HOW BRAIN AND NEURONAL NETWORKS EXPLAIN HUMAN REALITY

Cómo el cérebro y las redes neuronales explican la realidad humana

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ABSTRACT.

How is human reality presented to us as a phenomenological experience? It is, in fact, the one we see present in our daily personal and social life. We are made of matter, we are part of the evolutionary universe. In addition, a psychic life is formed in us: sensation, a system of perceptions, an integrated consciousness, a condition of psychological subject; Although we produce knowledge, emotions, motivations, we mostly have a mind that rationally moves and installs us into a world of human emotions; This emotional reason lies at the basis of the search for the universal truth, the meaning of life and the moral responsibility in personal and social life. Therefore, our human reality is a personal reality. What science, namely neurology, must explain is obvious: how our sensibility-consciousness, our condition of psychic subjects, knowledge and emotional reason have emerged in the universe.

Keywords: Neurology; Sensitivity-awareness; Subject; Emotional; Neural networks.

RESUMEN.

Cómo se nos presenta, fenomenológicamente la realidad humana? Es la que vemos diariamente en nuestra vida personal y social. Estamos hechos de materia, formamos parte del universo evolutivo. Además, está formada en nosotros una vida psíquica: la sensación, un sistema de percepciones, una conciencia integrada, una condición de sujeto psicológico; producimos conocimiento, emociones, motivaciones; pero, sobre todo, tenemos una mente que discurre racionalmente y nos instala en un mundo de emociones humanas; esta razón emocional está en la base de la búsqueda de la verdad del universo, del sentido de la vida y de la responsabilidad moral, en la vida personal y social. Nuestra realidad humana es, pues, una realidad personal. Somos personas. Lo que la ciencia, a saber, la neurología, debe explicar es obvio: el hecho de que haya emergido la sensibilidad-conciencia, nuestra condición de sujetos psíquicos, el conocimiento y la razón emocional.

Palabras clave: Neurología; Sensibilidad-conciencia; Sujeto; Razón emocional; Redes neurales.

The scientific importance (as a strictly scientific question) of the causal explanation of the appearance of the animal and human psyche (ie sensitivity-consciousness) depends on the monistic hypothesis which are related with the evolutionary process; Hypothesis, essential in science, which respond to the general expectation of the world's scientific explanation. In fact, for billions of years, since the big bang, there was only a pure physical universe. From this physical reality, it must have been originated the passage to the mechanical structure of. However, within this germinal mechanism, should come the first emergence of biophysical sensibility (which may have taken place at a certain moment of unicellular evolution); That must also be postulated as a principle; Than later, among the complexity of advanced multicellular organisms, comes the appearance of a central nervous system, the sensory-perceptual systems, and the animal consciousness. Therefore, the evolution that emerged as a pure physical set has then entered the emerging level of the psychical world: the psycho-bio-physical. Now, is there any scientific alternative to this initial assumption? We do not think so. It is therefore an essential scientific hypothesis for the harmonious unity of our universe understanding: the primordial physical world ontology must offer a sufficient explanation for the later evolutionary process. Such explanation is leading to the emergence of the actual fact of the *psyque*. That is, the appearance of living beings with the properties of the animal psyche and the human psyche.

Returning once again to the previous question, what is then the radical physical support that makes the evolutionary emergency of the *psyche* and the consciousness something intelligible? How does one understand how the physical world has evolutionarily produced the psycho-bio-physical ontology? How does one understand that this supports the real existence of the animal and human psyche? The answer, will obviously depend on the image that the physical sciences offer. If, according to the image they have so far offered of physical reality, physical sciences were not able to give a congruent explanation of the appearance of the psychic world, then obviously other explanatory hypotheses would be used; The new hypothesis should not be excluded (regardless dualisms and others). Nevertheless, science will always relate to the above-mentioned assumption. However, before entering into the exposition of our reflections on how to answer the proposed questions, we must make some introductory remarks about science.

PHYSICAL SCIENCE

For many centuries, science has been considered paradigmatic for two reasons. First, because it aims the knowledge of the universe from the most basic and fundamental: matter and the results of its evolution to constitute the physical universe; Therefore, all sciences, including biological and human sciences, depend on the results of physics. Second, because physics is the science that has been able to produce basic knowledge of the universe and applied technologies with greatest precision. It is in physics that the most rigorous demands of the scientific method are fulfilled. Physical science is the one that, in fact, has gotten more rigor. Since the Renaissance, the history of science shows how all sciences have tried to approach the model of physics.

Here we are going to assume the general epistemological framework or theory of science, commonly accepted today by most research. This includes both the establishment of scientific knowledge intentions (and the special sciences in their own epistemologies), the establishment of normative knowledge methods to construct the kind of knowledge that we call "science" (in general, and in the special sciences). Therefore, being the physical scientific knowledge of matter (matter that provided with dynamic energy produces the birth and evolution of the universe in the totality of its manifestations), the scientific idea of the physical universe (matter) determines the derived form of conceiving all our biological universe and our human universe. Physics (matter) is thus at the root of the holistic universal knowledge: matter, life, mankind and its integration into the system of the real-as-a-whole (which we call the universe, the world or the cosmos).

The parallel and autonomous scientific dialog was an attribute from past centuries. Today, they are more and more conceived according to their interdisciplinary connection. This does not allow them to produce unequivocally autonomous knowledge, but necessarily dependent on the interdisciplinary connection. Today, the so-called techno-science states a fact that is not an idea, but rather a pathology of science and technology; In reality, that makes the scientist and the technocrat, say, a functional proletarian serving of the social system, with the superior human "intelectual" condition reduced to minimums. But the great scientists from our time are, fortunately, not techno-scientific. They are still thinkers who try to approach the interdisciplinary field. This goes

as far as the scientific method allows them an answer to the great questions of human knowledge about the universe.

Therefore, science, such as physics, builds an interdisciplinary knowledge about matter, life and mankind. That knowledge is what we call the image of the universe in science. It is the most reliable rational image and, without a doubt, the one of greater social prestige, although we know that science does not cover everything and that there are other methods of knowing; Methods also legitimate and perhaps more important from the point of view of the last existential questions (for example, philosophy). As we shall see, our reflection will focus precisely on studying how this image of the universe in science, projected on neurology, affects our current image of the personal reality of man.

NEUROLOGICAL EXPLICANDUM AND PHENOMENOLOGY

Therefore, in order to understand the way in which neurology, as a science, explains the evolutionary causes of human reality, there is a first and fundamental question. That is, the scientific explanation of the fact that, over the evolutionary process, after billions of years of existence of a purely physical universe, the sensibility-consciousness has emerged into living beings. From the explanatory line that begins with the sensibility and the consciousness depends on everything that can later be said about knowledge, memory, emotions and reason; Of course, what we can say, from the conscience and neurology point of view, connects to man's personal reality. It is obvious that, in this article, although we cannot undertake a deep analysis and discussion of phenomenology, we still want to address three very important phenomenological features or contents of our human experience (reducible to two), which are part of the basic *explicandum* of the human sciences and to which we will refer later. Science cannot ignore or avoid explaining them. They are the following:

1) The unitary character of *consciousness*. Our consciousness is noticed as a system which integrates in a unity the different sensory modalities (vision, audition, proprioception...) which are projected at the psychical subject that coordinates them and sets responses.

2) The *holistic* character of consciousness. Our experience of consciousness is wide open: we feel the external space's openness through vision, the unitary extension of our sensations through our own body, or the wide unity of our internal experience when we close our eyes and follow the stream of our thoughts.
3) The *indeterminate nature* of the responses on a conscious subject. Subjects notice themselves as open to a multitude of possible responses and consider themselves as the cause of these responses. Responses may be driven by programmed automatisms, but subjects strategically exercise their control and feel that their lives are played out without an absolute determinism, with free indeterminate options (which does not mean absolutely unconditioned). This phenomenology from our own experience of indetermination (free will) creates the basic persuasion that provides sense to our personal and social life.

It is evident that these three features are not exclusive to the human domain. According to the modern views of comparative psychology, ethology, biology and evolutionary neurology, we can make a scientific inference based on the fact that these three features—the unity of holistic consciousness, and the flexibility/indetermination of adaptive responses. Such features are present in animals in varying degrees and with their corresponding characteristics. It is clear that animal indetermination is not comparable to the free will of man, opened by the exercise of reason; but it is certainly an evolutionary prologue. For that reason, the features that we select as a reference in our presentation are common, in this sense, to both the animal and human domains.

NEXUS

To explain sensitivity-consciousness, its physical origin and the way it produces the animal and human mind, science depends on its own view of the physical world. In this sense we all know that science has open two visions of the physical world (still today not harmonized satisfactorily): classical mechanics and

quantum mechanics. At the same time, neurology addresses the explanation of the *psyche* (the mind) through its understanding on what neural networks are. These constitute the functional architecture of the brain. This works by neural networks. But what is the architecture, the form of organization, and the matter's deep ontology that constitutes the brain? The problems are, therefore, the neural networks and the ontology of the physical reality that constitutes the neurons, the brain, in its depth. The answers depend on whether we organize explanations within classical mechanics or quantum mechanics. In each of these approaches we can explain, better or worse, the phenomenological features of our functional experience of the mind. We are going go see it. In the following epigraphs, we gradually enter into a vision of the brain from classical mechanics and quantum mechanics.

1. PSYCHIC ARCHITECTURE IN CLASSICAL NEUROLOGY

All of the essential lines of psychic architecture are already known. Further on in the article we will refer to Edelman, but we consider it convenient to stop here to present a brief synthesis of classical neurology (Monserrat 2007, 2008a).

We will begin with visual images. A pattern of light, codified by its differential reflection in the external world, processed by the optics of the eye before being eliminated in the layer of photoreceptors in the retina. If the point's image differences were codified in the light patterns, they would produce a trans-codification at the retina: it passes from a photonic code to a neural code. The electro-chemical signals, via ordinary synaptic communication, transmit the image to the brain. The signals arrive at the superior colliculus, the oldest visual nucleus in evolutionary terms, and then to more modern centers such as the LGN (lateral geniculate nucleus). From there the signals travel to zones V_1, V_2, and V_3 at the visual cortex. These zones connect with nearby zones like V_4 and V_5 and, more widely, with the brain through the "where route" (towards the superior parietal lobe) and the "what route" (towards the parietal lobe). The correct activation of the neural engram, pattern, or canon of a specific image creates the psychic effect of "seeing". In this active system (from the retina to the cortex), each of the parts plays a special role in producing the image.

The visual system produces the activation of a complex neural pattern which produces the psychic effect of "seeing" the image with its wide range of *qualia*.

> The image is constructed, then, in the module that processes images (for example, the image of a lion). But this image is also connected with the temporal lobe, in which its cognitive interpretation occurs (what is a lion); visual agnosia allows us to determine that it is possible to have an image without a cognitive interpretation (to see a lion without knowing what it is). The idea of a lion is connected too with the semantic and phonetic areas of the brain that process language, so we can shout: "a lion!". In a similar way, there are connections with the limbic system (the amygdala), so an emotional reaction of fear occurs because of the lion. Likewise other modules are activated in turn, especially in the prefrontal and frontal areas, and subsequently a plan of action is defined to confront the situation. (Monserrat 2008b: 7-28)

This psychological subject, which is also present in the animal domain, has emerged little by little in the process of evolution by neurally mapping the body in the brain (as explained by Antonio R. Damasio (1994, 1999, 2003). We simply want to point out that, in normal subjects, this psychological and neural architecture is not a closed or static system, but a very flexible one which can reach surprising degrees of plasticity. For example, when some parts of the body are missing, the brain can simulate them (i. e., phantom limbs); however, when it is a certain part of the brain that is missing, the brain can reorganize itself in amazing ways to still "deal" with the stimulation that comes from the body (i. e., reorganization of motor or linguistic areas after a brain lesion). *Classic architecture* has its own characteristics. We would point out seven of them:

1) It is stable, but also oscillating. It is not a neural network of retropropagation which can be controlled from some other system. Afferent stimulations (which arrive in the sensitive brain and move towards connected areas) produce interactive structures (engrams) in a classic, unitary system in which they are registered or "facili-

tated" (Hull), becoming then available for later reactivation. These structures are stable, not in a rigid but oscillatory way (as we can see in the fuzziness of our memories).

2) These structures (engrams) are co-participative connections: the same neurons and the same branches of synaptic connections (each neuron can have thousands of synapses) can co-participate in multiple different engrams.
3) These networks of connections expand in a classical three-dimensional macroscopic space which responds to the shape of the brain.
4) The networks are connected and activated in parallel inside the same three-dimensional spatial topology, i. e., when seeing an image in real time, the subject simultaneously notices that vague reminiscences flow into his memory, feels his own body and follows a line of thought.
5) These networks are built following the logic of a well-arranged topology: this ordering allows for an ordered interaction of, for example, the engrams which are activated and de-activated whenever exploring a piece of knowledge which was registered in the mind (in the frontal and prefrontal areas but interacting with other cerebral modules). This gives rise to what William James called the stream of consciousness, whether the engrams are images or thoughts. This ordering is both intra-modular (i.e., an ordered record of folders with images or sounds) and inter-modular (i.e., a knowledge system which, after the activation of the frontal areas, connects the images activated in parallel in the visual registry in real time module).
6) These networks are dynamic. This means that, although the neural records are stable, as we said before, they are being continuously transformed. As we postulated, the transformation should occur, for example, in the continuous stream of visual or auditory images, in the unconscious occurrence of engrams which control language, motility or among the stream of thoughts.
7) These networks are plastic in the sense that their functions allow the architecture itself to construct or improvise with the properties that

we discussed before: the brain can re-organize itself when either some substantial part is missing or after a brain lesion occurs. Therefore, we could say that the classical neural architecture is self-generating: a germinal architecture which is not yet developed allows its own functions to adequately generate the complex architecture that we observe in the mature system.

2. GERALD M. EDELMAN AND THE SUFFICIENCY OF THE CLASSICAL NEURONAL ARCHITECTURE

In this article, when speculating about sufficiency, we ask whether classical neurology offers a satisfactory explanation for the phenomenological *explicandum.* Many neurologists have taken for granted the classical explanation without noticing any problems. Others have observed, at least to some degree, that the classical view can be problematic and have tried to offer a convincing answer.

In fact, Edelman understands that classical neurology should explain phenomenological experience. In *The Universe of Consciousness* his phenomenology (which we will not detail here) presents two essential features described as "continuous unity" and "infinite variety", which are, to our mind, a light version of Edelman's ideas on holistic unity and indeterminate free will. "Continuous unity" refers to the unitary sensation at the body and of all the psychological modalities levels (sensations, emotions, etc...) and their convergence in the conscious subject. "Infinite variety" refers to the modality of human or animal actions caused from consciousness to the unknown (against the "instructional" determinism of computers). So, where then does Edelman's explanation take us? (Edelman; Tononi 2000: 9).

Edelman's explicative system is based on neural Darwinism and the theory of neural group selection (TNGS - Edelman 1987, 1989; Edelman; Tononi 2000). What has been selected was an amount of neural groups (not individual neurons but several groups of them) and the connections which form the most adaptive maps or engrams. The neural architecture, as Edelman conceives it, agrees with the descriptive characteristics of the classical architecture presented before. Edelman has mainly contributed to the explanation of the emergence

of the representative processes among the mechanisms of memory. Now it will be dedicated more focus to his concept of "dynamic nucleus" because it will be the basis for an explanation of the phenomenological features that we mentioned before.

The dynamic nucleus hypothesis is an explanation of how the brain works. Thinking about psychological experience: Our conscious self coordinates proprioceptive, visual, auditory, tactile and kinesthetic experiences in a single moment as if they were a remembered present of complex auto-images, dense systems of awareness, thought, registered imagination, emotional states, etc., that flow over into the present. All these guide the direction of behavior and coordinate our motor functions, although they vary and are redirected following changes in stimuli and the use of the ability to choose, degenerate and generate an infinite array of new possibilities (Edelman 2006; Edelman; Tononi 2000).

How is such complexity possible? Edelman responds with the dynamic nucleus hypothesis: In real time, in the hundreds of milliseconds that constitute collective activations occurring over and over again (generated and degenerated) and mapped from diverse modules that contain the neural bases for all the different psychological activities, everything flows together in the psychological subject as a single system because of the complex activation and de-activation buses that are coordinated by multi-directional re-entries. These complex relationships of re-entry among modules are the neural correlates that support conscious activity, both as a continuous unity and the way it can be informed (modular diversity and registered content).

Therefore, what science should now explain is the continuous unity and infinite variety. As we have pointed out earlier, the dynamic nucleus hypothesis must justify two mind properties: integration and re-entry (form the basis for continuous unity) and differential complexity (which form the basis of differentiation and infinite variety). Edelman believes that his dynamic nucleus hypothesis, as a synthesis of macroscopic neurology (of neurons and synaptic networks), explains how the different maps unitarily flow together in real time and how the complexity (i.e., the huge population) of the maps permits a selection that is controlled by the subject in the context of the environment. The mind is thus unitary as a parallel system, i.e., it is "selective". For Edelman, this

is the same as saying it is indeterminate, not "instructional". In this sense, due to its selectivity, neural Darwinism would be based both on indetermination and on animal and human behavior (Monserrat 2006).

3. THE PHYSICAL SUPPORT PROBLEM OF PSYCHISM

Does the mentioned Edelman's hypothesis explain the phenomenological *explicandum* that we started with? It seems clear that, partially, it does contribute something, at least by explaining it. Nevertheless, the problem should be analyzed in the light of our own ideas (as understood by the physical sciences) about "physical support," which proceed from our understanding of psycho--bio-physics. From this point of view, we can discuss whether Edelman's version of the classical explanation of phenomenological experience is sufficient.

The scientific expectation, as we have said before, is monistic. The biological world has been evolutionarily produced due to a preexisting ontology of "physical support". In return, the psychological world has also been produced due to the same preexisting ontology of "physical support". How do we know that this "physical support" depends on physical science?

Current ideas about matter no longer follow the atomic model from the Greeks. The primal matter of the *big bang* is radiation, which than extends to physical fields. Particles are "folded radiation" that gradually forms what we call "matter" or physical objects. There is, in certain conditions, a conversion of matter into energy or radiation, and vice-versa. Matter "unfolds" and converts into energy; the energy in radiation can "fold up" into matter. The wave-corpuscle (or particle-field) duality is one of the principles of quantum mechanics. The physical world has as many "field" properties as "corpuscle" properties. The ultimate idea, however, is that the ontology of real things is an "energy field", given that particles (and physical bodies) are made up of a folding or alteration of the base energy in that field (which has received diverse names throughout the history of physics and that today remains related to the concept of a quantum vacuum).

Important to remember that physics currently differentiates two types of particles. First, there is bosonic matter which is formed by a certain type of particle that has the property of easily unfolding in fields of unitary vibration.

In this way, the mass of bosonic particles, for example, the photon, lose their individuality when they enter into a state of unitary vibration that is extended in a field constituting a state which is recognized as quantum coherence. The wave function is symmetric and it is considered that this depends on these properties. The first description of these coherence states were Bose-Einstein condensates. Today, in modern physics, a multitude of quantum coherence states have been described within the most strict experimental conditions.

Second, there is fermionic matter. These are particles whose wave function is asymmetrical, so that their vibrations have difficulties entering into coherence with other particles. They persistently maintain their individuality, not fusing with other particles and remaining in a state of unitary indifferentiation. Electrons and protons, essential constituents of atoms, for example, unite and form material structures according to the 4 natural forces: gravity, electromagnetic force, strong nuclear force and weak nuclear force. Nevertheless, every particle maintains its individuality. Every electron in an atom, for example, has its orbit, which, when completed, makes the electron vibrate in its orbital space. According to quantum principles, we cannot know exactly where the electron is. The location in space depends on the "collapse of the wave function" of said particular electron; the collapse is produced, for example, by the experimental intervention of an observer. Due to the fact that the *big bang* energy caused the folding of this type of fermionic particles, the classical macroscopic world exists: stellar bodies, planets, living things and man. Their folding accounts for differentiation and the possibility of a multitude of unfathomable things, like the survival of living beings with stable bodies and standing firmly on the surface of the earth.

This enables an idea about how causality happened in the classical macroscopic world, i.e., the world organized in terms of fermions. One can think of two stones crashing into each other and breaking, or of a watch whose gears transmit motion. These physical entities, stones or metallic pieces, remain as closed and differentiated units. If we go down to the quantum level of microscopic fermionic entities, we can see that in molecules and macromolecules, every atom and every particle continue to have the same identity. Actions and cause-effect series are, in this world, associations and dissociations of independent particles, atoms and

molecules by means of ionic unions and covalence abiding by the four previously mentioned forces. Shared orbits of electrons can be formed in covalent links, but they are very localised and probably do not nullify the independence of the electrons. However, what is interesting to note here is a consequence: Causal interactions do not break the enclosure and differentiation of the component elements in the classical macroscopic world made up of fermions. In other words, holistic fields do not appear in the world of physical fields.

Furthermore, these causal systems are partly deterministic: The conditions that blindly produce a bond or dissociation follow the laws of physics and chemistry. On the other hand, however, these systems can give rise to indeterminate states: We will not know the precise effect of a state that is produced among a multitude of possible states. We attribute the effect to a chance that is unpredictable certain. This happens in the physics of chaotic systems and in biology, for example, in cytoplasmic biochemistry that gives rise to Darwinian selection. The fermionic evolution (mechanical-classical) of the universe has produced states or loops of indetermination; but what is finally produced in these indeterminate environs is caused by cause-effect series that are blind and deterministic.

We now return to the question that was asked before: Does the architecture of Edelman, as an excellent theory of classical neurology, explain phenomenological experience? The first thing we should notice is that classical neurology constructs its explanations based on a microscopic fermionic world. In discrete events occurring among neurons of this network, which is our brain, deterministic cause-effect series are transmitted (along with the previously mentioned chaotic reservation) that do not create fields nor break the differentiation of entities in each neuron or in other structural entities (macromolecules, molecules, atoms, particles etc.) conforming with their fermionic nature.

As a consequence: 1) The "unity of consciousness" is partially explained, as with Edelman, by the parallel convergence of all the engrams that project their effect in the psychic subject-coordinator, but this unity is made up of differentiated and isolated parts; it is like the unity seen in the complex mechanism of a watch. 2) The "holistic unity of consciousness" does not seem to be explained as a function of an adequate "physical support" for the same

reasons: In vision, for example, an image transmitted by a photonic code in light becomes disintegrated in the brain, and it is not possible to understand what the integration field observed in the phenomenological experience could consists of. 3) The explanation concerning the "indetermination of the conscious subject" can be accomplished in part through the mechanics of chaos and darwinistic biological selection within a fermionic classical macroscopic framework. However, phenomenological experience contains something more that is not explained: Animals choose responses based on the telenomic logic of their systems, and man, in addition, chooses responses based on rational and emotional thinking (it is not a pure chaotic indetermination chosen by chance because of darwinistic selection) (Monserrat 2008b: 14).

4. QUANTUM NEUROLOGY IN SEARCH OF A "PHYSICAL SUPPORT" OF PSYCHISM

Edelman makes the observation that "sensation" cannot be explained by science (Edelman 1992: 116-117, 138-139). We cannot know why matter is susceptible to producing sensation. We completely agree with this observation. Questions of the type like "Why does matter produce sensation instead of not producing it?" or questions also like the classic question of Leibnitz, reformulated by other philosophers, "Why does something exist instead of nothing?" are questions that do not have a response. We begin with the fact that something exists, and the problem of science, then, is not so much whether matter produces consciousness or not (something which is a fact), but to understand how the ontology of matter can explain its phenomenological properties.

Can a discontinuous world — with some entities isolated from others, corpuscular or "fermionic" in the previous sense — explain the unity of consciousness and its holistic contents (sensitive integration of fields of reality as in vision or in proprioception)? Can the causality produced by deterministic cause-effect series from interactions among entities made of fermionic matter explain certain variations in the indeterministic flexibility in animal behavior and human freedom? Everything is debatable, but many certainly think that it cannot be explained.

Where to find, then, an adequate "physical support" to ground in a sufficient manner the phenomenological properties of psychism? Current psycho-physics is moving towards the field aspects of physical reality, already known for many years now. It was almost an inevitable option to think that the solution, or at least a more convincing manner of explaining that comes closer to the phenomenological *explicandum*, could be found by searching in physical fields and among the properties of matter described in quantum mechanics. In 19th century classical mechanics, physical reality was corpuscular matter and radiation. Quantum mechanics unified these two aspects in the corpuscle-wave duality, with particles as "folded radiation" (as we said before). Every matter, either bosonic or fermionic, is "radiation" in its ontological core. Bosonic matter tends to be diluted easily in everything unified, in vibrating fields, losing the individuality of its particles in states of "quantum coherence". But, although fermionic matter firmly maintains its individuality, it can also produce states of coherence, as has been verified in extreme experimental situations. Note that fermionic matter also pertains to the quantum world. In other words, knowledge about quantum mechanics (e.g., the electron in its orbit is a vibrating wave) is applied to it. Quantum neurology considers the existence of macroscopic states of quantum coherence. Overcoming all difficulties for these states to occur, fermionic particles are involved in these macroscopic states.

What do we understand, by "quantum neurology" than? A more general definition could be the following: It is the search for and investigation about the quantum properties of the most primitive matter in order to relate them to the neuronal system aiming for the establishment of the appropriate "physical support" and to explain the phenomenological properties of psychism. To this end, authors like John von Neumann, Henry Stapp, Herbert Fröhlich, Stuart Hameroff, David Bohm, Roger Penrose, Albert F. Popp, among others, have contributed ideas. These authors have contributed with ideas and proposals, but they do not exhaust quantum neurology. Their contributions can be more or less certain, and above all, debatable, always setting aside experimental and empirical evidence. It is very possible that the truly prolific ideas for quantum neurology have not yet been proposed, and that crucial empirical contrasts perhaps have not yet been designed.

My position. What is my personal position on the proposals to address a quantum explanation of the animal and human psyche? My point of view is identified with what is known as the von Neumann-Stapp hypothesis (it is the hypothesis proposed by von Neumann, popularized and commented later by Henri Stapp). Its foundation is a realization: that between the phenomenological properties of psychism (indetermination, campal holism) and the properties of the physical world described in quantum mechanics (indetermination, physical fields) there is a surprising parallelism. This is not the case of classical mechanics (mechanistic determinism and a differentiated space in independent points). The hypothesis then arises with great obviousness: the search for the "physical support" of consciousness (psyche) should be done within the framework of the quantum properties of matter. It is, therefore, a merely heuristic hypothesis (which indicates a search horizon). It does not offer any explanation of the actual physical-biological implementation of quantum-effects in living organisms, so that in them were the "physical support" of consciousness. So what about concrete proposals for locating the quantum structures of consciousness, such as those of Bohm or Hameroff-Penrose? The truth is that I do not consider myself prepared enough to value them personally and take a position. I consider them extremely bright and suggestive; But it is still perhaps premature. They should be studied and discussed. In fact, I think that many indications point today to a new physics that, when formulated, may allow to save with precision the leap between the physical and the psychic world.

THE HAMEROFF-PENROSE HYPOTHESIS

In this article, we cannot deal with the exposition of the ideas of these authors mentioned. But we take for granted that their ideas are already known. Since we are now going to refer to them, we will at least recall the basic outline of the Hameroff-Penrose hypothesis (Monserrat 2008a; Edelman 1989; Hameroff 2006), now the center of discussions. Very briefly synthesized, the hypothesis consists in arguing that some structures of the cellular cytoskeleton, microtubules, widely distributed through the entire neuron, could possess the appropriate physico-biological characteristics, so that the phenomenon of quantum

coherence could occur in them. Vibrating states in quantum coherence would have a wave function that would be in "quantum superposition" (in multiple states at the same time or just at no defined state). However, at certain moments, a "wave-function collapse" of the system would be produced. The Hameroff-Penrose (1996) hypothesis would postulate that states of consciousness (and all the *qualia* that accompany them, e.g., in a visual image) would result from the entrance into quantum coherence of vast quantities of microtubules from different neurons and brain modules due to the effects of action-at-a-distance or non-local causation, already known in quantum mechanics from the imaginary experiment of Einstein, Podolsky and Rosen in 1935 (EPR effects).

The Hameroff-Penrose hypothesis, then, opens new avenues to explain the phenomenological properties of psychism. Quantum coherence states due to action-at-a-distance (EPR effects) the most appropriate would be the "physical support" to explain the unity of consciousness and field sensations (proprioception and vision); in order to produce "sensation" would be a field property of matter, as long as there was a "psychical subject" capable of "sensing it." The indetermination-freedom of behavior would have its physical support in indeterminate quantum states and in the property of superposition. The subject could induce the collapse of the wave function in a flexible manner that would allow the descending control of the mecano-classical mechanisms of movement.

Let us suppose that the Hameroff-Penrose hypothesis were correct, and let us think about the consequences it could have for vision science. In principle, we would consider the neuronal engram of an image, when activated, as producing the collapse of the wave function in a subsystem of microtubules belonging to that engram. The sensation of the visual image would be the psychic effect (phenomenological) of the system interaction because of action-at-a-distance (EPR effects) of the state of quantum coherence of those microtubules. The image's pattern would be given outside, objectively in the world, and would consist in the pattern of light that reaches both retinas. Since images are continually different in optical flow, one would have to think that the subsystem of microtubules involved would be varying in a continuous manner.

This makes us realize that the fundamental explicative problem would consist in knowing the mechanisms or series of interactions that begin from

the determinant pattern of light (the external physical world that "imposes" the content of an image) up to the collapse of some or other systems of microtubules. It would be a bottom-up process. In this process, a classical-quantum interface should mediate, since the transmission of an image is made by means of classical neural engrams (fermionic) that should induce precise effects in the states of quantum superposition of the microtubules within each of the neurons activated in an image, producing quantum coherence at a distance among microtubules as EPR effect. The almost totality of these interface processes are not known to us. The Hameroff-Penrose hypothesis and many other things that are being investigated today concerning the biochemistry of neurons (e.g., the proposals concerning how to understand the functions of tubulin dimers on the walls of microtubules, or the manner of producing quantum coherence, or the function of the so-called "hydrophobic pocket," or clatrins, etc.) are only initial proposals that should be given a relative value, as they are obviously debatable. We will not go into them.

In the same manner, but the inverse sense (top-down), the conscious psychical subject would be the result of a "subject engram" and of a special system of associated microtubules. Evolution should have designed a descending mechanism (top-down), so that the decisions (variable, flexible, indeterminate) of the subject would control action (motor system) for the same thoughts' (mind) flow. Superposition and quantum indeterminism would allow us to understand how the subject could induce the collapse of the wave function of some or other microtubules and how, from there, would be generated a quantum-classical interface that, supported by motor automatisms, would end in the final production of movement (Penrose 2005).

5. PSYCHO-BIO-PHYSICAL ONTOLOGY FROM THE SCIENTIFIC PERSPECTIVE OF QUANTUM NEUROLOGY

The way living beings are really constructed, together with the nature of their components, constitutes their *ontology*. If the superior factor is the mind, may be speaking of the mind ontology. It is a physical ontology, because it is made in a "physical world." It is a biological ontology because it is a "physical world"

organized as biological or living matter. It is a psychic ontology, because in the mind are produced psychic effects (sensation-perception-consciousness-subject) that interact (bottom-up and top-down) with the biological and the physical. In contrast, we see that, in agreement with all the available empirical evidence, current computers have a different ontology that is purely physical (neither biological nor psychic).

This psycho-bio-physical ontology has an *architecture*. In return, "architecture" is defined as the structural form of the physical construction of that psycho-bio-physical ontology. Depending on the preceding analysis and, within the supposed hypothesis, on of a quantum neurology, we could say that this architecture has three levels (or three sub-architectures) and two (eventually three) systems of interface among them. 1) The *physical architecture* of reference, since the mind is united systemically to the physical world (e.g., united to the electromagnetic fields of light for vision). 2) The *classical architecture,* constituted by the nervous system or neuronal system connected to the global physical structure by the system of senses, internal and external. The architecture of engrams, patterns, canons or neural networks connects stimulations to automatic (without producing *qualia*) and conscious (psychic life and the sensation of *qualia*) response loops. In this architecture, physical-biological-neuronal processes happen in a differentiated world of macroscopic, fermionic, objects, in which cause-effect series are transmitted among independent entities. Previously, in this same presentation, we analyzed more extensively the properties of classical architecture. 3) The *quantum architecture,* in which living organisms would have to construct "biological niches" that made possible the presence of matter in quantum states that were the support for sensations and for their holistic and indeterminate dimensions. Quantum coherence, superposition of states, indetermination and action-at-a-distance or non-local causation (EPR effects) would be the foundations of this architecture. Bosonic and fermionic matter could be involved in this architecture, since fermionic matter (although it produces individual differentiation) has a quantum nature (e.g., electron) and it has been verified that it can also enter into states of quantum coherence. 4) The *classical-quantum interface* would be the totality of ascending, bottom-up, mechanisms, because of which the world

imposes the selection of activated microtubules (e.g., in visual image). 5) The *quantum-classical interface,* because of which the conscious subject gets capable of generating a descending, top-down, cause-effect series; of controlling the mecano-classical, fermionic structures; and of breaking biological determinism by introducing continually the factor of psychic unpredictability (freedom). 6) Furthermore, one could add a *physico-biological interface* of lesser importance (e.g., the connection of light pattern to the retina through interface with the eyeball optic), which we omit so as not to prolong this analysis.

Functionality (operativity) of the psycho-bio-physical ontology. Every ontology has an architecture that, *eo ipso* (by itself), involves a certain mode of functioning that excludes other modes. The same happens for the psycho-bio-physical ontology of living beings and mankind. a) It allows a functionality founded on a deterministic causality proper to the mecano-classical world that produced all the system's automatisms. b) It also allows a new functionality, generated from sensation-perception-consciousness-subject states, that is supported by quantum coherence states. c) One actually deals with an integrated functionality in which, whatever is automatic, is coordinated with, and at the service of, a holistic functionality that is terminally directed from consciousness.

Operative logic of the psycho-bio-physical functionality. Some ontologies with their own functional systems can be presented as systems that operate within certain logical systems. This applies to the psycho-bio-physical ontology, since it has been formed evolutively in order to assimilate and to adaptively operate within the natural world order. Sensation, perception, consciousness, subjectivity, attention, memory, cognition, language, learning, thought, etc., have emerged by evolution to operate this natural order.

Phenomenological access to the logic of neural networks of the operative system. The Aristotelian logic itself was a first description of how the mind logically functions; the first space-time mathematics (arithmetic and geometry) was also a first description. A generalized phenomenological analysis of how our mind works (cognitive psychology) allows us to infer the most likely manner

of constitution of the logical networks of engrams of the neural system in its special modules and in the intermodular coordination of brain activity as a whole. Thus, for example, visual images are registered and organized in "folders" that have a logical order, allowing orderly access to them. Another example: When we study a certain university subject, we produce in our frontal and pre-frontal zones an enormous quantity of ordered engrams, allowing access from one to another (connected, in turn, to other brain modules, e.g., vision), which, whenever activated, produce an orderly flow of reasoning. This logic is possible because the architecture of the psycho-bio-physical ontology grounds it. Today, we still do not fully know the codes of the space-time order of those neural networks and the rules of their interconnection. Deciphering that physical order's code would be a discovery as important as, or even greater than, the discovery of the spatial ordering code of the DNA due to the work of Watson and Crick (Monserrat 2008b: 14).

6. ONTOLOGIES, ARCHITECTURES, AND ARTIFICIAL FUNCTIONAL LOGICS

By the word "artificial," we refer here to their production by man in a real physical or imaginary (abstract) manner. We begin with some observations about functional logics.

Functional logics, formal systems, and simulation. The natural mind already carried out some useful functional logics and mathematics in the field of life, its environment and about calculation. But the human mind, inspired by the structural and space-time shape of the world, has come up with formal systems that assume the natural operations of calculation and allow many other new, more complex, superior, and useful operations. We have in mind the mathematical analysis itself (potentiation, logarithmation, derivatives, integral calculus, theory of functions, etc.): not only the systems conceived by modern mathematics, but also artificial formal systems that allow the amplification of natural logical functioning calculation and life in general. Contrary to Penrose, I think the human mind can conceive formal systems that simulate

and exceed the functioning of the natural logic of the mind (it has already been done abstractly both in mathematical formalization and in logical formalization, e.g., in axiomatic systems). Nevertheless, the problem would not be so much the abstract conception of formal systems that integrally simulate the functional logic of the mind, but in the integral knowledge of the natural logic of the mind that we should simulate. At least, one could always design partial systems of simulation.

Ontologies and artificial architectures. Abstract and formal complex systems created by the human mind have been able to operate (that is, have been able to "function") in the human mind. Engineers, with paper and pencil, have been resolving numerous mathematical calculations. However, the human mind has been capable of conceiving and constructing new ontologies, with their own architectures, that allow receiving information and "operating" on them (processing them, working on them) through the application of abstract formal systems created by the same mind. Two ontologies are created today: First, the brilliant conception of Turing's universal machine that, in an algorithmic, serial, and computational manner, has allowed extraordinarily useful applications of all types, and will continue to allow them for many years. The second ontology would be that of the parallel distributed processing (PDP) connectionist computer.

Turing's machine will be very useful, but it is undoubtedly different at ontological, functional, and architectural levels from the human mind. In effect, it has no deposits of 1's and 0's; it has no CPU; nor is it algorithmic, etc. PDP systems are more similar to the ontology of the mind (this is what they intend), but much is still needed. The mind is not a neuronal network engaged in propagation that produces outputs analyzed from another system, and that permits the control of values by retro-propagation for the next propagation. In order for PDP systems to approximate what is neuronal, they would need, at least, one of the three architectures (quantum architecture) and the two systems of interface mentioned. Furthermore, if we do a one-by-one analysis of the seven points that we previously emphasized as characteristics of classical

architecture, we will also see how the so-called "artificial neuronal networks" are still far from "real neuronal systems."

Thus, neither the serial-algorithmic ontologies nor the PDP ontologies have properties, allowing us to argue that they are 1) ontological, 2) functional (since every ontology presupposes some possibilities and determinant functional-operative exigencies), and 3) architectonically comparable to the human mind. Nevertheless, the human mind has serial (e.g., in cataloging images, in thought, in language, in motricity) and parallel aspects that can be understood from a "weak metaphor" perspective, by applying the model of a computer, be it serial or connectionist. Ontologies and architectures, serial and connectionist computers, have thus been created that can assist us to "operate" logical-formal systems, which are created in order to simulate the human mind. This simulation, as we have said before, will be possible and credible, but it will not be perfect, nor will it presuppose ontological or functional identity with the real animal-human mind.

It is possible to continue searching for new ontologies and new architectures. Microphysical states susceptible to two states (0-1) and capable of registering and recuperating information are sought; for example, the Qubits' road to quantum computation. Physical engineering related to the field properties of the quantum world (for example, teleportation and quantum cryptography) is also possible. This engineering could progressively be applied to design systems in which artificial holistic fields are "sensed" by an "artificial subject". But then, rather than the creation of "computers", it probably would be more appropriate to speak of the creation of "artificial life". Penrose has referred to it recently.

7. FORMALIZATION TOWARDS NEW ONTOLOGIES AND ARCHITECTURES

Although today it may be difficult to think about the creation of ontologies and architectures similar to the natural mind (which we actually still do not know well), it is possible to create approximations that are ever more useful. PDP connectionism has already been a useful approximation. Nevertheless, which formal systems could serve as instrument to shape these new ontologies? We

conclude this presentation with a brief allusion to preferred formal systems. In our opinion, classical architecture should be inspired by mathematical formalizations based on *graph theory*: Trees growing in parallel and ending in "closed cups," but with infinite "vines" (or connections) among them. They would be immense forests with independent roots, but infinitely connected at the top (they would be Edelman's *re-entry*). On the other hand, quantum architecture should be inspired by *topology*, or the study of continuous environments in pluri-dimensional spaces. Unitary topological spaces with boundary, separated at a distance, should "cover" other second-order imaginary spaces. This, current topology should exert efforts to create new and more specific formal instruments that could serve as model formalizations for quantum-holistic spheres produced in physical ontologies and architectures of living beings.

A new theory of graphs that formalizes classical neurology and a new topology that formalizes quantum neurology, aside from an appropriate formalization for the classical-quantum connection interface: Are these the most appropriate suggestions? Are there other alternatives? How should we design the precise formal properties of these proposed systems? Which proposals in line with Feryerabend's own can we offer? We do not intend to respond to these and other similar questions in this article. We only aim to present an epistemological argument to show that the state of current classical-quantum explanation brings us conceptually to the need to create new types of formalizations tailored by the demands of current classical-quantum neurology. These formalizations do not exist yet. It is, though, important to realize that they should exist, since they would help in advancing our knowledge of real psycho-bio-physical ontology and of artificial psycho-bio-physical systems engineering.

8. HOW NEUROLOGY EXPLAINS HUMAN REALITY

As we have just seen, neurology explains the functioning of animal and human mind from two assumptions: a) the existence of complex neural networks that, by millions of entries and reentries, transmit millions of engrams or neural patterns; These constitute logical networks in which the automatic mechanisms of language, movement, or rational thought and of the emotional systems con-

nected with the cognitive are established; b) the assumption that these neural networks have an ontological substrate that contributes to the subjective effect (qualia) that manifests itself in the activity by phenomenological experience. We do not know, in a final and definitive way, the form of neural networks; We also do not know for sure what the final ontological nature of matter is, which is the substratum of the universe, of the biological and of our brain. The form of one explanation or another depends on whether we move within the framework of classical mechanics or quantum mechanics, or a balanced, harmonic equilibrium between one and another (this is our position). In any case, these assumptions are those that today allow neurology to construct a sufficient explanation of the birth of human reality; From the most mechanical to the finest one, to abstract thought, to the rational search for the meaning of life, to the deepest human emotions, both in a personal and social sense.

The evolutionary explanation of the animal mind. The first cells were almost certainly purely classical deterministic systems (as in us embryogenic determinism still governed by the genetic code). Sensitivity probably emerged at an advanced stage in the evolution of unicellular living (from the microtubules of the cytoskeleton, if the Hameroff-Penrose hypothesis was correct). In the multicellular animals, a nervous system was specialized to organize the internal and external sensation as well as to use it as an information system to respond to the medium effectively. In the stimulation / response connection, the psychic subject gradually emerged. Sensations in the various sensory systems were transmitted to the central nervous system (brain) where activation of engrams (or systems of interactive neurons via the classic synaptic route and, perhaps, with their consequent quantum effects on the microtubules) occurred. Activation of these engrams (or patterns, patterns, maps or neural networks) had as a psychic effect the correlate of sensations (sensitive images). Such effect began to register in the whole brain (from the old brain to the modern cortex). When the cortex appeared in mammals, memory mechanisms were perfected to register and connect the various engrams to each other by means of neural links and to order them in the mind, facilitating their recovery. The animal then begins to respond to the medium in function of the remenbered present,

the "presente recordado" of Edelman. The animal thus begins to act not only in terms of real time sense, but also in function of other contents of memory that are present when activated by the network of links that connects them. Through this combination of images, the present and the past, the animal begins to form "representative packages", produces abstractions, is able to categorize, perform primitive logical functions, anticipate the future and have plans of behavior. All this has not yet produced the rupture of the signitive or instinctive character that still dominates knowledge and animal behavior.

The evolutionary explanation of the human mind. Hominization is the evolutionary transition from the animal to the human, from knowledge-animal behavior to human knowledge-behavior. The turning point between the animal and the human is the emerging of reason. It is also clear that reason produced a new emotional world. For this reason we could say that the inflection took place in the emergence of the emotional-reason. Now, what are the causes of the evolutionary emergency of reason and what is its nature? What is reason? Within the emergentist theory, according to the theory of engrams or neural networks, a set of causes that probably produced the emergence of the reason: biological unspecialization (A. Gehlen); The work (Luria, Marxist neurology); Socialization-language in the animal group (Eccles, Tobias, Richard Leakey); The complexity of protohuman behaviors in the animal world (K. Lorenz, the biology of the knowledge of his disciple Rupert Riedl). The theory of the Spanish philosopher Xavier Zubiri, in my opinion the most correct, states that the cause of the hominization was the hyperformalization produced in the animal nervous system (which became human). These five theories are harmonious and congruent with each other to explain the system of causes that produced the hominization; That is, the evolutionary ortho of reason. Zubiri's theory of hyperformalization would hypothesize that the new specific state of the human nervous system (hyperformalization) would have produced a) feeling the stimuli no longer as pure stimuli, but as "realities", b) in such a way that this new Looking at real things in themselves would have made man realize that they are real as "structures", c) bringing all this to the emergence of a new function of mind, reason, which through analysis And synthesis of real

structures, would lead to the formation of rational representations of the world. By this search for the founding roots of reality the human mind would have been open to rational knowledge, science, and metaphysics. That the human psyche was able to produce this transit to reason is also explained by the state of psychic hypercomplexity already produced in higher animal species, especially in hominids. Abstraction, categorization, basic logical inferences, imagination, anticipation of the future ... were all functions of the animal mind; No doubt, made possible the evolutionary transition to the new "human representation of reality". I have referred to all these questions extensively in other writings.

History is explained as a product of the human mind. We have just seen how the nature of the human mind and reason are explained in the framework of current science. Ultimately, it is much more difficult to explain how and why the ability to "feel" (even in unicellular animals) has emerged to explain, already assumed to be the evolutionary existence of the universe and the emergence within it of "sensible life" The causes and processes that could lead to the hominization, that is, the emergence of emotional reason. We have, thus, offered a hypothetical scientific explanation of the origin and nature of the rational mind.

Do we need anything else to explain the causes of what mankind has done over history? We do not believe it. Mankind, in a very similar way to the animal mind, but already as a rational mind, is born with an organization of its sensory systems, internal and external, with a buses (connection ways) with the superior nervous system (normal organization of the species Which can be remodelledf to surprising extremes by brain plasticity). As you live you are setting up in your mind an enormous amount of engrams or mapped ones that, when activated, produce that the psychic subject sits in real time or remembers by the memory. The animal brain, only sensory-motor, has been completed by the knowledge, by the thought and by the emotions that interpret the sensible world.

Thus, both knowledge and interpretation of the world are recorded in engrams of frontal and prefrontal areas (specific to the human species). In lan-

guage the human species has found a superior tool to know and think about the world. Man knows and thinks not only through sensible images, but also through language. An enormous amount of neural records (engrams) are located in the brain, mapping it, in relation to the sensitive-imaginative, knowledge, creative-interpretive thinking and language. Each personal biography involves a personal mapping of his brain. At the same time, the world of knowledge and the world of actions, both in the same representative / motor system, are linked by a dense web of links to the emotional brain that connects with the determining "value" of "life". The human mind builds a moral system, both personally and socially. The human person, in all its rational, moral, existential and emotional richness, is made possible by the complex systemic activation of engrams in his brain. Man — namely, his "I", his sensory, cognitive, imaginative, representative, motor, emotional systems — is nothing more than the complex network of neural engrams of his mind. When the network fails, as it happens in old age and in degenerative diseases of the nervous system, its individual personality collapses dramatically and the "biographical self" disappears. It is an unquestionable fact.

Human thought, religions, social organizations, culture, science, philosophy, emotions, literature and poetry, art and all forms of human imagination, history in all its manifestations, are a product of the neural activity of the mind, as we have described. It is not, therefore, that man is not the man of possession, of art, of literature, the man of all the finer manifestations of his sensibility. But what we know today is that this man is capable of producing all those manifestations of his psychic life from the neural activity of his brain. It is true what is said today: scientifically, man is his brain. This is what today allows us to understand the results of science.

9. CONCLUSION

There is a certain prevention, extended among those who try to preserve traditional humanism, given the explanation we have provided. Astonishes that can be said: science explains everything. This must be qualified. It is true, as we have explained, for example, that feelings and poetry are produced as an engramatic activation of the brain; This is what science claims, although it is

not currently able to accurately describe the neural structures that are at the basis of most concrete psychic activities. However, this does not mean that science can or should explain the actual content produced by poetry. Studying Rilke's poetry, for example, describing and balancing it, is a characteristic of the human sciences and their methods. Ethics and its content, the senses of life, philosophy, the principles of social organization ... are characteristic of the human sciences. Nevertheless, they must be aware that the human mind products they are studying are the result of brain activity, as we have explained.

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