Art and science at the same table

Creative Arts and Scientific Research under the same Umbrella

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In the predominant mentality, the role of subjective factors in exact and natural sciences is very poor**.** It was really poor until the end of the 19th century; when the belief in a sharp distinction between subject and object began to diminish in all fields. This fact involved a general attenuation of the contrasts between art and science. This thing is not enough known, if not totally ignored, because the dominant systems of education in the 20th century failed in this respect.

The emergence of signs, the development of sign processes need attention in all directions, they are not the exclusive privilege of arts and humanities. We will try to bridge this gap. Indeed, there is a gap between the internal life of science, the very nature of scientific creativity, on the one hand, and the dry way science is exposed at all levels, from general school till university, with accent on procedure and operations, rather than on ideas and imagination. The true life of the so-called heavy sciences remains hidden to the general public. We will take one by one some basic ideas of semiotics and show their real face in the field of heavy sciences. We will begin with the role of the subject (in its relation to the object), then we will discuss the nature of scientific creativity (versus the artistic creativity), the emergence of meaning in heavy sciences, the way science rises the problem of existence and infinity, the essential presence of transcendence, of the negation-affirmation interplay (Tarasti 2000)

As we will see, all these problems involve semiotic processes.

Bohr, Heisenberg and Heidegger challenge the subject-object distinction

Classical science, as it was launched by Galilei and Newton, was based on the tacit but firm assumption of the existence of a sharp distinction between subject and object and on the assumption that the subject has no significant impact on the object of investigation. In other words, the latter is never significantly modified by the former or by the tools it is using in the investigation process. Generations after generations repeated the claim that science is objective, while poetry and art are subjective. Step by step, and from various directions, this representation of the subject-object relation had to be replaced

by another one, revealing an increasing role of the subject and the increasing difficulty to establish a border between subject and object.

The most spectacular results in this respect were Niels Bohr's complementarity principle and Werner Heisenberg's uncertainty principle, both stated in the same year 1927, when Martin Heidegger's *Sein und Zeit* is published. All these three authors throw a shadow over our capacity to distinguish the subject from the object. Heidegger considers that, as observers, we are a part of the world we are trying to describe. To some extent, when we begin to describe it, we introduce a separation from our practical life. A large part of what we are communicating and thinking is not deliberate; through it, it is our biological evolution and our cultural history that acquire meaning. According to Bohr, classical exact sciences were looking for a unique mode of description, able to eliminate any possible influence of the observer, of the subject. The description of nature was based on the determination of a line of separation between the object and the subject, so the role of the observer was negligible. This no longer happens in quantum physics. Bohr stated that one cannot measure at the same time the particle features (position, speed) and the wave features (wave length, frequency, amplitude) of an electron. Any experiment is obliged to select one of these two aspects. Heisenberg is also concerned with quantum objects. He stated that one cannot measure with unlimited accuracy both the position and the speed of a quantum object: measuring one of them is always at the expense of the accuracy in measuring the other one. This impossibility is factual, so it is not a result of the insufficient knowledge of the quantum object. In both cases (Bohr and Heisenberg) we are faced with some conjugate pairs, i.e., with some pairs of requirements, each of them very natural, but getting in conflict when they are considered together. So, the compromise is unavoidable: each of them can be satisfied only at the expense of the other. So, “complementarity does not mean collaboration, It always involves mutual exclusiveness among the considered terms" (Bohr, 1961:71).

Gamow on the crisis of observation at the atomic level

At the quantum level, the instruments we are using modify the behavior of the quantum object, events at this scale cannot be observed and registered with certainty. In this respect, Gamow (1958:3) proposes some interesting analogies:

> *In the world of everyday experience we can observe a phenomenon*
>
> *and register its behavior, without significant interference in its*
>
> *development. But if we try to take the temperature of a cup of coffee*

with the same thermometer we use to take the temperature of the water in a big recipient, then obviously the thermometer will absorb so much heat that the temperature of the coffee will change significantly. We can avoid this difficulty , by using a small chemical thermometer, whose influence on the coffee temperature will be negligible. One can even take the temperature of an object having the dimensions of a living cell if we use a miniature instrument, whose caloric capacity is almost negligible. But at the atomic scale we can never observe the modification determined by the introduction of a measure instrument. The impossibility to determine both the cinematic and the dynamic properties of quantum objects shows that at this level of reality no clear separation is possible between the action of the observer and the phenomena observed.

For Bohr, what we call 'phenomenon' in quantum physics is no longer something that happens in an 'objective reality', but "a totality of effects that can be observed in some given experimental conditions" (Bohr 1961: 85).

From quantum to computational and from physics to psychoanalysis

Quantum complementarity was supplemented by a principle of computational complementarity (Svozil 1993). If the author of an experiment is part of a system S, then any measurement of some aspect of S makes impossible the measurement of another, complementary aspect. If the physical world is conceived as the result of a universal computation, then complementarity becomes unavoidable in its operational perception.

According to Gilbert Durand (disciple of Gaston Bachelard), the author of *Structures anthropologiques de 1'imaginaire*, Heisenberg's uncertainty principle has a correspondent in the field of humanities: the impossibility to make precise both terms of a couple of entities which are naturally associated. The germ of this situation appears already with Freud and Jung: insight a phenomenon we may have two contradictory things, such that when one of them is made explicit by observation or explanation, the

other remains in obscurity. For Durand, the conscious and the unconscious are exactly in this situation. If one of them can be the object of a psychological investigation, then the other is no longer available psychologically, it becomes only a reservoir of socio-cultural and historical effects and resonances (Durand 1987:149-161).

Objective information, a chimera; from thermodynamics and biology to semiotics

The study of information emerged in the second half of the 19th century, from two sources: thermodynamics, for information as a quantitative entity, and Darwinian biology, for information as form, i.e., as a qualitative entity. Only the second itinerary agrees with the Latin etymology of 'information'. The first itinerary lead in the 20th century to Shannon's information theory born from the idea to separate information from meaning. Messages are reduced to signals and the information can be measured. But the price we have to pay in order to can measure the information is to renounce to its meaning aspect. Measured information is objective, but poor. On the other hand, information as form knows in the 20th century a spectacular itinerary. F. de Saussure, E. Cassirer, B. Russell - A.N. Whitehead, G. Lukacs, D'Arcy Thompson, D. Hilbert, Russian formalism,, Max Scheler, A. Jolle, V. Propp, M. Ghyka, L. Hjelmslev, R. Huyghe, R. Thom, R. Spencer-Brown, G. Bateson, U. Maturana-F.Varela, B. Mandelbrot, D.Hofstadter have, as a common denominator, the attention paid to various aspects of form. But information and meaning remained with the status of a conjugate pair. The field of objective information is very restricted, most information is of a mixed subjective-objective nature, as we have shown in (Marcus 1997a).

After many attempts, the marriage between information and meaning proved to be impossible. All kinds of compromises were adopted. Biology is still looking for an adequate notion of information. Let us recall that already towards the end of the 19th century the German biologist Augustus Weismann (1892) observes that it seems that in the field of heredity there are phenomena that cannot be explained only in terms of matter and energy; we need something more, and Weismann called it 'information'. After the appearance of Shannon's information theory, many authors in biology adopted his view. They did not observe that Shannon is dealing with global aspects of information, while in the field of heredity we need a local idea of information, able to make meaningful the information of a DNA string, for instance. Ultimately, the help came from the so-called cybernetics of second order, including the observer; the start in this respect belongs to Bateson (1973), who also proposes a new notion of information: it is a difference that makes a difference. In order to make clearer the mixed subjective-objective nature of this way to understand information, Hoffmeyer and Emmeche (1991) arrange Bateson's definition in the following form: it is a difference that it is perceived by somebody as a

difference. In this way, the dependence of information from a subject for whom it makes sense is made explicit.

The competition between information and sign

Sören Brier (CD-ROM, article 99169) formulates the problem whether the Wiener-Schrödinger quantitative paradigm of information could successfully cope with the problems of meaning and communication in living systems, in language systems and in social systems. In this respect, the information paradigm was in competition with the semiotic paradigm as it was developed by Ch. S. Peirce and, in the 20th century, by Thomas Sebeok, the initiator of biosemiotics. Schrödinger (1946), and Bateson (1973) are considerd by Brier as expressing an analogy between information, on the one hand, and neg-entropy and evolutionary order, as accumulation of thermodynamic neg-entropy, on the other hand. A link is suggested in this way, observes Brier, between matter and mind and, consequently, the possibility of artificial intelligence, followed by the possibility to transfer human mind on internet, under the form of self organizing programs. Making a clear distinction between the Shannon variant and the Wiener variant of information theory, Brier associates to Schrödinger and Wiener not only the name of Bateson, but also those of Stonier (1997) and of L. von Bertalanffi, the founder of system theory via biology. Brier sees in this line of thought a way to bridge information and consciousness, life and *qualia*. Making a synthesis of this approach, Brier claims that people, machines, animals and organizations process information in the same way. But he shows that this is true only if we ignore intuitions and emotions and we take in consideration only the conscious and logical thinking, while understanding is reduced to the analytical one. The subject is seen only in its cognitive aspect and, in this respect, we have a tendency to see it as a computer. Brier is suggesting in this way the compromise making information able to simulate human existence. Some improvements came from thermodynamics far from equilibrium, non-linear dynamics, deterministic chaos, and fractals. But despite all these additions, the information paradigm remains powerless in respect to meaning and sense.

Other failures in separating the subject from the object: induction, linguistic relativism and constructivism

The reasoning by induction was traditionally considered as a way to acquire knowledge about the objective world. At a careful examination however, we realize that induction is not a move from particular to general, it is a circular itinerary between them. Indeed, let us consider an experiment leading to a finite number of points in the plane, telling us that at various moments *t* we had a specific position of coordinates *t, s(t)*. If we want now to

dress a curve passing by all these points, we have to make a choice among infinitely many possibilities and this choice is determined by a previous idea we have about the respective phenomenon or by a purely psychological aesthetic need. So, subject and object become actors in the same game and it is impossible to separate their actions.

Another example of subject-object interference is the so-called linguistic relativism analyzed by Sapir (1921) and Whorf (1956) and according to which our very perception of the physical world is programmed by the language we speak. For instance, it was proved that the perception of colors is strongly influenced by the way in which color terminology is structured. On the other hand, authors such as Black (1962), Fishman (1960) and Herriot (1977), accepting the interest of Sapir-Whorf's hypothesis, try to restrict its domain of validity. Computer programming languages confirm to some extent the linguistic relativism.

In the last decades, a new doctrine emerged, called (linguistic) constructivism, whose main claim is that each speaker is building on its own the meanings of its language. The process of learning a language is a personal construction, a creative one, while the competence to perform this construction comes from our innate resources (Chomsky 1975; Siegfried Schmidt and his journal SPIEL, Grace (1987).

Predictions and speech acts under the sign of self-reference

The field of predictions is another example of subject-object circularity. Not all predictions are in this situation. Prediction of solar or lunar eclipses is based on a clear separation between the subject making the prediction and the object of prediction. Man has no influence on the movement of planets around the sun. It is not the same situation in the case of meteorological predictions, Man's influence on the state of the atmosphere is no longer negligible, as it was until the 19th century. Various modifications of the man-nature relations, as a result of the scientific, technological and social evolution, may have a considerable impact on the ecological system of our planet and the warnings coming from authors such as Commoner (1990) and Toynbee (12 volumes 1934, 1939, 1954, 1959, 1961) are symptomatic in this respect. Some changes observed in the last decades in the climate of our planet are the result of the human action. A sharp, rigorous separation between the subject making the meteorological prediction and the climate forming the object of the prediction no longer exists, although the precise nature of this influence exercised by human action on the atmosphere around us is not yet well known.

The circular nature of predictions becomes clearer and more significant when they are applied to the economic-social life. The subject making a social prediction belongs to the human society that is just the object of his prediction; at the same time, the society (in

contrast with the atmosphere, in the case of meteorological predictions) may become aware of the predictions concerning its future development and change its behavior, in order to invalidate the prediction. Opinion polls before various types of elections are typical in this respect, they have sometimes a decisive influence and this is the reason why they are under interdiction in the immediate days preceding elections. Another interesting situation is that of a prediction made by an economist, concerning some events whose realization essentially depends of the decision factors in economy, while the prediction was required just by the same decision factors, in order to know what decision to take.

Very relevant is the so-called speech act theory (Austin 1962;Searle 1969), whose basic assumption is expressed just by the title of Austin's book: the possibility to do things with words. Speech acts can simultaneously assert and perform (establish) the fact they are asserting. The sign becomes its own object. Promising or requiring something is a speech act, because in this case language is not referring to something exterior to it, it is referring to a situation created just by it. Once more, self reference is present.

From communication about the world to communication about communication

Communication is another process with strong self-referential tendencies. Marshall McLuhan's slogan "the medium is the message" (see McLuhan 1962), later the title of another book, by Lepri ("Medium e message: 1986, 2000) calls attention on a typical self-referential process in contemporary communication: the initial message about the world is step by step abandoned in favor of another one, about itself. The medium, initially a simple window to permit us to convey a message, becomes itself a message, claiming to be the main message we have to convey. The subject-object distinction is again in question. As subjects, we communicate, we change messages either about the world around us, or about our own person. At this stage, we may assume that the subjects which communicate may be firmly different from the object of the communication process. In other words, we start by communicating about the world. This first step, let us call it communication of first order, is followed by a second one, where the object of communication is just the communication of the first order. Continuing in this way, we reach, for any positive integer n, a communication process of order n. So, at least theoretically, the communication of the first order, let us call it primary communication, because it is directly about the world, is replaced step by step by communication about communication (more precisely, communication of order n about communication of order n-1). Is this a purely speculative way to approach communication ? Not at all! Look in any newspaper and you will find out that most news are communication of higher order, only a few of them belong to the primary communication.

Now, it is clear that any new intermediate level in the escalation of the communication process will work also as a new source of deterioration of the initial message. For n

enough large, the risk to get at the *n*-th step of the process a very distorted message with respect to the initial one is increasing.

But the big danger is that in most cases we no longer can reconstitute the initial message and sometimes even its existence is doubtful. Take for instance the huge enterprise called "Science Citation Index", where we find, for any published paper, who cited it, when and where. A big rooted tree is born in this way, but in most cases we don't know exactly the root, because it is very far in the past, and we don't know its further evolution, so it is a fragment only of a tree. Such trees account for that adventure of human being we call science. Communication turns to itself and it generates a new universe, the universe of communication, challenging the proper universe and sometimes replacing it abusively.

Models and metaphors: bridging the subject and the object

Tarasti considers (2000:11) that the subject becomes an existential being that creates the meaning across two acts, the first of which happens within the framework of objective signs. The emergence of meaning in science is placed within this framework but, as we have shown (Marcus 1997b), signs occurring in this process are not just objective, they cannot avoid the subject-object circularity. Let us recall that a model B for a phenomenon A aims to study A by a method incompatible with the nature of A or with its degree of complexity, but compatible with B. We need this strategy in those cases in which methods compatible with A prove to be insufficient for the understanding of A. For instance, if A is an empirical phenomenon, it cannot be directly approached by a mathematical method; we imagine then a formal construction B, by means of which we try to simulate the phenomenon A. Similarly, if A' is an entity that cannot be sufficiently understood in terms directly referring to A', we imagine another entity B' by means of which we could express better some properties of A'. For instance, if we want to say that somebody is courageous, beautiful, powerful, proud, noble, we better use a metaphor B' such as 'lion' and we say 'he is a lion'; in this way, by a single, very expressive word, we express better what we wanted to say. A model B of A accounts only partially for A, because their analogy is only in some respect true. Moreover, B has to fulfill two opposite requirements: on the one hand, B should be enough similar to A, in order to have a chance that what is valid and relevant for B is valid and relevant also for A; on the other hand, B should be enough different from A, in order to have a chance to find a method applicable to B, but not to A. So, B is only an approximation of A and this approximation can be always improved. There exists no final model of A, there is only a potentially infinite sequence of cognitive models 'converging' to A. Something similar happens with the metaphor. There is a permanent tension between *frame* and *focus*, to use the terminology of Black (1962), in analogy with the tension existing between an object and its model. The focus is both

similar to and different from the frame; similar, to show that it refers to the frame; different, in order to be able to bring something new, i.e., different with respect to the given frame (in "he is a lion", 'he' is the frame, while 'lion' is the focus). It appears that both models and metaphors have a conflictual structure, because they have to fulfill opposite requirements, like in the *double bind* situation known from psychiatry. For a more detailed comparative analysis of models and metaphors, see Marcus (1997b).

The creative power of models and metaphors; their circular structure

Now we have to show how models and metaphors acquire a cognitive and creative function, how do they make possible the emergence of meaning in science. Let us consider the example of the emergence of the idea of irrationality, so important for the Greek antiquity and playing a basic role in Tarasti's approach; for him, the existential thinking should be in its essence irrational. For those who fear that we give to this word a meaning different from what Tarasti has in view, we will come back on this question later. Pythagoras discovered the impossibility to find a number corresponding to the length of the diagonal of a unit square; for that time, only numbers which are of the form p/q, with p and q positive integers and q different from zero were known. The problem was how to enlarge the idea of a number, in such a way that the respective diagonal could be measured. The difficulty was determined by the fact that no number of the form p/q exists whose square is equal to 2. To put it in the form of a question, we will formulate it as follows: imagine an extension of the idea of a number, according to which, in the new framework, there exists a number x which is, in respect to 2 in a relation similar to that of n with respect to the square of n (n being a positive integer). If we succeed to solve this problem and because n is said to be the square root of the square of n, we will call x the square root of 2. As a matter of fact, it took about two thousands years to solve the respective problem; it happened in the second half of the 19th century, when the general notion of a real number was introduced. However, much earlier a special sign for the square root of 2 was introduced, despite the fact that this picture for x was meaningless. But here a remark is necessary: it was meaningless conceptually, but it was not at all meaningless metaphorically. Indeed, x is introduced by means of an analogy and the abbreviation of this analogy is just the metaphor: x is the square root of 2. In what is different this metaphor from the usual metaphors such as Aristotle's metaphor "Oldness is the evening of life" ? Aristotle's metaphor is the result of the analogy: "oldness is in respect to life what evening is in respect to the day". All entities involved here, *oldness, life, evening* and *day*, have an already existing clear status. On the contrary, in the Pythagoras situation only three vertices of the square have an already established conceptual status: 2, n and square of n; the fourth vertex x is conceptually meaningless and the role of the metaphor is just to help the emergence of a new concept. We could say that in Aristotle's situation the metaphor has an assertive structure, while in the case of Pythagoras the metaphor has an interrogative structure. Aristotle's metaphor is with

respect to an already existing entity, while Pythagoras's metaphor is no longer with respect to an entity which is pre-existent to the metaphorical process, but with respect to an entity which emerges just under the action of the metaphorical process: the notion of a real number. Clearly, in the second case we have a circular, self-referential situation, a subjective - objective process. According to a terminology introduced by Mac Cormac ( ), we call Aristotle's metaphor epiphoric, while Pythagoras metaphor was during two thousands years diaphoric and became epiphoric only in the 19th century. Let us observe that there are creative metaphors eternally diaphoric, for instance the metaphors of the Divinity. There are also creative metaphors today diaphoric, but that can become epiphoric in a near or distant future.

The psychological identity of scientific and artistic creativity

One of the most interesting analysis of the psychological nature of scientific creativity is the book "Essai sur la psychologie de 1'invention mathématique" by Jacques Hadamard (first half of the 20th century); English edition: (Hadamard 1954). Hadamard sees the process of scientific invention in three steps. There is first a *preparation*, that can be very long (accumulation of data, some of which are selected for further specific combinations); a second step is *incubation* (period in which some ideas are reconsidered, by a process that cannot be kept under control); then comes the third step, *illumination*, including the unexpected appearance of a new, seductive combination, which in many cases may disappoint. The last step, conscious and rational, is of verification and accuracy of details.

After this description of the psychology of invention/discovery in mathematics, Hadamard makes reference to a letter sent by Mozart to his sister (he mentions that this letter is reproduced in Séailles (1883:177). Here is the letter:

> *When I am in a good mood or when I am walking after a good meal, or during the night, when I cannot sleep, I am overwhelmed by all kinds of thoughts. How do they appear ? I don't know and I am not interested in this. I keep those that I like and sometimes I begin to hum them; or at least other people told me that I proceed in this way. As soon as I find out a theme, another melody appears, joining the previous one, in agreement with the global requirements*

of the composition: the counterpoint, the part of each instrument. All these melodic fragments yield the whole work. If nothing diverts my attention, my soul is in the fire of inspiration. The work grows; I extend it, I see it clearer and clearer, until I have in my head the whole composition. My mind seizes it at once, in the same way in which my eye captures by only one look a beautiful painting or a good-looking boy. The work does not appear to me in successive steps, with each part in details, as it will later happen, it is offered to my imagination as a whole.

How does it happen that, when I am working, my compositions get the mozartian form and style ? Exactly as it happens that my big and aquiline nose is only mine. I don't look for originality and it would be difficult for me to define my style.

Hadamard observes the striking similarity between his representation of the psychology of mathematical creativity and Mozart's representation of the psychology of musical creativity: both are organized according the scenario "preparation - incubation - illumination - verification and accuracy of details". The culminating step in this scenario is the third one, the illumination, associated by excellence to creativity; it is the explosion that in semiotics is usually associated with the abductive moment dominating the inductive and the deductive components, but impossible in absence of them.

Illumination as culminating moment of creativity is bridging illumination as symptom of transcendence

Now, going back to Tarasti's approach, we will observe how important is for him the illumination moment. In the second chapter of his book, "Signs and transcendence", the symptom of transcendence is a unexpected (surprising) illumination. At p. 21, Tarasti points out how a usual experience may change step by step in a transcendent one, taking the form of a new illumination of a sign, of an object, of a text from the field of *Dasein*. Giving several examples from the field of music, Tarasti observes (2000:29) that, examining the message of an artist, the semiotician reaches the illumination of existence,

as expression of the individual subject. So, illumination as symptom of transcendence reaches the illumination as culminating moment of creativity, be it scientific or artistic.

The importance of the illumination moment is asserted also by writers such as Lamartine and Paul Valéry and by scientists such as Henri Poincaré, Helmholtz, Charles Hermite, K. Weierstrass and Joseph Bertrand. This fact is organically associated to the importance of the unconscious factors (dreams, other activities during sleeping), intuitive and emotional factors in all types of human creativity.

Creativity as articulation of choices and combinations

Paul Valéry asserts that any act of intelligence involves two types of operations: choices and combinations; but genius is mainly related to happy choices. Poincaré has similar opinions, but he believes that possible rules in making choices are implicit rather than explicit, unconscious rather than conscious. He also stresses the basic role of affective-emotional life and of aesthetic factors in making good choices. Already Helmholtz, referring to his own experience, underlined the role of unconscious in making happy choices; he claimed that he never got a successful idea when he was at his working table.

A synthesis of the ideas concerning the representation of creativity as an alternation of choices and combinations was proposed by Hadamard (1954). More recently, Bouligand (1985) focuses on the same idea (in conflict with the common belief) that discovery and invention in mathematics are not rational acts. Like in other fields, creativity in mathematics involves intuitions, abductive inferences, imagination and revelation.

We could dress a typology of creators, according to their dominant feature. For instance, Karl Weierstrass , Bernard Riemann, Charles Hermite, Jacques Bertrand and Bertrand Russell are all mathematicians, but the first of them is predominantly analytic, the second one is predominantly intuitive, the third one is predominantly logic, while the fourth one is predominantly spatial and geometric. There is also a typology with respect to choices and combinations, according to which Riemann and Henri Poincaré were great in choices, while Paul Erdös, in the second half of the 20th century, was very inspired in combinatorial operations.

The contrast between the explicit, public appearance of science in terms of axiomatic-deductive logic, on the one hand, and the hidden life of science, dominated by questions, attempts, failures, intuition, emotion, abductive inferences, unconscious and aesthetic factors, on the other hand, is one of the main sources of the misunderstanding having among its victims the apparent impossibility to bridge heavy sciences and existential semiotics.

Irrationality

"The very concept of sign may be fundamentally irrational. The sign emerges from emptiness, from Nothingness, it is a happy fortuitousness" (Tarasti 2000: 173). This is a way to state an open problem: "How do the signs emerge?" This question seems to be of the same difficulty as "How life emerged ? " or as " How did the Universe start ?".

According to Peirce, signs emerge from signs and generate signs, there is no initial or final sign and any question concerning the move from non-semiosis to semiosis is ignored. Theoretically, semiosis is essentially a mediation process, in contrast with hermeneutics, which is direct, i.e., non-mediated. Professor Tarasti perhaps remembers the 1983 decade at Cérisy-la-Salle, focused on a debate between semiotics (Algirdas J. Greimas) and hermeneutics (Paul Ricoeur). The difficulty to approach the delicate problem of how signs emerge is the fact that we are part of the world of signs, so we are both observers and observed in this respect. Things are similar to the difficulty to understand the time, with respect to which, again, we are both observers and observed. Tarasti is right in considering non-semiosis as an empty space, because it is not available to us and, in this case, the emergence of signs from non-signs is 'irrational'. In mathematics, irrational numbers are those whose representation is essentially infinite, so they are available only partially, via some finite approximations; in this sense, the label 'irrational' is motivated.

We reach irrational numbers only transcending the world of mathematical processes with a finite number of steps. The old Greek civilization of Pythagoras was shocked by the impossibility to measure the diagonal of the unit square and we can imagine the feeling of Nothingness associated to the respective historical moment. This first step, essentially negative, was followed by another one, positive, of plenitude, related to the creation of the concept of a real number and to the possibility to consider, for each real number, its square root. But these two moments were separated by two thousands years.

Transgression, as a way to acquire meaning

When a problem is in front of us, in a given framework, a general procedure to approach it is to transgress the respective framework and to move into another one, with a more powerful explanatory capacity. For instance, art is proposing a fictional universe that may have in respect to the real one a higher capacity to mean and to explain. In his general relativity, Einstein, in order to better understand Newton's law of gravitation acting in the three-dimensional Euclidean space, considers a broader framework, a four-dimensional space-time, and he shows that gravitation in the three-dimensional space is the effect of the curvature of the space-time. From the elementary mathematics we

remember that the successive extensions of the numerical framework were motivated by the need to make meaningful in the general case some natural operations; so we moved from natural numbers to integers, from integers to rational numbers and from rational to real numbers.

Solving algebraic equations required, in its turn, the extension of the framework of real numbers to a broader one, of complex (imaginary) numbers. Things don't stop here.

The adventure of the infinitely small

Leibniz introduced the idea of an infinitely small, as a quantity which is fixed, but smaller than any number of the form $1/n$, where n is an arbitrary strictly positive integer. During about three centuries, nobody was able to give a coherent interpretation of Leibniz's idea. In the second half of the past century, A. Robinson succeeded to consider a framework more comprehensive than that of the real numbers, called the *non-standard universe*, where the idea of an infinitely small becomes meaningful, but not as a real number; it is however an element of the non-standard universe. This idea was applied to the study of exchange economy, in order to explain the behavior of the participants in a market economy, when the number of participants is increasing. The method consisted in replacing the standard universe by a non-standard one, leading so to what is called a non-standard exchange economy. One of the authors of this work, Gérard Debreu, got the Nobel prize for economics.

The nature of the metaphorical and of the metonymic processes

Very often, we transgress the initial framework not in the direction of a more comprehensive one, but in the direction of a framework being in relation of analogy or of contiguity with the initial one. Metaphorical and metonymic processes are transgressions of this type.

The universe of the infinitely small (the quantum universe, for instance) takes profit from the examination of the macroscopic universe, because in the latter we can use our intuitions and our language, while in the former our capacities are to a large extent powerless. We get a better understanding of our own country by transgressing its borders and knowing other countries. We understand better the Euclidean geometry by moving to the more comprehensive framework of absolute geometry, where the axiom

of parallels is ignored; so, both Euclidean and non-Euclidean geometries are parts of the new framework. Similar procedures are used in practically all fields of knowledge.

Transcendence: high spirituality, high complexity, high surprise

As a high form of spirituality, transcendence is a common denominator of all forms of intellectual creativity, their climax moment. But does science have a spiritual dimension ? A negative answer to this question is often suggested, rarely made explicit. We meet frequently slogans of the type: "science deals only with the concrete, material world", "modern science dehumanizes man", "science provides us with information, but brings about no spiritual gain". Such slogans are simply false, they denote ignorance or/and misunderstanding. At the Imatra 2005 session of semiotics we have lectured about the spiritual dimension of mathematics. Some meetings are organized under the slogan "Bridging science and spirituality". It is suggested in this way that science and spirituality are to such extent away each other that we need to build a bridge between them, in order to diminish their discrepancy. The reality is just the opposite. Science has a very rich internal spiritual life and this fact explains why it is able to interact with other spiritual fields.

In our Western culture, we refer to old Greek traditions, where chronologically myths appeared the first, then appeared literature (see Homer) and a few centuries later emerged mathematics, with Thales and Pythagoras.

Poetry and mathematics, daughters of the same mother

They are usually described in contrastive terms; however, they share some important features, inherited from myths: they all propose some fictional worlds; they all use symbolization; they all need to transgress the everyday logic and to adopt, more or less explicitly, what we call today a non-classical logic; as a consequence, they all are impregnated of syntactic, semantic and pragmatic paradoxes. So, the way is open to conflicts with the intuitive perception and expectations and to discrepancies between the intelligible and the visible. Myths, poetry and mathematics are all based on a principle of semiotic optimization: maximum of meaning in the shortest possible expression. They also share the assumption of a holographic principle: the local may account sometimes for the global, the instantaneous may account for the eternal, the anthropos for the cosmos, the individual for the general, the finite for the infinite. Recall William Blake's famous verses: "To see the world in a grain of sound/and the heaven in a wild flower./Hold infinity in the palm of your hand/and eternity in an hour". Infinity is one of the most important forms of transcendence, involving a whole hierarchy: the finite

accounting for the infinite, the countable infinite accounting for the infinite of the power of the continuum, the infinite of a given cardinality accounting for the infinite of a higher cardinality.

Imprecision is essential in both scientific and artistic creativity

A symptom of the high complexity associated with transcendence is the essential role of imprecision in all kinds of spiritual creativity. This fact is well-known in the case of poetry and art, but less known in the case of science. However, at a careful examination, we observe that most mathematical results involve approximation, randomness, fuzziness, generality, negligibility, ambiguity, roughness or other forms of imprecision. As a matter of fact, the distinctive feature of imprecision is just its high complexity: the number of parameters that should be evaluated is too large to can be performed.

Surprise, as a common feature of science and of art

From high spirituality and complexity there is only one step to high surprise. Let us take the Greek wonder faced with the existence of the phenomenon of irrationality. The surprise was so high that its effect was decisive for Greek mathematics. We could dress a hierarchy of facts with respect to their degree of surprise: trivial; obvious, but not trivial; expected, but not obvious; neuter (neither expected, nor unexpected); unexpected, but not surprising; surprising, but within the limits of human imagination; beyond what can be imagined at a certain historical moment.

From surprise to craziness, in both science and art

The last type could be associated with a kind of craziness, in its positive sense (in contrast with its negative, pathological meaning). Marston Morse writes somewhere that mathematics is sometimes crazy. Perhaps, he had in view moments such as Abel's discovery of the impossibility to solve by radicals algebraic equations of degree higher than 4 and Galois' theorem giving the deep purely qualitative reason of this fact. We may also think at non-Euclidean geometries and at Gödel's incompleteness theorem asserting the impossibility to have, for some types of formal systems, both consistency and

completeness. Robinson's non-standard analysis could be also included in these types of scientific results, we could call them crazy, meaning by this that they pushed far away the limits of human imagination. "Transcendence" is associated with "beyond"; with results of the mentioned type, human spirituality is moving beyond some already accepted limits. By Gödel's incompleteness theorem, for instance, we learn that in order to prove the consistency of some types of formal systems we need to leave the respective systems and reach a more comprehensive universe, whose consistency will require a new, broader universe etc. Going beyond an existing framework is thus a human need telling us how essential is the 'trans' operator having transcendence as its prototype.

Existence and its typology; what defines us as humans

Our stress on heavy sciences is motivated by the fact that they are considered a field of the object rather than one of the subject. We argued however in favor of a strong involvement of the subject in the so-called heavy sciences too and we used ideas belonging to all fields of spiritual creativity. We stressed the psychological identity of scientific and of artistic creativity, the similar role of illumination, of irrationality and of transcendence in science and in art. There exists however a whole typology of existence, according to its nature and to its degree of effectiveness. For instance, if we refer to the existence of the human body, we have first its material existence (related to the verb 'to have') consisting of some atoms. The most visible, material existence is also the most inconsistent, because during five years all our atoms are changed. More stable is its structural existence (related to the verb 'to be'), consisting of the patterns, the arrangements of the atoms. The genetic existence (associated to the verb 'to inherit') consists of the features transferred from our parents and ancestors. The reproductive and sexual existence (associated with the verb 'to transfer to descendants') consists of the capacity to have children; the managerial existence (associated with the verb 'to control' or 'to coordinate') is of three types, according to the nature of prostheses under control: muscular, sensorial and cerebral. The most important cerebral prosthesis is the electronic computer, leading to the computational existence (associated with the verb 'to do something effectively'), consisting of the capacity to make our products as constructive as possible. Here, we should distinguish the complexity (cost) of doing something. Very important is the interactive existence (associated with the verb 'to interact'), consisting of the interactions of our body with the external world. Here we should include the ecological existence and the communicational existence, as parts of our interactive (dynamical) existence. Then comes the semiotic existence (associated with the verb 'to mean', 'to signify'), consisting of the capacity to mean in various ways; this existence is one of the second order, because it consists of the capacity to signify the other, already considered types of existence. The procedures to mean may be of various types, for instance they may be symbolic, iconic (metaphorical) or indexical (metonymic). There is

a whole history of the metaphorical use of the human body in the Greek antiquity, during the Roman empire, in the Middle Age, until our time.

No claim to have given a complete account of the types of existence of the human body. Our desire was only to suggest the complexity of the problem. But even from this incomplete account we learn to what extent the existence of the human body cannot be understood in absence of reference to what is beyond it. From this apparently elementary problem there is a long way until we reach the idea of the existence (identity) of a person, with its mind, soul and spirit. Leibniz, with his famous mind/body problem, is challenging us still today and we realize the high complexity of the idea of self, of 'ego' and of 'human existence'. All these things are common to science and to art, they define us as humans.

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