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State-of-the-art of theoretical creativity models: three epistemological effects of a constructivist approach in systems thinking

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Abstract: This paper presents a brief state-of-the-art of the most influential theoretical attempts to model the creativity. Incorporating constructivist epistemology, systems thinking considers the relationship between the observer and the observed system. This dynamic loop explains that we do not discover reality, but rather construct it, and that what we observe is not the real world itself, but the real world exposed to the effects of our method of questioning. This approach has at least three epistemological consequences. First, the systems approach itself is intrinsically creative as a modelling method and the models created are capable of generating original solutions. Second, the possibility of parallelism exists between the evolution of theoretical models of creativity and the socio-cultural evolution of the scientific view from which researchers model them. Third, it is impossible to establish a perfect theoretical model of creativity because human beings' natural creativity comes from the dynamic distance between the real world and the augmented real world, and the gap it imposes can never be totally modelized. Finally, these three epistemological effects being defined, the systemic approach is relevant to the study of contemporary creativity because it integrates in particular the complexity of eco-social systems and the digitalization of the real world. Among other possibilities, we propose nevertheless to integrate more human imagination and non-human creativity in future models.

Keywords: creativity, systemics, epistemology, constructivism, model, state-of-the-art

When it is not seen as the effect of chance or transcendent beings, creativity is traditionally associated with the figure of the genius, lonely and original, with a special skill that the ordinary human being would not possess. In this case, the origins of creativity are conceived as mystical or biological. Indeed, the creator is able to create from nothing—*ex nihilo*—because he/she is inspired by a muse, because he/she is affected by a psychic disorder, or because he/she has a particular genetic heritage. The definition of creativity following from this type of hypothesis can lead to many fallacious theories—such as literalism or creationism—explaining the origin of the universe (Ussher, 17th century), the myth of the romantic genius capable of imagination, judgment, and taste (Duff, 1767), eugenics to justify the existence of innate creative capacities based on genetic origin (Galton, 1869), or the arbitrary positioning on a metric scale of intelligence by the systematic calculation of the intelligence quotient (Binet & Simon, 1905). The "creative imagination" studied at the same time in arts and sciences would come even from the "precocity" reducible to the expression of the innate, the "necessity" of a mission to accomplish and the "individualism" of the "great creator" (Ribot, 1900).

During the Second World War, in parallel with the development of cybernetics and computer science, the development of the first theoretical and practical models of creativity appeared in the wake of operational research and behaviorism, opinion control, and marketing techniques such as brainstorming (Osborn, 1953) or synectics (Gordon, 1961). Starting in the fifties, with a more structuralist approach, studies on creativity became more systematic and, in particular, led to the development of factorial theories of intelligence (Guilford, 1950, 1967), integrating the study of multiple dimensions of the phenomenon, pointing to the existence of "divergent thinking" (Guilford, 1950), and leading to the development of creative-thinking tests (Torrance, 1976).

In the post-war period, society valued and instrumentalized the concepts of technological *progress* and economic *growth*. Creativity was democratized, while researchers studied the creative processes mobilized in everyday or ordinary activities. The *modern* condition of the human being was partly based on the attribution to each individual of a personal creative capacity and positions the individual in a constant search for novelty. Instead of divine inspiration, the inaccessibility of genius, or biological inscription, it was the psychological processes in their complexity that were studied to explain creativity.

At the end of the sixties, a wave of protest shook the entire world. Although they differed from country to country, depending on the socio-cultural systems from which they came and the political regimes they opposed, these movements all challenged the order established after the Second World War. At the end of the exceptional period of prosperity of the Thirty Glorious

Years, marked by the oil crisis of 1973, the young generation showed its deep disillusionment with a world based on: consumer society, the idealization of technology, blind faith in standardization, the perpetual search for optimization, and the ideology of progress. They criticized a social, political, and economic approach, heritage of the Enlightenment and conceived mainly using the analytical method (Descartes, 1637). Produced during the tragic incidents of May 1968, the iconic posters printed by the École des Beaux-Arts de Paris made the slogans of this turbulent period legendary. This time, the *postmodern* condition tried to reconnect with historicity, subjectivity, and uncertainty.

At the meeting point between structuralism (Lévi-Strauss, 1958), cybernetics (Wiener, 1948), and the theory of information and communication (Shannon, 1948), systems thinking provides an epistemological counterweight to the Cartesian method (Le Moigne, 1977, 1990). It is established around the central concept of "system" (von Bertalanffy, 1968) as a "set of elements in dynamic interactions, organized around a goal" (de Rosnay, 1975). Systems thinking extends the understanding of reality by modelling complex phenomena, from the *closed systems* of first-order cybernetics (Wiener, 1948; von Bertalanffy, 1968) to the *open systems* of second-order cybernetics, the latter being considered first as "self-organized" (Ashby, 1947; von Foerster, 1959), then as "autopoietic" (Maturana & Varela, 1972). Systems thinking provides transdisciplinary concepts for modelling complex systems, both artificial and natural. In other words, the systems paradigm integrates the contextualization of the phenomena studied, the subjectivity of observers, and the uncertainty of processes. The systemic attempts to "*rise* to see better, *link* to understand better, and *situate* to act better" (de Rosnay, 1975).

During its emergence in the sixties, systems thinking was a pioneer in the awareness of the limits of available resources on earth, notably thanks to work in system dynamics (Forrester, 1971) allowing the prospective modelling of planetary ecosocial systems (Meadows, Meadows, Randers, Behrens III, 1972), or thanks to work on the themes of "degrowth" (Georgescu-Roegen, 1979), the ethics of sustainability (Jonas, 1973), or the management of the "metabolism" of cities (Wolman, 1965).

At least since the beginning of the 20th century, the "creative imagination" has been considered by some researchers as the combined expression of different factors. For example, the combination of an "intellectual factor", an "emotional factor", and an "unconscious factor", conditioned by "organic conditions" and converging in a "principle of unity" (Ribot, 1900). This type of approach was also present after the Second World War, as in factorial theories of intelligence (Guilford, 1950). But at the end of the 20th century, researchers multiplied the approaches with different types of "componential models" (Lubart, 1999): the "Three-Component Model" (Amabile, 1983), the "Investment Approach" (Sternberg & Lubart, 1991), the "Interactionist Approach" (Woodman & Schoenfeldt, 1990), the "Cognitive-Component

Approach" (Mumford et al., 1991), and the "Systems Approach" (Feldmann, Csíkszentmihályi & Gardner, 1994).

In the early eighties, creativity was studied considering the developments in social psychology. The social narrative of creativity, the detailed study of the lives of characters—famous for their impact in different scientific and artistic domains—challenged the myth of the creative genius (Simonton, 1984; Weisberg, 1986). The study of personality traits and profiles of creative people was completed by the study of the influence of social environment, individual creativity, and motivation (Amabile, 1983), in order to develop componential models of creativity (Amabile, 1988).

A systemic and ecological approach was introduced to models of creativity by considering the creator, society, and the environment, as well as their respective relationships (Csíkszentmihályi, 1988, 1996, 1999). Models of creativity became contextualized, interactive, and evolving. Alongside the existence of "multiple intelligences" (Gardner, 1983), there were "multiple creativities" (Gardner, 1993). Creativity therefore no longer came only from the intrinsic qualities of the individual, but would emerge from a dynamic process of co-design, inscribed in a socio-cultural context, affecting the daily life of organizations and institutions.

More recently, the extensive digitalization of reality also questions the potential creativity of artificial intelligence. By widely developing the cybernetic concept of "feedback" (Wiener, 1948) through the development of "deep-learning methods" (LeCun, Bengio & Hinton, 2015), the interconnected objects that surround us seem to become intelligent and capable of learning by themselves. So much so that some believe creativity will no longer be specific to human beings (Boden, 2011). Indeed, if intelligence is defined strictly as the capacity of a self-organized system to inform data from the environment to produce useful knowledge so as to learn, understand, and adapt its behaviour to new situations—in a more or less creative way—then other types of self-organized beings such as artificial intelligences or animals can be considered as intelligent—to a certain extent—and susceptible to developing other forms of creativeness. On the other hand, others promote a globalist and transhumanist posture, with the explicit objective of transforming human beings into a "humanity 2.0" (Kurzweil, 2005a).

The transhumanist posture must be clearly distinguished from a new type of humanities—post-humanities—that criticizes the anthropocentrism and Eurocentrism inherited from the Enlightenment and attempts to redefine humanity's place in the world through analysis of the biological and technological continuum in which the human being is only one lifeform among others (Wolfe, 2009; Ferrando, 2019). Ironically, by promising the

transformation of a "*homo doublement sapiens*" (Claeys, 2019)[1] into a "*homo deus*" (Harari, 2015)—immortal, happy, and divine—transhumanists revisit the myth of the human being creating the human being when they hybridize technological mysticism and genetic inscription of creativity.

More than fifty years later, the crises announced and denounced by the protesters of the late sixties have unfortunately become worse. Today, serious problems affect humanity: an imminent eco-social crash following the crossing of "planetary boundaries" (Steffen et al., 2015); the "silicolonization" of the world (Sadin, 2016) and the "injunctive power" of artificial intelligence (Sadin, 2018); social, political, and health crises, crystallized by the COVID-19 pandemic. This complex situation requires methods for modelling phenomena that are not limited to optimizing existing structures, but need methods that achieve deeper structural mutations.

In the face of these multiple crises, many researchers assert that the future of civilization lies in creativity. Some emphasize the *positive* effects of the "knowledge society" (Drucker, 1969), the "creative economy" (Howkins, 2001), or the "creative city" (for example, the UNESCO Creative Cities Network established in 2004) in the service of a "collective intelligence" (Lévy, 1994), a form of "noosphere" (Morin, 2001), open-sourced and egalitarian. Others believe that this situation of "creative destruction" (Schumpeter, 1942), catalysed by the inevitable eco-social crash announced by collapsologists (Servigne & Stevens, 2015) will lead to the creation of an *economy of creativity* with an obvious impact on the job market. Scientific studies predict, in the near future, the disappearance of many jobs in favor of jobs that combine "creativity", "social intelligence" and "manipulation" (Bakhshi et al, 2015). Some argue that the world will be ruled by an urban, mobile, skilled and connected "creative class" whose members are the only ones capable of combining talent, technology and tolerance (Florida, 2002). Some even suggest that there will soon be a "complementarity quotient with artificial intelligence" to select workers for these new jobs, which will require skills of "adaptability", "neural flexibility" and "learning" (Alexandre, 2017). Indeed, the automation of industrial production processes, combined with the globalization of trade and the relocation of manufacturing activities, could be an unsurprising opportunity to lay off the least trained and least interchangeable employees (Ganascia, 2017).

Based on the premise that in times of eco-social crisis creativity can be beneficial to humanity, the cross-cutting question is clear: which epistemology should be chosen to model creative processes in a relevant way?

[1] Since in the taxonomic classification of the genus *homo,* "*homo doublement sapiens*" became *homo once sapiens*, in other words *homo sapiens sapiens* ironically became *homo sapiens*.

We propose to examine more precisely the creative structure of systems thinking—with its equally creative operational capacity for modelling complex systems—to help establish design processes that provide creative solutions to problems, while maintaining an ethical and sustainable perspective.

The hypothesis defended here is that the integration of a constructivist posture into systems thinking would have—at least—three important epistemological effects, which would make systemic approach particularly relevant for modelling creative processes confronted with contemporary problems.

Firstly, the thinkers of systems theory were determined to maintain it *evolving*. Systems theory has continuously developed by providing theories, methods, and tools useful for modelling complex phenomena in all scientific domains.

From the first-order to the second-order cybernetics, *observed systems* became *observing systems* (von Foerster, 1959). These question the conviction of scientists—forged in the 17th century from the hypothesis of mind-body dualism (Descartes, 1637)—that it is possible to have objectivity and to know reality. Without being a solipsism, the "constructivist epistemology" (Le Moigne, 1995) associated with the second-order cybernetics "claims that we *construct* and *invent* reality rather than discover it" (Segal, 2001, p.13). In other words, "we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning" (Heisenberg, 1958). The observation process is therefore itself affected. By modelling both the modeler (the system observer), the model (the observed system), and their interactions, the systems approach is therefore *intrinsically* creative because it integrates two interrelated creativities:

- firstly, from the point of view of modelling method, in a way complementary to the recognized scientific methods inherited from the modern sciences, systems thinking allows for conceptual "*bricolage*" (Lévi-Strauss, 1962), fundamentally taking advantage of resources, context, and the research environment;
- secondly, because of its creative modelling method, any model constructed from systems thinking provides feedback on the modeler, and the model is itself capable of producing creative thinking effects and providing creative representations and solutions to problems.

Secondly, by validating constructivist epistemology's principle of the dynamic relationship between the observer and the observed phenomenon allowing the production of knowledge, a parallelism exists between the evolution of theoretical models of creativity and the socio-cultural evolution of the postures from which researchers model them. From religious belief through the myth of romantic genius, hypothetical genetic superiority,

behavioural conditioning, emulative marketing techniques, cognitive ability tests, the influences of socio-cultural context, task motivation, environmental effects, economic impulses, to artificial intelligence, the structure of theoretical models of creativity reflects the nature of the theories, methods, and tools of the socio-cultural groups that conceive them. And since these aspirations are evolving, these models will evolve further. The creativity with which creativity theorists build their models thus seems limitless and could be a research topic in itself!

Thirdly, while it is not possible to definitively establish an ultimate theoretical model of creativity—creativity having the particularity of producing knowledge effects that are unpredictable at the time they appear—a constant seems to run through the entire history of research conducted on the subject of creativity. Based on the principle that "the same environment offers hundreds of realities specific to each species" (de Waal, 2016), each organism has an "*Umwelt*" (von Uexküll, 1909), a *surrounding environment* that it experiences in its own way. From there, below the eco-social conditions in which it evolves, the particular condition of the human being compared to that of other living beings is to give life to a complex interior world, parallel to the exterior world in which it lives. The human being thus has a *natural* creative capacity at work between two worlds: "The *homo sapiens* has undoubtedly conquered his humanity through an uninterrupted conversation between an adaptive intelligence which resorts to the creation of abstract ideas, and an imagining psyche, which replaces the real world by its mimetic representation, anticipates actions by a projective image, takes pleasure in the fictions and in the waking daydreams" (Wunenburger, 2003).[2]

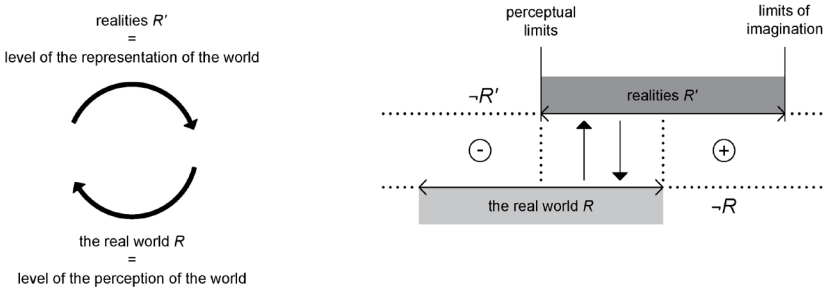

Figure 1. Damien Claeys, The dynamic shift between *R* and *R'*.

[2] "L'homo sapiens a sans doute conquis son humanité à travers un dialogue ininterrompu entre une intelligence adaptative qui recourt à la création d'idées abstraites, et un psychisme imaginant, qui remplace le réel par sa représentation mimétique, anticipe des actions par une image projective, prend plaisir aux fictions et aux rêveries éveillées" (Wunenburger, 2003).

Assuming reality is a mental construct and that "there is no absolute reality, but only subjective and often contradictory conceptions of reality" (Watzlawick, 1978), reality can no longer be considered as "real", nor exist as one singular reality. The consciousness of each individual generates its own reality, which evolves dynamically according to the individual personality and life experiences. The distinction between the *real world* and *realities* is an inherent feature of the human condition; besides, the human being (re)configures constantly an "augmented real world" (Claeys, 2013).[3] This augmented real world is "a double of the real world co-constructed by human beings—described as augmented—against which, impertinently, the real world resists as soon as it is challenged".

There is no complete correspondence between the real world and the plurality of realities, but a dynamic shift between *R* and *R'* (fig. 1). Indeed, *R'* is at the same time "*less* than the real world, since the processing of external information in our consciousness is subject to a cognitive limit; and *more* than the real world, given that our consciousness is capable of building an inner world that does not exist in the actual world" (Claeys, 2016). On the one hand, "the abstraction of parts of *R* seems to be inevitable, in order to prevent your mind from going mad"; on the other hand, "this reduction establishes a creative distance with *R*". Moreover, *R* and *R'* evolve both dynamically, but at different paces. As a result of this divergence, "a double balance sets in—in the less and the more—instilling existential anxiety and a sense of uncertainty, and often rendering the logical structure and limits of *R'* obsolete". The negative balance corresponds to the "non-augmented real world ($\neg R'$): it is composed of the infinite possibilities of the imagination non-activated in *R'*, which are capable of calling into question the integrity of *R*' ". By contrast, the positive balance corresponds to the "non-real world ($\neg R$): it comprises all the impossibilities of the real world activated in $\neg R'$, which prove to be untenable as soon as *R* resists" (Claeys, 2017).

From the dynamic relationship between the real world and the augmented real world, the imaginary is a process of mentally exploring the world, of conducting thought experiments before making decisions. In arts and sciences, consciousness acts as a real statistical generator of inferences thinkable between the limits of perception and imagination.

[3] Building on the terms *réalité augmentée* (*AR*) and *réalité virtuelle* (*VR*), we have defined in French the concept of "*réel augmenté*" in order to describe the *natural* cognitive ability of designer to create his individual reality. A conceptual distinction is drawn between *réel* and *réalité(s)* or, in other words, between *réel* (*R*) and *réel augmenté* (*R'*). Unfortunately, the literal translation of these concepts proved to be arduous, since *real* and *réel* seem to convey different meanings in French and in English – the word *real* designating both *réel* and *réalité(s)*. By the same token, we draw on the terms augmented reality (*AR*) et virtual reality (*VR*), in the English translation of this essay, in order to render the concept of *réel* and *réalités* by the following terms: *real world* (*R*) and *augmented real world* (*R'*).

The designer is affected by the phenomenon of "bounded rationality" (Simon, 1959): he/she is immersed in an environment generating a vast amount of information, but his brain cannot process all the incoming stimuli. As a result, the designer has a very *procedural* rationality and uses *routines* to make the majority of his decisions. In addition, the designer must adapt to the "natural complexity" of his environment, which exceeds his cognitive capacities, by means of "simplexity" (Berthoz, 2009)—a neologism concatenating the words *simplicity* and *complexity*. The designer proposes effective solutions that enable him/her to view issues in a different light and he/she uses simplifying principles (without distorting the complexity of the real world) to quickly process information before acting (taking into account the past and anticipating the future). Then, the designer reasons like a *statistician* (Dehaene, 2012): he/she reconstructs a probable reality on the basis of prior experiences (memory) and the ambiguous inputs interpreted by his/her mind (perception). He/she infers in a *dynamic* and *optimal* manner the probability of an event, drawing on the results of previous probability assessment of similar events and environmental inputs.

When stimuli activate the sensory systems, the main creativity resides in the human capacity to attribute meaning to a limited part of the perceived and imagined data in order to turn them into information. And when it associates this information within a meaningful and contextualized system, the human being creates knowledge. The novelty of the knowledge produced can also stimulate creativity.

After the brief state-of-the-art presented about the most influential theoretical attempts to model the creativity, the clarification of the constructivist posture integrated in systemic thinking induces the formulation of three epistemological effects:

- the imbrication of a double creativity intrinsic to systems thinking, that of the modelling method and of the model itself;
- the parallelism between the evolution of theoretical models of creativity and the socio-cultural evolution of the postures from which researchers model them;
- the impossibility of establishing a perfect theoretical model of creativity, the natural creativity of the human being coming from the incompressible dynamic gap between the real world and the augmented real world.

To conclude, through models integrating simultaneously the observer, the observed system, and their interactions, systems thinking is able to consider the natural creativity of human beings to design models and, through it, any creative form of theoretical model of creativity. This global capacity for modelling integration does not mean that it allows a modeler to design a

model representing the completeness of the real world. The distance between the real world and the augmented real world is irreducible when the human being apprehends the world around him, so it is just as irreducible when the system designer tries to model a phenomenon.

In addition to the epistemological questions raised, the state-of-the-art of theoretical models of creativity outlined in the first part of this text reveals that two dimensions are clearly valued in the most recent models: the eco-social and digital dimensions. And they correspond—not surprisingly—to the major challenges of the 21st century. With the use of the systemic approach, the question could be to know what the next dimensions to integrate could be. Among other possibilities, here are two proposals that continue the open debates by questioning eco-social systems and artificial intelligence:

- considering research in epistemology has overcome the rupture between nature and culture inherited from the 17th century to propose a "trajective" posture (Berque, 1987) for the study of eco-social systems—neither totally subjective nor totally objective—shouldn't we reintegrate more human imagination into theoretical models of creativity?
- considering research in artificial intelligence has extended the definition of intelligence—a capacity formerly associated only with the human brain—and posthumanist epistemology integrates animals and artificial intelligences into research on creativity—we don't discuss transhumanism doctrine in this paper—shouldn't we further reintegrate all other non-human species into theoretical models of creativity?

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