CREATIVITY AS A BIOLOGICAL EVOLUTION ENHANCER AND ITS RELATIONSHIP TO LANGUAGE AND CONSCIOUSNESS

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ABSTRACT: The appearance of creativity in animal behavior and, as its peak expression, human inventiveness, presented a major breakthrough in the evolution of life. It enabled for much faster adaptation and enhanced survival potential in changing environments. In addition, it also brought improvements based on a society rather than an individual. More complex solutions based on teamwork could emerge and advances could be passed on to the whole population in the same generation. For this creative activity to be possible the ability to make new associations and hypothesis was needed, which seems to require some degree of conscious processing as detailed below. In addition, collaborative efforts depend upon a sufficiently sophisticated communication system, which could also require some conscious activity. Therefore, it seems plausible that creativity was a remarkable advantage that was selected for, taking with it language and consciousness.

Introduction

Creativity has been given many definitions through history. It has even been said that over a hundred definitions of this concept can be found in the literature [1], although most of them agree that it involves «the production of novel, useful products» [2]. This originality allows for unexpected new behaviors, for innovative techniques and strategies, and also for artistic expression.

When comparing the existing versions of artificial intelligence to human intellect it seems intuitive that creativity is not present in them in the same form that we contemplate in human beings. For example, reinforcement learning methods [3] are able to find the optimal strategy for each situation from a universe of states and possible actions. Thus, it is able to build the optimal strategy for a pre-defined set of circumstances using a specified list of actions. However, it is impossible for the algorithm to enlarge the set of actions that it can take, or to modify the way in which it identifies its current situation. A further example to illustrate this point can be Artificial Neural Networks. They are widely used to successfully classify data and make forecasts. They base their classification on attributes of the data that are selected by the designer. The artificial system is not able to take any leap in that sense and modify them in any way.

Therefore, it seems plausible that creativity is an attribute only displayed by living beings and mainly humans.

In the next sections we will review the different understandings of creativity and the history of its study together with its connections to teamwork, language and consciousness.

Creativity

Although the origins of the word date back to the Latin term *creare,* create, the modern meaning of the word as an act of human creation did not appear until the Enlightenment,

with the first record of the term happening in Wordsworth in 1816 [4]. The concept, however, is present in virtually every culture although with different connotations. For example, in the Eastern traditions human creation was always a sort of mimicry from nature and so the idea of creation from nothing made no sense. On the contrary, for the Greeks, and with them the Western tradition, true creation could somehow be passed from the divine to the human by some Muses or mediators; the fleshly creator was overtaken by a deamon (in Greek) or genius (in Latin).

The study of creativity started with the philosopher Thomas Hobbes in the 17th century and later more properly William Duff in the 18th century, for whom creativity was one aspect of human cognition. Duff built an explanation on genius based on *imagination*, judgment and taste, imagination being the most important one [5]. In the late 19th and 20th centuries, some accomplished scientists and artists such as Poincaré, Einstein, Kekulé or Becquerel reflected publicly on their creative processes, which inspired theorists such as Graham Wallas and more practical psychologists like J. P. Guilford, who designed the first psychometric test to measure creativity as an aspect of IQ. It was precisely Wallas who first designed a widely used model of the creative process.

Wallas' phase model

According to Wallas [6], the creative process is articulated on four distinct phases. These are *preparation, incubation, illumination and verification.* The *preparation* phase identifies the problem and information on it is collected. Some preliminary conscious thoughts on it are produced. If the solution is sufficiently simple, it might well be found at the stage. If the problem requires of a more difficult leap, though, the solution will not come to mind immediately. It will be necessary to leave the mind unrestrained for some *incubation* time, when ideas will be free to associate and restructure. The outcome of this process will be an *illumination* moment, where a solution manifests itself. Hadamard [7] very interestingly defines this «aha» moment as the unconscious mind communicating a solution to the conscious one. After that, some *verification* is needed to establish whether the solution is viable and in that case develop it and communicate it. Depending on the complexity of the problem, it might be necessary to iterate these phases until an acceptable solution has been found.

Whether or not this classic model of creative activity is accepted, it is still to be established when in the history of life came to exist.

Emergence of creativity and childhood pretence

Carruthers [8] proposes that creativity is «the capacity to combine ideas together in novel ways in abstraction from any immediate environmental stimulation». In this form, he states that it did not appear until 40,000 years ago, although modern human beings have populated Earth since 100,000 years ago. This *creative explosion* of the Upper Paleolitic, manifested itself with novel stone tools (the ones employed until then had already been used by *Homo erectus* withough being substantially modified for thousands of years), paintings, sculpture and other manifestations of art and religion. According to Carruthers, creativity did not emerge in its current form for the first 50,000 years of human evolution. During this period there was however an ongoing selection for individuals which *prepared* themselves for creativity by the games of childhood pretence. With pretence, infants develop the ability to generate, and to reason with novel suppositions

and imaginary scenarios. This makes them more creative – and therefore fitter – as they grow into adulthood. This explanation of the historical appearance of the phenomenon does not account for the specific mechanism that generates the new ideas, neither does Wallas' phase model. However, Simonton proposes an understanding of the process under the light of Darwinian selection [9].

Darwinian interpretations of creativity

For Campbell and Simonton [9], the key of the creative process is in the incubation phase. While the problem stays in the subject's subconscious mind, it is reinterpreted from constantly changing perspectives given by the stimulus received at any moment. This responds to the psychological idea of priming. The associations occur in a completely blind and purposeless way. The individual then selects only the associations that make sense in relation to the problem. Moreover, according to Simonton, more creative individuals are the ones that have a flatter hierarchy of ideas so that they can foster more numerous and unusual associations. More personality traits have been linked to creativity.

Personality traits and emotional states

Many authors have tried to find a correlate of creativity which identifies highly creative individuals. Magno [10] and Czikszentmilhalyi [11] summarize the opposing factors that explain creativity in: genetic predisposition, access to the knowledge required, physical energy, being smart yet naïve, playful but disciplined, imaginative yet rooted in reality, introverted in some ways and extroverted in others, humble yet proud, able to escape stereotypes yet deeply valuing tradition, able to tolerate pain, very passionate about their work yet very objective to judge it. The contradictory nature of these traits can be explained under the light of the phase model, as different characteristics are needed for the different phases [12]. In addition to these features, the desire of the individual to solve the problem by itself, regardless of any compensation, has to be considered with even more importance. It has been extensively proven by scholars like Amabile that the single most determinant factor for success solving a creative problem is *intrinsic motivation* [13].

In addition, as thoroughly studied by Sternberg and Ludwig, emotional states have an impact on creativity and vice versa to the point of mood disorders as depression or bipolar disease being much more frequent in creative individuals [14]. It seems that the extent of these emotional consequences is determined by the specific area of work of the creative individual.

Different creativities for different areas

Simonton [15] studied the different areas of science to determine whether the creative process was in any way influenced by the specificities of the area where the individual worked. He started from the classic classification of Auguste Comte, who proposed a hierarchy that stretched from Astronomy to Physics, Chemistry, Biology and finally Sociology. Simonton tried to get measurements that correlate with the objectivity of a science and therefore with its position in the hierarchy. Among these measurements he included citation ratios (how often the same articles are cited), obsolescence rates, graph prominence (how many charts appear in papers rather than tables), talent recognition

(young researchers' age when first published, or average age of researches receiving an award), consultation rate (how many peers a researcher asks for opinion before submitting an article), or theories-to-laws ratios (how many theories are in a field compared to proven laws). He found a very significant correlation of all these indicators with the hierarchical position of a discipline. In addition, the incidence of mood disorders increases as we descend in the scale. Integrating the arts in this perspective he finds again that emotional instability increases as we descend in the scale, with emotional poets being the most susceptible of all creative individuals to suffer from depression or bipolar disorder.

Furthermore, he found that revolutionary or high-accomplished scientists and artists tend to work using methods more used for a discipline that sits lower in the scale; the so-called *domain-regressive hypothesis*. Therefore, revolutionary physicists tend to work more like biologists do, and genius novel writers are somewhat closer to poets. On commenting on depression rates of emotional poets, he explains that they «can only regress to insanity».

Paradoxes and Mistery

Since all definitions of creativity require some degree of originality, it seems that we can very easily fall into paradoxes that are difficultly solved. As Plato stated in Meno [16]: «You cannot search for what you don't know, since you don't know what you are looking for, and you can't search what you know since you know it already, in which case you merely remember it». Authors like Kronfeldner [17] highlight that there are many forms of originality (metaphysical novelty being too much of a requirement). We need to define originality in a psychological way, where not replicating a model or something learnt previously by the individual is a sufficient condition. When this happens there must be some degree of spontaneity too, this is, the outcome is partially independent from the plans of the individual. Using this definition, the originality of a solution is dependent on the subject.

In the opposite spectrum to Kronfeldner, who tries to reason and naturalize creativity, is Kaufman [18], who proposes a new model of divinity where creativity is the final mystery. This secret of emergence, of novelty in the world manifests with three different faces: the original creation of the Universe – why there is something rather than nothing –, biological evolution and the evolution of culture. Kaufman would like to think of God «no longer as a personlike being but rather as a profound mystery, the mystery of all this creativity».

Mystery or natural phenomenon, creativity was an impressive new adaptation tool. In the next sections we reflect on its mechanics, together with its relationship to teamwork, language and consciousness.

The new evolution

Creativity brings flexibility. And flexibility is a priceless asset in a changing environment. As Giaccardi [19] puts it: «In a world that is not predictable, improvisation and evolution are more than a luxury, they are a necessity».

Instead of modifying physiology as biological evolution does, creativity acts on behavior. This is much more efficient. For example, if temperatures drop it might take several hundred generations to develop an appropriate fur cover, and if temperatures increase again the newly generated hair will be a nuisance. Manufacturing a coat, however, will be of use immediately and if conditions change it can be discarded easily.

Teamwork

More efficient strategies arise when several individuals are working as a team. As stated by Hanson [20] «In our complexly interconnected world, effective problem solving often requires creative collaboration». Hanson focuses mainly on the corporative world of the end of last century, where global challenges started to be commonplace. However, this quote is true in a deeper sense, as the challenges of the peoples of the Paleolithic were in no way easier than the ones we face today.

Complex tactics can emerge when the individuals bring some differences into the group so they can take different roles in which they can specialize. This is not a phenomenon that is restricted to human beings. Teams form even inter-species. For instance, dolphins, sharks, gannets and sometimes killer whales hunt together huge schools of silvery sardines during their migration in East Africa, creating a feeding craze along the coastline. When they feel threatened, sardines automatically rearrange the school in a ball shape which the dolphins provoke so that the food is as concentrated as possible. The rest of the participants make sure that the shape stays for as long as possible and eat as many sardines as they can. This sort of inter-specific collaboration happens at every level, with even unicellular life displaying high levels of co-ordination and surprising complexity in biofilms. Biofilms are aggregates of microorganisms where cells adhere to each other and/or to a surface. These cells are often fixed in a self-produced matrix of extracellular polymeric substance (EPS). Several species can cohabitate the same EPS and their behavior when together is strikingly different from the one they present when free-floating. They specialize in different metabolic and protection functions, being much more resistant than when alone. For instance, in some cases a 1000x increase of resistance to antibiotics has been observed [21]. However, this sort of teamwork is not synonyms with creative behavior. Creative behavior demands a flexibility that requires that team strategy not to be engrained in the genes of the participant species. Nevertheless, these examples serve to illuminate the point that teamwork is what makes creativity reach its maximum potential.

On top of that, biological advantages like a favorable mutation will relatively slowly or relatively quickly impose themselves on a growing fraction of the population. On the contrary, cultural advances can be virtually immediately shared by all the individuals. This allows for a much quicker improvement and evolution of the cultural assets of a society, as every member in general can collaborate in that direction.

Language and Consciousness

The members of a team can work efficiently only when a sufficiently sophisticated language system is in place. Non-creative, rigid teamwork can get away with a relatively simple system – as the chemical messages sent by the bacteria in the biofilm. However, more complex, flexible strategies requires the use of abstract concepts and hypothetical scenario reasoning as the one described by Carruthers above. Much has been speculated about the relationship between language and consciousness. It could well be that consciousness is a pre-requisite for language, so that purposeful discussions can only be held by conscious subjects. It also seems plausible that it is needed for the full human creative process, namely the *preparation* and the *verification* stages. There is further evidence pointing to the creative activities alternating focus on (conscious) language processing areas and (unconscious) visual processing areas [22].

Therefore, both in itself and through teamwork and language, consciousness is related to creativity. This makes it seem plausible that consciousness was selected for, at least partially, due to its relationship to creativity which might be understood as the biggest evolution enhancer appeared in history until now.

Conclusions

When creativity appeared in the evolution of animal life, it phenomenally increased its existing potential for adaptation. This flexibility allowed for a quicker response to environmental changes, for strategies that could be passed on to all the members of a society and for more complex teamwork behavior.

Teamwork in turn required of language for the efficient communication among its members. It is very plausible that language requires of consciousness, which seems to also be necessary for some of the so-called phases of the creative process. In this way, consciousness could have been selected for due to its relationship to creativity.

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