THE BRAIN AND THE AESTHETIC EXPERIENCE

1. Introduction

In this paper I discuss the dissipative many-body model of the brain by closely following a recent paper and adopting the standpoint of Desideri concerning the sense and the specificity of the aesthetical experience.

Brain functioning is characterized by the continuous attempt to reach the equilibrium with the environment in which the brain is embedded. The balancing of the energy fluxes exchanged between the brain and the world in reciprocal actions/reactions is finalized to a harmonious fitting of the self in the world. Such a perfect ‘to-be-in-the-world’ defines the aesthetical dimension of the brain activity. The aesthetical experience, the brain active search of its equilibrium in the environment, thus appears to rule the brain functioning.

The dissipative many-body model describes the collective neuronal activity providing many features of the brain macroscopic behaviour in terms of its microscopic...
dynamics. The model considers the brain constituent cells, neurons, glia cells, other biological microscopic units, and the water bath in which they are embedded. Its main objective is to fill the gap between the description of biochemical and physical properties of the elementary constituents and their observable collective behaviour at a macroscopic level. Such a gap is indeed the challenging problem for biology and neuroscience studies. It is similar to the problem in many research sectors of contemporary science, namely the question of the derivation of the macroscopic behaviour of the system from the dynamics of its elementary constituents.

The mechanism of spontaneous breakdown of symmetry (SBS) provides a key tool in the study of elementary particles and condensed matter physics and has revealed to be of help also in the study of biological systems and brain modelling. It is at the root of the dynamics describing systems which present observable ordered patterns, for example crystals, magnets. Ordering implies the persistence of a constant phase \( \text{phase locking} \) or \( \text{in phase oscillations} \) in the oscillatory motion of the elementary components. The ordered patterns cannot be derived as the sum of the properties of the components. For example, the magnetization, the electrical properties, the stiffness, etc. are system properties of magnets and crystals not of the individual atomic or molecular components. In order for this to happen, the dynamics of the system components needs to have the property of nonlinearity producing long range correlations among them. Ordering is thus of dynamical origin, not created by forcing each of the components to sit in specific positions or oscillating with a given phase and frequency. The range of the correlations, much greater than the typical size of the components, dictates the macroscopic size of the system as a whole. In quantum field theory (QFT) one can show that the existence of long range correlations, and of their associated quanta, the so-called Nambu-Goldstone

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(NG) bosons, is a consequence of the breakdown of the symmetry characterizing the component interactions\(^8\). Consider, for example, a collection of atoms in a condition such that their positions can be shifted without producing observable changes in the system (symmetry under spatial translations). If such a space translation symmetry is broken, so that the atoms can only occupy definite sites at definite distances (multiples of the lattice length), then a long range correlation arises in the form of an elastic wave connecting the atoms. The associated NG quantum is called the phonon. The crystal ordering of the atoms in their lattice sites thus appears as a dynamical effect of the symmetry breakdown: crystal ordering is lack of space translational symmetry. In full generality, order is lack of symmetry. Note that the macroscopic behaviour and properties of systems like the crystal can be explained only by recurring to the microscopic quantum dynamics. In this sense, such systems are macroscopic quantum systems. The SBS mechanism thus dynamically produces a change of scale, from the microscopic to the macroscopic scale. The NG bosons are collected (condensed) in the least energy state (called the vacuum) of the system. The ordering is quantitatively expressed by the common phase of the NG bosons. This is denoted by saying that we have coherent boson condensation\(^9\).

Notice that the ‘spontaneous’ symmetry breakdown process is triggered by a weak stimulus, which can be switched off after symmetry breakdown has occurred. The system is driven to the ordered state by its internal dynamics.

NG bosons are real quantum particles interacting with other components of the system. They therefore enter in the list of the system elementary components: they belong to the system structure. They are, however, also responsible of the ordered patterns and shapes (forms) in which the components are organized; in other words, of the system function, e.g. the magnetic, the crystalline function. Thus, we see that in macroscopic quantum systems structure and function cannot be separated, their distinction vanishes.

In Section 2, the dissipative model and the possibility to describe the act of consciousness is presented. The aesthetic experience is discussed in Section 3. Section 4 is devoted to conclusions and to the perspective of obtaining an integrated ecological vision where coherence plays the role of a paradigmatic law.

2. The brain and its Double

The SBS mechanism of QFT was applied to the study of the brain by Umezawa and Ricciardi (UR) in 1967\(^{10}\). They observed that the (weak) stimuli from the external world may trigger the SBS of the brain microscopic dynamics, thus producing memory recoding as a coherent boson condensation phenomenon. Memory recollection was

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\(^8\) UMEZAWA, *Advanced Field theory: micro, macro and thermal concepts*; BLASONE - JIZBA - VITIELLO, *Quantum field theory and its macroscopic manifestations*.

\(^9\) Coherence is observed in many systems in nature and in a wide range of temperature, from thousands of degrees Celsius °C (diamond crystal melting point is 3545 °C) to very low temperature (below -252 °C in superconductors).

modelled as the excitation of NG bosons out of the condensed state. Their proposal was an attempt to answer to the ‘Lashley dilemma’ : «nerve impulses are transmitted […] from cell to cell through determinate intercellular connections. Yet, all behavior seems to be determined by masses of excitation […] within general fields of activity, without regard to particular nerve cells. […] The problem is almost universal in the activity of the nervous system». In fact, «here is the dilemma. […] What sort of nervous organization might be capable of responding to a pattern of excitation without limited specialized path of conduction?».

QFT could indeed provide a solution to such a dilemma. However, it was not possible to account for the huge memory capacity of the brain: in the UR model every memory recording process overwrites (cancels) the one previously recorded. Moreover, the brain was not considered to be a dissipative, i.e. open, system and it was not specified which one is the symmetry broken by the external stimuli. In the model the neurons, the glia cells and any other biological units are not quantum objects.

Stimulated by the proposal that a dominant symmetry in living matter is the electrical dipole rotational symmetry of water molecules, Jibu and Yasue and the author (G.V.) proposed that in the UR model the external stimuli break the dipole rotational symmetry. The quantum variables are identified with the vibrational dipole quanta and the recorded memory is specified by the number $N_A$ of NG quanta condensed in the least energy state. A radical modification of the UR model was then introduced by considering that the brain is a dissipative system. In the dissipative quantum model it is required that the brain and its environment be treated at once in order to deal with a closed system. The requirement that the energy fluxes between the brain and environment be (dynamically) balanced is satisfied by doubling the degrees of freedom. The environment is described in the same way as the brain system is described, as the brain’s Double. The energy flux balance is obtained by balancing the number $N_A$ of the brain NG bosons and their Double image, $N_B$; $N_A - N_B = 0$. Infinitely many vacua are then possible, depending on the infinitely many values that $N_A$ and $N_B$ may take so that $N_A - N_B = 0$. Since different memories are specified by different $N_A$'s, infinitely many memory states may be allowed: dissipation is discovered to be the key to solve the memory capacity problem unsolved in the UR (non-dissipative) model.

Since fluxes ingoing in the brain are outgoing fluxes from the environment (Double), and vice-versa, the Double is described as the time-reversed image of the brain system, its ‘mirror in time’ image. The permanent entanglement between the

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14 Vitiello, *Dissipation and memory capacity in the quantum brain model*. 
brain and its Double is described in terms of a continuous undergoing through *phase transitions* between different dynamical regimes, namely as processes *far from the equilibrium*, approaching to and departing from the stationary point where variations of free energy are vanishing\(^{15}\) and depicting the «landscape of attractors», that is the «memory states».

The act of *consciousness* resides in the restless dialog of the self with its Double\(^{16}\). It belongs to the present since the present stays on the surface of the ‘mirror in time’ in which the self reflects in its Double, and vice-versa. The word σουηδός, which means to ‘see together’, in the act of ‘immediate vision’, was used by the ancient Greeks to denote the consciousness (to be conscious of), stressing the ‘present’ as the time dimension of the consciousness (the verb ὁράω is used for the act of lasting vision)\(^{17}\). Consciousness is thus an ‘act’ of sudden, intuitive knowledge (Spinoza’s ‘intuitive science’), not dividable into rational steps, as the present is\(^{18}\), and it is non-separable from our body. Our ‘to-be-in-the-world’ is realized in our ‘listening’ to it through our perceptions\(^{19}\), in a flow of self-referential *emotional* experiences through our body\(^{20}\); any distinction between subjectiveness and objectiveness, between the self and its Double, definitely vanishes in the consciousness act.

Trajectories from memory to memory in the attractor landscape are chaotic ones\(^{21}\), therefore quite sensible to tiny fluctuations in the initial conditions. An important role is played thus by noise and weak perturbations, explaining the observed relevance of small stimuli to the brain functioning and the fact that the same stimulus in different contextual conditions may lead to different brain reactions\(^{22}\). Any new information, through the processes of *abstraction* and *generalization*, produces a full rearrangement of the whole attractor landscape (the learning process), and becomes meaningful in such a contextualization process: *memory is not recording (and/or recollection) of information* in the Shannon sense. The brain is not an encyclopedia\(^{23}\). *Memory recording is always formation of meanings*. The *growth of knowledge* is realized at each rearrangement process, at each formation of

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\(^{16}\) Vitiello, *Dissipation and memory capacity in the quantum brain model*; Id., *My Double Unveiled*.

\(^{17}\) B. Bonazzi, *Dizionario Greco-Italiano*, A. Morano, Napoli 1936.

\(^{18}\) Vitiello, *The dissipative brain*.


\(^{21}\) Vitiello, *Classical chaotic trajectories in quantum field theory*.


\(^{23}\) Naturalism is a necessary but not sufficient step to knowledge (cfr. Vitiello, *My Double Unveiled*). The brain functioning shows the fallacy of the enlightenment illusion that encyclopedia (naturalism) is knowledge.
a new meaning. The vision of the world is thus generated and creates expectations driving the brain in the intentional search of situations considered satisfactorily on the basis of previous experiences. This in turn determines our actions and also provides a test of reliability for our expectations and our knowledge. Our vision of the world thus becomes trustable (credible) or not due to its verifiability. Brain functioning provides a living realization of Galileo paradigm.

3. The aesthetic dimension

In the process oriented towards the ‘optimal balance’ in the trade with its Double the brain continuously puts under discussion the previously reached equilibrium and the whole state of its attractor landscape. The balancing effort is finalized to give a meaning to our ‘being-in-the-world’. The reciprocal emotional exposure between the self and its Double may acquire the aspects of the search for survival²⁴. In this way, the dissipative quantum model formally describes the perception-action arc of neuroscience or the intentional arc in the Merleau-Ponty’s²⁵ phenomenology of perception.

Each rearrangement process of the attractor landscape induced by a new perception provides an always new vision of the world, so that the dimension of the functioning of the brain is the one of the surprise, of the astonishment²⁶... «and suddenly, all at once, the veil is torn away, I have understood, I have seem»²⁷; and of the Now, the magic dimension of the present, the time that stops his course in the photographer ‘surprise’: «when at the precise instant an image suddenly stands out and the eye stops» forcing «the time to stop his course»²⁸. These are the features of the aesthetical experience characterizing the brain functioning, its harmonious ‘to-be-in-the-world’, exposed to the ‘emotion’ of the perception, and the pleasure of exploring, in the satisfying, although never definitive, trade and play with its Double²⁹.

The entire landscape texture of our perceptual experiences is thus described by the aesthetical dimension³⁰, which therefore also enters the construction of knowledge, thus establishing a link with Spinoza’s ‘intuitive science’³¹, and determining

²⁶ Vitiello, The dissipative brain.
²⁸ N. Prete, Doubling image to face the obscenity of photography, in GlobUS - PAriram -Vitiello, Brain and Being, p. 1.
³⁰ DesiderI, Il nodo percettivo e la meta-funzionalità dell’estetico.
itself in the aesthetical judgment which involves always *solely* the first person\(^{32}\), never matter of discussion. Rather, opposing often to previously consolidated views, it carries the flavor of being *ever-sive*. This connects to the chaotiness of the trajectories in the attractor landscape and allows *imagination* and *different views*\(^{33}\) of the world. It also shows that mirror neurons\(^{34}\) cannot be at the basis of the complexity and novelty of behaviors, of *creativity*. A *mimeosis* (after Aristotele) is necessary in order to produce a *variation* of the observed action, an extension by imagination\(^{35}\) of the *meaning* of the world, of its *significance*\(^{36}\). To that aim the undetermined bounds of imaginations are necessary\(^{37}\).

The same *act of thinking*, usually almost synonymous of ‘logical consequential necessity’, appears grounded on the *erratic*, chaotic trajectories in the attractor space. Our possibility of ‘making mistakes’ thus becomes the ‘privilege’ of following unexplored paths, eluding conformity and homologation, opening the possibility to ‘invention’ and ‘novelties’, making the real difference with mechanical machines\(^{38}\). The dissipative model seems to suggest that *errare e pensare* (to err and to think) maybe is not too far from von Neumann observation that «the mathematical or logical language truly used by the central nervous system is characterized by less logical and arithmetical depth than what we are normally used to. [...] We require exquisite numerical precision over many logical steps to achieve what brains accomplish in very few short steps»\(^{39}\).

### 4. Concluding remarks. Towards an integrated ecological vision

The aesthetical experience also implies reciprocal «active responses» in the dialog between the self and the world, which in turn imply responsibility and thus they become moral, ethical responses in a larger social dialog. A ‘social brain’ and social consciousness then emerge in a new dynamical regime where a common ‘culture’ is originated from long range interpersonal correlation. A higher level of knowledge, structured levels of meanings in a shared common view of the world; new cultural atmospheres and trends, whose novelty may even acquire a *revolutionary* character, or simply new ‘fashions’, may span large assemblies of people, which thus become a *community*. Aesthetical experience implies then disclosure, *language*, to *manifest* ‘signs’, including artistic *communication*\(^{40}\), typically not carrying information, but
meanings, with the essential aspect of ‘vagueness’, crucial to leave open the doors to dynamical formation of further meanings.

It is also remarkable that hierarchically structured levels of activity are observed in the coherent structure of the brain background through phase patterns with power-law distributions and self-similarity properties of fractal structures\(^{41}\). The discovery of the isomorphism between fractal self-similarity and (deformed) coherent state\(^{42}\) and the observation that fractal structures occur in a large number of natural phenomena\(^{43}\) suggest that the dynamical law of coherence acts as a basic law of form, a dynamic paradigm ruling morphogenetic processes and the formation of meanings. Coherence is by itself the primordial origin of codes. These are then expressions of meanings (semantic level), not of pure information (syntactic level)\(^{44}\). This view seems to be confirmed by the PCR (polymerase chain reaction) processes commonly used in biology and in recent experiments by Montagnier\(^{45}\). The possibility to duplicate and reproduce DNA molecular chains (the genetic code) through PCR is due to the fractal self-similar property of the electromagnetic signal emitted by the aqueous solutions of DNA. Perhaps, modifications in the signal coherence\(^{46}\) may play an important role in the dynamical origin of epigenetic modifications, which, in such a view, signal the appearance of new meanings associated to deformed coherent signals. DNA appears in conclusion to be the vehicle through which coherence and its dynamical deformations propagates in living matter.

**Abstract**

The brain is an open system continuously attempting to reach the equilibrium with its environment. Its harmonious relation with the world defines the aesthetical experience. This is the primary experience of our to-be-in-the-world, where the perception-action arc in the Merleau-Ponty’s phenomenology of perception finds its description. In its continuous dialog with the world, described in the dissipative model as the brain’s Double, the brain constructs


\(^{42}\) Vitiello, Fractals, coherent states and self-similarity induced noncommutative geometry; Id., Struttura e Funzione. Una visione ecologica integrata.


\(^{44}\) Vitiello, Fractals, coherent states and self-similarity induced noncommutative geometry; Id., Struttura e Funzione. Una visione ecologica integrata.


meanings and knowledge, leading to a meaningful vision of the world. Coherence is the product of the symmetry breakdown induced by the external inputs to which the brain is exposed and manifests itself in the auto-similarity properties of fractal structures. The occurrence of self-similar fractal structures in the brain and in a large number of natural phenomena leads us to the vision of Nature unified by dynamic coherence ruling morphogenetic processes (laws of form) and the formation of meanings.

*Keywords*: Aesthetical experience, Brain dynamics, dissipative systems, Merleau-Ponty’s perception-action arc, fractal self-similarity