Models and Frameworks for Design Creativity

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A SYSTEMIC MODEL OF CREATIVITY TO ADDRESS COMPLEXITY IN DESIGN: THE STATE OF THE ART AND PERSPECTIVES

P. Bila-Deroussy[1], C. Bouchard[1] and S. Diakite Kaba[2]

[1] LCPI, ENSAM, Paris, France
[2] DRIA, PSA Peugeot Citroën, Velizy-Villacoublay, France

Abstract: This article provides a state-of-the-art review of the complexity of creative mechanisms, and compares them with practice of creativity in the industrial context. Our work has led to the development of a systemic model of creativity that, we argue, can guide the development of creativity tools suited to complexity in design. We begin by presenting a creativity method that has been deployed in an industrial context, and our observations from the analysis of around thirty creativity workshops. Next, we present a comprehensive overview of the complexity of creative mechanisms at various conceptual scales. We conclude by presenting a systemic model of creativity that highlights ways to develop new tools suited to the stimulation of creativity in a complex industrial environment.

Keywords: *creativity cognition, creative design process, creative tools and methods, systemic complexity, industrial context.*

1. Introduction

The problems we currently face are increasingly complex, and there is therefore a need for a change in design mentality and different ways of thinking (Charnley et al., 2011). It is often difficult to visualise solutions to these complex problems. They consist of a large number of interconnected and scalable systems and sub-systems, which makes it difficult both to have an overview of the whole and carry out an analysis (Manzano, 1998). It is this awareness of the complexity and uncertainty of the modern world that has led to the spread of the systemic paradigm, which takes full account not only complexity and uncertainty, but also ambiguity, vagueness and randomness (Durand, 1979). In general, solutions to such complex problems are very difficult to understand and represent as they consist of multiple sets of objects, services and relationships. In design, the systemic approach can be used to examine a problem as a whole, identify and use the relationships between its various parts, and to develop trans-disciplinary skills (Charnley et al., 2011).

Our research is motivated by the needs that we have identified both as researchers and as practitioners working in an industrial context – in particular, a car manufacturer. Responsible for managing creativity and running creativity workshops in a division dedicated to the user experience, we use existing creativity tools and methods that are widely used in the industrial environment, such as brainstorming, Synectics, TRIZ, etc. However, the issues we face have become so complex (both in technical and organizational terms) that these tools can no longer meet day-to-day needs. They have

been pushed to their limits, and it is very difficult to use them to stimulate creativity at the levels of performance required in complex design environments that are often difficult to understand.
We hypothesize that the perceived complexity in design projects in the industrial context, and the difficulty in finding creative tools to address it, comes from a lack of understanding of complexity and the systemic character of creativity mechanisms themselves. We argue that a systemic creativity model will make it possible to develop appropriate tools to stimulate creativity in complex industrial settings.
The first part of this article presents the creativity method that is deployed in our industrial context and a synthesis of observations from around thirty creativity workshops. Next, we propose a state-of-the-art review of creativity at several scales: the "environment", the "individual", and the "object". The third part proposes a systemic model of creativity that highlights ways to develop new tools. We conclude with a discussion of our model.

2. Feedback from the industrial context

2.1 Current creativity method

The context for our work is the User Experience division of a French car manufacturer, which is responsible for the design of the overall user experience of a client. Our mission is twofold, first to design Human Machine Interfaces (HMI) that provide new services and features both inside and outside a vehicle, and secondly to script experiences for prospective customers that show a systemic view of mobile use. In parallel with our design and scripting responsibilities, we organize creative group workshops where the raw material derived from field studies is transformed into usable outputs.
Our creativity method consists of the organization of creative workshops that aim to transform a set of data from preliminary studies into a synthesis of ideas and concepts that can feed into a given innovative project. The number of workshops depends on the project.

The workshop itself is divided into three parts:

- An information phase: Various input data are presented to participants in order to stimulate their knowledge with these new pieces of information.
- A generation phase: Participants combine this new information with their existing knowledge, and formalize the ideas and concepts that come to mind. Each participant or group of participants then gives an oral presentation of their ideas to the others.
- An evaluation phase: Stakeholders evaluate proposals by ranking them on several criteria that vary depending on the project, such as compatibility with the company's business sector, technical feasibility, or value for the customer.

Various existing creativity tools are deployed and can be used interchangeably in each of the three phases described above:

- Sentential tools: Brainstorming (rapid generation of ideas, written or oral), Challenging questions (essentially oral reminders), Role playing (experiments in social situations)
- Visual tools: Free sketching (unconstrained drawing), Sketching with canvas (constrained drawing and visual stimulus), Writing with canvas (constrained writing and visual stimulus)
- Objectual tools: Bodystorming (experiments with objects), Quick-and-dirty prototyping (formalization of a "draft" prototype), Scale modelling (spatial ideas on a one-to-one scale).

2.2 Observations from creativity workshop analysis

As around thirty creative workshops are held each year, we are able to highlight recurring observations and draw some conclusions about our current practice.

2.2.1 Lack of systemic vision

We note that there is a lack of exposure to a systemic vision, which is often the result of focusing on "targeted marketing snapshots" and the examination of only one use case, which obscures the overall vision. We also note that interconnections between ideas receive little attention; they are considered independently and the potential links that can be identified between them when they are generated are not highlighted. Ignoring these links immediately limits opportunities to identify potential combinations. Similarly, the separation of participants into thematic groups that do not communicate leads to a loss of systemic vision.

2.2.2 Impact of graphical tools

We noted that asking participants to draw encourages a playful mood, without creating an overly permissive climate detrimental to the quality of the ideas generated. The illustrated presentation of the results of earlier workshops is beneficial and is put to good use, particularly if it is visible throughout the workshop. However, it must be prepared with care, in order to be easily understandable.
We found that the quality (novelty and usefulness) of an idea is independent of its representation, while the quality of visual representations has an impact on understanding, acceptance and diffusion.
Finally, the summary of a creative workshop is less widely distributed in cases where there is no clear stakeholder who can take responsibility for disseminating the document to design teams.

2.2.3 Influential factors and process

Group workshops are based on the creative profile of participants, together with their involvement as a stakeholder in the project. Regarding the context, there is a balance to be struck between a stimulating and uninhibited atmosphere, and a fun environment that is overly permissive and unstructured. An excessively long workshop has a negative impact on the attention of participants and data integration. In the industrial context, we noted that participants feel secure when there is a rigorous method, and a process is followed that is clearly divided into specific phases.
A final recommendation is to pay attention to subjectivity when ideas are selected. This assessment should be only be carried out by experts and not by the group of participants, even if it seems beneficial to group cohesion and motivation.

3. Creativity at the scale of the environment, individual and the object

3.1 The environmental scale

Our brain organises itself following a comparison of perceived information and past experience (De Bono cited in Aznar, 2012). Creativity can be seen as an auto-poïetic system made up of discoveries that are constantly reproduced, which develops over time (Iba, 2009). This system is composed of interacting processes that mutually reinforce each other: between an individual and society, and between an individual and a given technical environment (Chanal, 2004; Fisher et al., 2005).
It should be noted that the processes of creativity and design are similar, the difference being the nature of the outputs and the actors (Basadur et al., 2000; Kryssanov et al., 2001; Lattuf, 2006; Bonnardel, 2006). Moreover, we cannot clearly and sequentially differentiate creation and evaluation, or definition and resolution, as these activities progress in parallel (Getzels and Csikszentmihalyi, 1976; Cropley, 2006; Visser, 2009). Thus, creativity is not a series of steps (Cortes and Robles, 2006; Howard et al., 2008), rather it is a long process that is intrinsic, reflexive, iterative and evolutionary and cyclical, permanent and continuous (Hybs and Gero, 1992; Weisberg, 1988, 1993, 1999; Ward, 2007; Lubart et al., 2003.). The environment stimulates the individual, both physically and socially, to begin generation and evaluation (Lubart et al., 2003; Fischer et al., 2005) at the same time, the problem and solution spaces constantly co-evolve (Maher, 1994; Maher and Poon, 1996; Wiltschnig et al., 2013). It is important to note that collaborative processes are convergent and limit divergent creative performance (Hoegl and Parboteeah, 2007). For greater efficiency, it is therefore necessary to switch between individual creativity for production, and group creativity for evaluation (Gordon, 1961; Drazin et al., 1999).
The choice of creativity techniques is a function of the type of ideas, the process and the context (Gryskiewicz, 1988; Brightman, 1988; VanGundy, 1988) but companies often lack the resources and the risk-taking attitude needed to deploy them (Degrange, 2000; Thiebaud, 2003; Tyl, 2011).

3.2 The individual scale

It is necessary to distinguish creativity (a potential capacity) from creation (a validated output) (Anzieu, 1981; Csikszentmihalyi, 1999). Creation must be new and suited to context in which it takes place (Lubart et al., 2003; Bonnardel, 2006). In design, creativity is a process that generates artefacts that must be both useful and valuable (Weisberg, 1998, 1993, 1999; Christiaans, 2002; Sarkar and Chakrabarti, 2008, 2011). The creative act consists of the identification and exploration of potential associations, and then building and modifying the right combinations (Poincaré, 1908; Oxman, 1997). This happens through the externalisation of knowledge structures present in representation and re-representation (Oxman, 1997). It is also the ability to identify multiple cross-references between various analogue matrices that were previously separate (Koestler, 1964). Analogical reasoning consists of comparing and contrasting different elements side-by-side (Gordon, 1961). The cognitive processes that come into play are fundamental and commonplace; they are not specific to creativity (Weisberg, 1988, 1993, 1999; Ward, 2007; Lubart et al., 2003).

The psychoanalytic approach suggests that creativity results from the creation of a new equilibrium after a period of psychic crisis (Anzieu, 1981). When analytical capabilities reach their limit, frustration triggers a period of unconscious incubation (Hadamard, 1956; Lubart et al., 2003.). The unconscious then highlights useful combinations, for example by linking ideas with evaluation criteria (Koestler, 1964; Ritter et al., 2012.). This is similar to the emotional resonance model where emotions that are reactivated by an environmental stimulus reveal the source concepts associated with them (Lubart et al., 2003). Awareness can be put to one side, which leaves room for the unconscious to work without inhibiting the ability to react (Bernèche cited in Aznar, 2012). Switching between conscious and unconscious work reduces mental fatigue and allows a new and unbiased perspective to emerge (Poincaré, 1908; Posner, 1973; Smith and Blankship, 1989; Melcher and Schooler, 1995).

Emotion is essential and has an impact on the motivational, contextual and functional aspects of creativity (Ribot, 1900; Lubart et al., 2003.). For example, a negative attitude is effective for long-term problem solving, while a more positive mood is better in the short-term (Kaufmann and Vosburg, 1997; Davis, 2009; Yang et al., 2012.). Similarly, the concept of 'flow' describes the merging of action and attention, focused commitment, concentration and enthusiasm (Csikszentmihalyi, 1988, 1999). The final phase of creation is ambivalence; this features an alternation between separation anxiety from the work and the desire to communicate it to the public (Rogers, 1951).

3.3 The object scale

Creativity is a cyclical reconfiguration and reinterpretation of traditional ideas and existing knowledge (Hybs and Gero, 1992; Lubart et al., 2003), together with a slow accumulation of new elements, where the quality of the material used is important (Weisberg, 1988, 1993, 1999; Ward, 2007; Lubart et al., 2003). The initial cognitive material is the result of sensations; the percept. This changes over time into a mental image, then into an idea-concept (Bernèche cited in Aznar, 2012). Pictorial thought therefore dominates the unconscious, as it is more primitive (Koestler, 1964; Ritter et al., 2012). In preconscious processes, the symbol is used allegorically and figuratively without being translated into words (Koestler, 1964; Kubie, 1958; Leboutet, 1970). Consequently, these visual images are recalled from associative memory in order to understand a perceived object (Oxman, 1997).

The forms are used, individually or together, as a symbolic language that can describe, store and process (Oxman, 1997, 2002). They structure relations in the consciousness of the individual, and interact with their mental images (Bruner, 1996; Van der Lugt, 2000, 2005; Visser, 2006, 2009; Iba, 2009). As the form encodes information and the knowledge that helps in reasoning, it must be qualitative and imprecise (Oxman, 1997, 2002; Visser, 2006, 2009; Iba, 2009). It is a hybrid contextualized representation (modelling and representation) that evolves along with knowledge (Mer, 1998; Blanco, 1998; Jeantet, 1998; Prudhomme, 1999; Lattuf, 2006). Thus the individual transforms one representation into another; although they are different they represent the same artefact (Visser, 2006, 2009). On a larger scale we can argue that it is the modification of 'memes': units of information whose integration is needed to develop the culture (Csikszentmihalyi, 1996).

Individual knowledge, judgment and personal meaning form the foundation for ideation and evaluation (Boden, 1990, 1994, 1999; Runco, 1992; Gardner, 1995; Fischer et al., 2005). Thus, the choice of creativity techniques does not matter much. Their effectiveness relies heavily on the experience of the facilitator, and the lack of formal methods has led to criticism of techniques that do not have a rigorous theoretical framework (Degrange 2000; Thiebaud, 2003; Tyl, 2011). Brainstorming, lateral thinking or Synectics can improve productivity but the results are often poorly structured (Jones, 2001). More formal methods can improve production, but they also 'over-organise' creative workshops (Jones, 2001). Similarly, there is no criterion that does not require assessors or peer-reviewers, whose evaluations are a function of their expectations and cultural norms (Csikszentmihalyi, 1999; Karni and Shalev, 2004). There are few evaluation methods because they are based on subjective ideas (Amabile, 1983). Analyses are inconsistent and lack rigour as evaluation is an uncertain stage where knowledge is limited (Ferioli, 2010; Tyl, 2011).

3.4. The systemic model of creativity

Following an analysis of the literature, we are able to summarise a creativity model, that highlights the fundamental interactions (perceptive, cognitive, and social) to stimulate to increase performance.

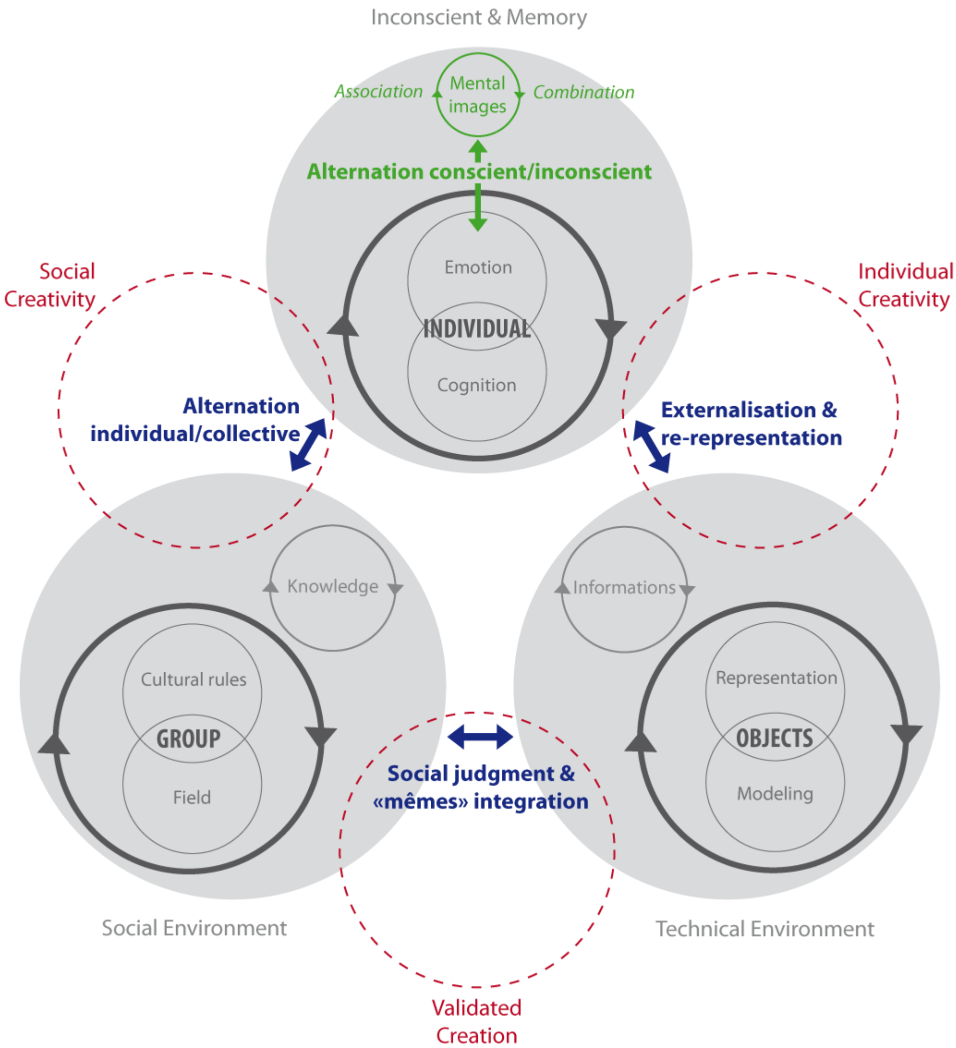

Figure 1. Systemic model of creativity

4. Discussion

Creativity is a complex system composed of processes between an individual and an interacting technical and social environment. This system is open and produces knowledge links between the experience of individuals and new information from the environment. Thus the individual and the elements that make up the environment (objects, other individuals) co-evolve over time, through an interactive cycle of description and changes to representations or intermediate objects. Consequently, the individual carries out two operations that are characteristic of the act of creation: description (extension of the perceptual field to improve the quality of informational elements available to them), and modification (externalisation of knowledge in memory by materializing it into a representation or intermediate object). Knowledge that has been externalised is evaluated through the subjective judgment of domain experts and integrated into the culture as a validated creation.

From this model and our experience in the industrial context, we propose three axes for research into the design of suitable tools to stimulate creativity in a complex industrial context:

- Promote the use of analogy-based tools to maintain the structural links between perceived new information and existing knowledge in memory, in order to improve perceptive interactions.
- Visually represent this knowledge using a structured graphical language to facilitate its description, memorisation, and transformation, in order to improve cognitive interactions.
- Alternate (in the context of an ongoing cyclical process) individual creativity, collective design and expert evaluation, in order to improve social interactions.

Deployed together, we argue these three research axes improve creative performance in complex contexts, by acting together on the tools, data, and the process.

5. Conclusion

Taken together, the results of our experience in the field compared to the literature review have enabled us to propose a systemic model of creativity that addresses design complexity. This model is intended to serve as a basis for the identification of mechanisms and flows that improve business performance in the domain of creativity. Not only can it indicate flows that have already been taken into account, but it also helps to uncover new avenues of research for the design of better creativity tools. Although the issues we address here are particularly relevant to the business in which we operate, as they provide methodological support for its innovation strategy, we believe that they are transferable to other sectors. We will continue our work in the areas presented here, in order to design and test new creative tools for industry. These experiments will be the subject of future work.

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