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FROM QUANTUM PHYSICS TO PHYSICAL MODELS

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ABSTRACT

As regards the issue of complexity, human brain is one of the most complex systems we know. The study of neural networks, their relation to the operation of single neurons and other important topics do and will profit a lot from complex systems approaches. As regards quantum physics, there can be no reasonable doubt that quantum events occur and are efficacious in the brain as elsewhere in the material world – including biological systems. This paper is intended to present an exhaustive viewpoint regarding the main actual hypothesis in what concerns human brain mechanisms of structuring and functioning.

Keywords: brain, information, neuroscience, psyche, consciousness, complex systems, quantum physics, electromagnetism, semantic.

INTRODUCTION

Information technology appears to be the major challenge of the beginning of the third millennium, as it has started to rapidly modify all the human life fields in a direction which is hard to anticipate.

Besides the evolution in the technique and technology of information, a reevaluation of all the paradigms that founded the epistemic knowledge for the last century becomes necessary. It is thus more and more pregnant that the information should be given its due ontological place, alongside with the substance and the energy. Several dilemmas and contradictions that were already in discussion a hundred years ago, related to the wave-particle duality and, generally speaking, to the Copenhagen standard view of quantum mechanics, the problem of defining and describing the field, the holographic principle and even the mystery of the dark energy and the dark matter might receive a new impulse and thus have a new evolution if the information was included in the hypotheses and theories built along the latest century.

We have entered the third millennium with a few theories that need to be further developed and that offer some patterns of the structure and dynamics of reality much more nuanced and therefore much closer to the reality. The chaos theory, the fractal geometry, the nonlinear dynamic, the topology, in other words, the theory of the complex systems, all these impose the introduction of the information as a necessary paradigm in the developing of these concepts. Speaking of information we speak of the technology of information, of artificial intelligence, in relation, of course, to the human intelligence.

The newly built theories of information will have to solve another challenge, concerning the functioning of the brain and the mysteries of the psychic. When it comes to the mental, it seems that things are deviating towards a reality impossible to explore. Descartes's old assertion, *res cogitans res extensa,* that has dominated epistemic knowledge for centuries, could be exceeded precisely by means of the information paradigm, as long as information structures and controls dynamic in both realities.

In order to succeed in the knowledge adventure and to face all these challenges we need new principles and new methodologies of knowledge. Such a modality is represented by transdisciplinarity, that admits as ways of knowledge science and phi-

losophy, religion and art. These are attributes of the mental, and the mental is, partially at least, a reflexion of reality. This transdisciplinary approach supposes the overcoming of some complexes and prejudices, that have twisted knowledge for centuries. As long as we admit that information is immaterial, that it is an ontologic compound of reality along with substance and energy, the arbitrary division between physics and metaphysics, between brain and mind, between real existence and spiritual existence should not represent opposing views on reality, but complementary ones.

QUANTUM APPROACHES TO CONSCIOUSNESS

The original motivation in the early 20th century for relating quantum theory to consciousness was essentially philosophical. It is fairly plausible that conscious free decisions ("free will") are problematic in a perfectly deterministic world so quantum randomness might indeed open up novel possibilities for free will. However, randomness is problematic for volition.

An important aspect of all discussions about the relation between mind and matter is given by the distinction between descriptive and explanatory approaches. For example, correlation is a descriptive term with empirical relevance, while causation is an explanatory term associated with theoretical attempts to understand correlations. Causation implies correlations between cause and effect, but this does not always apply the other way around: correlations between two systems can result from a common cause in their history rather than from a direct causal interaction.

In the fundamental sciences, one typically speaks of causal relations in terms of interactions. In physics, for instance, there are four fundamental kinds of interactions (electromagnetic, weak, strong, gravitational etc.) which serve to explain the correlations that are observed in physical systems. As regards the mind-matter problem, the situation is more difficult. Far from a theoretical understanding in this field, the existing body of knowledge essentially consists of empirical correlations between material and mental states.

It seems that at a level at which conscious mental states and material brain states are distinguished, each conscious experience has as its physical counterpart a quantum state reduction actualizing "the pattern of activity that is sometimes called the neural correlate of that conscious experience". More precisely, this pattern of activity may encode an intention and, thus, represent a "template for action". An intentional decision for an action, preceding the action itself, is then the key for anything like free will in this picture.

The approach by Beck, 2001 and Beck and Eccles, 1992 is most detailed and concrete with respect to the application of standard quantum mechanics to the process of exocytosis. However, it does not solve the problem of how the activity of single synapses enters the dynamics of neural assemblies, and it leaves mental causation of quantum processes as a mere claim. Stapp's approaches 1993, 1999, 2006, 2007 and 2015 suggest a radically expanded ontological basis for both the mental domain and status-quo quantum theory as a theory of matter without essentially changing the formalism of quantum theory. Although related to inspiring philosophical and some psychological background, it still lacks empirical confirmation. The proposal by Penrose, 1989, 1994, Penrose and Hameroff 1995, 1996 exceeds the domain of present-day quantum theory by far and is the most speculative example among those discussed. It is not easy to see how the picture as a whole can be formally worked out and put to empirical test.

The approach initiated by Umezawa is embedded in the framework of quantum field theory, more broadly applicable and formally more sophisticated than standard quantum mechanics. It refers directly to the activity of neuronal assemblies as the neural correlates of mental representations. A clear conceptual distinction between brain states and mental states is most often missing, although the approach is not intended to be reductionistic. Vitiello's more recent accounts 1995, 2001, 2002, 2012, 2015 and also that of Pessa and Vitiello 2003 offer some clarifying hints in that direction, which point to an understanding in terms of a dual-aspect approach. Other such approaches, like those of Pauli and Jung 1995 and of Bohm 1989, 1990, Bohm and Hiley 1993, Hiley 2001 are conceptually more transparent in this respect. On the other hand, they are essentially unsatisfactory with regard to a sound formal basis and concrete empirical scenarios. A novel

dual-aspect quantum proposal by Primas 2002, 2003, 2007, 2009, based on the distinction between tensed mental time and tenseless physical time, marks a significant step forward, particularly as concerns a consistent formal framework.

For further progress, it will be mandatory to develop a coherent formal framework for this approach and elaborate on concrete details. For instance, it is not yet worked out precisely how quantum superpositions and their collapses are supposed to occur in neural correlates of conscious events.

The activation of a neuronal assembly is necessary to make the encoded content consciously accessible. This activation is considered to be initiated by external stimuli. Unless the assembly is activated, its content remains unconscious, unaccessed memory.

This leads to the conclusion that the application of quantum field theory in the model serves the purpose of motivating that and why classical behavior emerges at the level of brain activity considered. The relevant brains states themselves are decidedly viewed as classical states. Similar to a classical thermo-dynamical description arising from quantum statistical mechanics, the idea is to identify different regimes of stable behavior (phases, attractors) and transitions between them. This way, quantum field theory provides formal elements from which a standard classical description of brain activity can be inferred, and this is its main role in the model.

Other considerations on this subject can be found in Aerts et al. 1993, Aerts and Aerts 1994, Atmanspacher 2014, Atmanspacher and Filck 2006, 2010, 2013, Atmanspacher and Fach 2013, Filck and von Müller 2009, Tononi and Koch 2015, Wigner 1967, 1977 etc.

PSYCHIC SPACE AND COMPLEX SPACE

If we confer a real existence to immaterial information, in general, which is to be found next to structure, and also to the information from a soft next to the hardware, then we can accept the existence of the complex space, where it seems that information is to be found at potential level, under the form of Bohm's implicit reality, a physical space together with the real space, with which it is in a permanent dynamical connection. The existence of this physical space, at the interface with the real space through the Hilbert space, involves the acceptance of the fact that this space contains the real space at potential, a-temporal and a-spatial level (Bohm's implicit reality). Thus, this space is formed by information before this becomes substance and energy, the conclusion to this being that within this space and within this interface, the context of human imagination, of creativity and of psychism is formed.

In our view, the Hilbert space is an interface between the real space and the complex space and a proof that the complex space is a physical space connected through a permanent dynamics with the real space, as long as we accept the wave as real, with its wave function and wave equation. In our opinion, the complex space includes information in a potential form, which becomes explicit (real) under the constraints generated by the real space (Crumpei, Gavrilut, Crumpei and Agop 2016).

The whole cosmologic and biological evolution is resumed to a dynamical link between chance and necessity, between diversity (chance mutation) and selection, between chaos and structuring, as in the human body (permanent renewal of cells and tissues, as well as the dynamics between inflammation (disorder) and structuring). Thus, old age, disease, epilepsy, rhythm troubles can be interpreted as losses of the fractal character, through the reduction of the chaotic character.

Information represents codified energy which is expressed under the form of patterns, structure patterns, initiated by attractors which activate in the phase space, between the chaotic and the structured part. Information is stored in the spectral space and expresses the patterns in the structure of atoms, molecules, macromolecules and cells. It has a potential existence which is expressed through substance and energy in certain conditions of local coherence.

A virtual, Newtonian reality as projection of physical reality is completed by the unstructured, a-causal, apparently chaotic component: the imagination, the dream, the failed acts, the subliminal mechanisms, the unconscious etc., which can be associated with the a-causal, potential, unstructured and non-differentiable component of complex systems, the source of inspiration, of creation and of access to non-Euclidean realities to holospace.

These potentialities can become conscious through patterns (the archetypes and the collective unconscious of Jung and they can be found in logical, algorithmic, organized and systematic form in everything that is creation (from making a speech, conversation, improvisation, to creating new musical pieces, new artistic work, new scientific work). The chaotic, unpredictable part does not only contain the Newtonian reality to which we all have access, but much more, maybe even the structure of the whole Universe, at potential informational level.

The brain has access to the implicit part (Bohm's implicit reality), if we associate this part to what the classics called unconscious. From here derives the capacity for mathematical reasoning, for physics, for reasoning reality in finite dimensional spaces, a-temporal realities, a-spatial realities.

The dynamics between the complex and the real space (the neuronal network), through the spectral field (wave field represented by the totality of the waves associated to the corpuscles in the neuronal network) is the basis of the psychological system functioning. This paradigm can generate new hypotheses which could explain the mysteries of the psychological life, just as the old ''mind-brain'' duality.

This new topic structure of psychism, associated with the theory of complexity and simplicity, applied to fractal geometry, through which reality is structured, allows the brain to have access also to the knowledge of the fractal as a whole, when the mathematical model is reduced as a number of informational bytes, to put it different as a symbol, but also, through the analysis and synthesis capacity, to be able to conceptualize the fractal at any point or at any scale, with the cost of an enormous informational content.

The implementation of the functional structure of complex systems to psychic life can explain a series of classical concepts circulated during the last century. Thus the unconscious from psychoanalysis can be associated with the unpredictable, non-causal and potential part from the structure of the complex system, while the conscience, as well as the unconscious behavioral patterns (superego of psychoanalysis) can be associated with the structured, causal and deterministic part of the complex system. Between the two parts, there exist a permanent dynamics through attractors, describable in the phase space. The chaoticity existing between the two components is absolutely necessary for the functioning of the brain.

When it is affected by repetitive cycles (epilepsy crisis) the conscience is blurred. This new representation on brain's functioning leads to new conclusions concerning different mental processes that have not been fully understood yet.

Thus, the whole psychological life can be considered to take place in this Hilbert space which allows also for a Minkowskian perspective, a spatial-temporal continuum, under the form of the fractal space-time, where the information trigonometrically stored is a-spatial and a-temporal, thus creating the conditions of a stable memory, but also a spatial-temporal tridimensional perspective which represents sections in time and space of this continuum. This material component of the neuronal network allows for the processing of information, but for the superior psychological processes, the processing is achieved in the complex space, so that the synthesis, generalization, abstractization, conceptualization, all assume a multidimensional perspective, which can be made only in the infinite dimensional complex space. More precisely, the dimensional dynamics from the null dimension to infinite dimensional which in our reality is realized only up to three dimensions, can be realized multidimensionally in the psychological reality in the complex space (through the fractal potential).

SPECTRAL HYPOTHESIS IN NEUROSCIENCE

The main difficulty of the neuroscientists is the prejudice to study only the neuronal, neuroglial and neurotransmitters structure. Starting from the quantum theory according to which every particle has a corresponding wave, and taking into account that starting from the newest cell structures, the neurofibriles, down to the cell, tissues and organs, one can observe the existence of a strong wave spectral activity. This spectral wave component has been understudied, even if it is contained in the quantum physics theories, but also in the neurophysiological concepts and is rudimentary highlighted at the level of overall cerebral activity through EEG and EMG. This spectral component associated and related to the material, corpuscular one (the neuronal and

non-neuronal structures of the brain) must be at least as important as the corpuscular part, which is structured and was studied in the last hundred years. Thus, we should pay more attention to the wave, spectral component of the brain.

Also, even the neuroscientists came fifty years ago to the conclusion that the transmission of signals at the level of analyzers is made spectrally. De Valois and de Valois 1993 proved that, at the level of perception of the visual analyzer, the signal is transmitted towards the cerebral parietal cortex on a spectral way, using for the interpretation of their experiences the Fourier series, used in describing the wave phenomena. Also, von Békésy 1970 proved that the tactile transmission is made spectrally, later on drawing the conclusion that the transmission of the signals of all analyzers can be described by mathematical equations specific to waves.

All these data, as well as the laser and hologram technology made it possible that Bohm and also Pribram 1971 brought arguments to sustain a theory of the holographic and holonomic brain, according to which in the spectral space associated to the structures of the brain there were structuring conditions of a holographic system, which could both explain the enigma of memory structure and the connection with cognition and affection.

The description of fractals and of their role in structuring reality upheld this spectral approach, as the hologram is nothing else but a fractal structure, even more because the architecture of the brain, of the blood vessels in the brain and of the whole human body has a underlying fractal algorythm and fractal geometry.

The approach of the structure and activity of the brain from a spectral perspective allows the study of the brain from the perspective of the complex systems theory. We can try to identify the unstructured, chaotic, stochastic component, along with the structured, causal component with linear dynamics, as a dynamics between the two components on the phase space, in which there is a permanent exchange of energy, but also of information. If we come to accept this, then certain principles, properties and characteristics from plasma physics, fluids and nonlinear dynamics in general could be used to study the mental.

THE ELECTROMAGNETIC THEORY OF BRAIN AND PSYCHIC PROCESSES

The electromagnetic theories of consciousness propose that consciousness can be understood as an electromagnetic phenomenon. However, theorists differ in how they relate consciousness to electromagnetism. Electromagnetic field theories (or "EM field theories") of consciousness propose that consciousness results when a brain produces an electromagnetic field with specific characteristics. Pockett 2000 and McFadden 2002, 2006 have proposed EM field theories, while Uttal 2005 has criticized McFadden's and other field theories.

Locating consciousness in the brain's EM field, rather than the neurons, has the advantage of neatly accounting for how information located in millions of neurons scattered through the brain can be unified into a single conscious experience (sometimes called the binding or combination problem): the information is unified in the EM field. In this way EM field consciousness can be considered to be "joined-up information".

This theory accounts for several otherwise puzzling facts, such as the finding that attention and awareness tend to be correlated with the synchronous firing of multiple neurons rather than the firing of individual neurons. When neurons fire together their EM fields generate stronger EM field disturbances; so synchronous neuron firing will tend to have a larger impact on the brain's EM field (and thereby consciousness) than the firing of individual neurons. However their generation by synchronous firing is not the only important characteristic of conscious electromagnetic fields – in Pockett's original theory, spatial pattern is the defining feature of a conscious (as opposed to a non-conscious) field.

The starting point for McFadden and Pockett's theory is the fact that every time a neuron fires to generate an action potential, and a postsynaptic potential in the next neuron down the line, it also generates a disturbance in the surrounding electromagnetic field. McFadden has proposed that the brain's electromagnetic field creates a representation of the information in the neurons. Studies undertaken towards the end of the century are argued to have shown that conscious experience correlates not with the number of neurons firing, but with the synchrony of that firing. McFadden views the brain's

electromagnetic field as arising from the induced EM field of neurons. The synchronous firing of neurons is, in this theory, argued to amplify the influence of the brain's EM field fluctuations to a much greater extent than would be possible with the unsynchronized firing of neurons.

SEMANTIC INFORMATION

The processing of information for the information provided by analyzers is made in a differentiable, causal, algorithmical form at the level of the neuronal network (Barabasi 2010), whereas beyond the analyzers it is made within a complementary network found in the complex space, which is mediated by the fractal potential from the spectral potential of neurons.

As a result, the qualitative leap represented by the appearance of culture would not have generated only the appearance of mirror neurons which are present also in some animals, but the development of genetic patterns which allowed for a better connectivity between the two networks. It is not a matter of chance that the appearance of articulate speech is associated to this qualitative leap in human development. The center of speech appears to represent a system of processing information which allows for connecting to the infinite and complex-dimensional space and thus to the possibility of emergence of superior psychological processes.

Reality is nothing else than the linguistic universe. This means especially the approaches of linguistic structuralism and of the Glosemantic School, as well as of the English Schools of Analytical Philosophy. What is common to these schools is that both bring nearer the language to mathematical structures. The Glosemantic School, for example, sees in the linguistic structure a profound similarity with the mathematical structuralism and combinatorics. The sentences could be dependent on these rules of mathematical combination, or, at least, are built on the same laws. If reality is a code of linguistic signs, then reality is expressed through sentences, and the sentences are dependent on the same rules of mathematical combination. Hence, the form of seeing and understanding reality depends on these rules of Mathematics.

Reality is dependent on language, too, and language seems to encompass the form of thought. Through the form of thought I express a logical and structural matrix, which translates reality into linguistic signs and orders it according to principles, rules and logical categories. Logics is also, however, of mathematical nature, and is based on the rules of Mathematics. For example, the four principles of Classical Logics are of a mathematical nature. If we suppose that we could change the axioms of Mathematics, then we would also change Logics, which will change in turn the form of thought, and through it we transform the perception of reality, which means that we will ''wake up'' to a new reality.

The semiological studies of the natural language were extrapolated in the era of information into artificial languages, in the design of semantical algorythms, semantic webs and ontologies. In the conception of the programmes for artificial intelligence, the logical and semantic mechanism which is processed by the human brain through natural language is highlighted. Boolean Algebra, which lies at the basis of machine language based on which computers work, topologically encodes the whole layered architecture of semantic logic. Before the emergence of computers, Gödel elaborated in 1931 within his Incompleteness Theory a complex topological construct based on the so-called Gödel numbers.

Practically-speaking any Algebra is a Syntax, any logic is a Semantics, which, at the level of psychological processing encompasses the hermeneutical level, too, all these being topological expressions of information. This field of Syntax, Semantics, Semiotics, Pragmatics and Hermeneutics which derives from the analysis of natural language is to be formalized by artificial languages and IT programs, through the instruments offered by topology.

FROM THE SEMIOLOGY OF LANGUAGE TO THE SEMANTIC BRAIN SYSTEM. THE SEMANTIC BRAIN SYSTEM

Research in the last century has made semiology, as a field of philology, which studies the significance of natural language, to be extrapolated through semiotics as the science of sign meaning in many fields of social and human sciences, as well as in natural sciences and information technology.

Today, we are talking about semantic web, semantic algorithms and semantic logic, with the goal of building artificial intelligence programs and systems.

At the same time, the semantics of information is a field of research of human cognition, starting from the reality that language is the expression of thought, and studying the semantics of language is an analysis of human specific processing. Syntax, semantics, pragmatics, as well as the hermeneutical and holistic approach are logical mechanisms that can explain superior psychic processes, such as abstraction, conceptualization, generalization, symbolization and metaphor. All these have been used in the narrative process forever, but have not been analyzed in the holistic perspective of structuring the reality of both physical and psychic reality. New approaches in cognitive psychology, and generally in neuroscience, are at the forefront of information and how, starting from data, information becomes a set of knowledge that can describe reality.

Beyond the quantitative aspect of the information present in Shannon and Weaver's information theory 1963, it is psychologically important that its qualitative component is important. This qualitative component is given by its significance. Semiology and semiotics, meaning and semantics, are therefore notions resumed today from a different perspective, not only the philological one. This led to the development of semiology as a way of analyzing the text. Today, semantic information is a syntax analyzed both by philosophers and by computer scientists (semantic information, semantic web, ontologies).

Semantic aspects of information become very important for psychologists as the structure and the way the nervous system works impose this approach. The nerve structures, from the periphery to the cerebral bark, contain dense nervous nuclei of increasing complexity, from the spinal cord to the bulb and the cerebral trunk, then to the diencephalon and the subcortical centers. Information is complemented by simple binary data, combined in frequencies and amplitudes, to more and more complex information structures, which, at the level of the brain skeleton, create mapping images used for our representations of reality. The meaning of language is represented in the regions of the cerebral cortex, commonly referred to as the semantic system. Up to now, a small part of the semantic system has been mapped, the semantic selectivity of most regions remaining unknown.

In April 2016, Gallant et al. of the University of Berkeley published in the journal Nature a study in which they systematically mapped semantic selectivity in different regions of the cortex using voxel-wise in functional MRI research. The subjects have been subjected to narratives they have listened to over several hours, highlighting the organization of the semantic system in stable patterns from one individual to another. Generative narrative models were then used to create a semantic atlas in detail. The results suggest that many areas in the semantic system are information related to specific semantic domains or groups of concepts in the relationship that are positioned in brain areas related to multiple meanings that notions and concepts can have.

The purpose of the study was to structure how the brain represents the meaning (or "semantic content") of language. Most previous studies on language and brain based on isolated words and sentences. Gallant et al. they used narrative scenario stimuli because they wanted to outline the whole range of semantic concepts in one study. This has made it possible to produce a semantic map for each individual to show which areas of the brain react to similar words as meaning or semantic content. Another purpose of this study was to create a semantic atlas by combining data from multiple subjects, showing which parts of the brain represented similar information but different contexts / themes.

The study did not aim at testing a single hypothesis or addressing a simple question. It exhaustively concerns the representation of meaning, or semantic information in narrative language, throughout the cerebral cortex. The resulting maps show that semantic information is represented in complex patterns distributed across several broad cortex regions.

Moreover, each of these regions contains many distinct areas that are selective for special types of semantic information, such as people, numbers, visual properties, or places. It has also been discovered that these cortical maps are relatively similar to different people, to the smallest detail. These semantic maps give us for the first time a detailed

map of how the significance is represented on the entire surface of the human cortex. Instead of limiting the language to a number of areas of the brain, we find that it activates quite large areas of the brain. We also find that these representations are bilateral: the reactions from the right brain hemisphere are about as large and varied as the left hemisphere reactions. Continuing research in this field as well as the approach related to semantic logic can lead to new theories related to the functioning of the mental component of the mental system.

At this hour we have two separate but complementary approaches: a semantic brain system, described by the modern techniques of functional MRI, statistical programs and computer processing, on the one hand, and on the other hand, a study of semantics language and a semiology of signs generally during the last century. Given that language is the basis of superior psychological processes (the logic of language expresses the logic of thought), a theory is needed to explain this connection between thinking and language. If the new emphasis on the brain's semantic system describes the localization of polysemantic meanings of words in neuronal structures (semantic hardware), it is necessary to bend the program using this neural structure (semantic software).

In our conception, this program involves the description of a special logic, semantic logic. For reasons of coherence, this logic is used both in structuring the brain as an emerging complex system and in structuring the semantic mind. This is the semantic emerging logic. So there is information that we call emerging semantic information. The related logic on which this information is structured will be called semantic emerging logic. This is different from bivalent logic, but also from multivalent or fuzzy logic, since the values that can be true cannot be estimated probabilistically, but are conditioned by their semantic value.

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