A possible model for the interaction of the factors involved in the emergence of the insight phenomenon

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Sometimes we feel that our ideas come unexpectedly, after many attempts of trying to find a solution to a given problem, when we have lost the hope that we could ever solve it. Their sudden emergence gives us the feeling that we can no longer control our own mind and reveals us an autonomous movement of our thoughts. The statements from above could serve as a description of some of the essential aspects of the subjective feeling of what has been called by psychologists with a variety of terms that are quasi-synonymous: intuition, illumination, inspiration, "Aha!" reaction or insight. Those terms designate at the same time a specific way of knowing and its effect on the problem solving process. The way of obtaining knowledge associated with the insight phenomenon is considered to be direct, concrete (perceptual processes are predominantly involved), passive (through contemplation), inward oriented, revealing profound and essential aspects of the things or anticipatory (it offers a glimpse of the solution, before it can be fully acknowledged). The influence of this way of knowing on the problem solving process is revealed in the subjective feelings of discontinuity (illumination moments) and autonomy of the thought flow.

Many authors have noticed that the two key meanings of the term "insight" are confounded. The first meaning refers to comprehension in general - more exactly to its internal aspect according to Dominowski and Dallob (1995) -, as representing a special state of knowledge and the process of its acquisition, that can be sudden or, through knowledge accumulation, a gradual one (Gick & Lockhart, 1995). In its second meaning, insight is seen as a kind of subjective feeling associated with the sudden emergence of an idea or solution into the consciousness. Between the two meanings there is a relationship that can be easily ignored: the first meaning refers to the insight as a cause, and the second one as an effect.

Experimental research on the insight phenomenon was initiated by gestaltists (Duncker, Kohler and Wertheimer, cited in Mayer, 1995 and Davidson, 1995). They were also those who dedicated the term "insight" and the syntagma of "Aha!" experience to designate the sudden emergence of a solution to a problem, without a relationship with the prior attempts to solve it, as a result of the reorganization of the visual field (Kohler, cited in Mayer, 1995). Since then, studies have been concentrated on a series of controversial aspects of the insight phenomenon. One of the disputed aspects is the very existence of the discussed phenomenon. Behaviorists (Thorndike and Maltzman, cited in Mayer, 1995 and Davidson, 1995) denied its existence, because they considered that the insight is a result of a simple association stimulus-response, reducing it to the finding of a response or a response combination that was associated in the past with the problem situation (Mayer, 1995). Among the authors that recognize the insight existence two types of approaches can be distinguished (Davidson, 1995; Mayer, 1995; Schooler, Fallshore & Fiore, 1995). The first one considers that the insight phenomenon is something special, with an independent existence, that implies specific processes and abilities and that could not be explained using the standard framework of the cognitive psychology. Such an approach can be recognized at gestaltists, at Gruber (1989) and Metcalfe (1994). For the second approach, insight does not have an independent existence; it is a commonplace phenomenon that could be explained in totality by the means of the current concepts of the cognitive psychology. In this approach, the insight is viewed as a simple extension of the common processes of perception, recognition, learning, categorization, the solutions of the new problems being based entirely on the past experience (Weiseberg, 1986; Perkins, cited in Mayer, 1995).

Trying to systemize research on the insight theme, Schooler et al. (1995) considers that it is necessary to recognize two distinct types of theories: those that offer explanations for the insight phenomenon, by specifying the involved processes, and those theories that merely describe the subjective feeling associated with an insight event, by specifying the components of the conscious experience. That distinction allows the integration of the various results obtained in the insight research: although multiple (even contradictory) explanations could be invoked, the explained experiences have to be similar and the validation of the explicative theories must be founded on operational definitions based on descriptions of those subjective experiences. Also, the insight could be consider in the same time as a process and as a product of a process, in that way being possible to end the debate on this theme (Dominowski et al., 1995).

Various theories have been formulated in order to explain the insight phenomenon. (see Mayer, 1995). It has been considered successively the result of a cognitive schema completion (Selz, cited in Mayer, 1995), of the visual field reorganization (Kohler, cited in Mayer, 1995), of the problem reframing (Duncker and Maier, cited in Mayer, 1995), of the selection of an adequate code for information (Glass & Holyoak, 1986), of the spontaneous employment of the selective encoding, combination and comparison of the information (Davidson & Sternberg, 1995), of the discovery of a analogous problem (Wertheimer, cited in Mayer, 1995), of a special organization of the information in memory when confronted with an impasse in the solving process (Seifert, Meyer, Davidson, Patalano & Yaniv, 1995), of an attitude oriented toward what is new, unexpected, similar with an investor attitude who buys cheap and sells high (Sternberg & Lubart, 1995), of a heuristic strategy based on the invariants detection after repeated unsuccessful attempts of solving a problem (Kaplan & Simon, Wickelgren, cited in Gick etl al., 1995), of a mental model building through the intentional repetition of a selected perception (Ippolito & Tweney, 1995), of a specific structure of the information processing system that allows an easy recognition of the coherent informational patterns from environment, in the same way the visual system detects the invariants of the visual stimulation, the insight being the moment when the coherence in a set of initially disparate elements is recognized or when a coherence model is replaced with another (Dominowski et al., 1995; Schooler et al., 1995) or of a specific behavior that characterizes any creative system (Gruber, 1989; Perkins, 1995).

Various authors identified different components of the subjective feeling associated with the insight. Sudden change, spontaneity, surprise, satisfaction are components mentioned by almost all the authors. Frustration is mentioned only by Gick et al. (1995), as a reaction that occurs when the solution seems evident after being discovered. There can be noticed that in the insight feeling, affective reactions are mixed with metacognitions. That is why, Metcalfe (1994) relates the insight phenomenon with metacognitive phenomena like “feeling of warmth” (FOW) and “feeling of knowing” (FOK). Also, Simonton (1991) considers the insight as a “solution presentiment”, a kind of unconscious prediction of a forthcoming solution.

Formulated definitions for the insight phenomenon comprise very often elements that refer in the same time to its possible explanations as well as to its characteristics as a subjective feeling. Some of them emphasize more on the behavioral aspects. An example in that direction is the definition given by W. Kohler (cited in Mayer, 1995), who considers intuition to be a generated behavior that represents a complete method for obtaining a solution and not just an individual response who occurs suddenly, without being gradually reinforced or previously exercised. Other definitions insist more on the internal aspects of the intuition, on the mental processes associated with its emergence. An illustration of that kind of definitions is that given by Ericsson and Hastie (1990) or Schooler et al. (1995) who consider that intuition is a sudden emergence of decisive ideas, without any relevant preceding thought. The occurrence of the “Aha!” reaction is consider by Gick et al (1995) as an essential component of the intuition, while the cognitive reorganization is viewed as a component that although it is usually present it is not necessary needed. On the contrary, for Weisberg (1986) the cognitive reorganization is the unique defining criterion of the intuition and the “Aha!” reaction is the unnecessary component. Ippolito et al. (1995) consider that the cognitive reorganization and the “Aha!” reaction are both without relevance for an intuition definition, which is considered by them as a special kind of perception by which selected aspects of the physical environment are mentally created, independently of the sensorial input. Gick et al. (1995) define the intuition as a process with three stages: an initial stage (when the problematic situation is not understood but there is a sentiment that the problem is solvable), a transition toward a solution state (without a conscious progress through all the steps of the solving process) and finally, the affective response of surprise when the solution emerges.

Of the above mentioned studies four aspects could be detached that I consider to be important in order to define or study the insight phenomenon: a *dynamic* aspect (related with the type of changes that could occur in the solving process), a *qualitative* aspect (revealed by a modification in the problem situation representation), a *causal* aspect (that refers to the causal mechanisms through which changes can occur: for example, by changing the code or by forming a new mental model etc.) and the *subjective feeling* aspect, with its affective and metacognitive components and their role in the future progress of the solving process. A characterization of the intuition based on one of the above mentioned aspects depends on the characterizations made based on the other three aspects, given that among them there is a tight interaction.

Some of the terms and syntagmas used in association with the insight phenomenon, which were mentioned in my very short review of the research on the insight theme, like: sudden change, emergence, mental model, transition suggest the possibility to approach the discontinuities that could occur in a problem solving process from the mathematical nonlinear dynamic systems theory (DST) perspective. That theory can provide the needed concepts in order to study the temporal behavior of a dynamic system, its evolution in time. Such a new approach on the process of solving problems through insight uses in a qualitative way the DST, as a heuristic procedure, in order to explain some of the properties of the investigated phenomenon. That kind of approach, a mere metaphorical one, is considered by Barton (1994) as being justifiable, based on the argument that, at the beginning of a new “paradigm”, research needs the liberty to be speculative. Some elements of this

new approach can be recognized in the gestaltist theories, at Ippolito et al. (1995), Schooler et al. (1995) and Metcalfe (1994). The last cited author considers that those problems that are solved through insight processes are problems that are solved by a catastrophic subjective process, and not by cumulative processes.

In order to have a better understanding of what will follow, it is necessary a short familiarization with basic concepts of the DST. A *dynamic system* could be defined in a short manner, in simple words, as a set of interdependent variables (being totally connected in a stable manner), the evolution in time for the values of each of them being dependent on the values of all the other variables and its own value in a previous moment. A set of dynamic systems that interact with one another constitutes a *complex dynamic system*. The temporal behavior of a dynamic system, its *trajectory*, can be visualized in the *phase space*: a multidimensional space, each dimension representing one of the variables of the system. The set of the states from the phase space toward which a dynamic system tends to evolve in time (towards them its trajectories are directed) is named an *attractor*. There are many kinds of attractors: point attractors, cyclic attractors, thorus attractors, chaotic attractors. The evolution in time of a dynamic system is influenced by a series of external conditions: the *control parameters* (whose values are constants in the equations that define the relationship between any two variables of a dynamic system). The behavior of a complex dynamic system that has a great number of sub-systems can be described by a reduced number of global parameters, named *order parameters*, which are also control parameters for those sub-systems.

My supposition is that the solving process could be interpreted as a process in which a complex dynamic system with a function in the problem solving is formed and evolves toward an attractor. That dynamic system would have as components representational dynamic sub-systems that interact in the context of a solving problem process. It is constrained by its interactions with the whole psychic system and the environmental systems. The attractor states of the representational dynamic systems could be associated with cognitive representations. A problem is solved when a representation of the target state is obtained, based on the interaction among the representations formed for the problem data, through the building of a coordinative model of the involved representational dynamic systems, which is specific for the required solution. Such a dynamic approach for the solving problem process is intuitively attractive and suggestive, but is hard to be made clear analytically. One advantage for interpreting the solving process through a nonlinear DST view is that it could offer an explanation for the unexpected, qualitative and sudden changes occurring in the modeled solving system. Such changes characterize the solving processes for insight problems, distinguishing in that way a type of temporal behavior for a dynamic system associated with a solving problem process. By using the DST concepts, a specification of the “insight”, “intuition”, “restructuring” notions could be initiated. Of the above mentioned notions, Eysenck and Keane (1990) think that they are easily understood, especially when they are accompanied by perceptual demonstrations, bearing a touch of the mysterious dynamics of the human creativity, but they are radically underspecified, the existing theories being not so clear about the insight’s implications and about its occurrence conditions.

A dynamic approach has to offer a new vision of the importance of the temporal dimension in the solving process progress. It is needed to surpass what Gibson (1986) considers to be a common belief: that the past ceases to exist if it is not stored in memory, that whatever the effect of the past on the present, it must be attributed to the memory, that the present must be understood only by reference to the past, attaching it to the present, and by doing that, separating an instantaneous time and a linear past. The new dynamic conception postulates that the past is embodied in the present. As a consequence, the changes occurring in the solving problem process, finding the solution, could not be attributed exclusively to the discovery of a relevant information (in the environment or in the memory) or of a manner of information processing required by the given information, that is to some specific information or to the past experience. Solving the problem could be instead attributed also to some unspecific inputs, to some dynamic properties of the involved systems. Any past state, any previous value of a control or order parameter or of a dynamic variable could have a contribution in determining the current state or a future one of a problem solving process, without the necessity of them being stored in some kind of memory warehouse. In the same time, significant modifications of the relevant or the irrelevant input could not lead to an effect, the state of the system remaining unchanged (in spite of what one could expect), because of the nonlinearity of the system.

Consequently, the evaluation of how close to the solution it is a solver could be based not only on indices related to the problem as such, but also on indices that are related to the properties of the problem solving dynamic system and to the change of its order and control parameters. From a metacognitive point of view, as an index for the closeness to the solution, the insight should be distinguished from the other forms of appraisal of the problem solving process: FOK and FOW (Metcalfe, 1994). The suggested distinction could be partially supported by the experimental results obtained by Metcalfe (1994) that have indicated that, for the solutions obtained by insight, an increased FOK was a negative predictor for the solving problem performance. My supposition is that FOK is based on comparing the degree of similarity of the problem data with data of some problems solved in the past, and FOW is based is based on comparing the degree of similarity of an intermediary state of the solving problem system with its expected final state. The insight, instead, could be based on

registering and tracking of the changes of some order parameters of the problem solving system. At a first analysis these could be: the global sense, given by the coordinative pattern (the attractor state in which the complex dynamic problem solving system is placed) of the representational dynamic sub-systems involved in the solving process (see Haken, 1994/1995), the scale of the connections among the various elements of the dynamic problem solving system, the cohesiveness degree of the problem situation data (that could be indicated by the number of disparate elements of the given data), the number of the new formed connections in an unit of time (new elements included in the system), the consumed energy by reference to the changes undergone by the problem solving system, the stability of the system (that could be measured through the state variation of the system in an unit of time). Among the control parameters, whose changed values could lead to major modifications of the order parameters of the problem solving system, could be included: the general activation of the neural net that serves as a neurodynamic support of the problem solving system, the noise level in that neural net, the proportion of the net involved in the problem solving process, and, an index suggested by Brown (1988), the similarity criterion threshold, that could indicate the ratio between the under- and over-connectivity in the neural net. Gradual changes of such control parameters could progressively decrease the stability of the dynamic problem solving system, and when a critical value is reached, the system will suddenly evolve toward a different attractor (that is, a new representation, maybe one required by the solution) or the phase space of the system will be radically modified, having other attractors than the old one (that is, a reframing process). My suggestion is that, in order that the affective reaction associated with the insight phenomenon to occur, the emergence of the solution as such is not essential, the important thing being a sudden modification of the above mentioned order parameters (for example, a significant decrease or increase in the stability of the system), that could signal the coming solution. As an indirect support for that hypothesis, the experimental results obtained by Tikhomirov (cited by Simonov, 1991) could be invoked. Those results indicate a maximal decrease of the electrical skin resistance simultaneous with the emergence of a solution idea, but before this idea is formulated such that it could be verified.

Based on the above mentioned ideas, from the subjective feeling point of view, the emphasis in the insight phenomenon characterization should be on the subjective experience of unity, qualitative change and separation of the problem solver from the problem solving process (that acquires autonomy due to the interaction of the representational dynamic sub-systems). Also, that subjective feeling could have various intensity levels, dependent on the size of the changes in the order parameters values, and different qualitative types, dependent on the type of dynamic transformation of the system: system formation or modification (by including new variables), change of the attractor (in the case of a multi-stable system), a transition of the system toward a different region of a chaotic attractor, phase space transformation (modification of the attractors structure). Transitions between two qualitatively different states (different dynamic regimes) could be indicated by what in DTS is named *hysteresis*: for a given control parameter, there could be two threshold values for the transition between two qualitatively different states of a dynamic system, dependent on the direction in which the parameter values are modified.

The way in which the insight phenomenon is generated could be dynamical characterized, in some situations, by what Salthe (1991) calls extensional emergence: a transition of a dynamic system from a scale of its internal connections to another one, by a sudden change, passing through unstable states. The interaction among the micro-systemic entities could lead to the emergence of a coherent macro-system, satisfying some constraints given by the values of the control parameters. Through an extensional emergence, a new system is obtained, because an increased connectivity scale leads to the incorporation in the old system of some aspects of what had been considered previously environment constraints and by that, they become a part of the new system as dynamic variables. It is important to note that the way an insight is generated and the way is subjectively experienced (as a qualitative change in the dynamic problem solving system) could be the same for an insight that is relevant for finding out a solution as well as for an insight that is irrelevant for the problem solving.

Qualitatively, the insight phenomenon could be characterized as an intensional emergence (Salthe, 1991), as a change that is referred to an observer, in relationship with the specification manner for that state of the system in which new properties are emergent. The insight phenomenon essence is connected with the meaning of the intensional emergence because it implies that an observer who describes his or her problem solving process is unable to specify a connection between a previous idea and the emergent one. Such an observer does not have a trace in memory, a symbolic description for a derivative transition (a logical inferential process) between the two ideas and therefore he or she is unable to communicate the way they are related. The reason for that is that a discontinuity has occurred in the dynamic system behavior, which implies a leap over several intermediary states from the phase space.

Summarizing, in this paper I tried to identify some aspects that could serve as a base for an approach of the insight phenomenon from a DST perspective and to characterize that phenomenon on the four dimensions identified as relevant for its definition. This new approach needs to be more thoroughly examined theoretically and experimentally in the future.

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