Is Cultural Selection Creative?

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People don't invent complex tools, populations do. (Boyd et al. 2013, p. 3).

Abstract This paper aims to draw some theoretical relationships between two fields of research that have remained more separated than they should have: theories of creativity and theories of cultural evolution. Particularly, it argues that the mechanisms of cultural selection postulated by cultural evolutionary theories can make a hitherto neglected contribution to explanations of human creativity. To that end, I extrapolate the arguments in favour of the creativity of natural selection and weigh its applicability in the field of culture.

Keywords Creativity · Cultural evolution · Creativity of natural selection · Cultural selection

1 Introduction

The intelligent design argument (Paley 1802; Sober 2019) used for proving the existence of God can be reconstructed as follows:

(i) Biological organisms are designed objects.

(ii) Every designed object has a designer.

Therefore,

(iii) Biological organisms have a designer.

Dennett (1995) has argued that Darwin's theory provides sufficient means to refute the second premise, given that natural selection and not God would be the process responsible for the design. A 'cultural version' of the argument would apply almost trivially to cultural items, with the necessary modifications in the first premise and the conclusion (exchanging 'biological organisms' for 'cultural items'). On

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culture, it is typically assumed that if something has extraordinary characteristics, it must be the result of the cognitive abilities of a brilliant mind. In discussion with that, in this article, I want to explore how the involvement of Darwinian processes in the cultural domain applies to this modified version of Paley's argument. Particularly, the scope of my argument will consider a paradigmatic case of designed items: creative products. In that sense, I set myself to link two areas of research that have remained, from my perspective, less connected than they should have been: theories of creativity and cultural evolution.[1]

Theories of cultural evolution claim that culture evolves according to Darwinian principles (Acerbi and Mesoudi 2015). Although there are significant differences between schools, a significant subset of theorists – whom Sterelny (2017) calls the Californian school[2] – consider that, in some significant respects, both genetic and cultural transmissions behave in the same way (Cavalli-Sforza and Feldman 1981; Boyd and Richerson 1985), through a mechanism analogous to natural selection. These theories hold mechanisms of cultural selection guided by different biases (Richerson and Boyd 2005; Mesoudi 2011). In many cases, these theories draw an explicit analogy between natural and cultural selection. Particularly, it has been pointed out that biassed transmission processes – processes by which some cultural variants are favoured over others during the process of cultural transmission – are selective retention processes (Richerson and Boyd 2005, p. 79). In the same vein, Mesoudi defines cultural selection as 'any condition where one cultural trait is more likely to be acquired and passed on than an alternative cultural trait' (2011, p. 64).[3]

This application of Darwinian processes to the cultural domain would have straightforward consequences for creative products that would render false the cultural version of Paley's argument. Creative products are defined as original and functional items: original means that they are of a different type than what already exists; functional means appropriate, useful or adaptive concerning task constraints

[1] Although some relevant theorists of creativity, such as James (1880), Campbell (1960), and Simonton (1999), adopted an evolutionary perspective on this phenomenon, they did not explore the connection between creativity and cultural evolution that I am trying to propose.

[2] The other principal school is what Sterelny (2017) calls the Parisians. The Parisian school is that of cultural epidemiology, a proposal developed by Sperber (1996) and supported by other anthropologists. According to this school, cultural transmission generally implies a transformation, not a replication. I will not deal with it in this paper.

[3] Memetics also explains the cultural change as an evolutionary process (Dawkins 1976; Blackmore 2000; Dennett 1995, 2017). The term 'meme' designates pieces of culture subject to a Darwinian evolutionary process. According to this theory, culture evolves by differential replication of memes. The proposal I will try to put forward shares with memetics the strong analogy between natural and cultural selection. Likewise, Dennett (2017) argues that this theory has much in common with Californian's theory of cultural evolution. While my suggestion is compatible with memetics, I will draw on the Californian theory, particularly Richerson and Boyd (2005), since they focus more on the human processes that explain why some cultural items are replicated and others are not. In other words, if at least some culture changes in the way this theory states, my argument holds. A more detailed analysis of the link between Memetic Theory and Californian theories is beyond the scope of this paper.

(Boden 1991; Csikszentmihalyi 2014; Kozbelt et al. 2010; Kaufman and Glăveanu 2019; Runco and Jaeger 2012; Simonton 1999; Stein 1953; Sternberg and Lubart 1999). According to theories of cultural evolution, cultural products are the result of the 'collaboration' of innumerable people who may not even know each other nor have a complete understanding of the processes to which they contribute. In this sense, they open the possibility of leaving behind the conjecture that behind every brilliant invention there must be a brilliant mind that designs it. The consequences of applying the cultural-evolutionary framework to creative products, however, have not been sufficiently explored. For example, although theories of creativity have increasingly recognised that, to account for creative processes, it is necessary to posit other factors besides individual cognitive abilities, this research area does not usually consider cultural evolution.

How far-reaching the consequences may be, however, is disputed. Under a popular view of theories of cultural evolution, selectionist models built by Californians who, '*assuming the prior existence* of a certain set of variants, intend to explain the *distribution* of such variants' (Baravalle 2017, p. 295, italics and translation mine).[4] Thus, according to a preliminary view, it seems sensible to think that the selective mechanisms postulated by the theories of cultural evolution could not make a relevant contribution to theories of creativity as they could not explain the creation of new cultural variants. If one looks at the mechanisms of cultural evolution proposed by most theories of cultural evolution, one will see that they are of a selective type. But – this hypothetical argument in favour of the separation between cultural and creative processes would continue – the mechanisms of cultural selection only specify the conditions under which one cultural item or trait is more likely to be acquired and transmitted than another (Mesoudi 2011, p. 64). In short, cultural selection would consist of a set of mechanisms that aims at explaining the preferential selection of cultural items but not their emergence. Their emergence could still be accounted for in terms of individual design: creative processes would still be totally prior phenomena that generally occur at an individual scale and are determined by an agent's plan.

In this paper, I will provide an argument against this view and to counter the idea that individual cognitive processes are the only relevant factors to account for the emergence of creative products. Specifically, I will argue that the selective mechanisms postulated by theories of cultural evolution may make a hitherto ignored contribution to theories of human creativity. Specifically, it is a model according to which the two distinctive features of the aforementioned creative products, *originality* and *functionality*, can be explained, at least partially, by resorting to population selective mechanisms. As Boyd et al. (2013) point out in the epigraph to

[4] Although this quotation illustrates the thesis that I intend to dispute, it does not mean that my proposal contradicts what Baravalle defends in this article. Instead, I will also understand biases as mechanisms that modify the frequency of cultural items. However, I intend to argue that such a mechanism can be attributed to an explanatory role different from that assumed at first sight.

this chapter, sometimes it is not individuals who create sophisticated artefacts but rather populations.

To develop my argument, I draw on a dispute that has taken place in evolutionary biology and philosophy of biology: the debate on whether natural selection is a creative force (Wallace 1867; Weismann 1896; de Vries 1906, 1909; Morgan 1909, 1925; Chetverikov 1926; Dobzhansky 1974; Fisher 1958; King 1972; Gould 1977, 1982, 2002; Nei 2013; Orr 2005; Ayala 2007; Razeto-Barry and Frick 2011; Beatty 2016, 2019). The discussion is about whether natural selection constitutes a positive force or merely a negative one. If the latter is the case, selection would only eliminate unfit variants while the onset and direction of evolutionary change would be determined by the production of variation (for example, by mutation).[5] Those who endorse this view understand evolution by natural selection as a two-step process: first, variation occurs and, then, selection takes place.[6] Comparing selection to a sieve would summarise this view (see, for example, Sober 1984, p. 159). On the contrary, if natural selection is a positive force, then it may initiate evolutionary change and impart the direction of evolutionary change.[7] If it was shown that natural selection not only eliminates what is useless but also defines the course and timing of evolutionary change, it would seem that such a mechanism actively contributes to the creation of the designed traits of living organisms. Therefore, the correct analogy would not be that selection is like a sieve, but rather that selection is like a designer.

I take as sound the arguments for the creative force of selection in the natural domain and extend them to the cultural domain. My argumentative strategy consists of extrapolating the arguments in favour of the creativity of natural selection and weighing its applicability to the field of culture by considering cultural selection as a creative force. I then test this thesis by analysing real-world examples that show that the *originality* and *functionality* of creative products can and should be explained by resorting to cultural-evolutionary processes – granting a relevant role to the intervention of mechanisms occurring at the population level. These arguments show that, just as the contention that natural selection is creative disagrees with the conception of evolution by natural selection as a two-stage process, the contention claiming that cultural selection is creative disagrees with the separation between

[5] How this variation comes about is irrelevant for our purposes. I mention mutation because it is the prevailing way variation has been considered to occur. However, variation can also occur by genetic recombination. Moreover, since this discussion of the creativity of natural selection predates the incorporation of Mendelian genetics into Darwinism, to speak of mutation would be anachronistic. For this reason, we will keep the more general term 'variation'.

[6] Although this way of presenting the evolutionary process is quite widespread, it is nothing more than a didactic simplification (Dawkins 1996), which does not adequately describe how the vast majority of evolutionary biologists understand the process to occur (Beatty 2019). Thus, the view of evolution as a two-step process is called into question by the interpretation of natural selection as a creative force, which still prevails within evolutionary biology (Beatty 2019). The presentation of evolution as a two-step process (first variation, then selection) is found, for example, in Mayr (2004).

[7] As we will see later, many notable evolutionary biologists have subscribed to this interpretation of the creative nature of the Darwinian theory.

evolutionary processes and creative processes. Thus, in the same way that natural selection can account for the design of natural objects, so does cultural selection.[8]

I believe these arguments are relevant for constructing a naturalistic model of creativity.[9] While I do not want to deny the relevance of cognitive processes operating at the individual level for explaining the emergence of creative products, I do want to counter the idea that individual cognitive processes are the only relevant factors. In that sense, I favour a pluralistic model in which explanations from different levels can be seen as complementary to each other.

The structure of the paper is as follows: in the first section, I present a characterisation of creative products and evolutionary products according to the relevant literature in each case. Furthermore, I argue that it is possible to establish some equivalences between their distinctive features. In the second section, I expound on Beatty's (2016, 2019) definition of natural selection, according to which it is creative given that it (1) initiates and (2) directs evolutionary change. In the third section, I argue that cultural selection sometimes does indeed operate creatively.

2 Creative Products and Evolutionary Products

Psychologists and philosophers specialised in creativity agree that creative products must be, on the one hand, original or new and, on the other hand, useful, valuable, or functional (Boden 1991; Csikszentmihalyi 2014; Kozbelt et al. 2010; Kaufman and Glăveanu 2019; Runco and Jaeger 2012; Simonton 1999; Stein 1953; Sternberg and Lubart 1999). First, no one would consider a product creative if it is an exact replica of one that already exists. *Originality* is a fairly obvious requirement for creativity. Second, *functionality* is what allows us to distinguish a creative product from a delusion or an idea that is original but has no value whatsoever. On this second

[8] Someone might object that my argument incurs a sort of 'categorial error' since the analogised mechanisms (natural selection and cultural selection) are very different from each other. What I am going to offer is an argument by analogy. Arguments by analogy require that the analogised elements are not identical but share relevant aspects (Gensler 2003). The vast majority of the literature on cultural evolution understands that the processes of cultural evolution and biological evolution differ in important respects (e.g. in culture, inheritance is blending, and there is a lot of directed variation) but that they share relevant aspects. Centrally it is understood that there is, in both cases, a process of selection given that the conditions of variation, inheritance and differential fitness are met (Mesoudi 2011). The other starting point of the argument is that, as some evolutionary biologists have argued, the proper way to interpret how these features operate in the case of natural evolution is to indicate that natural selection sometimes initiates and directs evolutionary change and is, therefore, creative. I intend to argue that, in the same way, cultural selection sometimes initiates and directs evolutionary change (and it is, therefore, creative). Now, for this extrapolation to be well-founded, as we will see below, the significant similarities between natural selection and cultural selection must be conceived as high-level similarities.

[9] As it is known, naturalism has various meanings. Here I am referring to a model that considers scientific knowledge, especially the Darwinian theory of the evolution of species.

criterion, Simonton (1999) points out that its standard of application varies with the sort of domain considered. According to this author, in the technological domain[10] creative artefacts are functional if they work properly.[11] This definition of creativity in which a product to be creative must be both original and functional has been called the *standard definition of creativity* (Runco and Jaeger 2012).

The argument I am going to propose depends on this predominant conception of creativity. However, it is not the only possible conception of creativity. Some believe that a more restrictive definition of creativity is necessary. For example, according to Gaut (2010), creative products should also be the result of an intentional agency exhibiting relevant purposes and understanding. Specifically, Gaut (2010) holds that creative processes are, by definition, those that exhibit relevant purposes, understanding, some degree of judgement, and an evaluative capacity directed at the task at hand (Gaut 2010, pp. 1040–1041). To synthesise these traits, Gaut argues that creative actions must show *aptitude*.

If Gaut's characterization of creative products were adequate, this philosophical endeavour would be in trouble. In other words, if this conception were adopted, the evolutionary-cultural processes I want to consider would not furnish a relevant contribution to the understanding of creative processes. That is because, as we shall see, evolutionary-cultural processes have a population character, involving both cognitive and non-cognitive abilities, and intelligence is distributed in those processes. Therefore, these population processes could be left out of Gaut's proposed aptitude requirement for creativity. However, Gaut's position is in the minority, since the literature on creativity generally assumes that a product must be original and functional to be creative.[12]

Nonetheless, as Kozbelt et al. (2010), as well as Kaufman and Glăveanu (2019) state, the vast majority of theories of creativity address the phenomenon as an individual capacity.[13] Thus, most theories explain *originality* and *functionality*

[10] In the realm of philosophy of technique, some authors have proposed to distinguish between the generic term 'technique' and the more specific 'technology' – reserved for scientifically based industrial techniques – (see Quintanilla 2017, p. 46). However, I will keep the latter as a generic term because it is used as such in the literature on creativity (see Simonton 1999; Kozbelt et al. 2010; Kaufman and Glăveanu 2019).

[11] Simonton's characterisation is consistent with memetic approaches to artefacts but also more generally with any non-intentionalist views of artefactual function, such as those of Dennett (1990, 1995), Kelemen and Carey (2007), and Vermaas et al. (2013). Non-intentionalist perspectives on the artefactual function object to the idea that the designer's intentions determine the artefact's function. In turn, Simonton's characterisation is inconsistent with intentionalist views of artefactual function such as those of Dipert (1993), Kroes and Meijers (2006), or Cuevas-Badallo (2008). Those who rely on the analogy between artefacts and organisms try to move away from the intentionalist perspective.

[12] For a specific defence that the definition of creativity must depend on these products characteristics, see Briskman (1980). For an argument against the idea that creative processes must involve understanding, see Dennett (2001).

[13] Yet, researchers have recently argued that some creative processes are essentially collective (Glăveanu 2011). For example, Csikszentmihalyi's (2014) Systemic Model Theory. But, this theory

appealing to the cognitive abilities of the individual creator (cf. Kaufman and Glăveanu 2019, p. 34). Many of these theories hold or assume that creative achievements were caused by the individual cognitive abilities of some brilliant mind.[14]

Evolutionary theories, for their part, attempt to explain two main aspects: on the one hand, the *diversity* of traits present in living organisms; and, on the other hand, the complexity of the *adaptations* of these traits to their environments (Mesoudi 2011).[15] It is well known that evolutionary theory was originally developed to explain the origin and diversity of biological species, and later extrapolated to the realm of culture. Thus, cultural evolution is a growing scientific field that attempts to provide a naturalistic and quantitative explanation of cultural change. Cultural evolution studies assume that culture evolves according to Darwinian principles (Acerbi and Mesoudi 2015). Thus, cultural evolution studies have proposed a strong analogy between, on the one hand, the *diversity* present in living organisms and cultural items, and, on the other, the *adaptability* of living organisms and cultural items (Mesoudi 2011). Therefore, it would make sense to provide evolutionary explanations for the change of cultural items over time. Some have objected to this approach, since *diversity* and *adaptability* would be explained by the human understanding involved in the design process. However, cultural evolutionary theorists have argued that such understanding is insufficient (Richerson and Boyd 2005; Sterelny 2006; Dennett 2006, 2017). According to Dennett (2017, p. 75), 'top-down design is in fact responsible for much less of the design in our world than is commonly appreciated'. As I pointed out in the Introduction, according to cultural evolution theories, cultural products are the result of the 'collaboration' of countless people who may not know each other nor have a full understanding of the processes to which they contribute (Sober 1994; Sterelny 2006; Boyd et al. 2013). In Sterelny's terms (2006):

> [t]his impressive fit between aboriginal technical, ecological and social organization and their environment is prima facie support for a broadly evolutionary view of culture. For we can safely assume that these adaptive features of their social life were not consciously designed for Australian conditions by some local Plato. Rather, they were assembled piecemeal, just as the biological adaptations of eucalyptus to the same environment were assembled piecemeal (p. 146).

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still claims that the background and training of creative people are essential for the emergence of creative achievements.

[14] Note that this is the same assumption that the intelligent design argument had (Paley 1802) and it is now used to argue that the world was intentionally created by an intelligent being (see Sober 2019 for analysis).

[15] The idea that these are the main aspects explained by an evolutionary theory is present in the vast majority of evolutionary theories and models – such as Mesoudi's (2011), mentioned above. Although it is convenient for our purpose, it is a non-exhaustive characterisation which places special emphasis on explanations that resort to the action of natural or cultural selection. However, Darwin's theory of evolution also allows us to construct other types of explanations. For example, homologies are explained by appealing to the common ancestor (Blanco et al. 2020).

In developing their theories, Californian theorists of cultural evolution have constructed formal models to explain the distribution of traits over time. To build these formal models, they applied a similar method to that developed by Fisher, Haldane, and Wright for population genetics models (Cavalli-Sforza and Feldman 1981; Richerson and Boyd 2005; Mesoudi 2011). These models focus their attention on the long-term dynamics of cultural variants and not on individuals (Baravalle 2017). Generally, evolutionary theories explain the *diversity* and *adaptability* of traits of organisms or cultural items at a population level.

Cultural selection mechanisms occupy a central place in the theories of the Californians (Houkes 2012). Cultural evolution mechanisms refer to 'any condition where one cultural trait is more likely to be acquired and passed on than an alternative cultural trait (or no trait at all)' (Mesoudi 2011, p. 64). Among the most important processes are the action-driven processes of *content biases*, *frequency-dependent biases*, and *model-based biases* (Richerson and Boyd 2005). *Content biases* refer to the preferential adoption of features based on their intrinsic attractiveness. *Frequency-dependent biases* refer to the preferential adoption of traits by their frequency (e.g. adopting the most popular trait). Finally, *model-based biases* refer to the preferential adoption of traits based on the characteristics of the trait bearer (e.g. if s/he is successful).

Californian theories also account for the mechanisms responsible for providing cultural variation. According to the Californians, the mechanisms of variation are *cultural mutation* and *guided variation* (Mesoudi 2011). *Cultural mutation* refers to 'effects due to random individual-level processes, such as misremembering an item of culture' (Richerson and Boyd 2005, p. 69). *Guided variation* refers to nonrandom changes in cultural variants (see Richerson and Boyd 2005; Mesoudi 2011). According to Richerson and Boyd (2005, p. 69), it is the force that 'results from transformations during social learning, or the learning, invention or adaptative modification of cultural variants'.

The existence of *guided variation* in culture is connected to one of the main objections against theories of cultural evolution. It is objected that the project of explaining cultural change according to Darwin's theory is somehow erroneous, given that one of its principles is that variation is blind. This does not seem to be the case in the cultural domain, where the appearance of new variants is sometimes conditioned by the possibilities of their subsequent selection. So, there is a disanalogy between biological and cultural evolution since in the former, variation is random and, in the latter, variation is directed. However, different researchers have argued that this is not a problem for theories of cultural evolution (Sober 1994, p. 487; Ginnobili 2016; Mesoudi 2011). According to such an objection, in Darwin's theory, variation *has to be* blind to evolutionary change. However, as Ginnobili (2016) points out, in Darwin's theory, variation *can be* blind to evolutionary change. In other words, Darwin claimed that variation does not necessarily have to arise in response to a need. This does not imply that if a characteristic is not 'blind', there is no point in appealing to an explanation by natural selection. Mesoudi (2011) defends something similar when he states that guided variation is not necessary to explain the diversity observed in the natural world, but this does not imply that it is incompatible with Darwinian evolutionary theory. Thus, there would be no impossibility, in principle, of including guided variation in Darwinian models.

Now, I think that the component of (creative) *originality* is equivalent to that of (evolutionary) *diversity* and that the same is true of (creative) *functionality* and (evolutionary) *adaptability*. *Originality* and *diversity* would be equivalent, for they play the same role in the phenomena at stake (creativity and evolution). Given a set of items, the emergence of a new one could be either a repetition of what already exists (which would imply that a new specimen would come into existence, but not a new type of item) or an innovation. Both, creativity and evolutionary change require the emergence of something different: a novelty in type. The origin of something different allows creative *innovation* and results in the *diversity* on which selection acts to bring about evolutionary change.

On the other hand, (creative) *functionality* and (evolutionary) *adaptability* seem to be the same kind of normative dimensions.[16] *Functionality* is what makes a creative product valuable, worth preserving, and useful. In evolutionary theory, the *adaptation* of a biological or cultural trait refers to its adjustment to the environment. Such adjustment presumably favoured its conservation. Perhaps the sphere of creativity in which this equivalence is most clear is technology. As I pointed out above, in technological creativity, the second component of creative achievement (*functionality*) consists precisely in the fact that an artefact, in addition to being new, happens to work. This equivalence is supported by the comparison of artificial designs with biological organisms, which gave support to the Argument from Design (Paley 1802). Some interpretations argue that Darwinian theory shares Paley's intuition (natural organisms have many 'designed' features), but challenge the theological explanation of that design (Dennett 1995; Gould 2002). This equivalence allows Dennett (1995) to point out that we should literally understand biological organisms as designs. The equivalence also permits that the name chosen by Simonton (1999) for the second component of creative achievements is adaptability. Thus, although not without discussion,[17] we can say that, at least in the technological sphere, the analogy between functioning and adaptability is closer than in the artistic or scientific sphere (because, in the technological sphere, it is easier to determine if a product 'works').

More generally, the extensive literature on creativity assuming the adequacy, in some sense, of a Darwinian account of phenomena we call creative (Campbell 1960; Simonton 1999), also supports equivalences between (creative) *originality* and (evolutionary) *diversity,* and between (creative) *functionality* and (evolutionary)

[16] In fact, Simonton (1999) uses the term 'adaptability' to refer to this dimension of creative products.

[17] There are some ways to complexify what it means for something to work in the technological sphere. For example, Lemonnier (2013) argues that the 'technological choices' that different societies make are more the result of cultural values and social relations than the inherent benefits of technologies themselves. Even if this were true, it seems adequate to assert that, for some technological artefacts, it is possible to determine whether they perform a given function. Therefore, I do not consider that this type of complexity would jeopardise my analysis.

variability. Thus, based on the above equivalences and given that evolutionary theories assume that *diversity* and *adaptation* are, at least in part, explained by population selective processes, it seems sensible to take this debate about the creativity of natural selection as an indicator that these kinds of population processes could be extrapolated to the field of human creativity. The latter would allow us to partly explain *novelty* and *functionality* by the intervention of selective processes of the same population character. Although I consider that this analysis could also be applied to artistic and scientific spheres, for the time being, I will only keep in mind cases of technological creativity, a field in which I consider that the second equivalence (between *functionality* and *adaptability*) is more evident.

In summary, the mechanisms postulated by cultural evolution should be relevant to theories of creativity. The only reason for not contemplating this option would be that evolutionary processes take diverse and adaptive products for granted and only explain their distribution. Some evolutionary biologists have understood evolution in biology in this way. However, this is a minority position and one that can be considered anti-Darwinian (Razeto-Barry and Frick 2011; Beatty 2016, 2019). At stake is the discussion of whether natural selection constitutes a creative force. I present this discussion in the next section.

3 Is Natural Selection Creative?

Many researchers consider that the creativity of the natural selection thesis (hereafter CNST) is at the heart of Darwinian thought (Gould 1977, 1982, 2002; Ayala 2007; Razeto-Barry and Frick 2011; Beatty 2016, 2019). They also point out that some of the considerable objections that the theory has received are linked to this thesis (Gould 1977, 2002; Beatty 2016). But what precisely does the CNST consist of? While there is some polysemy in this thesis,[18] it mainly concerns the relative evolutionary contribution of natural selection and variation. Specifically, those who defend the CNST understand that variation is always available and that natural selection initiates and directs evolutionary change. In contrast, opponents of the thesis argue that variation is not always available and, therefore, natural selection must 'wait' for variation before it can act. In other words, there is a debate about

[18] The CNST also addresses the more general point that natural selection is a mechanism that *produces* evolutionary change and not one that *prevents* it. Thus, Gould (2002) points out that it distinguishes Darwin's theory from earlier theories that also postulated the existence of natural selection. For example, Blyth's theory (1835) held that natural selection is a process that eliminates extreme and maladaptive variants and thereby helps species to retain their essential traits. No one with an evolutionary perspective would argue against the idea that natural selection is a mechanism that contributes to change rather than conservation. Instead, the interesting discussion is about the role of this mechanism in evolutionary change. Thus, we will leave aside this interpretation of CNST, according to which it serves to distinguish an approach in which selection produces change from one in which it prevents change.

whether or not the origin of the traits of organisms is, among others, an *explanandum* of the theory of evolution by natural selection (Razeto-Barry and Frick 2011).

Through a historical-philosophical analysis, John Beatty (2016, 2019)[19] has reconstructed the arguments used at different historical moments by defenders and detractors of CNST. According to his analysis, two main positions can be established, an orthodox one in its defence of the Darwinian theory of the evolution of species and CNST, and a more critical one. In addition to Darwin himself, CNST was supported by Wallace (1867), Weismann (1896), Chetverikov (1926), Dobzhansky (1937, 1974), and Fisher (1958), among others. Some of its principal critics were de Vries (1906, 1909), Morgan (1909, 1925), King (1972), and Nei (2013). Beatty (2016, 2019) calls the position that opposes the CNST 'mutationist'[20] because it claims that mutation initiates and drives evolutionary change. Without ignoring that the mutationist current designates a more specific movement in biology, for the sake of simplicity, I will call the position defending CNST 'selectionist' and the position that criticises it 'mutationist'.

According to Beatty (2016, 2019), the CNST should be understood in terms of (1) natural selection *initiating* evolutionary change, and (2) natural selection *directing* evolutionary change. I will examine each of these assumptions.[21]

The first assumption is that (1) natural selection *initiates* evolutionary change. Although according to Beatty (2016, 2019), this assumption acquires different specificities in different historical moments, I will try to capture its more general meaning. A sensible way to illustrate this is to bring up two scenarios proposed by Darwin in the first edition of *The Origin of Species* (one of which he later eliminated). According to the first scenario, there is a population of wolves whose individuals are very diverse in terms of size and speed. Evolutionary change begins when an environmental change occurs and decreases the number of preys. This change makes the fastest wolves, for instance, those with the largest legs, more fit. After many generations, the entire population of wolves will have longer legs than at the initial time, when there still was greater diversity regarding this trait. As we know, natural selection refers to the non-random differential reproduction of phenotypes within a population. In turn, environmental conditions both favour and hinder the reproductive possibilities of living organisms. Thus, the environment

[19] Beatty (2016, 2019) makes a detailed historical reconstruction of the different instances in which the debate about the creativity of natural selection took place and the positions at stake. I will not go into that grain of detail here since it is irrelevant to my analysis.

[20] According to Beatty (2016, 2019), this position was held by mutationists such as Hugo de Vries and Thomas Hunt Morgan, and by neutralists such as Jack King and Thomas Jukes and Daniel Hartl and Clifford Taubes. However, they all share the idea that the TCSN is false. For this reason, he calls these neutralists 'neo-mutationists'.

[21] Beatty (2016) is offering a reformulation of Gould's (2002) proposal. According to Gould, CNST rests on three assumptions regarding the production of variation. First, variation is abundant and takes place in all directions. Second, while large-scale variation can occur, small-scale variation serves as the material for evolutionary change. Finally, the production of such variations is 'decoupled' from the direction of evolution. For the sake of length, I will directly consider Beatty's (2016) proposal, which I judge to be superior.

constitutes *selective* evolutionary pressures insofar as it impacts the reproductive success of phenotypes in the population. Therefore, an environmental change that modifies the reproductive success of individuals, decreasing the reproductive success of some of them, implies the natural selection of specific phenotypes. Hence, according to this scenario, natural selection initiates evolutionary change.

In the early editions of his famous book, Darwin proposed a second scenario which was, though, later eliminated. According to it, another variable triggers evolutionary change (let us call it a mutation). In this case, there appears a variation previously unavailable in the wolf population (such as a new food preference). This variation confers a high survival value, so natural selection preserves it and, many generations later, it is present in the entire population. Beatty (2016) points out that Darwin is satisfied only with the first conjectured scenario, which gives selection, rather than mutation, a more significant role.

Beatty's second assumption is that natural selection is creative to the extent that (2) it *directs* evolutionary change, 'for example by *creating the variation that it subsequently acts upon*' (Beatty 2019, p. 705). This principle has to do with the cumulative character of selection. The discussion in biology has been expressed in a simplified way as follows. In relation to the *mutationist* view, if natural selection was the only force involved, species might change up to a certain point, but then evolutionary change would come to a halt. According to this position, natural selection eliminates genetic variation to the point where evolution stops and then the appearance of new beneficial variations is necessary for the evolutionary change to restart. Thus, evolution would 'consume its own fuel' (Gould 2002, p. 142). In contrast, proponents of the CNST argue that beneficial variation is always present. This means that evolution by natural selection never stops due to lack of variation; and the process is initiated, directed, and redirected entirely by fitness differences in genes or phenotypic traits and fitness changes in fluctuating environments. Thus, the action of natural selection defines the direction of evolutionary change.

Assumption (2) refers, at least for early *selectionists* such as Wallace (1867) and Weismann (1896), to whether selection can shift the *range* of variation. This would occur if selection in a particular direction results in the production of subsequent variation in the same direction. In other words, the discussion at stake is whether selection, when choosing one variable within a range of possibilities, can make the possibilities available in subsequent generations 'move' in that direction.[22] Thus, the question about the responsibility of natural selection for the variation on which it then acts is not only about an increase in the proportion of an advantageous trait. Instead, as evolution by natural selection moves in a particular direction, there is an increasing amount of variation in that direction for natural selection to continue to

[22] However, as a reviewer remarked, this is not incompatible with asserting the importance of mutation within the evolutionary process. Indeed, *selectionists* recognise that mutation is ever present and in all directions (Beatty 2016).

act on.[23] According to CNST advocates, this is the case: natural selection shifts the range of variation. In contrast, opponents of CNST assume that if it were true that natural selection shifts the range of variation on which it then acts, then CNST should be considered true; but, according to *mutationists*, 'evolution by natural selection doesn't work like this' (Beatty 2016, p. 673).

However, evolutionary biologists associated with the Modern Synthesis offered a reformulation of assumption (2) that natural selection *directs* evolutionary change (Beatty 2019). While previous proponents of the CNST believed that the most appropriate level of variation for evolution was individual genes, these scientists consider that variation occurs at the level of genetic combinations. Selection leads to the emergence of new successful combinations of genes. While genetic mutations are a matter of chance, new gene combinations are, to some extent, the product of natural selection, as this mechanism would have preserved, in the past, some of the components that would later form part of promising combinations.

Some members of the Modern Synthesis went further and pointed out that evolution by natural selection actively favours the accumulation of genetic variation (e.g. Chetverikov 1926; Dobzhansky 1937). Without going into technical details, suffice it to say that certain biological processes allow us to conceive of species as 'sponges' that accumulate more genetic material than what is phenotypically selected (Dobzhansky 1937).[24] Think, for example, of undetectable variability in the form of unexpressed recessive alleles. It is a genetic material that is not making any selectable phenotypic contribution, but can serve as 'raw material' for future mutations. Thus, according to the scientists of the Modern Synthesis, natural selection actively favours the accumulation of genetic variation.

Razeto-Barry and Frick's (2011) reconstruction of CNST refers only to Beatty's second assumption (2). Their way of presenting this thesis may be illuminating. In their terms, natural selection is a creative force because it 'allows' adaptations of a high degree of complexity to emerge, which, in probabilistic terms, would be very

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[23] The following quote from Beatty (2016) on how selection in Darwin's theory can imprint a particular direction on subsequent variations may be illustrative: 'By selective "accumulation," he did not just mean increasing the proportion of an advantageous trait within a species, as for example when an ancestral flying squirrel is born with a flap of skin, between its fore- and hind flanks, that is larger (say x+) than the flap possessed by other members of its species (say x), and the initially rare x + variation becomes more and more common. Rather, he was referring to the way in which selection in favour of larger flaps increases the mean flap volume from x, to x+, to x++, to x+++, etc. And the important point here is that, as evolution by natural selection proceeds in the direction of larger flap volumes, ever larger variations become available for natural selection to act upon' (Beatty 2016, pp. 667–668). Beatty (2016) makes a detailed case for selection being responsible for the variation on which it then acts are not incompatible with the Darwinian principle that variation is random (see Beatty 2016, pp. 662–670).

[24] There are various processes by which natural selection preserves variation (heterozygote advantage, disruptive selection). Dobzhansky groups these processes under the label of *balancing selection*. Thus, *balancing selection* refers to a series of selective processes by which multiple alleles (different versions of a gene) are actively maintained in the gene pool population at frequencies higher than those expected from genetic drift alone.

difficult to appear by the simple action of random mutation. Thus, natural selection 'makes more probable the occurrence of types of sequences of phenotypic steps that seem impossible (in other words, extremely improbable) to occur by the random accumulation of changes' (Razeto-Barry and Frick 2011, p. 6).

In summary, I note that, according to Beatty (2016, 2019), natural selection is creative because (1) it *initiates* evolutionary change and (2) it *directs* evolutionary change (e.g. by creating the variations that it subsequently acts upon). I consider that assumptions (1) and (2), as offered by Beatty's definition of CNST, can be taken as *criteria*, i.e. as rules, that would allow us to determine more or less clearly whether we are dealing with a creative force.[25] In the discussion I have reconstructed, the phenomenon that these criteria identify was whether natural selection is a creative force.

In contrast to the above two assumptions (i.e. against CNST), *mutationists* argue that mutation initiates and drives evolutionary change. Note that the presentation of evolution as a two-stage or two-factor process (first variation and then selection) seems consistent with this *mutationist* perspective. According to this presentation, the evolutionary process consists of a first stage concerning the origin of variations (or mutations), which initiates and directs evolutionary change, and a second stage concerning selection, which must 'wait' for the mutation to act and then simply 'chooses' among the available options.[26]

At the beginning of the chapter, I pointed out that I intend to argue that creative processes and evolutionary-cultural processes are not two separate and successive spheres: first creation, then cultural evolution. Such a conception is analogous to the *mutationist* perspective. On the one hand, the separation between creative processes and evolutionary-cultural processes assumes the following: individual creative processes give rise to original and functional (or diverse and adaptive) cultural products, while evolutionary-cultural processes merely determine which of them persist, which disappear, and which are replicated. On the other hand, the mutationist position understands evolution as a two-step process: first, mutation which results in diverse traits, some of which are also adaptive; and then selection, which discards those non-adaptive traits while conserving and replicating the adaptive ones. Thus, according to both conceptions, there is a first stage (creative processes and mutations) in which the *original* (or *diverse*) and *functional* (or *adaptive*) traits of cultural

[25] This is not to be confused with the definition of creative *products* given in the first section of the chapter. I am proposing that when a *process* 'behaves' in the way that either of these two assumptions indicates, I will consider that we have good reasons to assume that such a *process* is making a relevant contribution to the emergence of an original and functioning *product*. The reasons why I consider that processes that 'behave' in this way can be considered 'creative' will become clear later.

[26] Although the presentation of evolution by natural selection as a two-step process is quite widespread, its literal interpretation opposes CNST. This presentation is a way of expounding the theory to simplify it, which leads to confusion (Dawkins 1996; Beatty 2019). To maintain an orthodox Darwinian position on the creativity of natural selection, it would be desirable to avoid the two-step presentation.

products originate. And, according to both conceptions, there is a second stage (evolutionary-cultural processes and natural selection) that only modifies the resulting frequency of the first stage.

As I have said above, I aim to discuss the conception that creative processes and evolutionary-cultural processes are separate and successive stages. To this end, I will argue that cultural selection can, at least in some cases, be a creative force. To do that, I will draw on Beatty's definition of the creativity of natural selection. As I note, taking Beatty's (2016, 2019) reconstruction, natural selection can be considered a creative force insofar as it (1) initiates evolutionary change and (2) directs evolutionary change. I hold that these criteria can be extrapolated to the realm of culture, thus allowing us to identify whether cultural selection can be a creative force.[27]

Each criterion will indicate a different way in which cultural selection will be playing a creative role. Where these are satisfied, the distinctive aspects of creative products (originality and functionality) will be partially explained as effects of selectionist processes operating at the population level. Thus, these criteria contribute to the pluralistic model I want to advocate. According to my model, the assumption that originality and functionality of creative products are only the effects of cognitive processes operating at the individual level must be set aside. Instead, creative products are the effect of cognitive and non-cognitive processes taking place both at the individual and population levels.

4 Is Cultural Selection Creative?

In the previous section, I argued that we can understand assumptions (1) and (2) as criteria that allow us to detect the creativity of natural selection and I anticipated my intention to extrapolate them to the field of culture. This section will be devoted to the latter task. For this purpose, I will consider each criterion separately. This will allow me to analyse first whether it is possible to strip them of their biological specificity, and then to evaluate whether it is reasonable to characterise a mechanism that satisfies them as creative or not. Then, I will try to propose the extrapolation of these criteria to the field of culture and introduce some examples that satisfy them. In this context, the expression 'attributing creativity' is equivalent to 'considering that it may be playing a relevant role in the process of elaboration of a creative product'.

[27] In the following section, I will consider cases of the creation of cultural items, which are both original – not of the type that already existed – and functional – I will leave aside those that did not work. One might object that not every original and functional cultural product is a good case of a creative product, an attribute that should be reserved for exceptional achievements. However, theories of creativity recognise that there are different degrees of creativity: little-c, mini-c, Pro-C, Big-C (Kaufman and Beghetto 2009). Thus, all creative cultural products (and also those I chose as examples for my analysis) would fall into one of these categories.

4.1 Selection Initiates Evolutionary Change

As I pointed out, the first criterion for defending the thesis states that (1) selection initiates evolutionary change. I have explained this through Beatty's discussion of Darwin's two alternative scenarios in a wolf population (cf. Beatty 2016, pp. 665–667). The criterion is satisfied in the first scenario where a change in the natural environment triggers evolutionary change – in Darwin's example, a change in the availability of food. That environmental change leads to differential reproduction of those wolves with more favourable traits for obtaining food (in this case, those with longer legs). Let us try to extract this criterion from its biological specificity. What characterises this type of scenario (and similar non-biological ones) is that a new environmental pressure (whether it occurs in a natural or cultural setting) triggers evolutionary change. In other words, it is the selection rather than the transformation of the item that initiates evolutionary change.

In contrast, in Darwin's second scenario, the emergence of a new variant – that is significantly more adaptive than the available variants – initiates evolutionary change. In the case of biology, the second scenario refers to the emergence of a particularly beneficial variant. In the case of culture, the second scenario could refer to the emergence of a new invention, which in some sense is superior to currently available technologies, but whose production was not stimulated by any particular need or problem. The second scenario behaves as the presentation of evolution in a two-stage process: first variation, then selection. Thus, criterion (1) is not satisfied in the second scenario; instead, evolutionary change must 'wait' for variation to act.

Consequently, criterion (1) states that selection – and not the emergence of a new advantageous variation – initiates evolutionary change. It seems sensible to argue that criterion (1) is an indicator of creativity. In a scenario that satisfies this criterion (i.e. one in which the same selective process leads to the emergence of something original and functional), it seems justified to conclude that such a process would bear some responsibility for change. More precisely, the selection processes would pose a new problem to be solved, and to choose the solution.[28] Thus, the environment would delimit the framework or direction in which the change has to occur. The shaping of a framework where the change has to take place is not a null contribution. In fact, in the area of creativity, Csikszentmihalyi (2014) has pointed out that in many cases the most relevant contribution of creative discovery is due to a problem

[28] A certain degree of abstraction is necessary to perform this analysis. In more concrete terms, first, a change in the environment generates a problem; second, the action of biases leads to the replication of one of the possible solutions available. In evolutionary terms, all these components can be understood as part of a selective process. This is the same type of abstraction that is present in the analysis according to which Darwin's first scenario satisfies the first criterion. In this scenario, an environmental condition poses a problem (absence of prey). This leads to some wolves being better equipped to survive and reproduce, so that the traits that help them solve the problem spread through the population more rapidly. All these elements would be part of the process of natural selection.

statement, which, in addition, frequently leads to a delimitation of the type of answer to be given to the problem, even if it is in a coarse sense.

Let us now try to extrapolate this criterion to the field of culture. If the environment posed a new challenge and its resolution entailed a cultural change, this criterion would be satisfied. That would happen in a scenario where a change in the environment posed a problematic situation. Good examples would be the depletion of a natural resource used as raw material, or a new technological need caused by another innovation. Some of these problems might not have a clear resolution. Others, however, could involve an evolutionary-cultural change; as a consequence, a new invention would emerge, satisfying the problem in question and spreading the invention through that population over the years. This propagation is possible because, in human societies, good creations tend to be replicated and used by the entire population. Thus, it is not necessary to constantly *reinvent the wheel*.

Thus, in general terms, one could argue that criterion (1) is satisfied when, in a population that has many copies of cultural variant A, the environment poses a new challenge or problem P (e.g. the scarcity of materials to build A), and, through a selective process, variant B spreads through the population, while A decreases.[29] Variant B would fulfill the same functions as A and could respond adequately to P.

The evolutionary mechanisms that refer to the change in item frequency are selective processes. These processes concern the action of *content*, *model*, and *frequency biases*. Thus, in a scenario such as the one I am conjecturing, these biases would act in consonance propagating item B. If B is an alternative technology to another A, the propagation of B would imply a decrease of A.

Now, while the action of selective mechanisms explains why some cultural items expand and others disappear, it is necessary to point out how the modification of the item would occur. In other words, we need to explain how item B would originate. This question allows us to formulate two different variants of criterion (1). While in one case item B would be invented to solve the posed problem (1.a), in the other case, item B would be selected from an already existing item, which would have been created for other purposes or no purpose at all (1.b).

Let us begin by analysing variant (1.a). According to (1.a), selection initiates evolutionary change as the environment poses a new problem and 'selects' a cultural item created to solve it. In this case, whoever invents the item does so to solve a problem. In other words, it is a variation introduced in a directed way. For these reasons, I would say that the emergence of the new item constitutes a case of *guided variation*. As I pointed out in Sect. 1, the incidence of *guided variation* in evolutionary change does not constitute an objection to explaining such change by appealing to Darwinian selective mechanisms.

[29] While this schematic modelling attempts to capture the typical occasion when criterion (1) would be satisfied, strictly speaking, cultural variant A may not exist. While, in most cases, the new technology would replace an old one, in other cases, it would simply be an artefact that did not exist before.

On the other hand, according to variant (1.b), selection initiates evolutionary change, since the environment poses a problem leading to the replication of an item that already existed, although used for other purposes. In scenarios of type (1.b), a new challenge leads to the novel use of a cultural item that was manufactured and used for other purposes or no purpose at all (e.g. items that are by-products of the intentional manufacture of other products). Palaeontologists Stephen Jay Gould and Elisabeth Vrba elaborated the concept of *exaptation* that I will take on to analyse this possibility.

Gould and Vrba (1982) developed the concept of *exaptation* to identify a missing phenomenon in evolutionary biology explanations. According to these palaeontologists, *exapted* traits arose as by-products of other evolutionary processes or as adaptations to other functions and were co-opted for a new function. A famous example of exaptation is that of vertebrate bones, whose original function might have been to serve as a reservoir for calcium and, later, to protect vital organs and increase internal consistency. Eventually, the transition to terrestrial life led them to take on the function of support. Another well-known example is that of bird feathers. Initially, the function of feathers was to maintain body temperature more efficiently. Today, the feathers of the vast majority of birds favour flight because of their aerodynamic properties.

The article by Gould and Vrba (1982) was intended as a critique of evolutionary explanations that overemphasise the role of natural selection. However, some Darwinists dismissed this critical view by arguing that the idea of some traits being selected for another or no reason and then co-opted for new uses was already present in Darwin's theory (Dennett 1995). In that sense, I consider that the concepts of *exaptation* and *adaptation* are compatible within the same explanatory framework. Thus, we can say that the cases that satisfy criterion (1.b) are those in which evolutionary processes select an *exapted* cultural item.

To sum up, according to our extrapolation, cultural selection may be performing creatively as long as a new pressure from the environment initiates an evolutionary change that either (1.a) selects a variant invented to solve the problem (*guided variation*), or (1.b) selects a variant that has been produced for other purposes (*cultural exaptation*). Next, I will analyse some examples of technological change that will show that these situations have indeed occurred in the history of cultural change.

4.1.1 Some Examples

To present an example that satisfies criterion (1.a), I will turn to Basalla's (1988) historical reconstruction of technological change. According to Basalla, before the existence of self-acting (or automatic) spinning mule, the spinning mule present in cotton mills required the participation of skilled workers called spinners. Since they played a key role, these workers were in a very good position to demand better wages. After the three-month spinners' strike in England, the factory owners sought help from inventors to develop a device that would allow them to manage without these workers. And that is when the self-acting machines came into existence (cf. Basalla 1988, pp. 137–141). In this way, a cultural item that had remained stable for a long time (the spinning mule) changed radically, because a new pressure from the environment was produced – in this example, the environmental pressure is a socioeconomic conflict. The emergence of self-acting machines provided an answer to this conflict. This response was unfortunate for the employees but beneficial for the owners of cotton companies. In turn, the acquisition of the artefact provided these that allowed the artefact to expand further.

Once the self-acting machines were invented, this cultural variant spread first across England and then Europe. There was a decrease in the number of non-automatic machines and a progressive increase in the number of self-acting ones – i.e. the variant that allowed the problem of production stoppage to be solved. I consider that this example satisfies criterion (1.a) since the origin of the cultural variant constitutes a case of *guided variation* and its subsequent diffusion can be explained as an effect of the action of different *biases*.[30] I will justify this assertion below.

First, the emergence of the self-acting feature is a case of *guided variation* because it is an item created to solve a specific problem. The problem was that spinners were a scarce labour force that could exert union pressure on employers. For this reason, it was particularly tempting for entrepreneurs to acquire a machine that would make it possible to dispense with spinners. Thus, self-acting machines were a valuable invention in this context. It seems reasonable to conjecture that its chances of being invented were higher than those of an alternative device. For example, the spinning machine would make it possible to dispense with a lower-ranking operator. It would thus be a case of *guided variation* rather than *blind* variation.

Second, we have to consider why the self-acting mule has been replicated. The reason is the way its properties interact with the environment. These properties make the cultural item more advantageous than its alternative variant (the non-automatic spinning mule). These advantages are observable by textile mill owners. We can assume, therefore, that *content bias* is the mechanism responsible for the replication of self-acting machines. The *prestige bias* could also have accelerated the speed of the item's expansion. That would have occurred if, for example, those implementing self-acting mules first had already been the most successful ones (or if the implementation made them successful) and if other entrepreneurs had been sensitive to the formers' success. However, the most relevant bias must have been the *content bias*, which led to the multiplication of a technology that provided an answer to a problem

[30] It is beyond the scope of this research to carry out an in-depth analysis of all the empirical aspects related to the example to determine which of the evolutionary mechanisms proposed by the Californian approach to cultural evolution could have been operating in the production of this cultural change. That would require gathering historical information about the change in the frequency of these cultural items (i.e. the self-spinning machine and the old spinning machines) in the years following the introduction of the invention. However, I can make a more relaxed analysis based on the fact that it is an item created in response to a conflict and then expanded.

for factory owners. Note that this process of expansion of the cultural item is not a minor issue, since thanks to this expansion, the self-acting mule has consequently influenced the development of the spinning machines. If it had not expanded, nobody would know today that such a machine existed; by contrast, it would be a rarity, perhaps it would have rusted in a shed. Therefore, the invention of self-acting machines is a case of criterion (1.a).

On the other hand, criterion (1.b) establishes that selection would behave creatively if it initiated evolutionary change by selecting an *exapted* variant.

The notion of *exaptation*, originally proposed for biology, has been extrapolated to the realm of culture and technology (Lass 1990; Dew et al. 2004; Cattani 2006; Larson et al. 2013; Andriani and Cattani 2016; Ching 2016; Dew and Sarasvathy 2016; Garud et al. 2016). In other words, there has been an 'exaptation of exaptation' (Larson et al. 2013, p. 1). Indeed, it has been argued that the concept is more suitable for the realm of culture than for the realm of biology (Larson et al. 2013).[31]

Cultural exaptation refers to the co-optation for a new function of a product (or by-product) that has originated for other purposes or no purpose at all. For instance, microwave ovens are an *exaptation* of a technology that was originally employed by magnetrons in early radar systems (Osepchuk 1984). The original function of magnetrons was to convert electrical energy into electromagnetic energy. These devices were developed to power radars. However, after observing that a bar of chocolate he was carrying in his pocket had accidentally melted, engineer Percy Spencer discovered this alternative use. Nowadays, microwave ovens are used all over the world to heat food. Another example can be found in drug repositioning, which is a fertile ground for exaptations since many health problems have been solved by exploring the unknown effects of drugs already developed and approved for other purposes. One substance whose consumption further changed its function is gin, as it went from being a drink 'used to alleviate circulatory problems to an intoxicating liquor' (Andriani and Cattani 2016, p. 120). Moreover, there has been research on exaptation in natural languages (Lass 1990; Larson et al. 2013). As linguists have shown, languages evolve and some of their grammatical features become obsolete. While many of these obsolete features subsequently become extinct, others may persist as linguistic 'garbage' for many generations. Sometimes, these features even find a new communicative function, becoming *exaptations*. In sum, the concept of exaptation can be employed in culture as well.

As stated, *cultural exaptation* is a phenomenon compatible with theoretical frameworks that attribute a central place to evolution by natural selection. As a consequence, it can be argued that, although the term '*cultural exaptation*' is not used by Californian theorists, it can be incorporated as another type of mechanism of cultural evolution. More precisely, it is a mechanism of *variation* introduction; that

[31] According to Larson et al. (2013), the term *exaptation* has not become widely used in the biological sciences. They hold that *exaptation* lacks a formal definition that distinguishes it from *adaptation*. However, *exaptation* has been adopted with considerable success in studies of the history of technology. Frequently, technological innovations involve the use of a process or artefact in a new context.

is, it introduces a novelty within the diversity of competing options for a given trait.[32]

As Andriani and Cattani (2016) point out, exaptation is rarely considered in historical reconstructions of the origin of novelty. However, it is possible to recover some cases of *cultural exaptation* that may exemplify the situation postulated in (1. b). Optical fibre, whose genesis was analysed by Cattani (2006), is one of them. It is a small diameter glass-embedded fibre currently used in telecommunications. This technology came to replace electric cables since the latter entail more energy loss and, in addition, are affected by electromagnetic interference, which was very problematic in some implementation circumstances. Thus, optical fibre itself can be seen as a case of *exaptation* as it involves a change in the function of old technologies (embedded glass, used, for example, for pots), which are now used in telecommunications. Furthermore, Cattani (2006) conducted a historiographic study with documents on the transformation of the Corning company, a pioneer in the development of fiber optics, which was previously devoted to the development of glass for special items, such as optics, windshields, and cookware. Consequently, there is also a co-optation of knowledge and technologies used to work with glass in the manufacture of certain artefacts for the production of a new artefact. In conclusion, that knowledge and those technologies can be seen as cases of *exaptation*, too (Andriani and Cattani 2016).

In the example above, the pressure to develop a technology to transmit energy avoiding losses and electromagnetic interference led to the use of another technological development: the embedded glass. Therefore, it is a scenario where selection initiates evolutionary change, and the *exaptation* of an artefact occurs. The clear advantages of the new item are the reasons for its spread, replacing the old technology. Hence, we could think of this as the *content bias* effect.

Another example that could illustrate (1.b) are the disc pans used to cook some Argentine dishes. Originally, these disks were part of ploughing machines and, from time to time, had to be replaced, so they became a waste product. Although there are no formal records, it is quite evident that they began to be used to satisfy some other needs. It was probably the need for a large container suitable for cooking food for many people, during many hours, and in direct contact with fire. The disc fulfilled this function adequately, resulting in an efficient way of cooking, which does not require precise regulation of the flames, and is suitable for simultaneously cooking large quantities of a wide diversity of foods in a relatively easy manner. Consequently, it is not surprising that today this artefact is manufactured and marketed in a

[32] Since this is not a random introduction, but a directed one (co-optation has been carried out for the artefact to perform its new function), it could be considered a sub-type of guided variation. This question is irrelevant for the present analysis since I am interested in distinguishing processes involving cultural exaptation from those involving guided variation without *exaptation* (such as the invention of self-acting machines). It is also true that these delimitations will not always be precise and that many inventions should be considered a mixture of both. However, I believe that this fact does not preclude the possibility of making the distinction.

mass and customised way; that is, it is no longer obtained by ordinarily recycling old plough discs.

Although there are no records on the number of discs[33] present in the Argentine population so far, it is sensible to conjecture the following: discs are a cultural variant that emerged at some point in history (presumably on more than one occasion), then they were replicated by imitation (allowed by horizontal, oblique, and vertical transmission), and, finally, they began to be manufactured and marketed autonomously; so they increased in quantity. Therefore, although the emergence of discs was a response to an environmental challenge, discs were produced by way of *exaptation,* and later extended by a *content bias* mechanism. If it were proven that, after the television appearance of the famous Argentine chef Francis Mallman using a disc, sales increased significantly, the disc would also fulfill the prestige *bias*.

In short, I have presented some examples that satisfy criteria (1.a) and (1.b). In other words, these are scenarios where cultural selection is creative, given that a new pressure from the environment initiates an evolutionary change that either (1.a) selects a variant invented to solve the problem (*guided variation*), or (1.b) selects a variant produced for other purposes (*cultural exaptation*).

4.2 Selection Directs Evolutionary Change

Beatty's (2016, 2019) second criterion notes that natural selection is creative to the extent that (2) it directs evolutionary change. This assumption connects to what Razeto-Barry and Frick (2011) point out about the creativity of natural selection. The authors argue that natural selection allows adaptations of a high degree of complexity to emerge, which would be statistically almost impossible to occur by the action of mutation alone. For his part, Beatty (2016) argues that Darwinists of different times have formulated assumption (2) differently. Thus, Wallace (1867) and Weismann (1896) contended that natural selection directs evolutionary change, to the extent that it changes the range of available variation. If this was the case, selection in a particular direction would result in the production of subsequent variation in the same direction. For their part, the scientists of the Modern Synthesis stated that natural selection actively favours the accumulation of genetic variation since variation is the result of novelty in genetic combinations. Each of the above two variants would allow us to elaborate a different version of assumption (2) of the creativity of cultural selection.

Let us strip this criterion of its biological specificity and analyse whether it is sensible to regard any cultural selection process that fulfils this characteristic as creative. According to this criterion, a selective mechanism would be creative if it directs the variation upon which it acts. Thus, it does not limit itself to merely filtering out the available options. Instead, it is partly responsible for the course that

[33] In this paragraph, we are talking about discs as pans.

will be taken by the available variations on which selections will continue to operate. Hence, the selection process would exhibit active participation, which makes it somewhat responsible for the outcome. Therefore, it can be considered that, if a selective mechanism directs variations, part of the explanation for the *originality* and *functionality* traits of creative products must be provided by appealing to population-type selective processes.

Moreover, in the Modern Synthesis scientists' version of assumption (2), selection directs the course of variation since it actively favours the accumulation of genetic variation (Chetverikov 1926; Dobzhansky 1937). Indeed, it seems sensible to concede creativity if we detect that these selective processes keep variations that are not useful but could be helpful in the future (similar to the Modern Synthesis argument that species accumulate genetic variability). However, this would be a different way of attributing creativity compared to the change in the range of variation, so they should be distinguished from each other.

Consequently, it can be stated that cultural selection will be playing a creative role whenever this mechanism drives evolutionary change; either because (2.a) it simply changes the 'range' of variation, or (2.b) it retains elements that are not useful at a given time but may be helpful in the future.

Criterion (2.a) would be satisfied in a scenario such as the following one. Let us imagine that the action of biases leads to a set of available variants among which those whose values are in an 'extreme' are selected. For example, if there are five options of different sizes, selection mechanisms choose the option with the largest size. It is to be expected that, in subsequent generations,[34] the available variants will have the selected size and, in addition, there will be others of an even larger size.[35] In other words, the 'range' of variations would have shifted.

Second, criterion (2.b) would be satisfied in a scenario in which cultural selection processes preserve some designs that in the future may contribute to the elaboration of new ones. More specifically, one can say that this criterion is satisfied if, on the one hand, not absolutely all existing cultural variants are preserved, and, on the other, not only those that are useful at a given time are preserved either.

4.2.1 Some Examples

Let us begin by analysing criterion (2.a) according to which cultural selection constitutes a creative force since it changes the 'range' of available variation. One

[34]The notion of 'generation' in theories of cultural evolution depends on the context of analysis. That has to do with the fact that some cultural variants are more stable than others. Thus, for cultural variants that tend to remain stable over an individual's lifetime, the cultural generation may coincide with the biological generation; whereas, for cultural variants that tend to change more frequently, the generations will tend to be much shorter.

[35]For example, if in one generation there are size options (i.e. '1', '2', '3', '4', and '5'), and the biases lead to the selection of artefacts of size '5', in the next generation, the available size options will be '4', '5', '6', '7', and '8'.

might think that this occurs more evidently in culture than in biology. For example, consider the change in the weight of cell phones from 1980 to 2000 (Farley 2007). At a certain point, companies decided to develop some lighter-than-average options. Market demand took that direction since many people found it convenient to choose lighter-weight phones. Thus, we can assume that the production of lighter models has been longer than that of heavier ones, leading to a multiplication of the lighter variants and a decrease of the heavier variants – since they are no longer produced, and some of the existing specimens broke down or were scrapped. However, it is relevant that, in addition to this unequal replication of the different available variables, we can think that in the following generations the new models (the new variants) will include increasingly lighter options. Consequently, selection would not simply have chosen some of the available options but it would also have changed the range of available variations. In other words, it is the result of different biases. Presumably, the most relevant is the *content bias* since lighter phones would represent clear advantages over heavier ones. Perhaps, the *prestige bias* may also have been at work if, for example, companies had used the advertising strategy of showing stereotyped images of successful people using lighter phones.

Selection would be exhibiting creativity in a different sense if it met criterion (2. b). According to (2.b), selection is creative if it retains elements that are not useful at a given time but may be helpful in the future. Something similar to this happens with programming codes. Sometimes, a new version of a program leaves an old part of the code useless. Instead of deleting that part of the program, programmers leave it in suspension, in square brackets. In this way, they keep it in case it becomes useful again in the future.[36]

Companies engaged in research and development also serve as an example to meet criterion (2.b). Andriani and Cattani (2016) point out that many firms tend to intentionally retain knowledge, procedures, and designs that at some point have become obsolete but could be reused or exapted in the future. Thus, for example, Hargadon and Sutton (1997) analyse how IDEO, a design and construction company, organises innovation. IDEO initially focused on designing consumer products (from toothbrushes to office furniture to computers). However, in 2001 they began to focus more on 'consumer experiences', designing products such as non-traditional classrooms. Hargadon and Sutton (1997) argue that the reason for this company's innovation was that they had encouraged the storage, retention, and retrieval of knowledge. In fact, the company had retained not only knowledge that was clearly

[36]For example, the programmers of a new version of certain software (e.g. version 7) may add a component that renders a segment of code from the previous version (e.g. version 6) useless. They put that segment in square brackets and 'comment it out'. Eventually, if in the future, the developer of version 8 needs the segment in question again (present in version 6, absent in version 7), he merely has to remove the brackets that rendered it useless (this could happen if, for example, the programmer of 8 decided to remove that element of version 7 that rendered the segment useless). However, the same process of recovering the old segment could be done by obtaining the code of version 6 by another route. For its part, this programmer practice implies a conscious decision to leave behind a design that may be useful in the future.

useful, but also knowledge that had no obvious application. The company had been actively working on the conservation of knowledge that might prove valuable. Andriani and Cattani (2016, p. 125) call this preservation process the conservation of the 'memory of an organization'.

Finally, some developments brought about by the so-called 'maker culture' are also examples of criterion (2.b). This contemporary culture can be regarded as an extension of the so-called 'do-it-yourself' movement, but based centrally on new technology and the use of digital tools. It is mainly interested in engineering-oriented activities, such as electronics, robotics, and 3D printing. Makers are those people who design and produce their own artefacts (Anderson 2012), but they do not do so individually. The 'maker culture' emphasises the potentialities of repeatedly using the 'copy and pastes' strategy for standardised amateur technologies while encouraging the adaptation and reuse of designs published on websites and maker-oriented publications. This movement has encouraged the creation of virtual repositories where different contributors share designs and ideas. Other people use and combine designs made by strangers to build their own artefacts. In some cases, designs are used for the same purpose as were originally intended and, sometimes, for a different purpose. This is a conservation space to store designs that have no obvious use at the moment but may have some in the future.

I have brought up examples of cultural mechanisms responsible for conserving elements that would otherwise have been eliminated. They are, in this way, linked to selection mechanisms, which refer to the conditions by which some cultural items spread and others disappear – rather than to the emergence or modification of an item.

In sum, I have presented some examples that satisfy criteria (2.a) and (2.b). In other words, these are scenarios in which cultural selection is creative, given that it directs evolutionary change; either because (2.a) it simply changes the 'range' of variation, or (2.b) it retains elements that are not useful at a given time, but may be useful in the future.

The examples I have analysed show that, in principle, there are cases in which cultural evolution meets the criteria to be considered a creative force. They reveal different ways in which cultural selection processes, on some occasions, do play a relevant role in the elaboration of creative cultural items. Although future research supported by different types of empirical evidence could complement the present analysis, I consider that what I have offered so far constitutes a satisfactory advance in arguing that cultural selection is a creative force. As a consequence, evolutionary-cultural processes may be relevant to theories of creativity. If evolutionary-cultural processes affect creativity, the view that creative processes are limited to individual cognitive abilities must be abandoned. In the following section, I try to specify in what sense each of these scenarios contributes to this pluralistic view of creative processes.

4.3 Population Processes Matter to Creativity

Let us recapitulate, then, the criteria that I have extrapolated into the cultural domain and for which I found examples. I have argued that cultural selection may be playing a relevant role in the creation of a new cultural item as long as:

(1) a new pressure from the environment initiates an evolutionary change, which either

  (a) selects an invented variant to solve the problem (*guided variation*) or
  (b) selects a variant produced for other purposes (*cultural exaptation*);

(2) it directs evolutionary change; either because it

  (a) changes the range of variation or because
  (b) retains elements that are not useful at a given time but may be useful in the future.

Each of these criteria indicates four different ways in which selective mechanisms would be operating and thereupon contributing to the emergence of creative products. In addition, these criteria would allow us to subtract explanatory weight from the action of the individual mind's cognitive abilities.

Criterion (1.a) identifies cases in which the biases select one of the new variants that arise in response to a problem that was posed by the environment. On the one hand, I am interested in pointing out that the posing of a problem – and not only its resolution – is a considerable contribution to the emergence of a creative product. In fact, some creativity theorists have argued that the elaboration of a problem is one of the most relevant instances of the creative process (Csikszentmihalyi 2014). However, when we attribute creativity to someone, we generally consider the resolution of a problem, but not the posing of a problem. In short, the problem statement has guided the exploration and search for solutions in a particular direction and has contributed, at least modestly, to the emergence of the creative solution.

On the other hand, I am interested in indicating that when a suitable solution to the problem in question appears, cultural selection 'recognises' it, favouring its conservation and replication. In one of the examples previously analysed, the spinners' strike causes the problem and the solution emerging by guided variation is the self-acting machine. The conservation and expansion of self-acting machines can be explained mainly by the action of *content bias*. As this bias refers to the identification of how beneficial a given cultural item may be, we can assume that it involves standard cognitive abilities and that such abilities are 'distributed' in a population. So they are much less grandiloquent than those usually attributed to a single creative mind. Therefore, even if the solution to a problem, in scenarios such as the one analysed, is created by a single mind, many others decide whether it is a good one. In addition, I note that in the last examples and in some of the following ones, the *prestige bias*, whereby individuals imitate the trait that successful people carry, may also play a role. Although this bias involves cognitive skills, such as identifying who is successful in a given field, these are cognitive skills of a very different type from those generally assumed to be at play in creations. Californians understand that these abilities of our minds are the product of evolution itself, both by natural and cultural selection (Richerson and Boyd 2005). Thus, on the one hand, criterion (1.a) suggests that the problem statement (which is then solved using creative solutions) often does not have an author; however, it is posed by the environment itself. On the other hand, criterion (1.a) points out that, even if the answer to the problem were devised by a single individual using his individual cognitive skills, the recognition that it is a good answer would be in the hands of many other individuals, using standard cognitive skills (such as the recognition of the benefits of an artefact) and other less standard ones (such as the recognition of who is successful). Consequently, the environment would have contributed to the emergence of an original product by presenting a problem, and the standard and non-standard cognitive skills distributed throughout the population would have contributed to the selection of the option that, in addition to being original, worked out.

Second, criterion (1.b) selects those cases in which biases have *exapted* a cultural item to respond to a challenge posed by the environment. On the one hand, again, it is a problem without a definite ‘author’ and whose solution has been selected by the action of different biases. All the people involved in its replication have either recognised that it was a suitable solution or inferred so indirectly by imitating the most successful ones. Moreover, the exaptation of the artefact involved skills very different from those usually assumed to be involved in creation. In the examples given, the design of the *exapted* artefact fulfills the function assigned to it. However, this is, to some extent, haphazard. I can assume that the creation of the original artefact was guided by intelligent design and that the idea of implementing it for a new function is another intelligent decision. However, this intelligence is distributed in at least two different instances and by two different people, and it requires some dose of good luck. When one starts to dig up some facts, there seem to be many historical examples of cultural exaptations, but our intellectualist way of conceiving history has often made them invisible. I have analysed examples of *exapted* items that constitute creative elements, given that they are original and functional. Although they are items that existed previously, the originality may consist of a new way of using them. As a consequence, the confluence or encounter between an old item and its new ‘niche’ would guarantee originality. Hence, accidental elements played a relevant role in the emergence of these original and valuable items. For example, a problem was posed by the environment, a pre-existing artefact met this environmental challenge, and the old design and the new function matched. Thus, it is more a matter of taking advantage of a previous design and changing its function. Therefore, the cognitive skills involved in the elaboration of the solution are, at least, distributed into more than one person: the one who makes the original design and the one who employs it in a novel way. Moreover, the final achievement is more linked to chance than to planning.

Third, criterion (2.a) identifies circumstances in which selection directs evolutionary change because it modifies the range of available variations. I have pointed out that this occurs, for example, when users of a product choose to purchase models with features whose values are at some ‘extreme’ of the available possibilities. For example, when buying a cell phone, most people pick lighter models. This preference has led developers to design products in which this value is emphasised. Hence users have more influence than designers on the change direction of cell phones design. The proposed example – change in the frequencies of different cell phone models over time, where the lightest ones are the majority – may involve the development of some cell phone models that can be considered creative. In such a case, the design of lighter models involves an original and functional solution to the problem of reducing weight without reducing technological capacity. While the development of these designs surely involves cognitive skills of a group of individuals devoted to design and development to innovate on existing technologies, the framework in which this innovation must take place is determined (as in 1.a) by an external element, in this case: users’ behaviour. By choosing certain models over others, users have caused the range of available variations to shift in a particular direction over time. I have conjectured that this shift has been an effect of biases, such as *content bias* and *prestige bias*. Therefore, we are dealing with cognitive skills that are distributed among the population and are different from the single-mind-creating something type typically supposed to be at play.

Finally, criterion (2.b) selects cases in which a design that has no apparent utility yet but may have one in the future is retained. This practice has proven to be very productive, so it is quite common in different fields. The fact that this practice is rewarding shows that, if an expert does not know what a particular design can be used for, it should not be inferred that the design is useless. Although I have not been able to conjecture a typical Californian explanation of this process, I have pointed out that it is a selective type of mechanism, since it consists of conserving something for the future, preventing it from disappearing. The type of cognitive skill involved in this case is very different from the one usually assumed to be at play when someone creates something, since it does not imply knowing something (e.g. that an idea might work), but recognising that a design might have a utility, which has not been identified yet.

In sum, these are some scenarios in which the importance of individual cognitive skills is not absolute. Instead, it seems that mechanisms operating at the population level are significant in the emergence of some creative products.

5 Conclusions

I have argued that there is an equivalence between the distinctive features of creative products and the distinctive features of evolutionary products. Specifically, I have argued that there is an equivalence between *diversity* and *originality* and between *functionality* and *adaptability*. Thus, if evolutionary processes give rise to *varied* and *adaptive* products, one may expect that these same processes would also be relevant in explaining the production of *original* and *functional* outcomes. In other words, those evolutionary-cultural processes are relevant to the theories of creativity.

After that, I discussed the creativity of natural selection within the field of biology. I stated that, according to Beatty (2016, 2019), natural selection is creative because it (1) initiates and (2) directs evolutionary change. I argued that these assumptions can be considered as criteria that allow us to identify whether a mechanism is operating in a creative way or not.

Lastly, I have stripped criteria (1) and (2) of their biological specificity. After extrapolating each of them into the domain of culture, I have presented real-world examples that support our analysis. Thus, I hope to have shown that cultural selection performs creatively on many occasions. I have then made explicit in what sense, in these different instances, the *original* and *functional* character of creative products should be partially explained by processes that take place at a population level and that involve abilities of different kinds, both cognitive and non-cognitive.

In summary, I have provided reasons to conclude that the selective mechanisms postulated by cultural evolutionary theories can play a relevant role in creative processes.

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