THE ROLE OF THE AXIOMATIC SYSTEMS IN NEUROSCIENCE

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Abstract: In this paper, we use axiomatic systems from different physical and mathematical models which lie at the foundation of epistemology, in order to extrapolate them over some mechanisms and psychological concepts involved in the human perception and cognition. To this aim, we use a paradigmatic interdisciplinary methodology, from a structurally-phenomenological and naturalistic perspective. We also analyze the paradoxes of quantum physics and the wave-corpuscle duality, in order to find the same need for formulating axioms in the various psychological theories, as well as in the new discoveries made in Neuroscience. Our approach highlights an axiomatic unity as a gnosiological principle, while highlighting it both in the epistemological evolution in time, but also throughout the reality levels from various paradigms. We also point out the importance of the axiomatic paradigms which unify reality with the subject, the object and the observer, the mind with the brain, in a naturalistic approach which can generate new knowledge hypotheses.

Key-Words: Axiomatic system, the perception of reality, paradigms, cognition, neuroscience, information.

1 Introduction

The need for axiomatic systems in order to rationally understand reality appeared since the Antiquity. They had also been drafted before the Pythagoras School, Thales of Milet, Anaxagoras, etc., but Pythagoras was the one who actually built the first axiomatic system based on numbers. The greatest impact on science and knowledge is attributed to the Euclidean axiomatic system, which is still used nowadays, although it is completed by the Non-Euclidean Geometrical axioms. Hilbert set himself a goal to build a complete system of axioms in Mathematics, but was stopped in his endeavor by the Incompleteness Theory formulated by Gödel.

The need for formulating axioms is not present only in the Mathematical approach. It is a general necessity of the gnosiological capacity, which allows thus for knowledge to be discovered.

The Gestalt psychology brought arguments connected to a topological mechanism for information processing, which leads to an axiomatic system based on which the information is processed. This axiomatic system builds what the psychologists call the nucleus of beliefs, convictions and certainties, which lie at the basis of the knowledge and understanding of reality. It is different from a historical period to another, from one culture to another, from a community to another and even from one individual to another.

The paradoxes identified by the quantum physics one century ago can be understood from this axiomatic perspective, which presumes a coherence between mental representations, therefore our expectances, and the physical system of reality, which, by creating new variants, unveils the one with which our mind can get coherent. Thus we can understand the paradoxical aspects offered by the slit experiment, and, generally, the wave-corpuscle duality, which generated so many controversies.

An axiomatic change is needed in our mind in order to discover the reality from these new axioms perspective. As long as people extended their discovery area to only what could be covered by pace or with the help of animals, the axiom of the flat Earth was the only one which could be naturally accepted. Only the great travels of the famous explorers lead to the reality of a round Earth. Geocentricism was the dominant conception for hundreds of years. Only when doubts appeared, due to the discovery of new instruments (Galilei's telescope or Copernic's calculations), only then began the process of building, in the minds of the researchers of the time, new paradigms which lead to the heliocentric conviction, with the corrections made by Kepler regarding the orbits, and culminating with the coherent theory of Newton regarding the physical reality.

The emergence of new paradoxes at the end of the 20th century, based both on some experiments, in the case of electromagnetism, for example, or of new mathematical concepts, the non-Euclidean geometries, lead to the creation of new axioms, which allowed for General and Special Relativity Theory and Quantum Mechanics.

All these examples are not only specific to scientific knowledge, but also to other forms of knowledge (philosophical, religious, artistic), aspects which require that the multidisciplinary methodology or even the Transdisciplinary one constitute the most suitable approach in the knowledge of Reality, under all its axiomatic aspects.

2 The axiomatic systems and methods

In mathematics, an *axiomatic system* is a set of axioms from which some (or all) axioms can be used in conjunction to logically derive theorems. A mathematical theory consists of an axiomatic system and all its derived theorems.

According to Gödel's First Incompleteness Theorem, there are certain consistent bodies of propositions with no recursive axiomatization. Typically, the computer can recognize the axioms and logical rules for deriving theorems, and the computer can recognize whether a proof is valid, but to determine whether a proof exists for a statement is only soluble by "waiting" for the proof or disproof to be generated. The result is that one will not know which propositions are theorems and the axiomatic method breaks down. An example of such a body of propositions is the theory of the natural numbers.

Stating definitions and propositions such that each new term can be formally eliminated by the priorly introduced terms requires primitive notions (i.e., axioms) to avoid infinite regress. This is called the *axiomatic method*.

A common attitude towards the axiomatic method is logicism. In Whitehead and Russell [21], it is shown that all mathematical theory could be reduced to some set of axioms. The reader can refer to Hazewinkel [11], Potter [14], Weisstein [20], Whitehead and Russel [21] for other further considerations on axiomatization.

Mathematical methods developed to some degree of sophistication in ancient Egypt, Babylon, India, and China, apparently without employing the axiomatic method. Euclid of Alexandria authored the earliest extant axiomatic presentation of Euclidean geometry and number theory.

Many axiomatic systems were developed in the nineteenth century, including non-Euclidean geometry, the foundations of real analysis, Cantor's set theory, Frege's work on foundations, and Hilbert's 'new' use of axiomatic method as a research tool. For example, group theory was first put on an axiomatic basis towards the end of that century. Once the axioms were clarified (that inverse elements should be required, for example), the subject could proceed autonomously, without reference to the transformation group origins of those studies.

Classical physics is generally concerned with matter and energy on the normal scale of observation, while much of modern physics is concerned with the behavior of matter and energy under extreme conditions or on a very large or very small scale. For example, atomic and nuclear physics studies matter on the smallest scale at which chemical elements can be identified.

The physics of elementary particles is on an even smaller scale since it is concerned with the most basic units of matter; this branch of physics is also known as high-energy physics because of the extremely high energies necessary to produce many types of particles in particle accelerators. On this scale, ordinary, common sense notions of space, time, matter, and energy are no longer valid.

The two chief theories of modern physics present a different picture of the concepts of space, time, and matter from that presented by classical physics. Classical mechanics approximates nature as continuous, while quantum theory is concerned with the discrete nature of many phenomena at the atomic and subatomic level and with the complementary aspects of particles and waves in the description of such phenomena.

Relativity theory concerns with the description of phenomena that take place in a frame of reference that is in motion with respect to an observer; the special theory of relativity is concerned with relative uniform motion in a straight line and the general theory of relativity with accelerated motion and its connection with gravitation. Both quantum theory and relativity theory find applications in all areas of modern physics.

3 Modern paradigms in neuroscience

3.1. Complex systems theory

Complex systems is a new approach to science that studies how relationships between parts give rise to the collective behaviors of a system and how the system interacts and forms relationships with its environment. Complexity theory is rooted in chaos theory, which in turn has its origins more than a century ago in the work of Henri Poincaré.

Chaos is sometimes viewed as extremely complicated information, rather than as an absence of order. Chaotic systems remain deterministic, though their long-term behavior can be difficult to predict with any accuracy. With perfect knowledge of the initial conditions and of the relevant equations describing the chaotic system's behavior, one can theoretically make perfectly accurate predictions about the future of the system, though in practice this is impossible to do with arbitrary accuracy. Ilya Prigogine argued that complexity is non-deterministic, and gives no way whatsoever to precisely predict the future.

A fractal is a mathematical set that has a fractal dimension that usually exceeds its topological dimension and may fall between the integers (Mandelbrot [12]). Fractals are typically self-similar patterns, where self-similar means they are “the same from near as from far”. Fractals may be exactly the same at every scale, or, they may be nearly the same at different scales. The studies of the fractal geometry revealed new properties of natural objects and principled marked differences between them and artifacts.

Besides a better modeling, a fractal approach allowed the identification of the importance of the recursive fractal processes in nature. Another method is to generate complicated structures by very simple mechanisms. It has multiple applications in areas such as telecommunications (fractal antenna), mechanics (the modeling of the processes by fragmentation and solidification, the study of the surface quality, the diagnosis by evaluation of non-periodic structure signals (noise), the characterization of composite materials and biomaterials), biology (the quantitative evaluation of the tumors, the study on morphogenesis process, the operative assessment of health status etc.), economy (stability diagnosis on a macroeconomic scale, the diagnosis of some economic processes, the fractal market).

The emergence of complexity theory shows a domain between deterministic order and randomness which is complex.

A complex system cannot be analyzed principally by fragmentation components. It is made up of elements that make sense only in the privacy of the system. It has unpredictable evolution (no more than a short time, called temporal horizon). It can also undergo sudden changes, however great, without apparent external cause and it shows different aspects depending on the scale of analysis. It differs essentially from a complicated system in that the difficulty of prediction is not the observer is unable to take into account all the variables that would influence its dynamics; the sensitivity of the system is due to initial conditions (slightly different initial conditions lead to very different evolutions) plus the effect of a process of self-organization (the interactions among subsystems and components yield to spontaneous - unpredictable in principle –order relations).

While classical modeling starts by approximating what “sees”, functional modeling involves identifying an equivalent dynamic system, whose behavior is analyzed by a specific extremely high degree of generalization. A complex system is an evolution not result from the analysis of the response to a given stimulus (dynamic analysis), i.e. the dynamics and evolution of a complex system are two different problems that require specific approaches. For further considerations on the topic of complex systems theory, the reader can refer to Agop, Gavriluţ, Buzea, Ochiuz, Tesloianu, Crumpei and Popa [1], Agop, Gavriluţ, Crumpei, Craus and Bîrleanu [2].

3.2 THE ELECTROMAGNETIC THEORY OF BRAIN AND PSYCHIC PROCESSES

The electromagnetic theories of consciousness propose that consciousness can be understood as an electromagnetic phenomenon. However, theorists differ in how they relate consciousness to electromagnetism. Electromagnetic field theories (or "EM field theories") of consciousness propose that consciousness results when a brain produces an electromagnetic field with specific characteristics. Pockett [13] and McFadden [8-10] have proposed EM field theories, while Uttal [17] has criticized McFadden's and other field theories.

Locating consciousness in the brain's EM field, rather than the neurons, has the advantage of neatly accounting for how information located in millions of neurons scattered through the brain can be unified into a single conscious experience (sometimes called the binding or combination problem): the information is unified in the EM field. In this way EM field consciousness can be considered to be "joined-up information". This theory accounts for several otherwise puzzling facts, such as the finding that attention and awareness tend to be correlated with the synchronous firing of multiple neurons rather than the firing of individual neurons.

When neurons fire together their EM fields generate stronger EM field disturbances; so synchronous neuron firing will tend to have a larger impact on the brain's EM field (and thereby consciousness) than the firing of individual neurons. However their generation by synchronous firing is not the only important characteristic of conscious electromagnetic fields—in Pockett's original theory, spatial pattern is the defining feature of a conscious (as opposed to a non-conscious) field.

The starting point for McFadden and Pockett's theory is the fact that every time a neuron fires to generate an action potential, and a postsynaptic potential in the next neuron down the line, it also generates a disturbance in the surrounding electromagnetic field. McFadden has proposed that the brain's electromagnetic field creates a representation of the information in the neurons.

Studies undertaken towards the end of the 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.

3.3 Implications in psychopathology

In our opinion, the 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 anesthetic 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, 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) In brain's structure (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 information 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 behavioral 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, analyzers' setting etc.). It is organized in the spectral network, representing information, behavioral and information processing patterns, 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. In this way, personality has stability via some of its components, but it also has specificity and adaptability;

iv) It seems that the potentiality Chomski [6] was talking about, 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 center (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 psyche's functionality and structuring 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 which 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 motric, 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 be thus explained 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 behavior and even of the entire personality (see the considerations from ii)). Certain somatic trauma cases when the phantom limb sensation manifests itself (Ramachandran [16]) 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 on our day-to-day life: when we watch a film, participate in a game, get involved in a debate, the relationship between two partners in their passionate moments, all are contexts in which 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 in which 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).

Other interesting considerations can be found in von Békésy [3], Bohm [4,5], Davidson [7], Pribram [15], de Valois and de Valois [18], Pockett [13] etc.

4 Conclusion

The need for axiomatic systems in order to rationally understand reality appeared since the Antiquity. The need for formulating axioms is not present only in the Mathematical approach. It is a general necessity of the gnosiological capacity, which allows thus for knowledge to be discovered. An axiomatic change is needed in our mind in order to discover the reality from these new axioms perspective.

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 propose that consciousness can be understood as an electromagnetic phenomenon. Consciousness could be the dynamics result between the two networks: the spectral neuronal network and the structural one. For instance, the anesthetic 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 modeling 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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