Physical-mathematical models for new paradigms in neuroscience. Part II – An electromagnetic theory of the brain

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ABSTRACT
The principles of complex systems theory can be applied through specific properties at any scale or reality level, from the string theory to meteorology and to the cosmologic models. The 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. Another reality that coexists with us is the a-spatial and a-temporal reality, described by the wave formula, in which the undertaking of the spatial-temporal information is made by light through modulation of its frequency. The electromagnetic theories of consciousness suggest that consciousness can be understood as an electromagnetic phenomenon. The analysis of the Toda network with its fractal, but also structural-functional specific allows for modelling the neuronal network, under two components: a structural, corpuscular one and a functional, spectral one.
KEYWORDS
information, electromagnetic theory, spectral field, neuronal network, human brain

1. INTRODUCTION
The evolution of science in the second half of the 20th century has led to the development of fractals and of fractal geometry, of topology and chaos theory, as well as of nonlinear dynamics, which started to better explain various phenomena from different fields, which had previously been described only by Newtonian dynamics.

All these theories were grouped into something that, in the last decades, came to be called the science of complexity or the complex systems theory. The principles of this theory can be applied through specific properties at any scale or reality level, from the string theory to meteorology and to the cosmologic models.

In the case of many studies, scientists have tried to apply this theory to biological systems, human body and human mind. The development of research in studying the brain and its functioning has crossed a series of stages in the 20th century, from the era of the great anatomical discoveries to phrenology and towards the behaviourist stage, followed by the cognitivist one, whereas in the last decades neurosciences attempted to include the phenomenology of psychological reality into an interdisciplinary approach.

In the last years, however, neurosciences have had to open up even more to interdisciplinarity, as well as to transdisciplinarity, in order to include Quantum Physics, Information Technology, and even Cosmology scientists, as well as traditional specialists in Psychology, Neurology and Psychopathology. This need for a wide interdisciplinarity comes from the necessity to apply the principles of complex systems theory to brain activity. In order to achieve that, it is necessary to overcome the concept according to which the psychological activity is only the product of neuron activity, and to minutely understand how the main types of neurons perform; thus, we will understand how the brain works at a mental level.

In the past decade, the human genome project has experienced such an approach, which proved successful. As a result, in 2013, an European offensive on knowledge of the human brain, called the Human Brain Project and also a Human Brain Mapping Initiative was launched in USA. In both projects, there is a large concern from universities and private entities in a wide range of interdisciplinary research. The goal of the Human Brain Project is to pull together all our existing knowledge about the human brain and to reconstruct the brain, piece by piece, in supercomputer-based models and simulations. The models offer the prospect of a new understanding of the human brain, its diseases, and of completely new computing and robotic technologies.

One of the major obstacles to understanding the human brain is the fragmentation of brain research and the data it produces. In neuroscience, the project will use neuro-informatics and brain simulation to collect and integrate experimental data, identifying and filling gaps in our knowledge and prioritising future experiments.
2. 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 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 rudimentarily 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 50 years ago to the conclusion that the transmission of signals at the level of analysers is made spectrally. De Valois and de Valois [13, 14] demonstrated 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 using the Fourier series, used in describing the wave phenomena. Also, von Békésy [2] proved that the tactile transmission is made spectrally, later on drawing the conclusion that the transmission of the signals of all analysers can be described by mathematical equations specific to waves.

All these pieces of data, as well as the laser and hologram technology made it possible for Bohm [3] and Pribram [10] to bring arguments that 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 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 an underlying fractal algorithm and a fractal geometry.

The approach of the structure and activity of the brain from a spectral perspective allows the study of the brain from a complex systems theory perspective. 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 phases’ 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 non-linear dynamics, in general, could be used to study the mental.

3. THE IMAGINARY SPACE AND PHYSICAL REALITY

Mathematical research shows the need to use complex numbers and, implicitly,
imaginary ones in order to describe physical phenomena that involve the rotation motion, around one's own centre.

This phenomenon is present, first of all, in the electromagnetic waves and thus it can be found in many situations described theoretically or technologically. If we accept that a spectral wave component also exists in the living world, including in the functioning of the brain, then the description of phenomena at this level needs the use, in mathematical modeling of complex numbers with their imaginary part, of the complex plans and, thus, of complex spaces.

Therefore, the imaginary space, which comprises the space of psychological activity, can be described by imaginary numbers through complex analysis, so that the imaginary space of expression is not only a metaphor, but a real physical space.

Mathematicians have been operating for centuries with imaginary numbers, which form complex numbers, the complex plane and the complex space. All these are associated in describing different physical phenomena and physical realities that are, in one way or another, connected to the spectral reality, with that of the field and of the wave associated to every particle.

No matter how surprising this may seem, these complex spaces coexist with our Newtonian reality, they are present in our reality every day, as we are surrounded by a spectral, electromagnetic reality we are closely connected to. It would not be the only strange thing that mathematics and physics describe to us so well and that we do not know where to place.

Another reality that coexists with us is the a-spatial and a-temporal reality, described by the wave formula and is involved in the phenomenon of visual perception, in which the undertaking of the spatial-temporal information is made by light through modulation of its frequency, a phenomenon described by the Fourier transform, while the stimulation of the retina involves the collapse of the wave formula and the emergence of corpuscles that stimulate the retina cells by inverting the Fourier transform.

As a result, all we look at and see, in order to be seen, goes through an a-temporal and a-spatial phase in the interval that the light from an object needs to reach us. This interval can be a million of light years for cosmic objects or minutely small fractions of a second when we look at our friends, our home or our garden. The imaginary time represents only one of the dimensions of the imaginary space, the other ones being spatial dimensions, which can be described as imaginary dimensions of the complex space.

At small distances, at speeds within our Newtonian space, distances lead to imaginary values of time when the relativity formula is applied in the spatial-temporal continuum. This would lead to the conclusion that, practically speaking, we, as people, use only this imaginary space, or, to put it differently, our representations of time actually use the imaginary time in Einstein's relativity theory.

This imaginary time, or the time from the imaginary space, is a time that, as compared to the Newtonian one, does not have a single sense. In the imaginary space, time has the characteristics of a spatial dimension, as it can be run in both senses, in the past and in the present.
We have known for almost a century now about the existence, on the cortex, of projections of the body’s sensory and motor structure, of what was classically named the sensory and motor homunculus. Research on psychopathological situations, such as phantom limb syndrome brings arguments for a spatial projection at brain level of every segment in the body. The fact that this cerebral representation of the segment remains functional for a longer or shorter period of time demonstrates both the existence and the persistence of such representations.

The mirror box technique applied by Ramachandran for persistent, painful, and spasmodyc phantom limb cases shows that the representations of the segments of the body have a spatial character, as long as they can be influenced by the illusion of topological modifications, outside the imaginary space. The fact that the cerebral image of the lost limb segment persists away from the normal period after an amputation shows that some reverberating circuits maintained by remembrances marked by pain, contraction and suffering, are involved in the persistence of this structure, which is spatially cerebral.

These experimental facts lead to the conclusion that, in the imaginary space, there is a projection of the spatial structure of our body, to which it participates along with sensoriality and motricity, with the sensory organites and the corresponding neuro-motor plaque and affective, positive or negative processes.

In fact, Davidson [5] demonstrated in his research that affection is involved in all cognitive processes, including in the projection of the body and of the whole reality, at the level of the imaginary space.

The implementation of the functional structure of complex systems to psychic life can explain a series of classical concepts circulated during the last century (Bohm [3]). 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 behavioural patterns (super-ego in psychoanalysis) can be associated with the structured, causal and deterministic part of the complex system. Between the two parts, there is a permanent dynamics through attractors, describable in the phase space. The chaoticity 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 the functioning of the brain leads to new conclusions concerning different mental processes that have not been fully understood yet.

4. THE ELECTROMAGNETIC THEORY OF BRAIN AND PSYCHIC PROCESSES

The electromagnetic theories of consciousness suggest 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 [9] and McFadden [6 – 8] have proposed EM
field theories, while Uttal [12] 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 argued that the brain's electromagnetic field creates a representation of the information in the neurons. Studies undertaken towards the end of the 20th 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.

5. Toda Neuronal Network

The analysis of the Toda network (Agop, Gavriluț, Crumpei, Craus and Birleanu [1]), with its fractal, but also structural-functional specific, allows for modelling the neuronal network, under two components: a structural, corporuscular one, and a functional, spectral one. This new electromagnetic paradigm could have the following implications:

i) Consciousness could be the dynamics result between the two networks: the spectral neuronal network and the structural one. For instance, the anaesthetic techniques block the structural network. When this structural network becomes functional again, it recovers its dynamics through the multifocal coherence phenomenon with the spectral network (where the memory, the core personality can be found, as detailed in the following). The same thing happens in epileptic crisis, in concussions, electroshocks, etc., the structural network being unable to achieve coherent dynamics with the spectral network;

ii) The structure of the brain (as a physical object), memory can be located in the spectral neuronal network, whose spectral, and thus fractal character has all the properties that are necessary for the in-
formation storage. The memory means coherence achievement among certain structures of the structural neuronal network and the spectral one, where those information have been memorized;

iii) Memory localization could give clues on how personality is structured. Classically, personality has two components: temperament and character. The temperament is constituted of behavioural and information processing patterns originating from the genetic setting (and which are organized in the structural network). The second component, the character, represents the programs built from the individual relationship with the external medium (education, experiences, cultural environment, analysers’ setting, etc.). It is organized in the spectral network, representing information, behavioural and information processing patterns that are set in programs resulting from the system and the external medium dynamics. The genetic patterns found in the structural neuronal network give stability and the programs built in the spectral neuronal network are adapted to the environment, in a specific form given by the dynamics with the genetic patterns from the structural network. This way, personality has stability via some of its components, but it also has specificity and adaptability;

iv) It seems that the potentiality [4] about Chomsky was talking, related to every child’s ability to learn the language or the languages to which he is exposed, is related to the spectral neuronal network, which gives the memory space, while the structural network represented by Wernicke and Broca centre (of speech understanding and speech expression, built by patterns transmitted at the genetic information level) offers the language processing structure;

v) In the context of new discoveries about mirror neurons, our model concerning the functionality and structuring of the psyche could give explanations about mirror neurons’ functioning and their integration in the psychological functioning in general. In the last decade, the so-called mirror neurons have been highlighted and they gradually acquired scientific validity through research with functional IMR and that brought objective proof for the existence of a virtual or imaginary projection of the Newtonian geometric space in which we live. Excitation of these neurons in the motor, sensitive or sensorial area to the actions and the behaviour of the others comes to support what was previously called theory of the mind, which was trying to explain our ability of intuition, of feeling the feelings and thoughts of the other.

Mirror neurons come as objective arguments that support this theory, which was explained previously by psychologists as a result of relationships with the others, communication and our specificity as social beings. They also represent a proof of the existence of spatial and temporal structures in our imaginary.

So far, experimental data emphasizes only the elements from the structural neuronal network (excited neurons, highlighted by electrodes implanted or brain areas highlighted by fMRI). Accepting the spectral network could explain complex phenomena, concepts, feelings that could not be generated only by the activity of several neurons, but by complex processing that
could take place only in the spectral neuronal network. It might even be possible that the neurons excitation is achieved through the spectral network, where the information originates through interpersonal communications spectral vibrational ways. It could, therefore, explain a series of controversies about mimetic learning, empathy, mind theory, language, etc.;

vi) In neuropathology, our model could also generate new conclusions concerning both mental and neuropsychological illness. For instance, in vascular dementia, the blood deficiency affects, on one hand, the neurons (the structural neuronal network) and, on the other hand, it influences the dynamics between the two networks, while in Alzheimer dementia, the dynamics between the two networks is primarily affected, with the impossibility to access the information stored, with the damage of the spatial-temporal orientation, but also of the behaviour and even of the entire personality (see the considerations from ii)). Certain somatic trauma cases when the phantom limb sensation manifests itself (Ramachandran [11]) could have an explanation by the model we conceived; the structural network can be inhibited or destroyed by the respective limb or organ, its representation remaining in the spectral neuronal network, generating the painful and contracted phantom limb symptoms and allowing the alleviating and curing through a suggestion and autosuggestion mechanism (the mirror box technique);

vii) The neuroplasticity phenomenon related to brain's adaptive capacity would be more understandable if, causally, according to our model, the neurons and the neuronal connections development would achieve by the dynamics between the two networks, based on the patterns developed in the spectral side from the reaction with the environment.

viii) The dynamics between the two networks (the spectral neuronal network and the structural one) explains the mechanism of suggestion and suggestibility. The modern views on hypnosis have changed to a great extent as compared to the classical view of the Freud and Charcot period. The Ericksonian concept on the hypnotic phenomenon offers a much wider importance to the mechanisms of suggestion and suggestibility, beyond the hypnotic trance.

Practically speaking, suggestion and suggestibility are ground processes in assimilating knowledge, behaviours and abilities, as well as in forming beliefs and, in general, representations on the world and life in general.

The whole educational process, starting with family education from early childhood, is based on suggestions offered by educators, through their didactic, scientific, moral authority, as well as through their status as paternalistic leaders, and the suggestibility capacity of the human psyche.

Too little knowledge, of the type belonging to some fields, is assimilated on the basis of logical and experimental demonstrations to which the subject participates. The majority of the information is accepted through suggestions and suggestibility through different mechanisms connected to people of authority, to peer pressure, to the complex unity of beliefs and values involved in the educational process.
As a consequence, we encounter hypnotic phenomena at every step in our day-to-day life: when we watch a movie, participate in a game, get involved in a debate, the relationship between two partners in their passionate moments, all are contexts when we are suggestible and we let ourselves be influenced, in other words we are hypnotized. Reading a book or watching a broadcasted programme are all the more contexts where we acquire a certain imaginary reality, which is connected or not to the physical reality to which we have access.

The suggestion phenomena in states of modified conscience or of narrowing of the conscience field which appear in all these situations are all phenomena involved at the ground level in establishing and structuring the imaginary space (the dynamics between the spectral neuronal network and the structural one).

CONCLUSIONS

The spectral component associated and related to the material, corpuscular (the neuronal) one must be, at least, as important as the corpuscular part, which is structured and was studied in the last hundred years. The electromagnetic theories of consciousness argue that consciousness can be understood as an electromagnetic phenomenon. Consciousness could be the dynamic result between the two networks: the spectral neuronal network and the structural one. For instance, the anaesthetic techniques block the structural network. When this structural network becomes again functional, it recovers its dynamics through the multifocal coherence phenomenon with the spectral network (where the memory, the core personality can be found). The analysis of the Toda network with its fractal, but also structural-functional specific, allows for modelling the neuronal network, under two components: a structural, corpuscular one and a functional, spectral one.

In conclusion, neurosciences have to open up even more to interdisciplinarity, as well as to transdisciplinarity, in order to include Quantum Physics, Information Technology, and even Cosmology scientists, as well as traditional specialists in Psychology, Neurology and Psychopathology. This need for a wide interdisciplinary comes from the necessity to apply the principles of complex systems theory to brain activity.

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REFERENCES

1. Agop, M., Gavriluți, A., Craus, M., Birleanu, V. Brain dynamics through spectral-structural neuronal networks, submitted for publication.


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