Chapter 6

Causality, retrocausality and consciousness

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6.1 Supercausality and consciousness

In this chapter the model of supercausality and its implications in the field of consciousness will be described. The model of supercausality has been introduced by different authors:

1. Giuseppe Arcidiacono (physicist) and Salvatore Arcidiacono (biochemist) noted that quantum objects are forced to choose between causes which act from the past (diverging waves) and causes which act from the future (converging waves); the result of these choices cannot be determined in advance, and, as a consequence, quantum objects show a constant state of uncertainty and chaos (Arcidiacono, 1991).
2. The question about when a structure moves from the laws of quantum mechanics to the laws of classical physics is still under discussion, but it seems that this transition takes place gradually around 200 Angström (1 Angström equals the size of an helium atom). Synaptic vesicles and microtubules have dimensions which are lower than 200 Angström, it is therefore possible to consider these structure as "quantum" objects which constantly choose in response to past and future causes (Arndt, 2005).
3. Dynamical chaotic behaviors can be studied only from a probabilistic point of view and this fact would therefore explain the widespread use of statistics in living sciences.

Chris King in the article "*Chaos, Quantum-transactions and Consciousness*" (King, 2003), starts from Einstein's energy-momentum-mass equation, and states that all quantum objects

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are constantly faced with bifurcations which force the system to operate choices. King quotes Eccles, Penrose and Hameroff who proved the existence of quantum structures in living systems and arrives to the conclusion that life is moved not only by mechanical causes but also by final causes (attractors). According to King, a new and innovative description of the relation between mind and brain derives from this constant state of choice in which living structures are immersed. This constant state of choice would force living systems into a state of free will which would be common to all the levels and structures of life, from molecules to macrostructures, and organisms. This constant state of free will, would originate chaotic dynamics which, when attractors are inserted, organize in fractal structures which have the property of amplifying and selecting small perturbations. The classical example is the Lorenz attractor: "*even the flap of the wings of a butterfly in the Amazons could be amplified to the point of causing a hurricane in the United States*".

Starting from these premises King suggests two separate levels of explanation of consciousness. In the first level, information flows from the mind to the brain, through free will; in the second level, information flows from the brain to the mind, thanks to the selection and amplification of signals performed by fractal structures. King's considers mind to be immaterial, and its organization would be the consequence of the cohesive properties of –E (entanglement and nonlocality).

King suggests that, in order to understand what consciousness really is, it is necessary to start from free will, because at this level it becomes necessary to definitely refuse any attempt to use mechanical approaches. Kings describes:

- *Free will* as the process which the mind uses to act on the brain. Free will originates from bifurcations and supercausality which force living systems to operate choices. In chapter 3 it was shown that retrocausality and anticipation are strongly correlated to emotions, concluding that emotions are properties of –E, whereas rationality and memory seem to be a result of +E. In our daily life bifurcations would therefore be experienced in the form of the antagonism emotions/rationality. This constant antagonism would force humans into a state of free will and choice.
- *Consciousness* is the aptitude of the brain to act on the mind, selecting and amplifying sensorial perceptions, thanks to the properties of chaotic dynamics and fractal structures.

Sir John Eccles underlined the importance of free will in the cognitive processes of people: all sane people are considered to have the ability to modify and control their own actions through will and intentionality. Free will is usually considered to be at the basis of all the actions of human beings, but it absolutely contradicts the assumption that only classical causality and determinism are real (Hooper e Teresi, 1986). For this reason, when starting the study of consciousness from free will, it becomes impossible to agree with the assumptions of deterministic models, such as the computational one, which describe the brain as a complex machine. Attractors and chaotic dynamics are at the basis of fractal geometry which describes how complex structures originate, organize and cooperate shifting from chaos to order.

According to King:

- free will allows the flow of information from the mind to the brain;
- fractal structures and chaotic dynamics select and amplify the signals of the physical world allowing the flow of information backwards, from the brain to the mind.

In this description, supercausality is the new paradigm which permits to overcome the limits of the traditional theories of consciousness.

6.2 Empirical evidences

The model of consciousness described in the previous paragraph hypothesizes that it should be possible to observe:

1. living structures at the quantum level;
2. fractal structures in the organization of the different levels of the brain, from the neuronal level to the main structures;

3. chaotic dynamics in the brain processes.

First hypothesis: quantum structures

The question about when a structure shifts from the laws of microcosm (quantum physics) to the laws of macrocosm it is still discussed, but it seems that it is gradual at around 200 Angström (Arndt, 2005). In 1935 Eddington observed that synaptic vesicles had dimensions inferior to 200 Angström (Eddington, 1935) and, therefore, he can now be considered the first author who hypothesized quantum-mechanic actions on living systems. These considerations were formulated again in 1970 by Eccles, who arrived at the conclusion that synaptic vesicles can be considered quantum objects, which can be therefore activated in non-determinist ways, following in this way the principle of free will which leads the system to global non deterministic instability (Eccles, 1970). In 1987 Hameroff supported these considerations observing the fact that microtubules show dimensions which are inferior to 200 Angström, a fact which implies non deterministic quantum processes. According to Hameroff microtubules are quantum objects (Hameroff, 1982).

Second hypothesis: fractal structures

The second hypothesis requires that the brain be organized on the basis of multi-fractal structures organized at different levels: the global level of the nervous system, the cellular level and that of the molecules. Fractal structure would allow the selection and amplification of signals, and the transition of the information from the lower to the higher levels, producing the “butterfly effect” which has been described by Lorenz in meteorology. In this way the instability of the highest neurodynamic level, could be influenced by the instability of the cellular level, which could be influenced by the instability of the molecules and of the quantum level. A wide range of empirical evidence show that the brain, neurons, cells and their components are fractal structures. A wide range of evidence can be found in the volume “*Fractals of brain, fractals of mind*” by Mac Cormac and Stamenov (1996). The fractal structure of living systems, and particularly of the brain, is now well known and supported by empirical evidences.

Third hypothesis: chaotic dynamics

Walter Freeman, worked for over thirty years studying the chaotic dynamics of the brain. In one of his recent books "*How brains make up their minds*" Freeman underlines the enormous complexity of the brain, and the inability of the linear causal model to describe and explain its complexity (Freeman, 2000).
The brain is a highly dynamic and complex system: it contains approximately 10 billion neurons, connected in a complex non-continual network consisting of more than 1000 billion synapses. According to Freeman, the functioning of such a network can be understood only by using models derived from the modern theory of non-linear dynamical systems, based on the properties of self-organization and emerging phenomena: even simpler systems, such as the surface of a fluid or a mix of chemical products, which are characterized by a high number of interacting substances, can generate macroscopic and global properties under particular circumstances which do not exist at the level of the basic substances, and which are therefore indicated as "emerging phenomena".
These properties depend upon patterns which result from non-linear interactions among elementary substances. From a physical point of view, these non-linear interactions can be traced back to feedback loops in which the components of a system are connected circularly in such a way that each element stimulates the following until the last one stimulates the first. Thanks to this circular organization, the behavior of each element is influenced by all the others. This permits the system to self-regulate until it reaches a dynamic equilibrium where the elements which are part of the system are affected by the global state generated together.

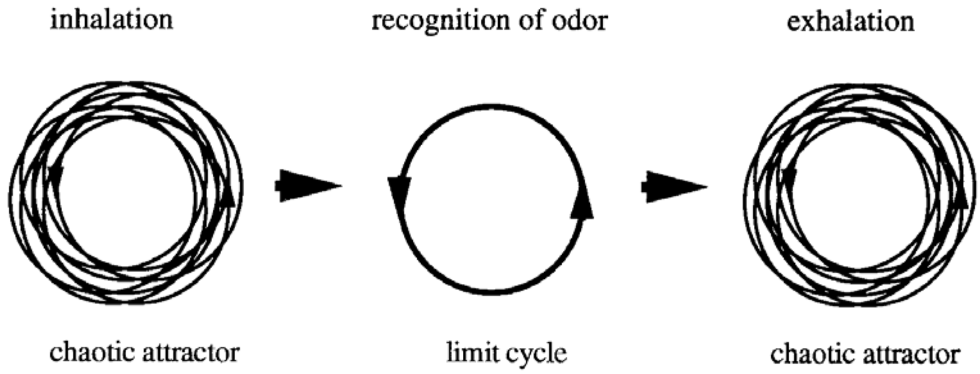

Fig. 1. Chaotic dynamics in the recognition of odors (Skarda e Freeman, 1987).

This circular interaction, or ring, permits the system to self-organize spontaneously without any external agent controlling the organization.

In his studies of brain dynamics, using rabbits which were left free to smell the environment, Freeman found chaotic processes in the recognition of odors. Using EEG, Freeman measured neural activity during and after the odor stimuli, and represented them in space using a computational model. Freeman showed that the forms which were obtained, which were irregular but structured, represent chaotic attractors (or strange attractors, as described in the fifth chapter). Each attractor corresponds to the behavior shown by the system as a consequence of a particular stimulus, such as a well known odor. The model interprets a smell act as a dynamic explosion from the chaotic attractor basin to that of another attractor: in other words, a reaction to external simulation gives place to a global activity (registered by EEG) which is chaotic, but ordered and structured; if the stimulations change even slightly, the neurons instantly produce another configuration, which is complex but still ordered. According to the author, these chaotic dynamics can also be observed in other forms of perception.

In conclusion, Freeman says that "*The great advantage that chaos can give to the brain is that chaotic systems can produce continually new types of activities. In our opinion these activities are essential to the development of groups of neurons different from those already established. More generally, the ability to create new types of activity may underlie the ability of the brain to reach for intuitions, and solve problems through trial and error*".

6.3 Evolution

Chaotic dynamics are defined as non deterministic, and reactive (Schuster 1986, Stewart 1989). Reactive means that the system is capable of selecting and amplifying even the slightest perturbation (butterfly effect), changing a chaotic system into a reactive system. At the same time a system of this kind cannot be predicted with computational techniques, because of free will which acts at each level of the system. The interaction of the chaotic and fractal properties repeated at the different levels (molecules, cells, neurons and nervous system) is indicated as the multi-fractal model. This model implies that all the components, from the molecular one to the global brain structures, can reciprocally activate each other. The fractal nature of their connections, the sophistication of neurons and synaptic junctions, leads to a modular and flexible structure.

According to King, the anticipatory properties of these systems, their flexibility and ability of performing decisions, justifies why this model has been selected during evolution. The advantage of conscious processes in terms of anticipation, flexibility, learning and self-organization are fundamental for the survival of the living system and therefore free will and consciousness have emerged, surpassing any eventual computational systems.

6.4 Entanglement

One of the most incredible properties of quantum physics is *entanglement*. Entanglement is the consequence of instantaneous communication among particles thanks to the spin which, once it has been activated, establishes non-local links in space and time (this topic has been discussed in chapter 2, paragraph 3). Entanglement can be traced back to the qualities of –E and from these properties originates a model of mind, based on immaterial connections and on quantum non-locality.

Dean Radin, in his book "*Entangled Minds*" (Radin, 2006) underlines that one of the most astonishing discoveries of modern physics is that objects which might seem separated at the macroscopic level, might not be separated at all when observed at the microscopic quantum level. The divisions among objects which are observed at the macroscopic level disappear at the quantum level. All that is left are relations, an incredible number of relations, which have been established among pairs of particles. These relations had been predicted by Einstein in his EPR experiment. Recently, it has been discovered that, in living systems, these properties of quantum physics do not dissolve when the system grows beyond the microscopic level, but they persist giving place to incredible consequences: the description of reality which originates is deeply innovative and different from our intuitive experience of reality.

It has been discovered, for example, that thanks to fractal structure, the properties of “entanglement” can emerge and reach the macroscopic level, influencing the way in which biological structures, neural systems and life are organized and work. A growing number of scientists, and especially physicists, is now studying whether the coherence and order of living systems could be a consequence of entanglement. For example, mind and binding could be an emergent property of entanglement. These discoveries support the hypothesis that different channels of causation and retrocausation, which bypass the classical physical channels, which have been studied by neurosciences, might exist.