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Exploring Creativity in the Design Process: A Systems-Semiotic Perspective

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This paper attempts to establish a systems-semiotic framework explaining creativity in the design process, where the design process is considered to have as its basis the cognitive process. The design process is considered as the interaction between two or more cognitive systems resulting in a purposeful and ongoing transformation of their already complex representational structures and the production of newer ones, in order to fulfill an ill-defined goal. Creativity is considered as the result of an emergence of organizational complexity in each cognitive system participating in the design process, while it is trying to purposefully incorporate new constraints in its meaning structures. The meanings generated in each system are identified as the contingent and anticipatory content of its representations, and where self-organization is the dominant process in which they are continuously involved. Furthermore, Peircean semiotic processes appear to provide the functionality needed by the emergent representational structures in order to complete the cycle of a creative design process. Creativity originates in the abductive stage of the semiotic process, the fallible nature of which is maintained in the proposed framework by the fact that the respective emergent representations can be misfits. The nodal points of the framework are identified and analyzed showing that a cognitive system needs the whole interactive anticipatory cycle in order to engage in a creative design process.
Keywords: *Creativity, Emergent Representations, Anticipations, Self-organization, Peircean Semiotic Processes.*

1.0 Design Activities as Cognitive Activities

There are many contemporary efforts to define design and even more, to try to establish the basics that can be said to bring about the design process. Simon, among many other scholars and researchers, is clearly considering design as a cognitive activity when he states that "everyone designs who devises courses of action aimed at changing existing situations into preferred ones" (Simon, 1999, pp. 111; See Banathy, 1996, pp. 11-13 for a list of definition of design). He is reinforcing his argument by stating that design process is a problem-solving process and that "every problem solving effort must begin with creating a representation for the problem—a problem space in which the search for the solution can take place" (Simon, 1999, pp. 108). In general, design consists of producing representations regarding certain requirements and characteristics of the outcome of the design activity and the constraints and goals that this outcome should satisfy.

Design activities are usually considered as a discourse between problem-framing and problem-solving (Simon, 1995). Certain design activities that traverse the design process consist of the construction, elaboration and modification of the representations of the problem. In the problem-framing phase, designers refine their

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mental representation regarding the problem, while during problem-solving they elaborate their representations and then they evaluate them (Bonnardel, 2000). Depending on the framework of thought or the perspective based on which one explains the design activity, one may give emphasis on the way an agent engaging in a design activity uses his representations (Simon, 1999), while somebody else may concentrate on the way these representations are generated during the design activity, particularly on the factors such as interaction with the environment and other design systems[2], that play an important role on the generation of such representations (Schön, 1992; Schön & Wiggins, 1992; Gero, 1998; Smith & Gero, 2004).

In a more inclusive manner, Friedman (2003) argues that most definitions of design describe it as a goal-oriented process, where the goal is a solution to a problem, the improvement of a situation or the creation of something new and useful. According to this and considering those things mentioned above, it can be clearly implied that, given that the ability to act upon an environment in order to effect a goal-oriented attribution of a certain purpose belongs to a cognitive agent, design should primarily has as its basis the cognitive process. Thus any framework explaining and supporting the design process should be based upon a cognitive framework.

At this point it should be noted that the rationale for a framework to support the design process is neither to seek for a formalism to reduce the complexity of the design process, nor to produce models of structured representations to guide potential computer simulations. Such models would necessarily be much impoverished versions of reality, while any such framework would run into problems regarding contextuality and evolvability issues (Macmillan, Steele, Austin, Kirby, & Spence, 2001). Rather this work seeks to show that an in depth understanding of the complex and dynamic nature of a design process requires a framework to support the modeling of such processes. Simon seems to be an exponent of such an attempt and he also often stresses that design encompasses the notions of problem solving and of representations when he states that "a deeper understanding of how representations are created and how they contribute to the solution of problems will become an essential component in the future theory of design" (Simon, 1999, p. 132). Hence, a framework explaining the emergence and the functionality of interconnected representations of a cognitive system engaging in a design process would provide further understanding in order to better explain, foster and facilitate the emergence of creativity in the design process.

For describing and modeling the design process, cognitive frameworks can be divided into two categories based upon the sets of principles that govern them. The first category is that of the classical causal cognitivist/representationalist frameworks

2. At this point the term *design system* refers to a cognitive system in a specific context or situation, which brings forth a design process. It is considered as a design system from the moment that it decides to engage in purposeful interactions with its environment (i.e. with other cognitive systems). However, from a systemic point of view, it seems to be more correct to consider a design system as the set of all cognitive systems which are intentionally engaging in interactive design processes. In this view, the design system is solely defined at the social (cooperative) level and the design process acquires an interactive nature (see §3 for a relevant analysis).

of cognition. These are either based on a static notion of information and knowledge structures which do not support the interactive nature of cognition (Fodor, 1975; Newell, 1980) or they allow for an etiological approach to cognition and representations by adhering to the superiority of the environment and the system's "right" history for the guidance and selection of this evolution (Millikan, 1984; Dretske, 1981). The second category consists of cognitive frameworks based on the systemic and dynamic properties of emergence and self-organization. It is these properties that are fundamental to the approach described in this paper.

1.1 Cognitivist Frameworks of Cognition and their Implications for Design

The cognitivist frameworks of cognition are primarily based on the hypothesis that the cognitive system processes symbols that are related together to form abstract representations of the environment. In the most extreme case the processing is assumed as deterministic and the environment as pre-given. In the evolutionary version information processing is guided by the laws of natural selection imposed by the environment. In both cases, the primary ingredient of these representations is causal information provided by the environment. The cognitive system is then acting based on externally provided representations.

The major negative implications of the cognitivist frameworks in modeling cognitive process are due to the encoded nature of representations. These are taken to be in an exact informational correspondence with the environment. Each encoding results in a representational content which relates the cognitive system to the environment. The relation has a referential nature which is examined for its truthfulness. The problem this raises, setting aside the examination of the nature of such a representation, is to find the source of this content.[3]

Bickhard (1993) argues that such encodings are just *relationships of representational content transfer*. Cognitivist frameworks of cognition do not give any answers about the source of the representational content upon which such a relationship can exist. Consequently, the cognitive system needs a set of predefined representations in order to carry out any cognitive process. From this perspective, the representational content of the system's internal symbolic representations, that is, the cognitive system's meaning structure, is either static (old, passive and highly objectified knowledge of the system) or externally determined and imposed.

Since meaning is externally transferred but internally processed, the syntactic and semantic aspects of the cognitive system are separated, making the creation and enhancement of inherent meaning structures impossible. As an immediate implication, information is taken as the vehicle of exchanging objective meaning structures between system and environment. In other words, the information structure of this vehicle is supposed to produce in the cognitive system the same semantics wherever

3. Similar problems are also associated with other evolutionary (Millikan, 1984) and covariation-based frameworks of causal representations (Dretske, 1981). These frameworks get into troubles when they try to explain the problem of misrepresentation and its detection into and by the cognitive system itself (Bickhard, 1993), a property that, as it will be argued below, is vital for the emergence of creativity in a design process.

and whenever it will be processed. The realization of cognitive processes based on objective (universal) and predetermined meaning structures deprives the cognitive system of the property of creative and inherent intentionality. The property which primarily specifies the ways that the system chooses to cognize is located outside of it, but inside the source of the representational contents. Even accepting that the initial intentionality is represented by the existing meaning structures of the system, this is as far as it can go. This type of intentionality is brought to an impasse. It is purely referential and is independent of the context of the interaction. Such a cognitive system exhibits limited adaptability in the face of the continuously changing demands of a dynamic environment.

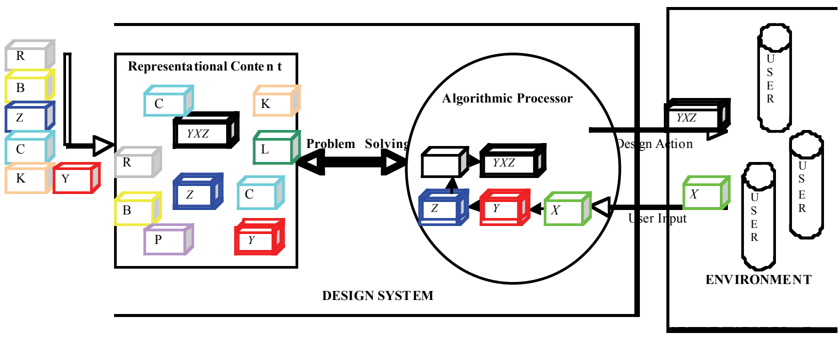

Fig. 1. The design process modeled under a cognitivist framework. A memory-like container contains externally provided representational content of knowledge about the environment. Perception of user input and design action are separated. Representational content X is objectively perceived. Predefined problem solving rules directly relate externally transferred representational content X with representational contents Z and Y and through the well-defined and predetermined searching of the existed possible solutions (taking place in the white box) the supposed appropriate solution is found. Questions such as where has the representational content come from, or whether the representations are in error cannot be answered and are not taken under any consideration.

The application of cognitivist frameworks of cognition to modeling and describing the design process merely reduces the latter to a rule-based and algorithmic process, or a process that is not directed by the design system itself. There are numerous related problems. The design process takes the form of algorithms operating within a finite and universal symbol system. The symbol system determines the basic representational space within which a problem domain can be defined. The design system needs to formally represent the domain of interest and then find some method of sequentially searching the resultant problem space. The problem solving operation is done by searching all the possibilities until the one constituting the appropriate solution is found. This means that all of the possible representational states must be defined before problem solving can begin. The fact that the information set used by the design system is assumed to be universal and predetermined in every context of interaction, limits the artifact's adaptability. There is no mechanism for the incorporation of new meaning structures based on feedback from the user of an artifact created by the design system. Hence, the result of such a design process cannot be scaled, and the design method itself cannot be easily applied to similar problems. The loss of feedback during the whole design process results in a separation between knowing and doing. In that case, the design system can be used only as passive meaning structures based on which the designer hopes to eliminate uncertainty in each design situation . The constructive dimension of the design process is removed and the design system cannot contribute in a direction that is not specified in the initial design space. The above mentioned are abstractly depicted in Fig. 1.

1.2 Essentials of the design process and the inadequacy of the cognitivist frameworks

1.2.1 Design problems are ill-defined and open-ended

Rule-based and etiological approaches in modeling and analyzing the design process would be successful if design problems were well-defined. Then, all that the design system would have to do would be to gather the necessary information in one universal information set, construct the initial and the goal states and the algorithms that will connect them. On the other hand, a design problem has many solutions, thus, there would be different logical paths that satisfy its constraints. The most appropriate one would be selected based on how well it satisfies the respective constraints. This presupposes that all the constraints are already given at the conceptual design phase and that their influence in the design problem is predetermined. Again, this is rarely the case (Goldschmidt, 1997), except for well structured subproblems of a larger problem space such as those sometimes found within engineering design, and where human activity plays a minor or non-existent role.

Most design problems are defined in terms of information about the people who will use the artifact, the purpose it has for them and the form the artifact should posses in order to be successful. Such design problems are ill-defined and the possible solutions are not clear from the beginning. Therefore, design solutions are almost never predictable and the design system never has sufficient information to define the desirable goal state in advance. Particularly, finding a solution requires in addition finding out what the real problem is, which in respect to human-center problems is improbable. The phases of solving and specifying are developing in parallel and drive each other. Claiming to have reached a static specification phase of the design process after the conceptual phase, because a clear understanding of the design problem has been reached is also rather misleading since solutions and problems co-evolve during the whole design process (Heylighen & Bouwen, 1999).

The ill-definedness of design problems is also mentioned by Banathy (1996), while he argues that design confronts interrelated complexes of problems. Particularly, he states that design confronts "a system of problems rather than a collection of problems" (Banathy, 1996, p. 29), and then he admits that "design problems are ill-structured and defy a straightforward analysis" (p. 29). Moreover, Banathy adopts an evolutionary approach to design (Banathy, 1989, 1996, 1998; Lazlo, A., 2001; Lazlo,

C. L., 2001), which justifies both the ill-defined and open-ended aspect of the design process. Lazlo tries to present Banathy's evolutionary design thesis in the following quotation: "The focus of designers is not the existing system. They leap out from it and push the boundaries of the inquiry as far out as possible. They attempt to paint the largest possible picture within the largest possible context…Designers have an expansionist orientation" (Lazlo, C. L., 2001, p. 382 referring to Banathy). For Banathy, design meant more than problem solving or mere planning and he acknowledged a more future- and action-oriented perspective. Nelson (2004), strongly and fundamentally influenced by Banathy's and Churchman's works (Churchman, 1971), argues that so far design inquiry can be characterized as the confluence of *truth-seeking inquiring systems*, that is, systems that try to find out what is true, *ideal-seeking inquiry systems*, that is, systems that try to find out what would be ideal (mainly in a religious and metaphysical way of thinking) and *desired-based inquiry systems*, that is, systems that try to find out what should become real, in terms of discerning "what would be a desirable addition to the real world" (Churchman, 1971, p. 263). Banathy, in all his work (Banathy, 1989, 1993, 1996, 2000) strongly argues in favor of the third type of inquiry systems, which he adopts as a design inquiry. As Bausch points out regarding Banathy's conception of the ultimate aim of a designer, "The idealized systems designer does not aim to create an ideal system. Rather he or she aims to create an effective ideal-seeking system" (Bausch, 2001, p. 144) in terms of seeking the now pragmatically attainable version of the ideal.

Therefore, the design process is a form of inquiry driven by intentional action. Accordingly, the representations of each cognitive system participating in the design process are continuously evolving and they are constantly incomplete and imprecise, no matter how much the problem solving progresses. Hence, design problems are also open-ended. As said above, there are different logical paths to reach a design solution, that is, different cognitive systems construct different representations of the design problem. This turns designing into a process which is difficult to model and even more difficult to prescribe. Consequently, in most cases, it is almost impossible to use computational tools and models to emulate the process of ill-structured problem solving (Goldschmidt, 1997). What is really needed is an analysis of the nature of ill-structured problems and of the representational processes that render them manageable.

1.2.2 The design process needs an interactive and systemic framework

The design process is very complex. The ill-defined and open-ended nature of a design problem makes both the goal state and the respective constraints highly ambiguous. An internal evaluation of a possible solution is not enough. Such an evaluation would be subjective and disregard real world needs. Internal evaluations of a closed system's actions are bounded to its initial organizational complexity. The result will always be satisfactory for the system itself but rarely for its environment and hence for other systems. The lack of valuable information from the system in all stages of the design process is confronted by the opening of its boundaries to interact with the environment. Banathy stresses the interactive and participatory nature of the design process arguing that a design system cannot design for others, but it can only design with others. Otherwise, as Lazlo (2001) also suggests, the design system cannot be said to engage in authentic design, rather, it tries to impose its visions and values, a situation supported by the conception of a design system in a cognitivist mode of operation. As it is mentioned by Jonas (2001), there is a need to grow the internal complexity of a design system to deal with increasing external complexity. Putting the design process into an interactive framework offers this possibility since now the emergence of the complex representational processes the design system engages in can be examined from a different perspective. Particularly, Banathy (1996) argues in favor of a systemic nature of the design process which is implemented in an interactive and iterated mode. These two modes are deemed as necessary for they allow the testing of alternative solutions, integrations of insights, the formulation of viable strategies, and a conscious attention to shifting parameters, factors that are all very crucial to complex design processes.

1.2.3 Design content is not the artifact itself

The assignment of the design process to an interactive framework raises the importance of the user of the design process outcome (user of the artifact). Users and stakeholders evaluate the artifact on the basis of their own individual experience. Considering that each user's experience and hence representational structures are different, the content of the design process should not be understood to be the artifact itself. Indeed, the content should not be attributed to the aesthetic and practical properties of a fixed object (Kazmierczak, 2003). The content of the design process is subjectively interpreted and changed by the user's cognitive processes, while in turn, she or he is purposefully engaging in future design processes. The design system should now provide form to a dynamic and ill-defined content in such a way that will facilitate its creative interpretation by the user/receiver and ultimately the other design systems.

1.2.4 The Design process needs to be anticipative in a future-oriented way

The different interpretation of content by multiple receivers with different representational structures implies that the design system has the potential to consider many possible outcomes and consequences of its actions before it proceeds to their realization. This does not necessarily require a known universal information set and a predetermined design problem space. As Rosen (1985) points out, such a past-oriented anticipation needs a model of cause and effect operating on an infinite regression. On the contrary, in the design process anticipations should be placed in a pragmatic context and be projected against the future, using different directions and time scales, (Nadin, 2000; Jonas, 2001). Design differs from mere problem-solving by its orientation towards the future of the whole system. It creates an image of the desired state, selects approaches and models the most promising alternatives. Banathy (1996) suggests that there are four ways that humans (primarily as cognitive systems and then as social actors) react to situations of abrupt and turbulent change. There is the reactive way, where one tries to find the solution in old choices and selections, the inactive way, where one does not react at all, the preactivist way, where change is anticipated and the possibilities are exploited and finally, the interactive way, where people interact with a desired future and try to bring it about by participating in its design. The interactive mode is the one that best conforms to Banathy's evolutionary approach to design (Banathy, 1996, 2000), as it implies a new kind of anticipation for the cognitive system engaging in the design process, such that it learns from the past and appraises what is presently useful and desirable by simultaneously projecting themselves into the future. As it will be shown below, such anticipations are emergent in the design process, they anticipate the possible future and they can be inappropriate. This kind of anticipation shifts the traditional perspective of intentionality and instead provides the basis for the emergence of a creative design process at the social and cooperative level.

A short review of known attempts trying to define and model the creative event in the design process is given in the next section. The respective problems and drawbacks in combination with the essential characteristics mentioned above are indicating the grounds for a radically different modeling of the design process in terms of the functional and representational properties of the cognitive systems that are engaging in and consequently, of creativity.

2.0 Creativity in the Design Process

Creativity, as a possible property of a cognitive process and consequently of a design process, is very hard to define. The problem is twofold. There is the difficulty of capturing the notion of the design process as creative and also, there can be no guarantee that creativity will occur (Dorst & Cross, 2001). The literature of research in creativity is substantial (Mumford, 2003) and spans a great variety of scientific domains (Simon, 1988; Health, 1993; Martindale, 1995). Much of the work on creativity to date has focused on the cognitive system as the design system itself. Early definitions of creativity defined it in terms of the creative process, that is a process essentially internal to such a design system by which ideas are generated.

Boden (1990, 1994) proposes the exploration and further transformation and expansion of well-formed conceptual spaces of a cognitive system as the basis for creative actions. Simon, in his attempts to construct an algorithm for implementing creative processing in a machine, models creativity as a three-stage process. Simon argues that in a creative process one should define the problem as concretely as possible, find the necessary heuristic rules and the solution will follow (Liu, 2000). Needless to say that, even now, a machine substituting for a cognitive process can only search through the conceptual space already provided by its designer (Brown, 2002). The representational structures of this space represent the two sub-processes recognized by Simon, leaving the last one to the machine. The problem with this approach remains even in a context that is independent of machine implementation.

As it is argued in Liu (2000), computer programs such as BACON (Langley, Simon, Bradshaw, & Zytkow, 1987) can be used to model the phase of solution-finding, when and only when the sub-problems in the first two phases are completed. But as Liu states, a whole creative activity also comprises the ways one should search in order to find the problem at hand and then the ways one should try to find the necessary heuristic rules.

Gabora (2002), who walks on the same theoretical ground as Boden and is somewhat consistent with Simon, considers that neurons represent memory locations, where the exploration of conceptual spaces is the revocation of these memory locations, while their transformation pertains to the formation of new associations between those neurons in order to produce new and creative ideas. On the same track, Santanen, Briggs, and de Vreede (2002) propose the Cognitive Network Model of creativity, suggesting that creativity involves a *multisociative process* where the purposeful and causal connection of previously unrelated frames of information produce a creative idea.

In any case, in the models mentioned so far, the emergence of personal creative activity is supported but the opportunity for further evaluation, and possible integration, of newly generated structures from the receiver and from the design system itself is not considered. However, some theoretical frameworks of cognition, such as Distributed Cognition (Holland, Hutchins, & Kirsh, 2000), focus on significant features in the environment and the role they play to support creativity. The role of the domain where the creative process takes place is emphasized by posing certain problems (i.e. people are judging the work of others) and by providing certain knowledge, resources and technological capabilities, it now sets the stage for certain kinds of creative advances. Dorst and Cross (2001) take one step further, proposing that in a creative design process there is a co-evolution and a respective interchange of information between the problem space and the solution space. Again, this latter situationalist view of creativity (Smith & Gero, 2004) does not move very far away from the individual perspective. It still becomes more appropriate to locate creativity with individuals, who build and shape their situation based on the coupling of internal characteristics with existing environmental conditions[4].

On the other hand, there is a recent emergence of researchers who have considered the social aspects of creativity (Banathy, 1996; Csikszentmihalyi, 1996, 1999; Mamykina, 2002). Csikszentmihalyi, who has approached the study of creativity from a systems point of view, and also Banathy, who emphasizes its interactive and conversational context, notice that although creative design systems are often thought of as working in isolation, much of our intelligence and creativity results from interaction, collaboration and co-operation with other systems engaging in the design process. Csikszentmihalyi suggests two levels of recognition, that of personal recognition by the creative design system itself and that of social recognition of the

4. For an analysis of why creativity and creative thought in general cannot also be an evolutionary (in a Darwinian manner) process the reader could see (Dasgupta, 2004) and (Gabora, 2005).

creative design system by other people within the same society and culture. Therefore, in Csikszentmihalyi's framework, the persistent examination and acceptance of a design system's creative process on a social level are required in order for a design process to be recognized as truly creative.

Whilst the above mentioned theories and models provide a partially possible explanation as to how creativity comes about in the mind of the individual, they do not give us in any way a notable understanding of creativity and they do not provide ways of studying it in the interactive and conversational context of the design process. Additionally, although representation is a central issue in cognitive theories, there is still no suggestion of the type of representations that could fully account for certain types of cognitive activity such as those that take place in the emergence of creativity in the design process. The presence of future-oriented anticipations, the interactive and consequently social nature of the design process, as well as the interplay between the personal and the social level of the evaluation of a creative action, call for the examination of creativity in an interactive framework supporting the cognitive as well as the communicative and cooperative aspects of design.

3.0 Self-organization, Design and Creativity

As it is suggested by Glanville (2001) the design process should primarily be examined within a cognitive framework based on 2nd order cybernetic epistemology. In that case, a cognitive system is able to carry out the fundamental actions of distinction and observation. It observes its boundaries and it is thus differentiated from its environment. As the system is able to observe the distinctions it makes, it is able to refer back to itself the result of its actions. This makes it a self-referential system, providing it with the ability to create new distinctions (actions) based on previous ones, to judge its distinctions, and to increase its complexity by creating new meanings in order to interact (Luhmann, 1995). The self-referential loop can only exist in relation to an environment, but it also disregards the classical system-environment models, which hold that the external control of a system's adaptation to its environment is replaced by a model of systemic closure. Due to that closure, the self-reference of an observation creates meaning inside the system, which is used as a model for further observations in order to compensate for external complexity. Each new operation based on observation is a construction and also an internal increase of the organizational complexity of the system. This process of emergent increment of order is a process of self-organization (Von Foerster, 1960).

As the self-organizing system evolves and interacts via structural couplings with its environment, it creates an internal network of interconnected structures representing its history and experience (Maturana & Varela, 1980). Their continuous internal differentiation creates certain functional subsystems with non-linear interrelations. This means that the emerging patterns are not the sum of their components and hence, a self-organizing system is a dissipative system exhibiting a far-from-equilibrium organization. In the subsequent interactions the system would be subject to external perturbations, which would be evaluated on the basis of pre-established structural couplings. Therefore, at any time, there are some internal dominant constraints suppressing all the rest and guiding the system's organization.

The constraints that are not suppressed are known as order parameters. The importance of order parameters in the analysis of creativity from the perspective of self-organization has also been elaborated upon in Knyazeva and Haken (1999). More generally, as Collier (2004) states, in a self-organizing system there is a production of order at a higher level of constraint, or "the promotion of order from one constraint level to another" (Collier, 2004, p. 156). During this phase transition, the newly formed organization enables the emergence of new kinds of possibilities that were not present in the system before. This increase in the degrees of freedom exhibited by the system is what Glanville (1998) sees as an increase in the variety of possibilities within which a creative system can operate. Glanville continues to argue that it can only be naturally assumed, but it can in no way be proved that "an increase in the variety of possibilities will lead to an increase in creativity" (Glanville, 1998, p. 60). Collier is thinking along the same lines when he states that in a self-organizing system, "constraints are always both enabling and disabling," and "they form the conditions required for more complex constraints to form" (Collier, 2004, p. 158). Combining these two arguments, it can be implied that creativity is considered as the result of an emergence of a new form of organization in a self-organizing system, while it is trying to purposefully incorporate always new and more complex dominant constraints.

At this point it should be noted that Jantsch (1975) and then Banathy (1996), being strongly influenced by Jantsch, have also adopted a self-organizing perspective in their approaches to the social aspect of the design process. Jantsch adopts Prigogine's *order through fluctuation principle* (Prigogine & Stengers, 1984) and applies it to society. Hence, he regards social systems as dissipative systems and in general, he adopts an evolutionary perspective which emphasizes process over structure. He also considers social systems as re-creative systems with self-transcendence as one of the most important evolutionary mechanisms, which will eventually lead to the open evolution of the respective structures. Banathy, who in his turn considers social systems as processes that first of all renew themselves and evolve, quotes Jantsch:

> When a system, in its self-organization, reaches beyond the boundaries of its identity, it becomes creative. In self-organization, evolution is the result of self-transcendence. At each threshold of self-transcendence a new dimension of freedom is called into play for the shaping of the future. (Banathy, 1996, p. 162).

Jantsch argues in favor of the process-oriented nature of design. Banathy, says that self-transcendence is the freedom to evolve and co-evolve by design, and Jantsch argues that design is a process and that the product of design is also a process. Both of them agree that design is becoming, it is learning, it is creating. Also, Jantsch acknowledges the self-reflexive property of dissipative social systems (although on a spiritual level. See Fuchs, 2002 for a thorough analysis.), which provides the social system with the ability to anticipate and guide the design process. Hence, both Jantsch and Banathy agree on the anticipative nature of the design process. In all, the essential suggestion of Jantsch and of Banathy is that social systems are purposeful systems whose evolution can be guided by design. They propose that evolution, through the incorporation of the self-organization paradigm in human systems (Jantsch, 1980) becomes the historically integral aspect of self-organization with design being the fundamental process of evolution (Banathy, 1998). Therefore, "design becomes the central activity in social systems, and competence in design becomes a capability of the highest value" (Banathy, 1996, p. 16).

However, Jantsch's approach to social self-organization has some implications for the design process that slightly but at the same time, quite substantially differentiates his position from Banathy's and also adds some problems in the conception of the design process. Although the evolutionary aspect of design, as well as anticipations and learning play an important role for both of them in the understanding and explaining of the design process and of creativity, Jantsch's conception, in a way, brushes aside the role of human beings in social self-organization and consequently in its evolution through creative design. Particularly, Jantsch suggests that at the moment, social organization is into a fully conscious design phase, having passed from an internalized and then from an increasingly competitive phase. In Fuchs (2002) it is argued that this conception is deterministic and does not take under consideration that the ability of humans to make conscious choices renders social evolution an open-ended process that does not have to follow the course from individuation to competition and then to co-ordination. This is not an unusual stance for some of the defenders of radical social self-organization. Fuchs (2002, 2003a) analytically describes Hayek's conception of the emergence of effective social order as fully based on the unintended consequences of individual action (Hayek, 1988) and on Mueller-Benedict's argument that individuals cannot participate in social self-organization. The later approaches social self-organization in terms of small quantitative changes at the individual level that result in qualitative changes at the social level. He stresses that new qualities at the collective level cannot be deduced from the individual ones, no matter the knowledge of the observer regarding the lower level. He suggests that such a process is non-intentional and that individuals cannot influence it (Mueller-Benedict, 2001). So, Hayek considers the actions of the individuals as unintended, while Mueller-Benedict almost totally rejects the role of agency in social self-organization. This rejection either implies the rejection of co-operation between individuals, or suggests the non-intentional nature of it. Certainly, Jantsch's position is not as radical since he does not exclude human intervention. Indeed, he admits that "individuals impart life to human systems and the latter in turn stimulate life in individuals" (Jantsch, 1975, p. 57). Specifically, although he suggests that human beliefs, ideas, imagination and invention influence the evolution of society, he considers these properties in a self-reflexive spiritual level and hence he does not manage to explain this interrelation between society and individuals any further.

Overall, Jantsch argues in favor of a reflexive spirit that design the evolution of society (Fuchs, 2002).

Banathy, on the other hand, acknowledges the important role of human agency. He is strongly based on Prigogine's "order through fluctuation" principle and considers social systems as dissipative systems that reach certain bifurcation points, where they can then disintegrate into chaotic behaviors or a higher level of order can emerge through a self-organization process. Banathy continues by arguing that in nonhuman systems the direction that the system will take at the bifurcation point cannot be determined and hence it is up to pure chance. He then mentions that this is not the case in complex social systems and that since "even small fluctuations may grow and change the system" one should expect as Prigogine and Stengers state that "as a result individual activity is not doomed to insignificance" (Prigogine & Stengers, 1984, p. 313; cited in Banathy, 1996, p. 170). So, Banathy (1996), introduced the term social systems design and evolutionary systems design (see also Lazlo, A., 2001) to emphasize the fact that the creativity of human beings allows them to actively participate in the design of the evolution of social systems. Indeed, Banathy states that "Yes, we can give direction to the evolution of our systems by purposeful design. We carry the burden, the responsibility, and it is our privilege to guide our evolution and be responsible for it" (Banathy, 1996, p. 170).

It should be clear by now that Banathy, in contrary to radical social self-organization approaches, admits and credits the role of agency in social systems design. As a matter of fact, for Banathy, but also for Jantsch, Hayek and Mueller–Benedict's suggestion that individuals cannot and should not intervene in the social self-organization is a misconception as all processes in social systems depend on agency and social evolution is not fully determined by chance, but on the contrary, individuals can consciously design evolution (Jantsch, 1975; Banathy, 1996). This does not mean that human beings can fully determine the course of evolution. In any case, full determination or mere chance is the basis for a reductionist argument regarding the role of individuals in the design of social systems evolution. Banathy, influenced by Prigogine's work, adopts a moderated and intermediate approach. He states that

> The various cultures of our societies are immensely complex systems. They are highly sensitive to fluctuation and potentially involve an enormous number of bifurcations. These, then, could lead our systems on an evolutionary path or reorganization at ever higher levels of complexity. (Banathy, 1996, p. 170)

Therefore, Banathy suggests that human beings may not be able to fully determine and choose the course of evolution, but they can act so as to increase the possibility of a desired outcome or, in other words, they can actively design the context of the evolution of social systems.

At this point, one should try to understand how this evolution takes place and the way that human agency plays a very important and design-oriented role in it. As it has been shown there are certain types of social *re-creation*, the way Jantsch suggested the term, which describe different ways of how social self-organization takes place. Fuchs argues in favor of a broader sense of re-creation where social self-organization takes place permanently and where the creative and self-conscious actions of individual actors constitute the core of the process (Fuchs, 2003b). Banathy, suggests that such a design process materializes as an ongoing conversation, where different individuals come together in order to "generate collective meaning and collective consciousness" (Banathy, 1996, p. 214), implying the participatory and cooperative nature of the design process. Fuchs suggests that in a broad sense, co-operation can be understood as co-action. Particularly, he states that co-action can be considered as the case where "two or more social actors (individuals or groups) act together in a coordinated manner (whatever the subjective reason and motivation for this action might be) and a new social property emerges" (Fuchs, 2003a, p. 12). Acts of this kind constitute social acts and they produce new meanings at the social level. Fuchs use the term *social information*, denoting the new social property and he argues that in order such new properties to emerge individuals must engage in social interactions. He continues stating that such social interactions result in social actions, which are "acts of co-operation" that "are mediated by acts of communication that, in turn, are mediated by acts of cognition" (p. 12). The approach adopted in this paper is in parallel to this conception of social action as it considers that the design process requires the engagement of individual cognitive systems in intentional (meaning-based) interactions with their environment and consequently with each other, where they simultaneously acquire a social ontology (Bickhard, 2004). Since the aim of this paper is the introduction of a framework that will better explain the emergence and the functionality of interconnected representations of a cognitive system engaging in a creative design process, we argue that the focus on the purposeful interaction of two or more cognitive systems must take under consideration not just the cognitive, but also the communicative and the cooperative aspects of the design process. We consider this the way that individual cognitive systems engage in design inquiry and the respective design conversation that Banathy suggests.

Following on from this, each cognitive system participating in the design process is considered a self-organizing system. In a serial description of the design process each one of the participating cognitive systems could be defined as design systems or user systems in different time instances. However, the systemic and interactive approach adopted in this paper yields a more participative and cooperative term, as the one of *user-designer* which is used by Banathy to denote the *designing within the system* approach to design (Banathy, 1996, p. 226). Hence, a cognitive system acquires the identity of a user-designer system the very moment that it intentionally decides to engage in a design process. Consequently, the design process is seen as an interaction between two or more self-organizing user-designer systems in order to build ever more adaptive representations towards ill-defined outcomes. The functional aspect of the design process in which each user-designer system interactively participates becomes the purposeful and ongoing transformation and expansion of its already existing representations. For each user-designer system, a different representational content is internally emerging from their mutual attempts to incorporate an artifact, as a perturbation and not as a static informational structure nor as a content in itself, into their organization. Additionally, the group of self-organizing user-designer systems engaging in such a design process constitutes a design system, which, as expected from the previous analysis, it is defined on the social level.

Although a logical sequence of the interaction cannot be implied, for the benefit of this analysis, it can be said that a user-designer system attempts to communicate its representations to the other user-designer systems participating in the design process via the creation of an artifact. Keeping creativity in mind, the aim of this communication is to induce, in the other user-designer systems, the emergence of the necessary constraints that will guide their organization to a new order, facilitating their actions towards an ill-defined problem. Thus, the design process is a purposeful communication between two or more self-organizing user-designer systems via the use of the artifact as the common cognitive interface. This has two implications for creativity in the design process. The first one is that the self-referential nature of each user-designer system provides it with the ability to exhibit creativity within the boundaries of its closure. Simultaneously and due to the closure of all the user-designer systems participating in the design process, the effectiveness of the artifact resulting from the creativity of the user-designer system that communicated it is not assured. This adds to the mix the social dimension of creativity. The second implication flows from the first and imposes a great responsibility upon each user-designer system regarding the effectiveness of their artifacts. The more creative the design process the deeper and more profitable the structural coupling between the user-designer systems participating in the design process. This makes each user-designer system responsible for something that in principle it can only perturb. The richness of each user-designer system's organizational structures will play a very important role in the effectiveness of this perturbation, but each user-designer system would have to anticipate the degree of this richness when it tries to communicate its artifact. This adds to the difficulty of creativity in the design process.

This description of the design process acknowledges its systemic, interactive, communicative and cooperative nature, since it considers that the cooperative aspect of the design process, that is, the intentional decision of two or more user-designer systems to interact in order to engage in the purposeful design of ill-defined outcomes, it is mediated by the communication of their representations regarding these outcomes to the other user-designer systems participating in the design process, which, in turn, is mediated by the self-organizing cognitive processes that each user-designer system interactively achieves. However, as of yet it can account neither for the type of representational structures and their content as they emerge in the design process, nor hence, for the future-anticipative nature of the design process or its iterated and recurrent mode of realization, two vital properties for its evolutionary and open-ended character. In general, the placing of the design process and creativity in an interactive and self-organizing framework of cognition provides no answer regarding the framework's functionality or the way that creativity can be identified and observed. A further complication is that there is an established rejection of the notion of representation in the self-organized approach to cognition (Varela, Thompson, & Rosche, 1991; Port & van Gelder, 1995). These are serious obstacles in our attempt to identify and model the complex representational structures that emerge in each user-designer system participating in a creative design process. In an attempt to deal with these problems we introduce, in the next section, a model that supports the emergence of representations in a cognitive system's anticipations of future possible interactions. This leaves behind the traditional notion of a general-purpose algorithmic representation, implying that any representational functional organization is an emergent product of the anticipative interaction between a system and its environment.

3.1 Emergent Representations and Dynamic Anticipations

Bickhard (1993), postulating a self-organizing system[5] and its functional subsystems, argues that in order for such a system to be adaptable to a dynamic environment, two properties are required. The system should have a way of differentiating environments and a switching mechanism in order to choose among the appropriate internal processes. For such a type of a selection mechanism to be generated, the self-organizing system should have several differentiating options available. The differentiations are implicitly and interactively defined by the final state that a subsystem would reach after the system's interaction with a certain type of environment. Although such differentiations create an epistemic contact with the environment they do not carry any representational content, thus they are not representations. Rather, they indicate the interactive capability of system's internal process.

Such differentiations can occur in any interaction and the course of the interaction depends on the organization of the participating subsystem and of the environment. A differentiated indication constitutes emergent representation, the content of which consists of the conditions under which an interactive strategy will succeed in the differentiated environment. Bickhard calls these conditions *dynamic presuppositions* and argues that this content emerges in system's anticipations of interactive capabilities. In other words, the interactive capabilities are constituted as anticipations and it is these anticipations that could be inappropriate and this is detectable by the system itself, since such anticipations are embedded in the context of a goal-directed system (Bickhard, 1993, 2001). This type of anticipation is very different from the one supported by the cognitivist models of representation, which are trying to find a mapping of the environment to their past decisions. Here, the activity is future-oriented and it can be inappropriate, should the chosen interactive strategy not internally yield the desired results, if the respective environment does not support the type of interaction that would lead to the anticipated internal outcome.

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5. Bickhard uses the term *recursively self-maintenant system*. For a thorough analysis see (Bickhard, 1993, 2001).

3.2 Dynamic Anticipations in the Design Process

It has already been noted that the ability of the user-designer system to anticipate the richness of another user-designer system's organizational structures is crucial for the emergence of creativity. Considering the dynamic and future-oriented type of anticipation described above, it can be said that each user-designer system participating in a design process should have the capability for anticipative interaction with the environment in order to achieve the closure conditions that will give it the opportunity to satisfy its constraints. Actually, the higher the degree of anticipation in each user-designer system, the higher its ability to evaluate its interaction and its ability to incorporate multiple possibilities in its performance. The problem is that all possibilities and selections cannot be inherent in the organization of each user-designer system. A possible solution is that the user-designer system should evolve learning capabilities. This would provide the way to expand its dynamical anticipation capacity and its ability to evaluate a possible interaction. The user-designer system becomes less dependent and more sensitive regarding its contextual interactive capabilities. It increases its ability to better recognize its environment, evaluate the conditions and properly formulate its goals regarding the problem (Christensen & Hooker, 2000). This provides an infrastructure better suited to the user-designer system's ability to define the design problem and anticipate the possibility of success in the emergent interactions between the other user-designer systems and the communicated artifact. Structural coupling is strengthened and creativity acquires a more prosperous field of emergence.

Of course not every external perturbation is useful to a dynamic, anticipative, interacting user-designer system. Only those contributing to the system's closure and therefore to the preservation of its self-organization would be selected for further exploitation. Since, in the proposed framework, closure is achieved at the level where differentiations take place and where the respective representational content emerges, creativity cannot be clearly defined, nor statically identified. Rather it has the nature of a dynamic interactive process. Hence, creativity is considered as an anticipative and future-oriented process and it is a vital asset being directly related to the promptness with which the self-organizing user-designer systems participating in the design process will internally create adaptive emergent representations towards ill-defined outcomes. The artifacts are not objects any more, but interfaces functioning as triggers that drive the formation of new representational content. These common interfaces between the user-designer systems should be seen as signals from one to the other that does not have a direct informational content in themselves. Rather, each user-designer system should exploit each artifact as the source of order for its own self-organization.

The consequence of this perspective is the paradigm shift from focusing on designing static things to focusing on designing the emergence of thoughts and of novel representational content. The interaction with an artifact results in a differentiated indication of the interactive capabilities of each user-designer system engaging in the design process. Taking this perspective, creativity is located in the degree to which the communicated representational content of each user-designer system, through the artifact, generates the proper indications. In other words, the measure of creativity is the extend to which the communicated representational content generates the appropriate action conditions, that, given the interactive capabilities of the user-designer systems that each time receive an artifact, will allow them to reach a closure condition, that is, these user-designer systems will be driven to interactive adaptation towards their ill-defined goals. What should be noted at this point is that based on this perspective, the content of the design process is not the artifact itself. It is also not static, since it is the attempt to communicate the user-designer system's representational content to the other user-designer systems actively participating in the design process. Moreover, all user-designer systems engage in a mutual dependence with each other, while they are trying to increase their anticipatory capacity. In their attempt to create richer representational structures towards their ill-defined goals, they are continuously interacting with the artifacts and hence, they learn to anticipate, or as it is suggested by Bickhard (2001) they anticipate the necessity to acquire new anticipations. Furthermore, the progressively increasing capability of the user-designer system's anticipation creates an intentional capacity. This is not the same as the traditional notion of intentionality considered as the sum of all system's representations. Intentionality derives from the user-designer system's capability of purposeful interaction and accordingly is measured. This makes creativity an intentional and dynamically anticipative self-organizing process.

3.3 Semiotic processes as vehicles of emergent representations

In this paper, the consideration of representations as emergent in a user-designer system's anticipations of interactive potentialities allows for the existence of representational content in a self-organizing context. Moreover, this representational content is responsible for guiding each user-designer system's interaction and accordingly its creativity. A problem that still remains is to find a way to follow and observe these representations. Indeed, it is very important that the representations emerging in a design process are indicated in order for each user-designer system to be able to manage their functional effectiveness during the design process. Following Brier (1996, 2005), who proposes the use of the Peircean semiotic framework as a medium of signification in his attempt to make a re-entry and complement the second order cybernetics framework, Peircean semiotic processes are examined to see if they can act as a vehicle of emergent representations. Specifically, Peircean semiotics provide a functional framework for the indication of important nodal points and their representational content in a self-organizing system's intentional interaction (Arnellos, Spyrou, & Darzentas, 2003).

In a Peircean semiotic process (Peirce, 1998) a *complete Sign* is the one in which a *Representamen* (sign) refers to a *ground*, to a *correlate* (sign-vehicle) and an *Interpretant*, which is itself a more developed Sign. The ground of the Representamen is the sort of idea in reference to which the sign stands for its *Object*, as it does not stand for it in all respects. The sign-vehicle is the representative element, the foundation over and above which a relation arises. In principle, the sign vehicle can be implemented in any kind of structure. Independently of its implementation, it is the element responsible for the conveyance of the Object signified to the cognitive system. The sign-vehicle is often called a Representamen. A cognitive system may link the sign-vehicle to its signified object. At this point Peirce's distinctions regarding the nature of Objects should be considered and briefly described. He distinguishes between the Immediate and the Dynamical Objects of a Sign as follows:

> We must distinguish between the Immediate Object—i.e., the Object as represented in the sign – and … the Dynamical Object, which, from the nature of things, the Sign *cannot* express, which it can only *indicate* and leave the interpreter to find out by *collateral experience*. (Peirce, 8.314, italics in the original)

Or else:

> we have to distinguish the Immediate Object, which is the Object as the Sign itself represents it, and whose Being is thus dependent upon the Representation of it in the Sign, from the Dynamical Object, which is the Reality which by some means contrives to determine the Sign to its Representation. (Peirce 4.536)

So, briefly, it can be said that the Immediate Object of a Sign is the Object as it is immediately given to the Sign, the Dynamical Object in its semiotically available form. The Dynamical Object is something in reality which the Sign can only indicate, something that the Interpreter should find out by collateral experience.

Applying this to the interactive and dynamic context of the design process, as it has been described so far, it can be said that each user-designer system creates a sign (and not an object) that is interpreted by the other user-designer systems (recipients) participating in the design process. The relation between each user-designer system is founded over the sign-vehicle (artifact), which plays the role of the representamen. Due to the organizational and therefore representational closure of the interacting systems, there can be no direct way for each user-designer system to determine the representational content of the other participants. Each user-designer system tries to realize this content in a form which is the ground of the representamen. The ground is understood as form, since this is the only way it can preserve the characteristics of the user-designer system's representational content, while allowing it to be realized by a different cognitive process from the recipients user-designer systems. Accordingly, the mediator (representamen) will exhibit this form by means of some qualities, properties and relations it has independently of whether it serves as a mediator. It is the qualities, properties and relations of the sign-vehicle that determine and constrain the form of the ground. The form of these qualities, properties or relations is what has been mediated from each user-designer system to the mediator. The latter will determine the ground of the representation for the recipients user-designer systems. The user-designer system is responsible for the creation of a mediator in such a way that will have the ability to include these aspects of the sign which concern its relation to the recipients user-designer systems.

In this paper an analytical description of the types and properties of the representational relations will not be given, but a useful analysis of the representational content regarding the relations between mediator/sign-vehicle, mediator/interpretant and sign/interpretant, as well as a thorough analysis regarding the different nature of Objects is provided in (Lizka, 1996).

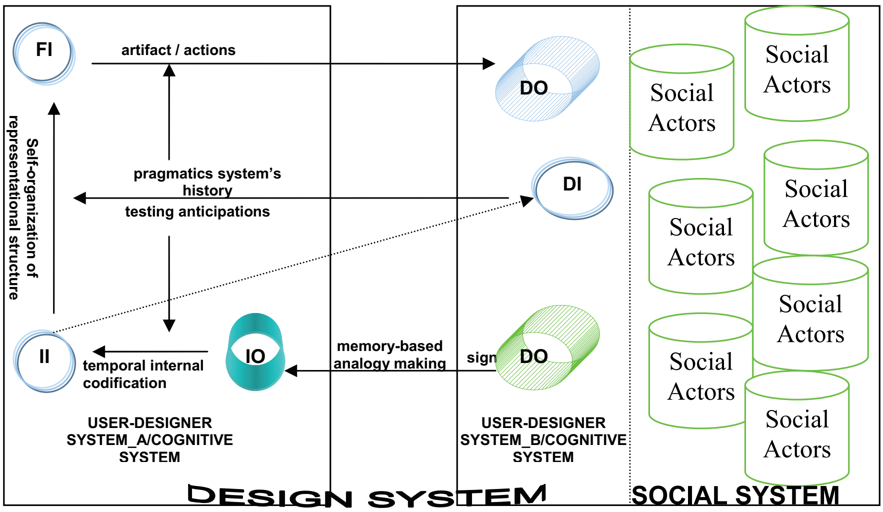

Fig. 2. Nodal points and functionality of emergent representations in a design process modeled under a framework of self-organizing Peircean semiotic processes. User-designer system_A purposefully interacts with user-designer system_B as they engage in a cooperative design process, where they try to communicate their representations regarding an ill-defined outcome via the construction of signs. They both constitute a design system. Social actors are cognitive systems that they are not participating in the specific design process and therefore, they do not belong to the specific design system. Social actors may engage in other design processes together with other social actors and hence form another design system. User-designer system_A and user-designer system_B are social actors belonging to the same social system in which the specific design system is defined. Due to space reasons, user-designer system_B is not fully presented in the figure. It is assumed that in some point at the course of the design process, after exhibiting a similar functionality as the one of user-designer system_A, it has created a sign that wishes to communicate to user-designer system_A.

As shown in Fig 2—examining the case, where the user-designer system_A is interacting with an artifact—before the user-designer system_A decides to interact with the artifact, there is only the dynamic object, which is the artifact with respect to the user-designer system_B. When the user-designer system_A decides to interact it firstly proceeds to memory-based analogy-making and indicates the nature of the dynamic object by a differentiation which forms the immediate object. There is an asymmetrical relation between the dynamic object and the immediate object. The former has an interactive potentiality that it can only be partly captured by the latter. It is impossible to reach the total of the interactive potentiality of the dynamic object, as it is infinite and dynamical. Hence, the immediate recognition of the artifact by the user-designer system_A is partial and incomplete. Furthermore, the resulting immediate object is not a representation and as such it has no representational content at all. It is just a differentiation that provides the necessary epistemic contact of the user-designer system_A with the artifact for the user-designer system_A's indications of interactive potentiality to be tested. As said before, such differentiations depend on the organization of each participating user-designer system and of the environment and as such they are context-dependent.

At this moment of the interaction, the sign-vehicle indicates the direction of the reality to which it refers. It contains several immediate objects which in turn refer to several dynamic objects. Which immediate object will eventually be realized depends on the user-designer system_A's anticipations. The given signal provided the ground for the object's perception, or its correlation to the user-designer system_B's representational content. There will be many internal tests needed for this interactive potentiality to be temporarily stabilized into a dynamic interpretant. At this point the external sign formed within the artifact begins to have a semantic effect on the user-designer system_A. The "objective meaning" (dynamic interpretant), which results from the semantic processes, needs to allow for revision. This requires processes that will dynamically manipulate the structures of new interactive potentialities in terms and by means of internal indications, which are simultaneously tested against the user-designer system_A's anticipations (pragmatics) within the conditions of the functional closure offered by the dynamics of the user-designer system_A. Ideally, the user-designer system_A identifies with the intentionality of the user-designer system_B, intentionality that is immersed in the artifact, and then the final interpretant has been reached.

In the next section the three interrelated levels of the complete interactive anticipatory cycle as well as the characteristic properties of their representational structures are described in order to argue for some necessary prerequisites for the emergence of creativity in a user-designer system.

4.0 Interrelated Levels of Creativity

4.1 Creativity and Abduction

In the context of Peircean semiotic processes abductive reasoning is considered as the base of a creative process. Abductive reasoning is derived from the experience of surprise in a system's perception of its environment. Peirce emphasizes the instinctive faculty as well as the fallible nature of abduction, as it can be witnessed in the following passage:

> This Faculty is at the same time of the general nature of Instinct, resembling the instincts of the animals in its so far surpassing the general powers of our reason…It resembles instinct too in its small liability to error; for though it goes wrong oftener than right, yet the relative frequency with

which it is right is on the whole the most wonderful thing in our constitution. (Peirce, 1998, Vol. 2. §217-218)

At this point it should be noted that Gonzalez and Haselager (2005) have also grounded their analysis of a creative process on the emergence of order parameters while also addressing the role of abduction and surprise. However, their work focuses on a different perspective which neither addresses the type of representations nor the role and the kind of anticipations that may support the emergence of creativity.

In the proposed framework, the experience of surprise is modeled as the perception of difference between a user-designer system's anticipations and the perceived environment. It is the point where a well established interactive strategy consisting of a network of indicated interactive capabilities conflicts with the present differentiation. User-designer system's certainty regarding the confronted situation is damaged. This results in surprise for the user-designer system_A as the immediate object cannot be actualized based on its anticipations. Instead the user-designer system_A has to proceed to a new differentiated indication of the environment in order to be able to change its interactive strategy and confront the new situation. In such a case the user-designer system_A enters in a state that Bickhard calls "a condition of anticipatory uncertainty" (Bickhard, 2001, p. 467). The newly selected differentiated indication can be in error, as the inference of a new immediate object (in respect to the present situation) has the nature of guessing. In that case, the indicated interactive strategy (the immediate interpretant) will not have the desired results and it will be incorporated in the overall organization as an interactive potentiality that is not suitable for the confrontation of the present surprising phenomenon.

Usually the differentiated indications fail to accurately represent the form of their dynamic object, in which case they are misleading. Collier (1999) states that in the pragmatic approach to meaning, an emergent representation can be misfit either by commission or by omission. In the former case the dynamic object does not support some of the dynamic presuppositions that the interactive strategy indicated by the differentiated indication needs in order to internally yield the desired results. This, accordingly, results in the functional failure of the respective anticipation, as the dynamic object cannot be manipulated in the anticipated way. In the latter case, the dynamic object provides a condition which has not been considered in the differentiated indication, thus, in the specific case the user-designer system_A is confronted with an unanticipated and/or even an incomprehensible dynamic environment.

Nevertheless, abduction is each user-designer system's only way to introduce a new differentiation resulting in the creation of new representational content. It underlies the user-designer system's capacity for open-ended epistemic contact with the environment, which is necessary in order for learning to emerge and consequently for creativity. In terms of the user-designer system_A it is the selection of a new immediate object resulting in a formation of a new intermediate interpretant. It is hypothesis-making regarding a possible solution to the ill-defined problem that it tries to solve in cooperation with the user-designer system_B. It is the invention and selection of a new interactive strategy and constitutes a presupposition for the next level of creativity in a dynamical anticipative interactive user-designer system. This kind of representational content is highly contextual and local, residing inside the boundaries of the user-designer system_A without having yet been communicated to or evaluated by the user-designer system_B or by any other user-designer system that may participate in the design process.

4.2 Codification and Interaction of Emergent Interactive Potentialities

This process requires the self-organizing properties of the user-designer system_A, which will try to incorporate to its functional organization the intermediate interpretant that is under examination. This requires self-reference and functional closure since the user-designer system_A must refer to itself in order for unsuccessful modifications of the functional organization to be obliterated. Certain anticipations of the user-designer system_A may not be fulfilled by the artifact, and this amounts to inappropriate user-designer system_B's anticipations. This is the reason for incorporating the pragmatic aspect of the representation. It is the passage from the intermediate interpretant to the dynamic interpretant, which codifies the new differentiation and categorizes the emergent representational content. This codification externalizes the surprising event to a context-independent group of user-designer systems belonging to the design system (Heusden & Jorna, 2001). It is important to stress that in order for the codification of an emergent interactive potentiality to take place there has to be the need of a new interactive strategy, outside the habits of the user-designer system_A so far, thus the user-designer system_A should be confronted with a surprising situation.

The communication of this content outside the boundaries of the user-designer system_A certifies the need for external evaluation of a creative event. At this phase the user-designer system_A is able to formulate the goal and the procedures that should be followed regarding the hypothesis of a possible solution made at the first creative level. Therefore, it introduces to user-designer system_B, by interacting with it, the invented interactive strategy. The user-designer system_A is somehow interactively knowing user-designer system_B to the degree that it is successfully interacting with it. In the perspective of this framework, successful interaction implies successful internal representation, which ends quite abruptly when a representational failure is internally encountered. This level is a presupposition of and it also prepares the terrain for the next level of creativity in the dynamical anticipative interactive user-designer system_A. This kind of representational content maintains a degree of contextuality, but it may now be communicated to other user-designer systems using the same codes.

4.3 Learning

The codification of the user-designer system_A's interactive capabilities in the context of dynamical anticipation makes possible the examination of the relations between the respective representational structures. This improves the user-designer system_A's anticipations and enhances the design process, as now the user-designer system_A acquires the abstract knowledge needed to operate at the level of the relation of anticipative indications. At this phase, the user-designer system_A acquires the ability to respond to interactive failure by incorporating a mechanism of a suitable for the case reorganization of its interactive control processes, hence, learning emerges (Bickhard, 2001). The user-designer system_A increases its ability to localize sources of success and error, hence evolving the capacity to preserve its closure by constructing more relevant differentiations of environments. It is the user-designer system_A's need to improve its anticipatory capacity that drives its learning, which in turn elaborates the indicated anticipations, which from being vague, implicit and contextual become explicit and well-articulated (Christensen & Hooker, 2000), but they can also be used by the user-designer system_A and thus be evaluated by the user-designer system_B. In this way, the user-designer system_A acquires a success of its pragmatic anticipations and it avoids the triggering of omissions and of commissions. This provides the prerequisite for the evaluation of anticipations of each user-designer system participating in a design process. At this phase the user-designer system_A is able to infer an explanation of the characteristics a solution of a certain goal should have.

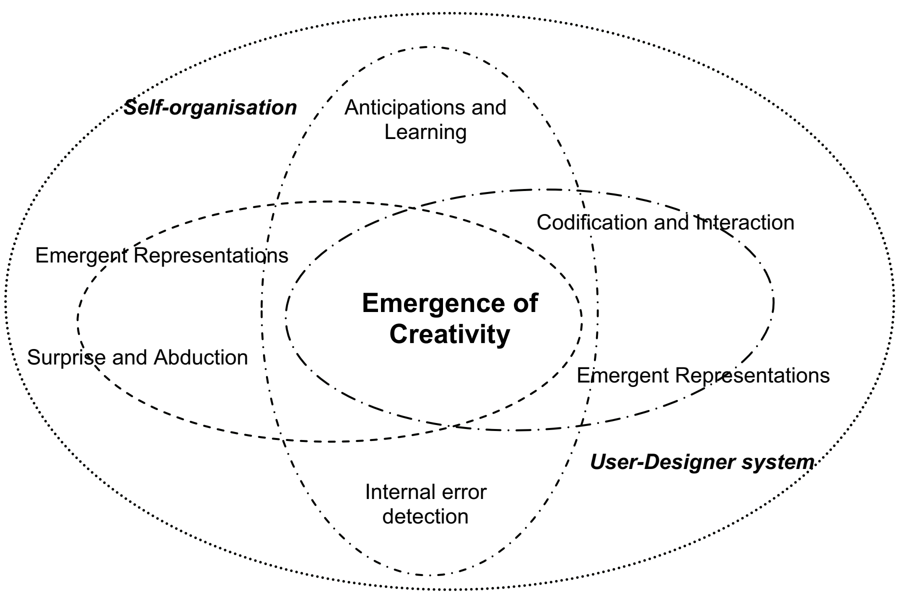

Fig. 3. Interrelated levels of creativity and their characteristic properties.

The three described levels, their interrelations and their characteristic properties in terms of fostering the emergence of creativity are abstractly depicted in Fig. 3. The relation between the three described levels is neither linear nor sequential. The three levels and their respective representational structures are continuously altered via each user-designer system's anticipatively modified interaction. As said above, creativity is modeled as an intentional and dynamically anticipative self-organizing process. As such it cannot be concretely located, or explicitly identified. What is argued in this paper is that in order for a user-designer system to be able to engage in processes that could be deemed as creative, there are some presuppositions that should be taken under consideration. These presuppositions are reflected in the three described levels and they are also abstractly depicted in Fig. 3.

Therefore, a user-designer system should have the ability to experience a surprise, which consists in the perception of events that do not conform to its complex network of anticipations. The user-designer system thus has the ability to enter a stage of abductive inference where a new differentiated indication is chosen and the possibility of the emergence of a new representational content is indicated. The user-designer system should have the ability to interact in order to communicate and test its new interactive strategy. This is the best way to internally test the validity of the respective emergent representational content. The user-designer system should also have the ability to learn in order to alter its organization in case of an internal detection of interactive failure and in order to relate its interactive capabilities into a network of anticipations. These abilities makes a user-designer system a self-organizing one. The measure of the complexity of its organization and hence, of the degree of creativity emerged through its interaction with other user-designer systems, is the extend to which these abilities are being developed.

These abilities and their respective levels are not sequential as each one somehow presupposes the other two. Hence, in order for surprise and abductive inference to take place, the user-designer system should have the ability to interact and it should also have the ability to learn in order to develop a background of a network of anticipations. Interaction in a dynamic and ill-defined environment should not take place via a strategy indicated by the same representational content. A new representational content should emerge and the ability for abductive inference based on events judged as surprising against complex anticipative structures developed by learning seems imperative. Likewise, learning and anticipations could not be developed without the ability to interact and to form hypothesis for new representational content to be tested.

Therefore, the indicated levels and their respective representational structures are developed in parallel of each other and they are enhanced as long as each user-designer system engages in purposeful interaction with the other user-designer systems. Moreover, the whole interactive anticipatory cycle is needed in order for creativity to emerge. This said, and considering the nature of creativity as it is described in the present work, a user-designer system should be enhanced on all these three interrelated levels in order to have the chance to engage in creative processes. In this way a design process may move from a creative event to a model formation, which is coded into an artifact in order to be further communicated. As has already been stated, the effect of this creative event is not assured. What is feasible in the proposed framework is that the degree of capability of a creative design process is bounded to the dynamical anticipatory capacity of all participating user-designer systems. The intentional interaction of each user-designer system with an artifact will create new perceptions, thus new possibilities of conflicting anticipations, therefore, inducing user-designer system's action towards creative processes.

5.0 Conclusions

Design should have a cognitive foundation. The cognitivist frameworks of cognition based on representations defined on a merely causal and predetermined information correspondence does not offer the necessary variety to study neither the design process nor creativity. An analysis of the design process in an interactive self-organizing framework has been attempted. This has shifted the design process to an interactive process of meaning communication between the user-designer systems that constitute a design system at the social level. The role of the emergent representations and their interactive and anticipative nature has been noted. Their type, relations and functionality have been indicated by the incorporation of Peircean semiotic processes. It is believed that the attempted analysis combined with the richness of the Peircean semiotic structures provides a way to identify the kind of representations emerging in a cognitive system interactively participating in a design process, as well as their respective functionality. The nature of creativity and its nodal levels are described. The suggested framework aims at providing a way of explaining the different but interrelated levels of a creative process and also, to stimulate the conditions for its emergence. Furthermore, the framework aims at a new and naturalistic explanation of the emergence of creativity in the design process, where each user-designer system constructs its own representational structures by its interactions with other user-designer systems in the environment of the social design system in which they intentionally participate. Future work is oriented towards the use of this framework as a central point of reference to develop and examine methodologies supporting creativity in the design of complex systems.

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