the emergence of creativity as a capability of individuals in the human lineage, as well as the subsequent spreading and fixation of such a trait, and b) a number of (if not all) the key cultural innovations that made our species as we know it nowadays, such as, complex sociality, complex articulate language, complex

technology, complex transmission strategies up to proper teaching¹⁶, complex institutions, and possibly even more recent ones like the fine arts, modern science and contemporary hi-tech. However, there are at present at least two main reasons to overcome that perspective, and to acknowledge that cultural evolution has a certain independence of – i.e., it is not completely reducible to – genetic evolution.

The first and quite general reason has to do with advances in evolutionary biology as such. Indeed, thanks to empirical findings and theoretical developments, the gene-centrism characterizing the Modern Synthesis is being overcome. Emergence of biologically relevant novelty (i.e. variation production) is acknowledged to happen properly at the phenotypic level, including also behaviour and cognition, without necessarily requiring gene change¹⁷. Transmission of biological information (i.e. variation transmission) is not only genetic inheritance but also behavioural and symbolical¹⁸, as well as environmental¹⁹ – i.e., organisms pass to future generations not just genes, but also behaviours, information and knowledge, as well as a modified environment²⁰. Natural selection (responsible for variation selection) is still considered in terms of environment eliminating unfit organisms, but the environment is now regarded as something that organisms actively modify and that can induce relevant novelty in the organisms dwelling in it²¹. Overcoming gene-centred approaches to biology and evolution is one of the most important emphasis of the so-called Extended Evolutionary Synthesis²². These developments have, and will have, momentous and widespread consequences in biology. They are relevant for anthropology as well – especially because, roughly speaking, the human species finds in behavioural, cognitive and cultural innovation and transmission the keys of its constitution²³. Now, if evolutionary biology as such attributes

¹⁶ Teaching can be intended as an intentional and dedicated transmission strategy where a) both the expert(s) and the beginner(s) are aware of the ongoing process and of their respective roles in it, and b) in which non-transparent aspects of the taught contents are made explicit by the expert to the advantage of the beginner.

¹⁷ A.P. Moczek, S. Sultan, S. Foster, C. Ledón-Rettig, I. Dworkin, H.F. Nijhout, E. Abouheif, D.W. Pfennig, *The role of developmental plasticity in evolutionary innovation*, “Proceeding of the Royal Society B”, 278 (2011), pp. 2705-2713; M.J. West-Eberhard, *Developmental Plasticity and Evolution*, Oxford University Press, Oxford, UK 2003.

¹⁸ E. Jablonka, M.J. Lamb, *Evolution on Four Dimensions. Genetic, Epigenetic, Behavioral and Symbolic Variation in the History of Life*, The MIT Press, Cambridge, MA and London, UK 2014.

¹⁹ J. Odling-Smee, *Niche constructing phenotypes*, in X. Plotkin (ed.), *The Role of Behavior in Evolution*, The MIT Press, Cambridge, MA 1998.

²⁰ G. Buffon, I. Colagè, *Pedagogical Ecology for an Alternative Sustainability: With Insights from Francis of Assisi and Contemporary Life Sciences*, “Sustainability” 14 (2022), p. 1395.

²¹ J. Odling-Smee, K.N. Laland, M.W. Feldman, *Niche construction*, *American Naturalist* 147 (1996), pp. 641–648; K.N. Laland, B. Matthews, M.W. Feldman, *An introduction to niche construction theory*, “Ecology and Evolution”, 30 (2016), pp. 191-202.

²² K.N. Laland, T. Uller, M.W. Feldman, K. Sterelny, G.B. Muller, A. Moczek, E. Jablonka, J. Odling-Smee, *The extended evolutionary synthesis: Its structure, assumptions and predictions*, “Proceeding of the Royal Society B” 282 (2015), p. 20151019; M. Pigliucci, *An Extended Synthesis for Evolutionary Biology*, “Annals of the New York Academy of Sciences” 1168 (2009), pp. 218-228.

²³ See, for example: T.W. Deacon, *The Symbolic Species: The Co-evolution of Language and the Brain*, W.W. Norton & Co, New York 1997; K.N. Laland, *Darwin's Unfinished Symphony: How Culture Made the Human Mind*, Princeton University Press, Princeton, NJ 2017.

a role to behaviour and cognition in the evolution of life forms with no cultural dynamics – or with incipient or elementary cultural manifestations – it should *a fortiori* acknowledge the relevance of such “supra-genetic” levels in human evolution, and in human cultural evolution specifically.

The second reason to overcome the gene-centric view stems from archaeological and paleo-anthropological considerations. If genetic evolution were sufficient for the emergence of creativity and ensuing (cumulative) cultural evolution, this should have happened through production of chance genetic mutations, selection of successful variants, and the ensuing emergence of a new cognitive endowment adapted to typically human creativity. This, in turn, would imply that innovations comparable (in terms of novelty and cognitive requirement) to those that our species produced in Africa at first should not be found outside of Africa before 60-70,000 years ago (i.e., before *H. sapiens* dispersed out of Africa). However, the patchy and discontinuous pattern of cultural innovations in the last 800,000 years seems generally incompatible with the idea that such pattern is the consequence of a parallel and underlying pattern of genetic evolution²⁴. Moreover, symbolic manifestations seemingly implying a cognition similar to our own one do not appear to be the outcome of a “cognitive revolution”²⁵ ensuing the sudden evolution of a novel brain anatomy; rather, they seem to spring from complex, nonlinear cultural trajectories. Indeed, many recent archaeological discoveries – or reassessment of known objects – suggest that many key cultural innovations appeared outside of Africa well before our species colonized those areas²⁶. Significant evidence is now available that cultural manifestations comparable to those attributed to *H. sapiens* in Africa have been developed in Eurasia well before the arrival of our species²⁷. This is incoherent with the idea that symbolic manifestations and other aspects of cumulative cultural evolution are the outcome of a new cognitive architecture deriving from a speciation event occurred in Africa at least 260,000 years ago²⁸, or to a neural rearrangement (possibly

²⁴ I. Colagè, F. d’Errico, *Culture: the driving force of human cognition*, “Topics in Cognitive Science”, 12 (2018), pp. 654-672.

²⁵ Cf. S. McBrearty, A.S. Brooks, *The revolution that wasn’t: a new interpretation of the origin of modern human behavior*. *Journal of Human Evolution* 39 (2000), pp. 453-563.

²⁶ See, for example: F. d’Errico, C.B. Stringer, *Evolution, revolution or saltation scenario for the emergence of modern cultures?*, “Philosophical Transactions of the Royal Society B” 366 (2011), pp. 1060-1069; P. Villa, W. Roebroek, W., *Neandertal demise: an archaeological analysis of the modern human superiority complex*, “PLoS ONE” 9 (2014), p. e96424.

²⁷ See, for example: D.L. Hoffmann, C.D. Standish, M. García-Diez, *et al.*, *U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art*, “Science” 359 (2018), pp.912-915; J. Jaubert, S. Verheyden, D. Genty, *et al.*, *Early Neanderthal constructions deep in Bruniquel Cave in southwestern France*, “Nature » 534 (2016), p. 111; J.C.A. Joordens, F. d’Errico, F.P. Wesselingh, *et al.*, *Homo erectus at Trinil on Java used shells for tool production and engraving*, “Nature” 518 (2015), pp. 228-231.

²⁸ This idea is put forward, for example, by F. L. Coolidge, T. Wynn, *The rise of Homo sapiens: The evolution of modern thinking*, Oxford University Press, Oxford, UK 2018. For the dating of the emergence of our species *H. sapiens* at 260,000 years ago see: C.M. Schlebusch, H. Malmström, T. Günther, P. Sjödin, A. Coutinho, H. Edlund, A.R. Munters, M. Vicente, M. Steyn, H. Soodyall, M. Lombard, M. Jakobsson, *Southern African ancient genomes estimate modern human divergence to 350,000 to 260,000 years ago*, “Science” 358 (2017), pp. 652-655.

due to a key genetic mutation within our species) happened about 50,000 years ago, always in Africa²⁹.

These and other, related considerations have prompted the recent proposal of a model of cultural evolution that fully acknowledges the irreducibility of cultural evolution to biological – namely, genetic – evolution³⁰, and that has been applied to the emergence of number symbols³¹ and, more generally, to the emergence of symbolic representations³² in human cultural evolution. Interestingly, this model also proposes specific mechanisms at the basis of cultural evolution. We now turn to this model, and its proposed mechanisms.

3. THE MECHANISMS OF CULTURAL EVOLUTION

Once the idea that cultural evolution is not totally reducible to gene-centred biological evolution is embraced, the issue of the specific mechanisms animating cultural evolution must be posed: they cannot be any longer the same ones at the basis of genetic evolution. The model we will take as a reference point in what follows identifies two fundamental mechanisms at the basis of cultural evolution. As we will see, though many kinds of interactions between genes and culture³³ are fully compatible with this model, the two proposed mechanisms do *not* require parallel genetic evolution, neither as a preparatory and triggering cause, nor as an ensuing necessary effect. They may act independently of gene change. They have been labelled “cultural exaptation” and “cultural neural reuse”. These two mechanisms are intended to explain the emergence and stabilization of cultural *innovations*. Therefore, they do not focus on the individual level but mainly consider the social dimension. However, on this level they appear to be capable of explaining *how* cultural

²⁹ R.G. Klein, *Anatomy, behavior and modern human origins*, “Journal of Word Prehistory” 9 (1995), pp. 167-198.

³⁰ F. d’Errico, I. Colagè, *Cultural Exaptation and Cultural Neural Reuse: A mechanism for the emergence of modern culture and behaviour*, “Biological Theory”, 13 (2018), pp. 213-227.

³¹ F. d’Errico, L. Doyon, I. Colagè, A. Queffelec, E. Le Vraux, G. Giacobini, B. Vandermeersch, B. Maureille, *From number sense to number symbols. An archaeological perspective*, “Philosophical Transactions of the Royal Society B” 373 (2017), p. 20160518.

³² E. Mellet, I. Colagè, A. Bender, C.S. Henshilwood, K. Hugdahl, T.C. Lindstrøm, F. d’Errico, *What processes sparked off symbolic representations? A reply to Hodgson and an alternative perspective*, “Journal of Archaeological Science: Reports” 28 (2019), p. 102043.

³³ Gene-culture co-evolution has been an important topic in human evolution studies in the last almost half a century (see: K.N. Laland, J. Odling-Smee, S. Myles, *How culture shaped the human genome: Bringing genetics and the human sciences together*, “Nature Reviews Genetics” 11 (2010), pp. 137-148). It concerns cases in which the existence of a cultural strategy in a population constitutes a selective factor able to influence the genetic evolution of that population. Gene-culture co-evolution has the historical merit of emphasizing the relevance of culture for biology. However, it is an instance of “classical” population genetics (how natural selection in a certain environment drives the distribution of genetic variation within a population) where the cultural strategy concerned can be conceptualized as a further “environmental” factor relevant to natural selection. In other words, gene-culture co-evolution explains genetic evolution also considering the presence of cultural strategies but does not elucidate how and why the cultural strategy emerged and stabilized.

innovations may actually emerge. In this sense, they can capture fundamental (social) aspects of creativity.

We will also complement the presentation of the two mechanisms with a subsection dedicated to the relevance of transmission in the overall model, then emphasizing how it is a key prerequisite for creativity and ensuing cultural evolution.

3.1. Cultural Exaptation

In 1982, Stephen Jay Gould and Elisabeth Vrba introduced the notion of exaptation³⁴ in evolutionary biology to indicate traits that have not been selected for the function they fulfil at a certain time, but that evolved either for another function or for no function at all. The key point is that biological exaptation allows for a new function to be implemented without waiting for *genetic* evolution to provide a structure dedicated to that function. A pre-existing structure may be co-opted for the new function even when the previous evolution of the co-opted structure is unrelated to the novel function. Once the pre-existing trait is exapted, it evolves also according to the constraints imposed by the new function, and comes to be progressively refined by natural selection of genetic variations. In other words, genetic evolution may refine a structure in view of a novel function *only after* the new function has already emerged, and it is not required for the emergence of the new structure to fulfil the new function.

A classic example of exaptation is that of birds' feathers³⁵, which seemingly first emerged for thermoregulation and were only later "exapted" for flying – and successively refined and diversified for the specific needs of their carriers. In general, the old function of an exapted structure does not need to disappear, as the exapted trait may keep performing the old function as well.

Cultural exaptation applies this idea to cultural innovations and refers to the co-option of existing cultural features for new purposes.³⁶ Cultural exaptation, as understood here, does *not* require concomitant biological exaptation; even less it requires heritable genetic changes as a prerequisite. Cultural exaptation occurs at the truly cultural level. In analogy with biological exaptation, however, the co-opted cultural feature may have been originally introduced for purposes quite different from the one for which it later became "culturally exapted". In some cases, as we will see shortly, a utilitarian cultural feature may be co-opted for nonutilitarian, aesthetic, or symbolic aims. It is exactly along this process that creativity – as the source of innovations – unrolls.

The use of ochre – natural earth pigment containing hydrated iron oxides – may provide an example. It has been shown that compounds made with ochre are powerful photo-protective means to shield the skin from harmful ultraviolet radiation.³⁷ There is evidence suggesting symbolic use of iron-rich pigments on personal ornaments since at least 80,000 years ago in

³⁴ S.J. Gould, E.S. Vrba, *Exaptation—a missing term in the science of form*, "Paleobiology" 8 (1982), pp. 4–15.

³⁵ S.J. Gould, E.S. Vrba, *Exaptation*, cit.

³⁶ F. d'Errico, I. Colagè, *Cultural Exaptation and Cultural Neural Reuse*, cit., pp. 215-16.

³⁷ R.F. Rifkin, L. Dayet, A. Queffelec, B. Summers, M. Lategan, F. d'Errico, *Evaluating the photoprotective effects of ochre on human skin by in vivo SPF assessment: Implications for human evolution, adaptation and dispersal*, "PLoS ONE" 10 (2015), p. e0136090.

Africa.³⁸ One can envision a scenario in which ochre was first exploited for its photoprotective function and, in a later phase, through cultural exaptation, became a means, for example through body painting, to reinforce cultural mechanisms related to intra- and inter-group self-identification leading to the emergence of diversified symbolic material cultures. A subsequent cultural exaptation may have occurred in an already fully symbolic context, when ochre was purposely employed on ornaments and clothes. As with biological exaptation, the old function of the culturally exapted trait does not necessarily disappear after exaptation.

It is worth stressing that in the example above, especially in the last step (when ochre was used on ornaments), there are, actually, two strictly related but distinguishable processes. One is the application of a pre-existing strategy to a novel end: using ochre pigments to paint objects and not the skin. The other is the combination of two strategies into a single more complex process: the strategy to produce the (uncoloured) ornament (which is quite complex *per se*), and the strategy to produce and apply the pigment (which is complex too, requiring many different steps). Regarded in this way, the process comes really very close to give rise to “an intentional configuration of material and cultural elements that is unexpected for a given audience”³⁹ – as we have seen with the definition of creativity in sociology. This is also linked with the idea of “*conceptual combination*” as a fundamental spur for creativity at the individual level. Introduced by Michael Mumford and colleagues, “conceptual combination refers to the creation of new knowledge structures through the integration of previously distinct concepts or, alternatively, the rearrangement of elements within an existing concept”.⁴⁰

3.2. Cultural Neural Reuse

Cultural exaptation directly concerns cultural strategies and practices, as we have just seen. The cultural evolution model we are focusing on also highlights a mechanism through which cultural practices may affect the involved *neural* substrates – i.e., they may induce changes at the functional or anatomical brain level – again *without* involving underlying genetic changes.⁴¹ This mechanism has been labelled “ontogenetic or cultural neural reuse”⁴². Before entering in little more detail, it is worth stressing that this notion can be shown to have broad implications⁴³, and to open fruitful research paths⁴⁴, for a comprehensive and interdisciplinary understanding of the human being, its evolution and its constitution.

³⁸ F. d’Errico, L. Backwell, *Earliest evidence of personal ornaments associated with burial: the Conus shells from Border Cave*, “Journal of Human Evolution” 93 (2016), p. 91e108.

³⁹ F. Godart, S. Seong, D. Phillips, *The Sociology of Creativity*, cit., p. 14.2.

⁴⁰ G.M. Scott, D.C. Lonergan, M.D. Mumford, *Conceptual Combination: Alternative Knowledge Structures, Alternative Heuristics*, “Creativity Research Journal” 17 (2005), pp. 79–98, p.80. See also: M.D. Mumford, M.I. Mobley, C.E. Uhlman, R. Reiter-Palmon, L.M. Doares, *Process analytic models of creative capacities*, “Creativity Research Journal” 4 (1991), pp. 91-122.

⁴¹ F. d’Errico, I. Colagè, *Cultural Exaptation and Cultural Neural Reuse*, cit., pp. 216-217.

⁴² I. Colagè, P. D’Ambrosio, *Exaptation and neural reuse: A research perspective into the human specificity*, “Antonianum” 89 (2014), pp. 333-358.

⁴³ I. Colagè, *Human specificity: recent neuro-scientific advances and new perspectives*, “ESSSAT News and Reviews” 23/2 (2013), pp. 5-19.

The notion of neural reuse – in its original sense and without the specification “cultural” to which we will come shortly below – has been introduced in the last less than two decades⁴⁵ to indicate that for a new *cognitive* function to emerge it is *not* always necessary that genetic evolution produces *new* brain areas specifically dedicated to fulfil that function. A pre-existing brain area or region – already evolved for a previous function – may be *reused* and put at the service of a new cognitive function, provided that the basic information-processing capabilities (or “workings”) of the reused region are somehow apt to fulfil the new function. Neural reuse is an evolutionary thesis and constitutes a specific form of *biological* exaptation of brain areas and circuits. As in “ordinary” biological exaptation, the reused brain area undergoes evolutionary refinement, constrained by the new role it assumes, only *after* it has been reused⁴⁶. Once reused, the brain area begins to work in a novel (or at least partially different) brain network with respect to the one where it worked previously, so that not only the reused area, but also the *newly resulting network* begins to evolve, via the ordinary mechanism of genetic variation and natural selection, under the constraints posed by the new function and the specifics of the network.

Let us now come to the “cultural version” of neural reuse. *Cultural* neural reuse differs from the general, or “non-cultural”, neural reuse in that it refers to a reuse of brain areas that a) happens at the ontogenetic timescale (i.e., during the individual lifespan, and *not* on the trans-generational, evolutionary level), and b) is induced by the acquisition of a cultural strategy or practice⁴⁷. Cultural neural reuse points to cases in which exposure to cultural practices induces the formation, activation, or stabilization of new functional and/or structural brain networks during the individual lifespan. It can be regarded as a particular case of neural plasticity⁴⁸ that, however, is not limited to local brain processes of synaptic selection and strengthening (as it involves changes in connectivity among different brain regions scattered across the cortex) and is not limited to developmental stages (as it can occur even in late adulthood). Indeed, the cultural reuse of a certain brain region for a novel function usually implies that such a brain region begins to work with other areas with which it did not work prior to reuse. Therefore, reuse of a brain region and formation of a new brain network are the two sides of the coin of cultural neural reuse. The changes induced by cultural neural reuse are *not* heritable via *genetic* inheritance.

Literacy acquisition (learning to read and write) probably is the best documented case of cultural neural reuse. The invention of writing may be considered as the most recent and

⁴⁴ I. Colagè, *Prospective Fruitfulness as a Criterion for Theory-Change and Research-Strategy Option*, “Comprendre, revista catalana de filosofia” **16** (2014), pp. 61-86.

⁴⁵ See, for example: M.L. Anderson, *Neural reuse: a fundamental organizational principle of the brain* “Behavioral and Brain Sciences **33** (2010), pp. 245-313; Id., *After phrenology: neural reuse and the interactive brain*. MIT Press, Cambridge 2014.

⁴⁶ M.L. Anderson, *Massive redeployment, exaptation, and the functional integration of cognitive operations*, “Synthese” **159** (2007), pp. 329-345.

⁴⁷ S. Dehaene, L. Cohen, *Cultural recycling of cortical maps*, “Neuron” **56** (2007), pp. 384-398.

⁴⁸ P. D’Ambrosio, I. Colagè, *Extending epigenesis: from phenotypic plasticity to the bio-cultural feedback*, “Biology and Philosophy” **32** (2017), pp. 705-728.

fundamental turn in the human way of living and thinking⁴⁹. In the last two decades, several neuroscientific studies have inquired into the neural substrates of the human ability to read⁵⁰. Without entering into too much technical details⁵¹, when a human being learns to read, a new network actually forms that strengthens the connections between left visual areas (in the fusiform gyrus) for objects and face recognition, and the core system dedicated to spoken articulate language (encompassing superior temporal, inferior parietal and inferior frontal areas in the left hemisphere). The brain region reused to read is a small portion of the left fusiform gyrus that has been called the “visual word form area” (VWFA)⁵², and it is precisely this region that also becomes more strongly connected with the core system for spoken language⁵³.

The relevant points to be stressed in this context are the following:

- Reading is a quite recent cultural innovation, invented for the first time 6,000 years ago in Mesopotamia, and until recent times only a tiny minority of humanity had this ability. Thus, it is improbable that ordinary biological evolution endowed our brain with a network suitable for reading. We did not evolve to read.
- Reading requires intense and enduring training (typically, years at school) to be acquired fluently. It can also be acquired in late adulthood. It cannot be acquired “spontaneously” as it instead happens in learning a spoken language (especially one’s own native language).
- Written language is a graphical rendering of spoken language. Written words are visual symbols of the corresponding spoken sounds or, in some ancient writing systems, symbols corresponding to the meaning of spoken word(s). This explains why reading induces connections between visual and spoken-language areas in the brain.

Literacy is not the only example of cultural neural reuse. Other examples include arithmetic⁵⁴ – as mentioned – but also tool making⁵⁵, spoken language itself⁵⁶ (to some extent at least), and other cognitive functions. We will not deal with them here, however.

⁴⁹ M. Donald, *Origins of the modern mind: three stages in the evolution of culture and cognition*, Harvard University Press, Cambridge 1991; W. Ong, *Orality and literacy: the technologizing of the world*, Routledge, New York 2002.

⁵⁰ Some of the key reviews presenting the relevant data and implication on the issue are: G. Jobard, F. Crivello, N. Tzourio-Mazoyer, *Evaluation of the dual route theory of reading: a metanalysis of 35 neuroimaging studies*, “NeuroImage” 20 (2003), pp. 693-712; S. Dehaene, F. Pegado, L.W. Braga, P. Ventura, Nunes Filho G., A. Jobert, G. Dehaene-Lambertz, R. Kolinsky, J. Morais, L. Cohen, *How learning to read changes the cortical networks for vision and language*, “Science” 330 (2010), pp. 1359-1364; S. Dehaene, L. Cohen, *The unique role of the visual word form area in reading*, “Trends in Cognitive Science” 15 (2011), pp. 254-262; T. Hannagan, A. Amedi, L. Cohen, G. Dehaene-Lambertz, S. Dehaene, *Origins of the specialization for letters and numbers in ventral occipitotemporal cortex*, “Trends in Cognitive Science” 19 (2015), pp. 374-382.

⁵¹ Which the interested reader can find in the literature quoted in the previous footnote.

⁵² L. Cohen, S. Dehaene, L. Naccache S. Lehericy, G. Dehaene-Lambertz, M.-A. Hénaff, F. Michel, *The visual word form area. Spatial and temporal characterization of an initial stage of reading in normal subjects and posterior split-brain patients* Brain 123 (2000) pp. 291-307.

⁵³ M. Thiebaut de Schotten, L. Cohen, E. Amemiya, L.W. Braga, S. Dehaene, *Learning to read improves the structure of the arcuate fasciculus*, “Cerebral Cortex” 24 (2014), pp. 989-995.

⁵⁴ For review: A. Nieder, S. Dehaene, *Representation of number in the brain*, “Annual Review of Neuroscience” 32 (2009), pp. 185-208.

There are two further important specifications about cultural neural reuse that are worth being made explicit for our arguments. First, it likely always involves as a preparatory step a cultural exaptation. Indeed, cultural neural reuse cannot be considered as the cause of the emergence of a cultural innovation (such as literacy in our main example, or the other mentioned cognitive functions): the former is actually triggered by the exposure to the latter. Cultural neural reuse may constitute a process able to stabilize a cultural innovation within a population – and this is all the more important especially from the perspective of cultural evolution as not reducible to genetic evolution, and even not involving heritable genetic changes. However, it unlikely can be the source of the innovation. For this reason, in what follows we will mainly focus on cultural exaptation – which, as we will see, is a plausible mechanism for emergence of cultural novelties and, thus, the context for creativity to take place. The second specification is that cultural neural reuse likely always involves dedicated transmission strategies as an accompanying process. This is evident for literacy and arithmetic, and it is reasonable to assume it is generally the case since remodelling of brain structures up to the point of creating a new (functional or structural) brain network is unlikely to happen suddenly and without strong, enduring and targeted (external) stimuli. In conclusion, we emphasize that a relevant implication of cultural neural reuse is that it shows how *creative* processes – like those bringing about true innovations in cultural evolution, such as literacy and many other ones – have the potential to induce changes also on the anatomical and physiological neural level, and not just on the level of behaviour and cognitive functions⁵⁷. Emphatically put, through cultural neural reuse, creativity may even shape human biological constitution.

3.3. Transmission Strategies

As we have just hinted at, the model of cultural evolution built upon the mechanisms of cultural exaptation and cultural neural reuse attributes a key role to transmission strategies. This appears to be crucial for cultural neural reuse, but it is even more important for cultural exaptation. Indeed, as far as cultural exaptation involves the repurposing and the novel combination/integration of *existing* cultural strategies, it is absolutely crucial that such cultural strategies are quite faithfully transmitted from generation to generation. Only this ensures the conditions of possibility for “old” cultural elements to be (re-)used – or, indeed, exapted – in new ways and in view of new aims. Consequently, emergence of cultural innovations can be expected (or “predicted”) to happen through the mechanisms emphasized by our model when:

⁵⁵ For example: E.E. Hecht, D.A. Gutman, N. Khreisheh, S.V. Taylor, J. Kilner, A.A. Faisal, B.A. Bradley, T. Chaminade, D. Stout, *Acquisition of paleolithic toolmaking abilities involves structural remodeling to inferior frontoparietal regions*, “Brain Structure and Function” 220 (2015), pp. 2315-31.

⁵⁶ For example: M.A. Arbib, *From monkey-like action recognition to human language: An evolutionary framework for neurolinguistics*, “Behavioral and Brain Sciences” 28 (2005), pp. 105-167, especially p. 108.

⁵⁷ I. Colagè, *The human being shaping and transcending itself: Written language, brain, and culture*, “Zygon” 50 (2015), pp. 1002–1021. In this paper, some broadly anthropological consequences of cultural neural reuse are discussed.

- i) the innovation somehow implies translation of context and/or repurposing of existing cultural items (requiring cultural exaptation);
- ii) the innovation (and/or some of its “elements”) are significantly opaque (not transparent) for potential learners in their operative implementation and/or long term goal – thus likely requiring dedicated teaching strategies to be transmitted⁵⁸;
- iii) the acquisition and implementation of, and ability to transmit, an innovation by a group member require intense and enduring training (possibly inducing cultural neural reuse).

Accordingly, empirical and experimental studies, as well as theoretical frameworks, suggest that transmission strategies are one of the pillars of cultural evolution and of the possibility to implement innovations. The first point to be considered is the *cumulative* character of human culture⁵⁹ – a character we have already briefly mentioned above. Every known human culture accumulates innovations over innovations, practices over practices – and even notions over notions. The key point, however, is not just in amassing items, but in building novelty upon pre-existing achievements⁶⁰. This is an essential prerequisite for cultural evolution. Without effective transmission strategies, cumulative culture will be impossible as, so to speak, each generation would be forced to restart from the beginning and reinvent everything.

Moreover, a great part of cultural innovations involves a strong *social* component. This point is clearly related to the social dimension of creativity addressed above. However, here the emphasis is on the fact that many cultural innovations not only are unlikely to be devised without a strong social dimension, but they also do not make much sense if not immersed in it. This social component of cultural evolution has been interestingly addressed by Michael Tomasello and his group thanks to the notion of “shared intentionality”⁶¹. Cultural innovations such as complex tools, languages, and institutions at all levels seem to require shared intentionality⁶², which is indeed regarded as a key for the “human adaptation to culture”⁶³. Shared intentionality is the ability and motivation to engage with others in collaborative activities with joint goals and intentions. This psychological attitude transforms social-cognitive skills widespread in the animal kingdom into “human-typical versions”⁶⁴. In particular, gaze following is transformed into joint attention, social manipulation into cooperative communication, group activity into real collaboration, and social learning into instructed learning (up to proper teaching).

Both cumulative culture and shared intentionality point to the relevance of *transmission strategies* as a fundamental force beneath cultural evolution. The literature about social

⁵⁸ See also footnote 16, above.

⁵⁹ C. Tennie, J. Call, M. Tomasello, *Ratcheting up the ratchet: On the evolution of cumulative culture*, “Philosophical Transactions of the Royal Society B”, 364 (2009), pp. 2405-2415.

⁶⁰ This feature of cumulative cultural evolution, in the framework of our proposal, may in part explain why cultures with more (and more complex) artifacts and practices are more inclined to further cultural evolution, as well as the fact that cultural evolution seems to accelerate its pace progressively.

⁶¹ M. Tomasello, M. Carpenter, *Shared Intentionality*, “Developmental Science 10 (2007), pp. 121-125.

⁶² M. Tomasello, M. Carpenter, J. Call, T. Behne, H. Moll, *Understanding and sharing intentions: The origins of cultural cognition*, “Behavioral and Brain Sciences” 28 (2005), pp. 675-735.

⁶³ M. Tomasello, *The human adaptation to culture*, “Annual Review of Anthropology” 28 (1999), pp. 509-529.

⁶⁴ M. Tomasello, M. Carpenter, *Shared Intentionality*, cit..

learning is enormous, and cannot be discussed here. However, there are reasons to think that sophisticated transmission strategies co-evolved with culture and with the progressive complexification of the cultural knowledges and practices to be passed on from generation to generation⁶⁵. Other studies⁶⁶ also address the issue of the coevolution of culture and transmission strategies from the neural viewpoint, further emphasizing the relevance of transmission strategies for the understanding of cultural evolution gained by the overall model⁶⁷ we are taking as reference for our discussion.

4. EXAPTATION, TRANSMISSION AND CREATIVITY

At the end of the previous section, we have stressed the importance of transmission strategies for cultural evolution, and in particular as a condition of possibility for cultural exaptation to occur. We have also hinted at the fact that transmission strategies co-evolved with the cultural practices to be transmitted. It can now be added that transmission strategies enhance fidelity of transmission – i.e. the exactness with which those practices are transmitted. Indeed, *imitation* is a key (and sophisticated) transmission strategy (based, roughly speaking, on copying what others do) playing a momentous role in human social learning. It can be defined as the propensity and ability to “copy the *form* of an action”⁶⁸, i.e., copying the minute details and not just attempting to reach the same end-result. Human beings also display an exalted form of imitation that has been labelled “over-imitation”⁶⁹, and has recently been formally defined as “imitation of perceivably causally *unnecessary* actions in relation to the goal of an action sequence performed by a model”⁷⁰.

Thus, transmission deeply rely on copying – and on doing it the most faithfully. *How can this constitute the root of creativity?* Creativity has to do with originality, unexpectedness, novelty; how can faithful transmission be placed at the root of creativity?

⁶⁵ M. Kline, *How to learn about teaching: An evolutionary framework for the study of teaching behavior in humans and other animals*, “Behavioral and Brain Sciences” 38 (2015), p. E31; F. d’Errico, W.E. Banks, *The archaeology of teaching: a conceptual framework*, “Cambridge Archaeological Journal” 25 (2015), pp. 859-866.

⁶⁶ T.J.H. Morgan, N.T. Uomini, L.E. Rendell, L. Chouinard-Thuly, S.E. Street, H.M. Lewis, C.P. Cross, C. Evans, R. Kearney, I. de la Torre, A. Whiten, K.N. Laland, *Experimental evidence for the co-evolution of hominin tool-making, teaching and language*, Nature Communication 6 (2015), pp. 1-8; D. Stout, N. Khreisheh, *Skill learning and human brain evolution: an experimental approach*. “Cambridge Archaeological Journal” 25 (2015), pp. 867-875.

⁶⁷ F. d’Errico, I. Colagè, *Cultural Exaptation and Cultural Neural Reuse*, cit., especially pp. 223-224.

⁶⁸ A. Whiten, N. McGuigan, S. Marshall-Pescini, L.M. Hopper, *Emulation, imitation, over-imitation and the scope of culture for child and chimpanzee*, “Philosophical Transactions of the Royal Society B” 364 (2009), pp. 2417-2428, p. 2418 (emphasis added).

⁶⁹ D.E. Lyons, A.G. Young, F.C. Keil, *The hidden structure of overimitation*, “Proceedings of the National Academy of Sciences of the United States of America” 104 (2007), pp. 19751-19756.

⁷⁰ S. Hoehl, S. Keupp, H. Schleihauf, N. McGuigan, D. Buttelmann, A. Whiten, *‘Over-imitation’: Review and appraisal of a decade of research*, “Developmental Review”, 51 (2019), pp. 90-108, p. 95 (emphasis added).

Let us now recap some already discussed points that, together with a few additional considerations, will offer an answer to this question. The first element is the sociological definition of creativity discussed above (Section 1): “an intentional configuration of material and cultural elements that is unexpected for a given audience”⁷¹. The word “configuration” points to the combination of existing material and cultural elements (which must already exist in order to be combined), and the reference to the “unexpected” points to the idea that such a configuration is in some sense novel, original, surprising. A similar reasoning holds also for the notion of conceptual combination we have seen (in Sub-sec. 3.1) to be central to psychology research on creativity. The use of the word “conceptual” surely depends on the psychological approach, but also hints at the fact that a novel configuration resulting in an innovation must be thought – or, better, *imagined* – at least partially before its implementation can be attempted. (Of course, this can be done individually or jointly.)

The second element is cultural exaptation. Actually, it is a combination of items; it gives rise to a novel configuration of material and cultural elements. It adds, however, the possibility to *repurpose* existing cultural strategies (and their possible combinations) in view of new goals. For both processes to occur, it is vital to have the *elements* that are to be combined and repurposed. It is exactly on this point that transmission strategies root creativity: by providing elements for it to work on. Under this light, over-imitation appears relevant too. Copying unnecessary action segments included – for whatever reason – in a goal-oriented complex action provides a repertoire that, though presently unnecessary, might turn out to be useful for future – *creative* – developments. It is also important to keep in mind that cultural exaptation (similarly to biological exaptation) does not necessarily imply losing the function that the exapted element fulfilled before exaptation. This is a solution to the potential tension between faithful transmission and creative developments. Novelty (or “creative developments”) does not need to happen “during” transmission: it usually emerges “on top” of (or “downstream”) faithfully transmitted information.

An interesting recent article by Oliver Schlaudt⁷² applies the notion of exaptation to the “co-evolution of technology and the mind”. We would like to briefly mention three points from this paper that will help clarifying our proposal in this contribution. First, in reflecting on technological evolution, the author stresses the relevance of the notion of exaptation exactly as it has been conceptualized in our reference model of cultural evolution and employed in what precedes – i.e., exaptation as the integration and repurposing of existing cultural strategies. Secondly, the author helpfully highlights important antecedents of this conception of exaptation “*ante litteram*” – i.e. before 1982, when the term was introduced in biology – and already applied to *cultural* evolution. These antecedents are found, among others, in the philosophies of Ludwig Noiré (1829-1889) and Michel Foucault (1926-1984). Noiré applied the idea to tool use and Foucault to the history of institutions. The third point is that – also elaborating on the just mentioned antecedents – the author generalizes the scope of exaptation by means of a generalization of the notion of tool. Besides the use of the notion of exaptation in biology, the author first acknowledges that the most widespread use of the notion concerns the evolution of “material tools” (i.e., the cultural evolution of technology); then, he stresses that it

applies to three other elements too: learned behavior, institutions, and language and writing. Accordingly, one can provisionally distinguish between four types of tools: material tools,

⁷¹ F. Godart, S. Seong, D. Phillips, *The Sociology of Creativity*, cit., p. 14.2

⁷² O. Schlaudt, *Exaptation in the Co- evolution of Technology and Mind: New Perspectives from Some Old Literature*, “Philosophy & Technology” 35 (2022), pp. 48.1-26.

physical or somatic tools, social tools, and symbolic tools. “Material tools” correspond to the traditional notion of tools as freely movable material objects, “somatic tools” refer to the use of one’s own body in learned behavior, “social tools” are institutions, and “symbolic tools” comprise spoken language and writing but also painting and the production of art works.⁷³

In this way, the notion of exaptation turns out to be generalized so to encompass the main cultural realms humanity engages in. This expansion of the scope of exaptation is interesting for our current argumentation because it allows us to apply our considerations not just to the “deep-time perspective”, but also to more recent cultural developments including, indeed, artistic production, institutional sets, and so-called theoretical culture (i.e. those dimension of culture developed mainly after the invention of writing and encompassing the fine arts, philosophy, as well as the natural and human sciences).

This, in turn, brings us to the last issue we would like to briefly address, i.e., the question about what *triggers* the creative process. Facilitating factors for the emergence of substantial cultural novelties are often related to:

- the natural environment⁷⁴ – what it affords and the challenges it poses;
- the social set⁷⁵ – different institutional frameworks, especially related to cultural transmission, either promoting or hindering innovation.

On top of such kinds of factors, what we might call “cultural contingencies” may occasionally play a very relevant role: particular natural happenings, accidental discoveries, or errors (including errors in transmission). However, the issue concerning the triggers of creativity is this. The farther we go back in time, the more the various devised cultural innovations have a survival and adaptive value. The closer we come to the present, the more we find that cultural innovations lack such a value, or their adaptive value is less effective or constraining in driving the process, or else it is not “immediate” and the advantages of the cultural innovation require time to become perceivable (so that the adaptive value cannot be considered as the motivation for innovating). To put it more intuitively: it is much more difficult to see the adaptive value of painting than of a hafted and sharpened stone tool. Consequently, if one can try to find the trigger of innovations in the needs they would allow to meet, this can work just for a subclass of innovations, especially the older ones more tightly linked to survival and adaptation needs. The issue is deepened by the assumption that – as we have seen – cultural evolution is not epiphenomenal to genetic evolution: under this assumption, indeed, chanceful genetic mutations cannot be a viable option either.

Another important class of triggering factors are those acting at the individual level, especially aspects related to the abovementioned intrinsic motivation principle of creativity. We bracketed this class of factors at the beginning of our contribution since, though acknowledging their potential role, they are not amenable to be studied by cultural evolution in the “deep-time perspective”.

It might be hypothesized, however, that precisely these factors may be crucial in triggering creative process even in absence of environmental challenges to survival and reproduction (as

⁷³ O. Schlaudt, *Exaptation in the Co- evolution of Technology and Mind*, cit. pp. 48.15-16.

⁷⁴ W.E. Banks, F. d'Errico, H.L. Dibble, L. Krishtalka, D. West, D. Olszewski, A. Townsend Peterson, D.G. Anderson, G. Christopher Gillam, A. Montet-White, M. Crucifix, C.W. Marean, M.-F. Sánchez-Goñi, H. Wohlfarth, M. Vanhaeren, *Eco-Cultural Niche Modeling: New Tools for Reconstructing the Geography and Ecology of Past Human Populations*, “PaleoAnthropology” 2006, pp. 68-83.

⁷⁵ M.J. Gelfand, J.L. Raver, L. Nishii, *Differences Between Tight and Loose Cultures: A 33-Nation Study*, “Science” 332 (2011), pp. 1100-1104

well as in absence of genetic mutations). Questions of origin always are the hardest ones. Solving the issues of the origin of creativity is outside the reach (of this contribution). Not by chance, we have been talking about the “*roots*” of creativity. However, a final consideration can be added. Recent literature about social learning and teaching as applied to cultural and cognitive evolution converges with our view that transmission strategies (and their evolution and sophistication) are at the root of the emergence of innovations and thus – according to what we have seen so far – of creativity. Although even this literature does not solve the issue of creativity in all its facets (something that we could expect only future interdisciplinary research might, one day, accomplish), it adds many key details, two of which are worth being considered here.

A study⁷⁶ enquiring the essentiality of social learning for human adaptation interestingly states that:

our uniquely developed ability to learn from others is absolutely crucial for human ecological success. This capacity enables humans to gradually accumulate information across generations and develop well-adapted tools, beliefs, and practices *that no individual could invent on their own*. We have entered the “cultural niche”⁷⁷.

We take this as a hint in favour of the idea that exactly the transmission strategies that are at the root of the creativity characterizing human cultural evolution can bring the process up to a deeply genuine social level, *beyond the single individuals*. Interestingly, the notion of cultural niche may also be considered as the place where two key aspects of our proposal coalesce into a unified system. The cultural niche can indeed be considered as encompassing both (i) the cultural *elements* to be combined and repurposed along cultural evolution, and (ii) the *transmission strategies* ensuring transmission of those elements and their potential combination and repurposing on the genuinely social level.

Another study⁷⁸, focused on pedagogy (i.e., “teaching”, according to the authors) as a fundamental human *faculty*, states that:

It [pedagogy] allows for the acquisition of knowledge contents that are not only functionally non-transparent, but that do not seem to (or actually do not) have any direct and perceivable adaptive value at all.⁷⁹

We take this as an argument in favour of the idea that exactly the transmission strategies at the root of the creativity characterizing human cultural evolution can uplift the process *beyond the adaptive value* of the devised innovations.

⁷⁶ R. Boyd, P.J. Richerson, J. Henrich, *The cultural niche: Why social learning is essential for human adaptation*, “Proceedings of the National Academy of Sciences of the United States of America” 108 (2011), pp. 10918-10925.

⁷⁷ R. Boyd, P.J. Richerson, J. Henrich, *The cultural niche*, cit. p. 10919.

⁷⁸ G. Csibra, G. Gergely, *Social learning and social cognition: The case for pedagogy*, in Y. Munakata, M.H. Johnson (ed.), *Processes of Change in Brain and Cognitive Development. Attention and Performance*, XXI, Oxford University Press, Oxford 2006, pp. 249-274.

⁷⁹ G. Csibra, G. Gergely, *Social learning and social cognition*, cit. p. 254.

5. CONCLUSION

We have addressed the issue of creativity from the viewpoint of cultural evolution, in the “deep-time” perspective. This has implied focusing more on the social level and on innovations than on creativity as an individual capacity. Cultural evolution has been considered as the “theatre” of creativity, the milieu where innovations occur. Focusing on a specific model of cultural evolution – based on the mechanisms of cultural exaptation and cultural neural reuse, and consistent with recent developments in both evolutionary biology and archaeology/paleo-anthropology – we have claimed that cultural evolution is independent of genetic evolution under important features.

This, conceptually and intuitively, opens up a space for creativity but, at a closer look, makes it more difficult to see what triggers creative processes. The idea we have proposed to solve this conundrum is that creativity finds its root in transmission strategies. Indeed, especially if considered from the side of innovations (i.e. novelties that reach social adoption, diffusion and stabilization), creativity unrolls through cultural exaptations, that is, combination, integration and repurposing of already existing cultural strategies and practices. For this to be the case, the “elements” to be combined, integrated and repurposed must be readily available to be worked on. Transmission strategies ensure the availability of such elements. Transmission strategies also make cultural neural reuse possible at all, as a step ensuing cultural exaptation and stabilizing the emerged innovations.

After having discussed this core idea, we have also seen that transmission strategies – i.e., social learning processes from imitation to pedagogy/teaching – seem to play two additional roles:

1. bringing the creative process up to a genuinely *social dimension*;
2. uplifting the creative process *beyond the adaptive value*.

Point 1. appears potentially able to bridge between the individual and the social sides of creativity. Point 2. seems promising in opening a path to address the issue of creativity without reducing it either to a process solely driven by survival and (immediately) adaptive value, or to an illusory and lucky chanceful process. Both points find their ground in the importance of transmission strategies.

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Abstract: This paper will enquire into the issue of human creativity from the viewpoint of cultural evolution and the mechanisms underlying it. Creativity certainly has an individual

and subjective dimension, but its social dimension is more and more acknowledged. This social dimension, moreover, is the one that can be addressed from the standpoint of cultural evolution. Current models in cultural evolution suggest it cannot be reduced, in its pace and fundamental mechanisms, to purely biological, genetic evolution. Genuinely cultural dynamics and drives boost the process. After presenting a specific model of cultural evolution based on the mechanisms of cultural exaptation and cultural neural reuse, the paper will focus on the importance of cultural transmission strategies (from various forms of social learning to proper teaching). The point the paper will make and argue for is that investing in transmission strategies is the root of creativity in cultural evolution. Dedicated transmission strategies actually create the conditions for having innovation in cultural evolution, hence prompting creative processes, by ensuring the availability of elements to be combined, integrated and repurposed by cultural exaptation. Finally, the ideas that transmission strategies may prompt the genuinely social dimension of creative processes and the possibility for innovations to go beyond the immediate adaptive value will be briefly discussed.

Keywords: cultural exaptation, cultural neural reuse, social learning, cultural evolution, innovation

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