INFORMATION AND COGNITION, INFORMATION AND CREATIVITY

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Resumen

Con el intercambio de la intercomunicación entre las ciencias han ocurrido grandes progresos que ofrecen nuevas vistas y cuestionan conocimientos, considerados hasta entonces como correctos. Ignoro en cuánto esto ha reducido la entropía, pero la *información* ha crecido exponencialmente y aprender a desaprender, es hoy un reto. Esto requiere seleccionar y operar con conocimientos certeros y hacer el puente entre el *tiempo biológico* y el tiempo con que nos llega la información, olvidando lo que no es lógico y lo que no ha sido verificado. Si bien el aprendizaje reduce la entropía aconteciendo caóticos eventos microfísicos pueden cambiar la situación y desde el orden de lo desconocido el talento creador puede comenzar a operar.

Palabras clave: Información - creatividad - tiempo biológico - tiempo psicológico.

Abstract

With increased intersciences communication unexpected advances have occurred in all the sciences opening new vistas and questioning knowledge considered to be correct. I ignore how much this has reduce entropy, but *information* has increased exponentially and *learning to unlearn*, has become a

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challenge. This requires to select and operate with trustworthy knowledge and bridge the gap between information and *biological time*, forgetting what is not logical and verified experience. If learning reduces entropy then, even chaotic microphysical events may change the situation, and from the verge of the unknown creative talent may begin to work.

Key words: Information - creativity - biological time - psychological time.

How cognitive processes organize information has been the subject matter of a considerable amount of work since historical times. It has concerned scientists and artists and some of the findings have influenced educational efforts across the centuries. In this presentation I will present some opinions of historical interest voiced by artists and scientists in different areas of knowledge.

Our interest in the subject began in Chicago around 1950, at the beginning of the so called *cognitive revolution*. Following and interdisciplinary approach, we developed a procedure to examine and evaluate problem solving tactics in a variety of areas. This procedure was mostly concerned with the information requested to solve a problem and the order in which this information is requested.

It would be almost impossible to review what has been done on the subject since those days, running the risk of being either ignorant or unfair in our comments, being aware that the acceptance or rejection of items of knowledge changes as new knowledge takes place. Considering the opinions made by scientists across time about some basic scientific concepts, I will try to interpret and generalize the results obtained when investigating, together with my collaborators, problem solving performances in various contents and methodological designs.

The relationship between the logical and the representional components of a cognitive act, is a needed requirement to understand how cognition occurs and perhaps to throw some light on the problem of creativity. In what follows the word image shall be used to identify the kind to the representation used to present the problem (words, numbers, drawings, sounds, objects, colors, etc.), and the word structure will identify the components of the problem their relationship and possible operations.

Logically isomorphic problems may be presented using different images and, the same kind of image may be used to present structurally different problems. Time ago Vygotsky stated that until we know the relationship between words and thinking nothing can be said, and on a similar vein, Boileau wrote: *Ce que l'on concoit bien, s'énonce clairment, et les mots pour le dire arrivent aisément.*

The complex dynamic interchange of knowledge with ignorance, lays at the roots of our efforts to cognize. In von Bertalanffy's terms, *cognitive processes* may be understood as open systems in which macrophysical events of a stochastic nature help to cognize. On the other hand unexpected, even chaotic microphysical events may change the macrophysical system in which we move, creating a new macrophysical system that reorganizes the previously known (see Figure 1).

The large amount of interdisciplinary and transnational information that we daily receive has brought about significant changes in all fields of endeavour either by questioning previous knowledge, by recapturing ideas that were assumed to be dead, by opening up new vistas and so forth.

In order to know how the present invasion of information helps to reduce entropy we need the implementation of measures that will reduce the disparity that exists between the biological time needed to understand and the electronic time with which information reaches us. It is not only a question of accumulating information but rather it is a question of being able to operate with it. Due to our biological limitations, the amount of information that we daily receive overcomes our possibilities of thinking about it. We know many things but, do we understand the relationships that exist between them? M. Kransberg said: "Info, info everywhere, but no one stops to think."

In a study on Science Education for the Public, Hiroo Imura mentioned that: "the enormeous increase in scientific information will become a burden for children who must study science. Already young people seem to be loosing interest in science, and this trend may increase in the future", and Centuries ago, Cesar of Heisterbach said: "Discipline brings abundance, but uncontrolled abundance destroys both, discipline and abundance" and, when visiting my Oxford College, I read: "The more I study the more I know, the more I know the more I forget, the more I forget the less I know. So; why study?" May be we need to learn how to forget or to learn to unlearn, to avoid what I have called *Self-acquired syndrome of confused intelligence.*

If information reduces entropy and if unexpected microphysical events change the macrophysical stochastic knowledge that we have, then from the

verge of the unknown creative talent opens new vistas, provided that, as stated by Bernard Shaw, we remember that: "the test of sanity is not in the normality of the method but in the reasonableness of the discovery". And science advances following the sometimes unexpected paths that structure a new the maps we build to better understand (see Figure 2).

The place paid by images, that is type of presentation, has been of concern throughout the centuries. In Meno's dialogue, Socrates wanted to know if the slave child knew greek before presenting him with a problem to solve, and Pascal wrote to Fermat saying: *et je vous le dirai en Latin car le Francais n'y vaut rien*. When in 1202 Fibonacci introduced the hindu-arabic number system the solution of many problems was made possible. Descartes, Newton and Leibnitz developped special symbols to facilitate the solution of many problems and Leonardo said that "painting is poetry made visible".

Einstein, in a prologue to a MaxPlanck's book, said that: "human nature tries to make a simple and synoptic image of the surrounding world. Consequently, tries to build an image that will give a tangible expression of what the human mind sees in nature", and Aldous Huxley wrote: "At its most perfectly pure, scientific language ceases to be a matter of words and turns into mathematics" to which Nagel and Newman added: "Formalization is a tricky business ..." but.... "it reveals structure and function in naked clarity". However, B. Russell also stated that "pure mathematics is the subject in which we do not know what we are talking about, not whether what we are saying is true", and I can only say with Hamlet: "the rest is silence" (see Figure 3).

In the development and use of images, cultural-environmental components play a complex role. Our experience with problem solving tasks presented to members of different ethnic groups suggest that before concluding that a subject is unable to operate with a problem with a given logical structure, we should be sure that there are no images (representations) that would make it possible to reach the searched solution.

Structures and images do interact differentially depending on the sciences and on the arts. While H. Poincaré mentioned that "science is a system of relations and that mathematicians study not objects, but relations between objects", an artist, T.S. Elliot wrote: "here is a logic of imagination as a well as a logic of concepts. People who do not appreciate poetry always find it difficult to distinguish between order and chaos on the arrangement of images".

Commenting on the Bologna Meetings, where the evolution of cognitive maps was discussed, Umberto Eco wrote: "I realize that the effort

of superimposing a cognitive act on another cognitive act (cognition of cognition) had already appeared in the inscription over the door at Delphi: Know Thyself! So perhaps the program we are pursuing is a very old one! Our instruments and methods may be new, but we remain mindful of that warning."

At the 1925 Lowell lectures Alfred North Whitehead stated that "Nature is a state of evolving processes. The reality is the process", and by differentiating facts from events he concluded that the same fact will have different meanings depending on when and where it occurs. In a cognitive process the information provided by the same item (fact) will generate different events according to where and when it occurs in the process. Across time changes the experiment, and change the subjects involved. And here I remember Ilya Prygogine's arrow of time. The temporal order in which information takes place in cognitive processes is basic to understand those processes. Unfortunately this has not always been experimentally considered, and it has been one of the main challenges we met in our studies.

With reference to time and order Heraclitus of Ephesus said: "you can not cross twice the same river, because new waters reach you continuously." Mathematicians and logicians, have discussed the influence of order in the solution of problems, and Pascal wrote: "*Les mots diversement rangées font un divers sens, et les sens diversement rangées font différent effects*" while Henry Poincaré stated that in some mathematical developments the order in which the elements are placed is more important that the elements themselves. Finally, Bertrand Rusell said that between series ordinal similarity is stronger than cardinal similarity and implies it, so that two or more series will be identical if and only if they contain the same components placed in the same order. Peano's postulates set the basis for the conceptualization of succesor functions, and Prygogine, when discussing the laws of chaos, mentions that psychologists should be aware that cognitive processes have *a before and an after* (see Figures 4, and 5).

The items of information requested and the actions performed to solve a problem define a subject tactics, where the word tactics (according to the Oxford Dictionary) means "a procedure to gain some end". The same item of information will originate different events reducing uncertainty differentially depending on when and where it occurs in the tactics. Tactics show how a subject organizes content, and help to define his cognitive style (see Figure 6).

Our studies investigating the tactics of subjects of different ages and cultural backgrounds when solving problems in mathematics, medicine,

psychology, logic, law and every day situations show that regardless of the kind of problem being solved, a given item of information will differentially reduce uncertainty depending on its location in the tactics. Thus, the same item of information will originate different events and performance curves.

The versatility of the events resulting from the same fact require appropriate evaluation techniques. We have developped different procedures, among which the one using information theory has been frequently used. A computational program has been prepared in terms of which we know the bits of information corresponding to each item in the sequence, the corresponding performance curve, the time elapsed between successive questions and so forth. When studying problem solving tactics using the Problem Solving and Information Apparatus it was found that regardless of the difficulty of the problem the subject's tempo had a constant value across problems of different difficulty.

The difference between the cognitive performances in structurally isomorphic problems presented using different images makes it possible to evaluate how different representations affect performance, and the comparison of the performance between problems presented with the same kind of images, makes it possible to find out the difficulty of the problem's structure.

Thus far we have discussed only tangentially the idea of creativity and I feel unease to discuss the problem, remembering that Alexander Pope said: "for fools rush in where angels do not dare to tread", and I dislike to be considered a fool.

It would take a long time to review what has been published. Some authors seem to understand creativity as the kind of performance that opens up new vistas whithin the macrophysical stochastic system in which they occur. However it seems that another thing happens when an unexpected irreversible event, that may occur randomly, reshapes what we know and creates a new macrophysical realm. As recently stated by Goldenberg, Mazursky, and Solomon "Randomness, is still clearly of value: several of the greatest inventions in history occured randomly, as nonreplicable creative sparks" and apparently this is what creative geniuses have done across centuries and cultures. This kind of creativity may be unexpected given that we do not know beforehand when, how or where it will occur, neither in terms of time nor in terms of the psychobiological characteristics of the one who is responsible for creating a new macrophysical system.

The conditions under which creative geniuses have appeared are heterogeneous, and in terms of their psychological characteristics it is very difficult to find a common ground. The variety and originality of cognitive

styles among creators is well known, but what does originality really mean? It looks as if unexpected microphysical events structure a new the stochastic knowlegde that we have reducing entropy. And while Roger Bacon spoke of Divine inspiration, Lombroso talked of *degenerative psychosis* not far away from criminality!

In spite of their apparent similarity it is difficult to identify the stages and events that relate, and differentiate, cognition and creativity. Within a macrophysical system it is not easy to invent a procedure to discover creativity. Perhaps the discovery of such talent is only possible after the creative act has occurred; as a result a new macrophysical system emerges. And if my imagination goes uncontrolled I could dream that within our psychobiological system a creative act could be interpreted as equivalent to a biological mutation (see Figure 7).

My closing paragraph refers to a statement by R.L. Gregory as cited by D.C. Dennett when saying that: "life is a systematic reversal of entropy, and intelligence creates structures and energy differences against the supposed gradual 'death' through entropy of the physical Universe."

Figure 1

Cognitive performance

Structure and images
Structure: Is characterized by elements, relations, and operations.
Images: May be words, drawings, objects, numbers, sounds, colours, abstract symbols and so forth.

Relationship between structures and images isomorphism

Problems
a) Logically isomorphic, different kind of images.
b) Logically heteromorphic, same kind of images.

Cognitive performances as open systems

Macrophysical events of stochastic nature help to better cognize.
Microphysical events (even chaotic) may change the macrophysical system and reorganize knowledge creating a new macrophysical system.

Figure 2
Electronic time versus biological time

KRANSBERG: *Info, info everywhere, but no one stops to think*.

CESAR OF HEISTERBACH: *Discipline brings abundance, but uncontrolled abundance destroys both discipline and abundance.*

The more I study, the more I know. The more I know, the more I forget. The more I forget the less I know. So, why study?

Self acquired syndrome of confused intelligence.

BERNARD SHAW*: The test of sanity is not in the normality of the method but in the reasonableness of the discovery.*

Figure 3
Images

SOCRATES: In plato's dialogue *Meno.*

FIBONACCI: (1202).

PASCAL: *Et je vous le dirai en Latin car le Français n'y vaut rien*.

DESCARTES: *Coordinate system.*

LEONARDO: *Painting is poetry made visible*.

EINSTEIN: *Human nature tries to make a simple and synoptic image of the surrounding world. Consequently, tries to build and image that will give a tangible expression of what the human mind sees in nature.*

HUXLEY: *At its most perfectly pure, scientific language ceases to be a matter of words and turns into mathematics*.

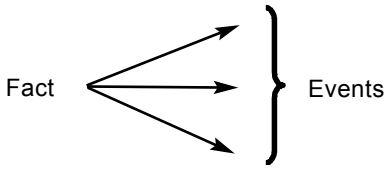
NAGEL AND NEWMAN: *Formalization is a tricky business but it reveals structure and function in naked clarity.*

RUSSELL: *Pure mathematics is the subject in which we do not know what we are talking about, not whether what we are saying is true.*

Figure 4

A.N. WITEHEAD: *Nature is a state of envolving processes the reality is the process.*

Processes have a temporal component.



Events have a past, a present, and a future.

Figure 5
Time and order

HERACLITUS: *You can not cross twice the same river, because new waters reach you continuously.*

PASCAL: *Les mots diversement rangées font un divers sens, et les sens diversement rangées font différent effects.*

POINCARE: *In mathematical developments the order in which the elements are placed is more important that the elements themselves*.

RUSSELL: *Between series ordinal similarity is stronger than cardinal similarity and implies it*.

PRIGOGINE: *Cognitive processes have a 'before' and an 'after'*.

Figure 6
Tactics

Sequence of questions asked to gain some end:

a) Length of sequence.
b) Order of questions.
c) Type of questions.

Tactics are characterized by cardinal and ordinal components.

Figure 7
Heterogeneity of creativity cognitive styles

ROGER BACON: *Divine inspiration*.

LOMBROSO: *Degenerative psychosis*.

Microphysical events and cognitive mutations.

Is a creative act equivalent to a biological mutation?

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Received: April 9, 2001
Accepted: July 17, 2001