Journal of Behavioral and Brain Science, 2015, 5, 348-367
Published Online August 2015 in SciRes. http://www.scirp.org/journal/jbbs
http://dx.doi.org/10.4236/jbbs.2015.59035

New Issue to Modeling Intentionality in the Field of Consciousness

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Received 9 July 2015; accepted 17 August 2015; published 20 August 2015

Abstract

Brentano in 1870s was the first to introduce intentionality to mean "conscious of". At the end of the 1960s, a version of this view was developed by analytic American philosophy to construct a theory of meaningful language. That led Dennett to claim that intentionality was mainly a feature of sentence, not mental states. In contrast, Searle in 1990s rejected the Brentanian thesis and explained intentionality by a biological naturalism. Thereafter, radical eliminativists such as Churchland claimed that all philosophical arguments merited replacement by neuroscientific knowledge. Unfortunately, very few neurophysiological studies attempted to scientifically tackle the problem raised by intentionality. The issue now emerging is a new conception of intentionality based on phenomenological, neurobiological and quantum theories, such as: 1) the notion of "intentional arc" proposed in the philosophy of Merleau-Ponty; 2) the neurobiological and quantum model of Freeman, in which self-organizing pathways are accompanied by quantum transitions in controlling intentionality in brain; 3) the recent hypothesis that some visuo-motor neurons would be involved in controlling these self-organized pathways; 4) the quantum models of Vitiello and Globus, in which a thermofield (dissipative) system governs the dynamic dialog of dual quantum modes between environment and brain. Based on this conception of mind-world interactions, it implicitly appears that intentionality might be a fundamental force which draws us irreversibly towards the future. An alternative hypothesis based on this promising proposal is argued.

Keywords

Intentionality Models, Consciousness, Quantum Theories, Cortical Self-Organized Systems, Visuo-Motor Neurons

1. Introduction

The concept of intentionality is not to be confused with the concept of consciousness. Intentionality has to do

with the directedness or aboutness of mental states. Consciousness is taken to consist in the monitoring of our own states of mind, or else in the accessibility of information to our capacities for rational control or self-report[1]. Likewise, intentionality is not to be confused with intention: intentionality is a pervasive feature of many different mental states, whereas intention is a specific state of mind. John Searle made another key distinction in his account of intentionality. According to him, "all intentional actions have intentions in action but not all intentional actions have prior intentions" [1]. Today, the term of intentionality is usually used to explain how human beings and animals engage the world, and come to understand it well enough to meet their needs. However, the distinction between intentionality and consciousness is often doubtful in a number of neuroscientifics. Several views of the relationship between intentionality and consciousness are discernable in their philosophical positions: consciousness has been regarded as being explanatorily derived from intentionality, or underived and separable or not from intentionality, or underived, inseparable and essential to intentionality[1]. Today, a new issue is emerging to explain intentionality. It is based on three main approaches: the "intentional arc" and the "maximum grip" proposed in the philosophy of Maurice Merleau-Ponty [2]; the reflex stimulus-response arc developed in the neurophysiological and quantum theory of Walter Freeman [3]; and the quantum systems of dual modes conceived by Giuseppe Vitiello [4] [5] and Gordon Globus [6] on the basis of thermofield (dissipation) quantum principles. My purpose is to provide a review of these contemporary dynamic models.

2. Historical Preamble to Issue

The notion of intentionality was founded when philosophers attempted to describe and solve the philosophical problem of specific quasi-relations between consciousness and objects, and the direction of our mind or language to the real world. The term of intentionality derives from the Latin *intendere*, which is literally "to stretch forth" or "stretching-toward" in the medieval scholastic philosophy. Intentionality was introduced by Thomas Aquinas from the biological doctrine of Aristote [7]. He used this concept to describe the process by which human beings and animals thrust their bodies into the world, adjust to the consequences of the action by accommodating to the sites of impact and then change themselves (brain and body) to assimilate, thereby coming to know the world through the adjustments needed to conform. In the 19th century, Hermann von Helmholtz replaced animal spirits with nerve energy [8]. Early in the 20th century, Franz Brentano and Edmund Husserl introduced the central concept of intentionality in their philosophy of consciousness, but with a different meaning. According to Brentano, intentionality meant "conscious-of". In this conception, consciousness has always an intentional character, it is always "about" something or other, "of" this and that [9]. As Brentano, Husserl adopted the concern that "stretching-toward" becomes prescriptive for consciousness, but with properly understanding the way in which thought and experience are directed towards objects: the prescriptive conditions of satisfaction was called "*noema*", and the prescriptive conditions of intentional meaning, the noematic "*Sinn*" [10]. The "*noema*", refers to internal structure of mental act, whereas "*Sinn*" gives the act the very same intentional character that it would have if it did actually have an object. Treatment of Husserl of the Brentanian theme had a wide philosophical influence on the European continent in the twentieth Century: this approach was taken by prominent philosophers such as Martin Heidegger, Jean-Paul Sartre and Maurice Merleau-Ponty under the aegis of phenomenology [11]. In particular, Heidegger reintroduced the original Thomist meaning of intentionality. He described a type of directed comportment towards Being in which it "shows itself" as "ready-to-hand" or available: consciousness succeeded by thrown "*Existenz*", always finding ourselves already encountering Being amidst world affordances [12] [13].

The philosophical notion of intentionality initiated by Brentano was also developed in the logistic-linguistic approaches of the Anglo-American philosophy. These approaches were derived from the studies of Gottlob Frege (1892) [14] and Bertrand Russel (1905) [15] [16]. Central to the legacy of Frege for discussion of intentional content was his distinction between "sense" and "reference". This led to a credo pervasive in analytical philosophy: "sense" determine "reference". Frege applied "reference" (*Bedeutung*) to proper names, where it means the bearer of the name, the object in question, but also to other expressions, including complete sentences. By contrast, "sense" (*Sinn*) associated with a complete sentence is the thought it expresses. The "sense" of an expression is said to be the mode of presentation of the *item* referred to. Thus, the notion of *Sinn* is distinctly intentionality in Frege, the core idea of *Sinn* being the way in which an object is given to us. The exhaustive anal-

[1]Consciousness and Intentionality, Stanford Encyclopedia of University, 2006.
http://plato.stanford.edu/entries/consciousness-intentionality

ysis of complex expressions by Russel was then the important bridge between Frege and the Anglo-American philosophy. Russel is generally recognized as one of the main founders of modern analytic philosophy. He is the philosopher which attempted to discover a logically ideal language. The underlying project of Russel was to obtain a language that will exhibit the nature of the world in such a way that we will not be misled by the occidental, imprecise surface structure of natural language. Particularly, he rejected the distinction "sense-reference" of Frege. For him, "sense" is wholly semantic, whereas "reference" is intimately connected with the name of object. At the end of the 1960s and at the 1970s, some philosophers began to try constructing a systematic theory of meaningful language, and on the basis of such a theory to formulate specific metaphysical statements [17]. Following this view, intentionality was suggested to involve representations with propositional content [18] [19]. Representationalism can be understood as a qualified form of eliminativism, insofar as it denies the existence of properties that conscious mental states are commonly thought to have, namely those that are mental but not representational. Thus, a number of analytic philosophers accepted a version of the thesis of Brentano that conscious mental states exhibit intentionality. For example, the philosophers Michael Tye, Fred Dretske and Martin Davies [18]-[20], although they differed importantly among themselves, did not appear to estrange consciousness from intentionality.

Other analytic philosophers, who accepted also a version of the Brentanian thesis, showed however that the mysteries of phenomenal consciousness can be explained away (*i.e.*, dissolved). Daniel Dennett was the most consistent eliminativist advocate of this view [21]-[23]. For Dennett, for example, there are no properties that meet the standard conception of qualia (*i.e.*, properties of experience that are intrinsic, ineffable and private). Our conception of qualia is so confused that it would be obtuse to try to salvage the notion: qualia should be resolutely denied. Inspired by the method of Ryle [24], Dennett attempted to dissolve the Brentanian approach to intentionality. He suggested that intentionality is not a thing, but only a way to look at human beings. He claimed that we should reject the idea that there is a tenable distinction between the manner in which we represent the way things are, and the manner in which simple intentional systems like thermostats represent the way things are. For him, whenever we look at them this way, we are taking what he calls the "intentional stance". This notion may be defined as the strategy of interpreting the behavior of an entity (person, animal, machine, etc), as if it were a rational agent whose choice of a line of action is determined by the consideration of its beliefs and desires [25]. That is, interest of Dennett in intentionality is shaped by the idea that intentionality is mainly a feature of sentences, not yet mental states. Among the philosophers who rejected the thesis of Brentano, the analytic neuroscientific Searle thought that consciousness and mental acts are essentially and intrinsically connected with intentionality [1] [26] [27]. Searle was not satisfied of the mental-physical cleavage which led Brentano to a kind of dualism. He believed neither dualism, nor materialism have a chance of being right. In this regard, his concept of intentional perception is remarkable [27]. According to him, the concept of perception is an intentional and causal interaction between the mind and the world. The direction of fit is mind-to-world, whereas the direction of causation is world-to-mind. Searle introduced this problem using the following example. When we see a car, we have a certain sort of visual experience. In the visual perception of the car, we do not see the visual experience, we see the car. But in seeing the car, we have a visual experience: this visual experience is an experience of the car. For Searle, therefore, the visual experience is not itself the visual object, it is an experience of the object. That is, Searle rejects the obsolete problem of the mental-physical cleavage and accepts the assertion that mind and world are parts of nature. He opens the problem of intentionality using the expression of "experience of", because the "of" of "experience of" is the "of" of intentionality. He sees the solution of the mind-world problem as a "biological naturalism".

Some eliminativist philosophers argued against these philosophical researches. Rather than rejecting only some of prominent features that are commonly thought, such as qualia and conscious self, several eliminativists were radical in their negative assessment. For example, Paul and Patricia Churchland [28] claimed that consciousness and intentionality are sufficiently off targets to merite replacement by neuroscientific knowledges. Indeed, as our neuroscientific knowledges increase, the relevant new concepts are more reflective of the true nature of mind. In the recent decades, a great variety of contemporary theories have been proposed to explain consciousness as a natural feature [29]. Based on a wide range of analysis and experimental studies, two categories of consciousness models have been performed with physical and neural approaches. Unfortunately, till now, these models have done very little to tackle the fundamental question of the intentional behavior. Stuart Hameroff and Roger Penrose [30], for example, claimed that consciousness is created by quantum physical operations carried out in the brain cells by means of quantum objective reduction involving microtubules. Their hypothesis

was that microtubules could support macroscopic quantum features known as Bose-Einstein condensates. This approach is certainly fascinating, because it collects several top level mysteries, among them the relation between mind and matter, the ultimate unification of cell physical interactions, and the understanding of brain dynamics across hierarchical levels. But such a deep issue does not explain how quantum reduction process could be at the basis of the action-perception cycle for the comprehension of an intentional intelligence in consciousness. Today, the neurobiological models of Stanislas Dehaene [31] and Gerald Edelman [32] can be regarded as neurobiologically sound and accurate descriptions of consciousness. Particularly, it is worth noting that Edelman developed a theory in which he distinguished primary and secondary consciousness, the later being commonly associated with having awareness of our consciousness. This higherorder consciousness was thought to be the activity of the dynamic thalamo-cortical system which converts the signals received from the outside and inside of the body into oneself, what Edelman called "phenomenal transformation". However, although such a hypothesis refers to a direct subject/object relation, implementation of an explicit intentional behavior in multiple neuropathways recursive through the brain, body and environment is still lacking.

Other approaches were also attractive, such as the phenomenal cognitive model of Humberto Maturana and Franscisco Varela and the neuro-cognitive approach of Jesse Prinz. In the original attempt of Maturana and Varela, there is no separation between the cognitive act and the environment, since the interaction between a living autopoietic unit and components of its environment is a global dynamic process, in dynamical equilibrium, emerging from interactions of constituants and interactions of interactions [33] [34]. Here the mind is not in the head, it is in a non-place of the co-determination of inner and outer. Moreover, the sensorimotor and the ideomotor appear to be unified since each of them describes a dynamics that belongs to the same basic process of re-modulation of boundaries between body and world. Therefore, this model cannot reach down to the physical and molecular level of neurobiological understanding so as to distinguish between sensation and perception. It cannot explain how the circular and reciprocal influence of brain and environment supports patterns of intentional behavior. By contrast, the work of Prinz aimed to marry a neo-empiricist theory in cognitive and neurobiological sciences with the main themes found in contemporary theories of consciousness and intentionality [35]. Prinz is well-known for his outstanding contribution to the revitalization of concept empirism in philosophy. He developed a complex and sophisticated theory of concepts which he applied to other domains like a theory of emotions, a theory of intentionality, and a theory of morality. His version of conceptual empiricism is based on the idea that concepts are perceptually derived representations that he calls "proxytypes". Proxytypes are structured representations couched in modality specific formats that we employ in thought, insofar as all (human) concepts are copies of perceptual representations. Prinz claimed that a proxytype version of concepts provides what he calls the "intentionality" and "cognitive content" desiderata better than any current competitor. His theory consists in combining the informational component of informational atomism (*i.e.*, the view that concepts get their intentional content through mind-world relations) with the view that concepts are semantically complex (*i.e.*, the view that concepts have internal structures). According to Prinz, it ought to deliver the intentionality and cognitive content desiderata: intentionality is the property in concepts of representing things outside themselves, and intentional content are the things that concepts refer to [35]. However, some authors, such as Raffaella De Rosa, have recently argued that the hybrid character of the proxytype theory generates a "threatening dilemma": either it is novel but fail to deliver the intentionality and cognitive content, or it delivers these desiderata but then it is not novel [36].

The issue now emerging in the theory of intentionality is a new conception of duality based on interference between receiving and transmitting signals. Such a principle had been put forth by the American pragmatists, most clearly by John Dewey [37] in his critiques of the conditional reflex. It was further developed by Gestalt psychologists, who led to the conception of a field of force which resonated with brain dynamics. Koffka [38] expanded this concept to include interactions between fields of force in the environment and in the brain. James Gibson further introduced the concept of "affordance" to complement his theory of direct perception that stands in sharp contrast with the prevalent inferential theories of perception [39]. Affordance theory states that the world is perceived not only in terms of object shapes and spatial relationships but also in terms of object possibilities for action. This view was similar to the "intentional arc" of Merleau-Ponty, but with the difference that an affordance was provided by information in an object, and the resonance transferred that information into the cortex. According to Merleau-Ponty, the intentional state defined the object in terms of a goal created in the brain, corresponding to "maximum grip", with its unity of inner context [2] [40]. In the ideas of the behavioral concept of Merleau-Ponty, Freeman gave new life to principle of least action of energy minimization. In his

neurophysiological model of intentionality, energy minimization is spontaneously achieved by nonlinear dynamical systems based both on classical neurobiology and considerations of quantum mechanics [41]-[47]. Vitiello further accepted the general view of Freeman, but he introduced considerations of quantum thermofield (dissipation) neurodynamics to explain intentionality and consciousness: he proposed a model of dual modes of the ground on vacuum state [4] [5] [48]-[50]. Based on electromagnetic physical properties, this model of intentionality became highly developed when Globus proposed his own thermofield framework theory of dual modes [51]-[54]. At the same time, theorists such as Johnjoe McFadden [55] and Susan Pockett [56] also suggested that consciousness could be understood as an electromagnetic phenomenon. The starting point for their electromagnetic field theory of consciousness (called "CEMI field theory" by MacFadden) was the fact that every time a neuron fires to generate an action potential, and a postsynaptic potential in the next neuron down the line [57]. Since neurons generate a disturbance in the surrounding electromagnetic field, McFadden and Pockett viewed the electromagnetic field of brain as arising from the induced electromagnetic field of neurons. The central idea of their theories was that the cerebral electromagnetic field creates a sort of representation of the information in the neuronal networks, and thereby a conscious experience. Studies argued indeed that conscious experience correlates not with the number of neuron firing, but with the synchrony of that firing [58]. However, one main difficulty with this theory is that it does not explain how such a electromagnetic process could lead to a single conscious experience in brain.

In contrast to theories of McFadden and Pockett, the models of Freeman, Vitiello and Globus are based on an electromagnetic field (in this case referred to as cortical field) which is constituted by molecular and biomolecular dipoles. This cortical field is postulated to act through quantum coherent waves generated by the molecules in neurons, which are suggested to be propagated along the neuronal networks. Since recent studies have shown that classical electromagnetic waves may be used to implement quantum algorithms [59], the cortical field theory might be able to perform quantum computations. Moreover, the cortical field theory has the advantage of nearly accounting for how information located in millions of neurons could be unified into a single conscious experience in brain. These operations require that massive number of neurons cooperate in spatial and temporal patterns that shift rapidly in concert with the surround. In such a quantum theory, production of activity with long-range correlations in the brain takes place through a mechanism of spontaneous breakdown of symmetry. The symmetry which is considered here is the electrical dipole rotational symmetry. External environmental stimuli are assumed to be the triggers of the symmetry breakdown. The perturbations give rise to phase transitions which are quenched and replaced as rapidly as they are formed, thereby maintaining the system in a robust metastable state. Thus, each system of brain constructs with itself an understanding of its surround, which constitutes its own world. The relations that the self and its surround construct by their interactions constitute the meanings of flows of information that are exchanged during the interactions. However, it is unclear how neuronal pathways of brain might be coupled to quantum systems for building a basic dynamic mechanism underlying intentional action. Recent neurophysiological studies have shed new light on the possible mechanisms underlying the goal-related chained organization of neurons. In particular, the recent discovery of some visuomotor neurons suggested an account on how our actions could be constituted by finely organized motor sequences of neurons to attain a desired final goal [60]. Such motor neuronal systems might be of great interest to explain intentionality. We will describe the approaches of Merleau-Ponty, Freeman, Vitiello and Globus to modeling intentionality, as well as the properties of motor neurons which might play a role in some dynamic processes leading to intentionality.

3. Intentionality in the Philosophy of Merleau-Ponty

The world and the lived body together form what Merleau-Ponty calls an "intentional arc" which binds the body and the world. For example, the movement of the lived body actually creates (produces) an existential space. It is not however the objective movement of the body as such, instead it is the experience of this movement. To feel our body (*kinaesthesia*) is not merely an exercise in self-reflection but the means by which we prehend the world. The "intentional arc" means that the agent acquires skills, those skills are "stored", not as representations in the mind, but as dispositions to respond to solicitations of situations in the world. The kinaesthetic feedback is the means by which we both objectify the world and orient ourselves within it. Merleau-Ponty also recognizes the role of the world (or environment). The "intentional arc" is then the knowledge of how to act in a way that coheres with our environment bringing body and world together. According to Merleau-Ponty: "the life of con-

sciousness-cognitive life, the life of desire or perceptual life, is subtended by an "intentional arc" which projects round about us our past, our future, our human setting […], which results in our being situated in all these respects. It is this "intentional arc" which brings about the unity of senses, of intelligence, of sensibility and motility" ([40], pp. 135-136). Many phenomenologists seek to understand the "contact" with the "primitive fact" of immediate experience. For Merleau-Ponty, by contrast: "the thing appeared to us above as the goal of a bodily teleology, the norm of our psycho-physiological setting […]. The "real" is that environment in which each moment is not only inseparable from the rest, but in some way synonymous with them, in which the "aspects" are mutually significatory and absolutely equivalent […]. The thing is that manner of being for which the complete definition of one of its attributes demands that of the subject in its entirely […]. For example, every touch of colour applied by Cézanne must, as Emile Bernard says, contain the atmosphere, the light, the object, the relief, the character, the outline and the style" ([40], pp. 376-377). For Merleau-Ponty, the "contact" with the "primitive fact" is therefore not made solely by mind, but by the union of mind and body, that is, by an embodied consciousness. Furthermore, according to Merleau-Ponty, the notion of intentionality as "consciousness of" suggests that consciousness possesses that unique ability of placing before itself exactly what it intends to find. It is this notion of placing "before" which extends the notion of intentionality as "intentional arc". Merleau-Ponty says indeed that: "In order to perceive things, we need to live them" ([40], p. 379). In other words, the "intentional arc" is that dimension of embodied-consciousness that does not consciously "weigh up" the given of a situation before acting. Instead, it is the manner in which one becomes "involved in the world through stable organs and pre-established circuits" ([40], p. 87). By embodiment, Merleau-Ponty intends to include all three ways the body opens up a world: innate structures, basic general skills, and cultured skills ([40], p. 146). Merleau-Ponty uses the word "habit" as synonymous with skill, so when he wants to refer to skill acquisition he speaks of "acquisition of a habit" ([40], p. 143). The habit-body suggests that an agent is in full possession of his or her body, and does not need to discover the appropriate bodily part in order to investigate an action. For example, when a baby seeks out an object, she watches the object and not her hand ([40], p. 137). The "hand" is that which the baby is in intimate possession of and does not have to consciously find before it can be used. The fact that the baby unequivocally reaches out suggests that the object sought has already been invested with meaning. In other words, the object sought is already understood as a "thing-to-be-touched", a "thing-that-can-be-grasped", and the hand is already understood as "that-which-can-grasp". The notion of "intentional arc" means therefore that all three ways our embodied skills determine the way things show up for us.

For Merleau-Ponty," maximum grip" names the tendance of our body to respond to solicitations in such a way as to bring the current situation closer to the sense of an optimal Gestalt. Higher animals and human beings are always tending towards getting a maximum grip on their situation. Merleau-Ponty has an original account of what leads one to act on the basis of the skills one has, and to acquire new ones. According to him, in everyday, skillful coping is experienced as a steady flow of skillful activity in response to our sense of the situation. One does not need a goal or intention to act. Our body is simply solicited by the situation to get into equilibrium with it: "Whether a system of motor or perceptual powers, our body is not an object for an "I think", it is a grouping of live-through meanings which moves towards its equilibrium" ([40], p. 153). Skillful coping does not require a mental representation of its goal. It can be purposive without the agent entertaining a purpose. As Merleau-Ponty says it; "A movement is learned when the body has understood it, that is, when it has incorporated it into its "world", and to move our body is to aim at things through it; it is to allow oneself to respond to their call, which is made upon it independently of any representation" ([40], p. 13). For Merleau-Ponty, when we are looking at something, we tend, without thinking about it, to find the best distance for taking in both the thing as a whole and its different parts. When grasping something, we tend to grab it in such a way as to get the best grip of it. Furthermore, "maximum grip" means that we always tend to reduce a sense of disequilibrium. In the tennis, for example, the situation on the court requires my arm to go up and move in a certain way. Thus, the "I can" that is central to account of embodiment is simply the ability of the body to reduce the tension or to complete Gestalt. This is why Merleau-Ponty holds that perception and skill acquisition require an active body. In such a thesis, neural networks provide a model of how the past can affect present perception and action without needing to store specific memories at all. It is precisely the advantage of simulated neural networks that past experience, rather than being stored as a memory, modifies the connection strengths between the simulated neurons. New input can then produce output based on past experience without any specific memories. Neural networks allow us, therefore, to give up seeking an associationist explanation of how the past experience can affect present perception and action. The phenomenological interpretation of Hubert Dreyfus consists also to consider

motor intentionality as a sort of tension experienced through the body [61]-[64]. This tension is endowed with purposely meaning and motivation goal-oriented actions. For Dreyfus, motor intentionality is inseparable from its bodily content and from the environment in which action takes place. According to a sensorimotor account of action, an agent performs an intentional motor-action as soon as he is seeking an adequate response of his body to the environmental situation, because the intensional meaning of the action is exactly determined by the dynamic relation between the body and the world.

4. Intentionality in the Neurophysical Biology of Freeman

For twenty years, Walter Freeman developed a neurobiological model structurally isomorphic with the theory of Merleau-Ponty [41] [42]. According to Freeman, the alternative neurobiological concept to this phenomenological model is the "reflex arc", commonly thought to begin with the delivery of a stimulus to receptors and to be completed with the performances of the response. In this proposal, the stimulated neural networks of brain operate according to the Hebbian theory of learning, that is the strength of connections between the neurons changes on the basis of experience. Such a global interaction of the motor, sensory and associated areas creates spatio-temporal patterns that are conceived to express the present state of brain. From experimental studies on rabbits, Freeman showed that the necessary and sufficient part of the vertebrate brain to sustain minimal "intentional arc" is the ventral forebrain. That includes those parts that comprise the external shell of the phylogenetically oldest part of the forebrain, the paleo-cortex and the underlying nuclei with which the cortex is interconnected. Such a system is a nonlinear neurodynamic one which is destabilized by sensory input, leading to the endogenous construction of its own spatio-temporal pattern of activity. The brain spontaneously self-organizes towards a minimum energy state. This state is called "attractor", although this so-called "attractor" has no active power. To the contrary, this state is the end-product of a self-organizing process. Freeman proposed that: "this self-organizing system has multiple chaotic attractors with their attendant basins of attraction, and the capability for rapid global state changes from each attractor to the next" [41]. The implementation of intentional behavior, therefore, results from multiple pathway loops recursive through the brain, body and environment. It is transmitted by cortical neurons into the brain stem and spinal cord, with feedback via corticostriatal, corticocerebellar and corticothalamic loops constituting the global control loop of the limbic architecture. Thus, intentional action is engendered by a counterclockwise flow of activity consisting of two essential loops: a loop that regulates by circular causality the body, all the sensory systems, the entorhinal cortex and all the motor systems, and an inverted loop that regulates by circular causality all the sensory systems, the entorhinal cortex and all the motor systems (**Figure 1**). That means that the global control system engulfs not only the limbic system and sensory cortices, but also the motor cortices that implement action, and the hippocampus that implements multisensory integration and space-time orientation. In the theory of Freeman, therefore, intentionality "orchestrates" the musculoskeletal system, the autonomic nervous system, the neuroendocrine system and even the neuroimmunological system.

Pre-afference signals compensate for the self-induced changes in informational input that accompany the actions organized by the limbic system, whereas pre-efference signals prepare the effectors for preferred actions on anticipated objects in the world. Freeman experimentally showed that the intersection of pre-afference and pre-efference with the input flux produces a succession of brief durations at *theta* and *alpha* frequencies (called "frames"). Each frame has its own adequation and optimizes towards assimilating intention to reality. External reality is considered to be an extrinsic constraint joining with intrinsic constraints on the self-organizing nonlinear dynamical evolution of the brain system towards attractor states. Each new frame is a phase transition which is a classical condensation of a quantum global property called "Many-Body theory" by the physicians. Many-Body theory is an area of the quantum field theory that deals with the condensation (condensation of Bose-Einstein) of large numbers of particules such as the Nambu-Goldstone (N-G) boson. The global collective mode over macroscopic regions, indexed to local cortical field potentials, is indeed identified with the N-G mode of Bose-Einstein condensation in the quantum vacuum state[2] [43]-[47]. Let us recall that one has a spontaneous symmetry-breaking if the dynamics of the system have a global symmetry that the states of the system

[2]The quantum vacuum may be viewed as an ocean of energy that permeates the whole universe, making the vacuum in reality a plenum. It can be represented by the residual statistical fluctuations of a state fundamental vector which is called "vector of Fock" (symbolized by the ket $|0>$). Fluctuations of the ket $|0>$ can be interpreted as being "jumps" quantum h [66]. To obtain an absolute vacuum, it is not enough to disencumber any matter, it is also necessary to lower the temperature towards the absolute zero to eliminate the thermal radiation (which is observed, for example, in the Black Body of Planck). It exists therefore fluctuations of "item zero" at null temperature: the quantum vacuum is then defined as the state of a fundamental field in which the energy of fluctuations is minimal.

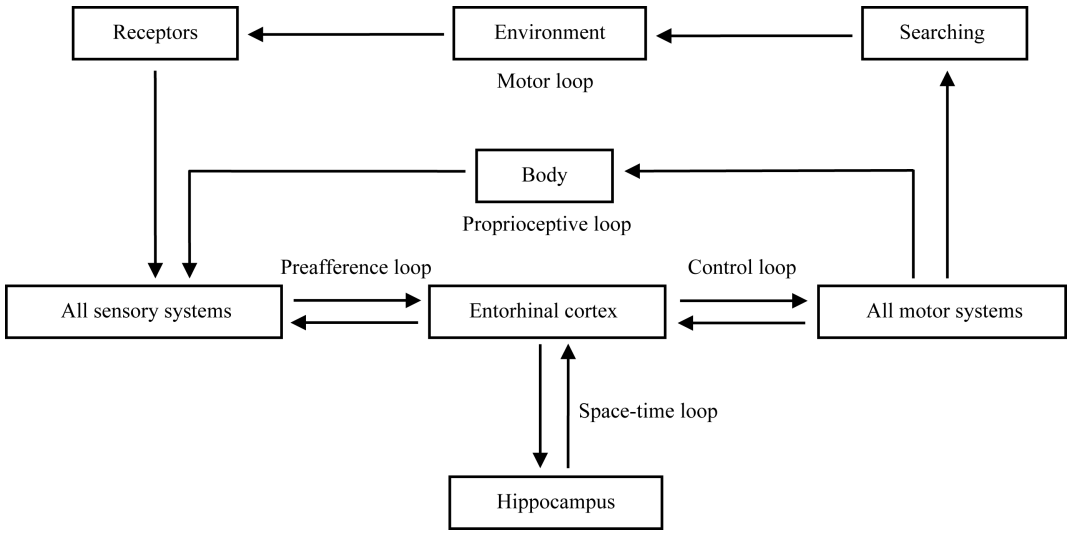

Figure 1. The implementation of intentional behavior by multiple pathways recursive through the brain, body and environment (from Freeman, [42]-[47]).

do not have. For example, let us imagine a matter field of quarks and leptons whose potential has the Abelian global symmetry of a mexican hat [65] (**Figure 2**). The symmetrical state of energy of the hat is unstable, except in the hat drain where there is a state continuum of stable energy: a ball would not hold in equilibrium at the top of the hat but would be stable in the hat drain. To introduce symmetry-breaking is therefore equivalent placing the ball at a selected place of the drain to break its continuum of symmetrical energy. In this case, the theorem of Nambu-Goldstone stipulates that there is a N-G mode of Bose-Einstein condensation, called the N-G boson, in the chosen quantum vacuum state. Since the N-G boson is a massless particle, it makes possible to pass from the chosen state to another state in the hat drain without changing its energy. It results from this conjecture, when there is symmetry breakdown, that the vacuum is an ordered state and massless particles propagate over the whole system which are the carriers of the ordering information (long range correlations). Order manifests itself as a global macroscopic property which is dynamically generated at the microscopic quantum level. The N-G mode is therefore the bridge between the quantum field theoretical level and the classical level of frames of local cortical field potentials.

To sum up, the dynamical view of Freeman proposes principally that a self-similar hierarchy of neurobiological patterns is continually assimilated through interactions of the brain with the multiple environments of the body and world, in forms close to those of Aquinas and Merleau-Ponty. In spite of a diffident quantum approach in accounting for intentionality, however, such a system appears to remain primarily classical. Indeed, as Globus suggested it [54], the model of Freeman seems to provide only a theory of traces modeled on the N-G boson mode. In this model, intentional awareness appears to be the true primitive experiencing of objects to account for world appearances that fulfil intentions. It should be noted that consciousness is meant here to be a self-organizing control on the succession of aware states. Dreyfus also described close correspondences between nonlinear brain dynamics and the basic conceptions of intentional behavior dynamics [61]-[64]. However, he began with concepts that emerge far above the raw sense data. Owing to this entry at only a phenomenological level, he could not reach down to the level of physical processes so as to distinguish accurately between sensation and perception.

5. Visuo-Motor (Mirror) Neurons in the Formulation of Intentionality

In the early 1990s, Giacomo Rizzolatti, Giuseppe Di Pellegrino, Lucians Fadiga, Leonardo Fogassi and Vittorio Gallese, a team of neuroscientists at the University of Palma, made a surprising discovery about a distinct class of visuo-motor neurons found in the ventral pre-motor cortex (area F5) of the macaque monkey. With electro- and magneto-encephalographic methods, they discovered that these neurons become active not only when the monkey performs a given motor act (like grasping an object), but also when it observes another individual performing a similar act [67]-[69]. That is, although these “mirror neurons” are part of the motor system of brain,

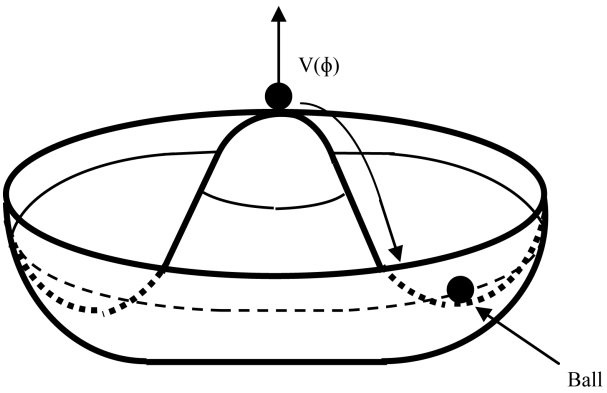

Figure 2. Potential (V[ϕ]) of matter field in the shape of Mexicain hat (From Cohen-Tannoudji & Spiro, [65]).

they seem to be correlated not only with specific movements, but also with specific goals. Further studies showed also that the observation of grasping hand actions activates the rostral part of the inferior parietal lobule, including the cortex within the intraparietal sulcus and some prefrontal areas [70]. These experiments indicated that many neurons of the inferior parietal lobule are active during the execution of specific motor acts, and many of them also respond to somatosensory and visual stimuli: these neurons have therefore mirror properties very similar to those of F5 neurons. More recent experiments using functional magnetic resonance imaging provided evidence that, in human too, the inferior frontal cortex and the superior parietal lobe are active when the person performs an action, and when the person sees another individual performing an action. Thus, it was admitted that these human brain regions are also mirror neuron systems [71]-[73]. The existence of mirror neurons raises therefore questions of great importance to neurophysiologists. Particularly, the possible role of mirror neurons in the dynamic process leading to intentionality is under active discussion. In order to support this conjecture, a computational model has been recently proposed by Wiedermann [74]. The model consists of two neural network-like systems called "mirror neural net" and "cogitoid". Attached to these systems are so-called perception-motor units. Each perception-motor unit delivers corresponding perception-information to the "mirror net", and the "cogitoid" sends instructions for motor actions to perception-motor units. Of course, such a computational project is more speculative than experimental, but it might open the road to elucidating in the near future some principles underlying intentional behavior and cognition. It is very interesting that account of Merleau-Ponty's skillful coping by Freeman seems at least hypothetically compatible with the mirror neuron theory. If we think that each kind of adaptive and goal-oriented action corresponding to a mirror neuron circuit consists in a specific type of skillful coping, then we can assume that this circuit might work like (or together with) an attractor basin. It is indeed plausible that the attractor basins could match perceptual states and motor reactions exactly like mirror systems do. This suggests that these two intervening systems could be reciprocally enriched by their unification. However, since the basins are temporary and elastic structures, perceptual stimuli and motor responses may be two functionally separate moments of these neural networks. In contrast, perceptual stimuli and motor programs appear to be more strictly matched in mirror neurons. In addition, it is not mandatory that the two intervening systems coincide from a strict anatomical-functional point of view. Indeed, the basic type of expertise corresponding to the activation of mirror neurons appears to concern organized motricity, whereas the attractor basins seem to contain expertise only in somatosensory and perceptual information. In other terms, mirror neurons may codify primarily how one should act according to goal, whereas attractor basins may codify what one should perceive in order to act [75].

The discoverers of mirror neurons suggested that these visuo-motor cells could be the neural basis for our ability to understand action of others, called "action understanding" hypothesis. The postulated view was that we understand the intentions of others because we are able to represent them as having mental states. Without this meta-representational ability their behavior would be meaningless to us. What emerges from these proposals is that mirror neurons would have a central role in imitation-learning, simulation of other people's behavior, empathy, speech and even action. However, the odd thing about it is that they do not respond to patamimes, or to meaningless gestures, or to random animal sounds. Rather, mirror neurons seem specially tuned to respond to

actions with clear goals, whether they are perceived through sight, sound, or any other sensory stimuli. Despite excitement generated by the discovery of mirror neurons, a number of scientists have therefore expressed doubts about their role in explaining intentionality. One of the first scientists to question the role of mirror neurons was Oreg Hickok, who published an extensive argument against the claim that these cells are involved in action-understanding [76]. Hickok performed several dozen studies and found dissociations between motor control and conceptual understanding. He concluded that action understanding is clearly not a function of the motor system. Patricia Churchland also expressed both scientific and philosophical objections to the theory that mirror neurons would be responsible for understanding the intentions of others [28] [67]. Churchland stated that: "A neuron, though computationally complex, is just a neuron. It is not an intelligent homunculus. If a neural network represents something complex, such as an intention, it must have the right input and be in the right place in the neural circuitry to do that" ([28], p. 142). Recently, Cecilia Heyres advanced the thesis that mirror neurons are not evolved specifically for understanding, imitation, or any other purpose [67] [77]. According to her, they are simply ordinary motor-cortex neurons that happen to take a social role as we learn to associate motor action with sounds, feelings, goals and so on. In other terms, mirror neurons in humans would be the product of social interactions and not an evolutionary adaptation for action-understanding.

6. Intentionality in the Neuroquantology of Vitiello

As indicated above, a number of studies have used concepts of quantum physics for inquiries into the nature of consciousness and intentionality [78]. Among these approaches, the one with the longest history was initiated by von Neumann in the 1930s, later taken up by Wigner, and currently championed by Stapp [79]-[81]. Since the 1980s, Stapp developed his own point of view on the background of von Neumann and Wigner. He started with the distinction of Heisenberg between potential and actual event. In Heisenberg, the notion of actual is related to measured events in the sense of the Copenhagen interpretation of the quantum physics[3], whereas the notion of potential, of tendency, relates to the situation before measurements or expresses the idea of a reality independent of measurements. In the theory of Stapp, immediately after its actualization, each event holds the tendency for the impeding actualization of another subsequent actual event. Therefore, essential move is to attach to each actual event an experiential aspect, called the feel of the event, which is considered to be the aspect that gives the status of the actual event as intrinsic reality. This is related to the cosmology of Alfred North Whitehead [82], in which mental and physical poles of so-called "actual occasions" are considered as both psychological and physical aspects of reality. In a more recent communication, Stapp [83] [84] specified that ontological features with respect to process of Whitehead are intrinsically correlated with the process of quantum state reduction. He related the fundamentally processual nature of actual occasions to both the state reduction and the correlated psychological intentional act. Another idea, proposed by Ricciardi and Umezawa [85], was to treat mental states, particularly memory, in terms of vacuum states of quantum field. In such a quantum system based on the Many-Body theory, an agent acts as a trigger of spontaneous symmetry breakdown with the consequent condensation in the ground state of N-G modes, and in this way it induces the dynamical process of the ground state ordering [65] (**Figure 2**). Different external inputs or agents may thus trigger different ground state orderings corresponding to associated different short-term recordings. However, in this model, there is a problem of capacity of memory because each recorded memory appears to destroy the previous record. Consequently, when the sensory signal recorded by the macroscopic N-G condensate is repeated, the memory trace is activated and consciousness, tantamount to activation of memory traces, is likely not capable of taking an intentional point of view on the world.

The extension of the quantum model was required in order to solve the problem of memory overprinting that seemed to be a strong defect in the model of Ricciardi and Umezawa [85]. The brilliant solution proposed by Vitiello is a model of modes of the ground on vacuum state. The ontological significance of the proposal lies in the primacy of duality, a new conception of duality sharply distinguished from the classical dualism. Here the duality is that of a system in which brain is opened to external world (process of dissipation) [48] [87]. The ontological bonus of this new duality is its between: ground is between-two. Brain system and environment are time-reversed, in that when one gains energy, the other loses it, and *vice versa*. The brain system is labeled

[3]The interpretation of Copenhagen considers that we never deal directly with the quantum objects of the microscopic realm. We therefore need not worry about their physical reality, or their lack of it. One of the key elements of this interpretation is that the Schroedinger equation or the Heisenberg matrix gives the probability of observing particular outcome when an experiment is performed. An experiment that allows such a calculation of effects of quantum objects on our macroscopic instruments is enough for us to consider [86].

"non-tilde-mode", and the environment is labeled "tilde-mode". The tilde-mode is the time-reversed copy of the non-tilde-mode, *i.e.* its conjugate image, its "Double". These dual modes are unavoidably coupled, lacking independent existence in the quantum thermofield dynamics of the open brain. As already indicated, the elementary constituents are vibrational electric dipole fields of water molecules and biomolecules present in brain. When sensory inputs dissipate their energy and fall into the ground, the symmetry of electric dipole fields is broken. Under energy conservation law such broken symmetry must be conserved. The preservation is then in the form of a dynamically created boson condensate (N-G bosons) which may extend over macroscopic regions. This macroscopic N-G condensate is the memory trace. For Vitiello, since there are infinitely many unitarily inequivalent ground states, sequential recording of inputs does not overlap but accumulates, so that, contrarily to model of Ricciardi and Umezawa, the brain achieves a huge memory capacity [4] [5] [46] [47] [49] [50]. Such a thermofield quantum dynamics is based on a continuously coupled heat bath (the environment) with which the dual mode system can exchange energy to maintain its broken symmetry process [4] [5]. Contrarily to a closed system that irreversibly leads to a stable equilibrium state, Lya Prigogine and its co-workers showed indeed that an open dissipative system can maintain itself in an instable ordering state at far-from-equilibrium conditions. Let us point out the thermodynamic principle on which this open system rests. Given an open system which exchanges energy and matter with the outer world. The entropy variation d_oS/dt of the increasing macroscopic uniformity of the outer world is added to d_iS/dt, the entropy variation of the inner world of the system, so that $dS/dt = d_oS/dt + d_iS/dt \geq 0$: the system underlies its entropy evolution towards an ultimate thermodynamic equilibrium (second thermodynamic law). Therefore, the differential variation dS of the entropy flux has always a negative or zero value ($d_oS \leq 0$, $d_iS \leq 0$). When the system is isolated, $d_oS = 0$ and $d_iS/dt \geq 0$. However, when the system is opened, it is possible that d_oS becomes sufficiently negative to exceed d_iS in absolute values, so that one would have permanently $dS/dt < 0$. It is exactly what occurs in open dissipative systems which maintain themselves at far-from-equilibrium conditions [88]. These conditions are obtained in providing the sufficient energy to open the system from the outer world, in order to keep permanently far-from-equilibrium conditions between the inside and the outside of the system. One can therefore briefly summarized the proposals of Vitiello as follows: 1) The brain is a system permanently coupled with the environment, an open or dissipative system; 2) There is nothing changes if the dual modes exchange quanta; 3) When quanta in the non-tilde-mode are exited out and annihilated, then an equal number of quanta must be created in the alter tilde-mode of the vacuum; 4) Since, as shown above, N-G quanta are condensed in a state of minimal energy, the crucial property of the quantum field theory is the existence of infinitely many states of minimal energy, the so-called vacuum states or ground states, and on each of them there can be built a full set of other states (a space). There are thus infinitely many state spaces. The vacuum of each of these spaces is characterized by a specific ordering and is identified by its code, the value of the order parameter, that is taken to be the memory code. Vacua identified by different codes are distinct ones: they are unitary inequivalent vacua which guaranty protection from memory overprinting. The differently coded vacua are therefore accessible to the memory printing process [4] [5] [49] [50].

Under the usual quantum terms, the two-mode state is "entangled" in the vacuum state, in the sense that it cannot be factorized into two single-mode states, the non-tilde-mode and the tilde-mode. The quantum term of "entanglement" represents the impossibility of cutting the link between the brain system and the external world. The brain/environment interaction cannot be switched off because there is an unavoidable dialog between the non-tilde-mode and its Double. Indeed, if the system would allow the existence of the non-tilde-mode independently of the existence of the tilde-mode, then the system would be deprived of its physical essence which is the dissipation. Moreover, in the absence of dissipation, any time could be arbitrary taken to be the origin of the time axis, because the origin could be freely translated without inducing any observable change in the system. To the contrary, dissipation induces a life-time which carries the memory of "when" the dissipative system has started. That is a true origin, so that memory and origin of time are the same thing. The time axis is divided by a singular point, the Now, which divides the past from the future. According to Vitiello, the Now is that point on the time-mirror where the non-tilde-mode and the tilde-mode join together in the Present [48] [49]. The Now continually renews itself in the dialogic relation of the non-tilde-mode with its Double. By introducing the Now, information continuously introduces the feeling of past and future of the arrow of time pointing forward in time. Thus, the dialog between the environment and the brain is necessary and evolutive, because it carries the memory, the story of the past, and is inserted in the psychological and cosmological arrow of time. In the present theory, since tilde and non-tilde conjugate in a circular (non-linear) recognition to join together in the Now, consciousness appears to reside in this permanent dialog and thus to be rooted and diffused in the between-two,

in the dissipative brain dynamics [4] [5]. In other terms, the root of consciousness seems to be grounded in the permanent trade of the brain with the external world, on the dynamical relation between the non-tilde and its Double. Since consciousness is between-two, it is therefore only possible if dissipative opening onto the outside world is allowed. Thus, the conscious identity emerges at any instant of time, as the minimum energy of brain state which separates the past from the future: this active point of view on the world carries in it the unfaithfulness of subjectivity and constitutes permanently the self. In such a scenario, input acquires a sense, a meaning, a meaningful representation implying adaptiveness and plasticity of brain. Moreover, it is interesting to note that whether consciousness is a function of the brain, it is possible also to consider that the brain is a function of consciousness since the brain cannot avoid to be an active/passive system. However, in addition to criticism arguments of Globus (below-mentioned), one difficulty with this model is that external inputs may comprise only one portion of informational movement. Indeed, the brain itself might possibly generate a plethora of signals which are intentional self-tuning ones no different from signals arising from sensory inputs. It is therefore unclear how such intentional self-tuning signals might be incorporated into the dissipative model of Vitiello.

7. Intentionality in the Neuroquantology of Globus

According to Globus, the tilde-Double is anything but intentional in the theory of Vitiello, because it is locked into copying the doubled non-tilde [54]. For Globus, the problematic key in Vitiello is the conventional quantum brain/consciousness relationship which has made no clear advance on the intentionality appearances that we encounter right now. For him, it is more advisable to consider the relationship between the quantum brain and Being, the quotidian world appearances that we encounter right now. As noticed by Globus, what "is", within the framework of the theory of Vitiello, requires an observer who stands outside and knows how things turned out. Without the observer, this quantum theory is completely blind to observables, having only probabilities of Being. In the Vitiello's model, the dual modes are like actors forced to act. The subject is the action whereas the play is the between-two. But in the dialog between the actor-modes there is no occasion for reciprocity, because the participants in the dialog are already in full agreement [52] [88]. In order to overcome this conceptual difficulty, Globus attempted to solve the problem of intentionality within the horizon of surprising overlapping formulations of the physician Bohr and of the philosopher Heidegger. Let us recall that the central concern of Heidegger is with the "*Seinsfrage*", the question of Being, which is an ontological investigation into the meaning of Being. In contrast, the quantum approach of Bohr is "ontic", only operating within a commitment to Being in the guise of observables. For both Bohr and Heidegger understanding of the quantum domain is a reality which is inaccessible, unknowable, unrepresentable, inconceivable, untheorizable and undefinable (it is in itself neither wave nor particle): their approaches are compatible with respect to the unspeakable at the quantum level [13] [89]. However, there is an Heideggerian supplement which is not found in the theory of Bohr. For Bohr, the difference between quantum and classical levels is essentially a scale change. For Heidegger, Being of world is not a mere shift in the scale of our consideration but a gift of an Abground operation: the event of lighting-up or disclosure. Heidegger wants to explain the lighting-up as the state of a between which is between-two. In such a conception, on the one mode there is the Abground gift of Being, of world, on the other mode there is the Abground gift of being "there" (*Dasein*). Dis-closure occurs between these two gifts of Abground: it entails an action on closure of Abground in which Being, the Presence as such, appears. As argued by Globus [52] [53], in the philosophical context of the Heideggerian Abground, Being is obtained through the contribution by Abground of the quantum brain: Being ontologically depends on Abground [13] [55] [89]. Such an Abground cannot be "outside" the brain because Abground has no spatial properties: it is a pre-space-time that sustains the projection of space-time whilst staying-away, an originary essential sway. Abground is not an eternal plenum which lasts forever. Rather, it can withdraw in the moment in order to return again, and is beyond objectuality, originary to no-thing. Abground is a closure that operates to dis-closure, so that one can identify the dis-closure with truth, lighting, clearing, the Heideggerian *Dasein* [53] [55]. For Globus, therefore, other than Being there is only the "is" of default of the approach of Vitiello, an alter that is an Abground lacking in all Being. It should be observed that the proposal of Globus is still a version of ontological duality, but it is quite different from the *res cogitans* and *res extensa* of Descartes or of two aspects of the neutral reality of Spinoza. The present proposal is a dualism of quantum modes in which the *res extensa* is constituted by their between-two, and the *res cogitans* is one of dual underlying modes. In this assumption, the dualism is formatively creative: it gives birth to Being, fruit of the between-two.

In the thermofield-holoworld framework model of Globus, intentional (self-tuning) and/or sensory inputs are represented in the non-tilde-mode (so-called Double or memory trace), and recognition trace of these signals are represented in the tilde-mode. Furthermore, in contrast to dual modes that must always locally make a match in the theory of Vitiello, the dual modes in the theory of Globus need not match locally, although they must match globally in conformity with the fundamental law of energy conservation [6] [51] [53]. In this alternative representation, the non-tilde-mode is not necessarily the mirror-image of the tilde-mode in the between-two of dual modes. According to the theory of Globus, when an input comes in and is recognized, quanta are exited out the non-tilde-mode of the vacuum and annihilated from the non-tilde vacuum state. It follows from the energy conservation law that an equal number of quanta must be created in the corresponding tilde-mode. After a time, the exited quanta dissipate their energy and fall back into the non-tilde-mode of a different vacuum, creating quanta there. But then an equal number of quanta must be annihilated from the tilde-mode. Globally across vacua, quanta are equal in number across dual-modes, but locally, in a particular vacuum, there may be dual-mode inequality so long as the total energy remains constant [52]. In other terms, when the intentional (self-tuning) and/or sensory signals are repeated, this repetition energizes the non-tilde trace out of the vacuum, from which it follows that quanta are created in the tilde-mode. However, when the repetition of intentional and/or sensory signals is again repeated, then there is possibly a match between-two, the belonging-together of intentional/sensorial signals and of their recognition traces: this match occurs between the intentional/sensorial signals of the non-tilde-mode future approaching towards the Present, the Now, and the recognition traces of the tilde-mode past approaching towards the Now [6] [51] [53] [55] [88] [90]. Such a dual mode match is not consciousness, as in Vitiello, but existence: “intentional fulfillment, world dis-closure with us always already amidst its affordances” ([6], p. 234). It corresponds to an achievement of the thermofield dynamics under an energy minimization principle, that is an achievement in the intentional dis-closure of Being. This extent of belonging-together is a new degree of freedom. Globus is not content with the conventional attitude that distinguishes the classical split subject/object or the immanence/transcendence of Husserl. For Globus, consciousness is not between-two, but only “world thrownness”. For him, there is no consciousness of the external world: consciousness is no longer perceptual, not an “immanent consciousness-of-transcendent-being”, but pure thought, as in the *res cogitans* of Descartes deleted of all substantival properties. It is a consciousness blinded, confined to thought, decentered, shorn of perception, that is only intellectual. We simply find ourselves in the world, always already amidst pragmata, without prior ground. Our existence is to be such. Our situatedness is an attunement to perform experiments.

Although the way of thinking of the present model is complex and unconventional, it can be more easily comprehended if a physical and mathematical interpretation is given. Let us recall that there are infinitely many coded vacua accessible to memory printing processes. As mentioned above, these processes are not only generated by external inputs, but possibly also by a plethora of brain intentional (self-tuning) signals. Intuitively, the statistical distribution of different point-oscillators of dual modes should therefore be a chaotic scattering, of which each point-oscillator would correspond to trivial values of amplitude, frequency and phase (since each mode is not necessarily balanced with its alter mode). Nevertheless, amidst this scattered oscillator population, a myriad of point-oscillators might be remarkably ordered, confined to a critical zone where amplitude, frequency and phase would achieve a perfect balance. These nontrivial values would correspond to physical situations where a chaotic attractor comes back aperiodically to its initial state. The nontrivial points would be points where the dual modes balance, belong-together, whereas for all trivial points the dual modes would be imbalanced. These arguments are supported by the prediction of the fundamental theory of prime numbers. Let us recall that the prime numbers cannot be factored into more basic components: they appear to be randomly scattered on the real number line. In 1859, the mathematician Riemann converted the chaotic disorderliness of prime numbers to a striking order. Euler had shown that a certain function Zeta is grounded in powers of prime numbers. This function takes a number as argument and converts it to exponents on a serie of integer reciprocals. Artfully, Riemann used complex numbers (c-numbers) as arguments of the function Zeta, so that the values of this function were also complex numbers. By this mathematical trick, he represented geometrically the argument/value relationship by a complex c-plane whose the horizontal axis is the real number line, the vertical axis is imaginary, and a third vertical axis represents the values of the function Zeta for the different c-planes. Each value point can be thus conceived as a dual mode-like oscillator with an amplitude, a frequency and a phase. Now, there is a critical region of the argument c-plane. Riemann showed that the nontrivial values of the function Zeta have all a real part 1/2, while the imaginary component varies [6]. Geometrically, there is a vertical

line in the c-plane at real part 1/2, the critical line along which these nontrivial values lie. Explicitly, indeed, when the real part of one oscillator mode increases, the real part of the other oscillator mode must decrease proportionally. It follows that the only place where oscillator dual modes can balance in amplitude is at 1/2. These modes are mirror images, so their frequency must balance too at 1/2. Furthermore, the dual phases of each oscillator-point must be polar opposites at 1/2 [6]. This precise prediction of the Riemann prime number hypothesis shows how the achievement of balance of amplitude, frequency and phase might be the necessary condition for having the dual-mode match. It gives some mathematically plausible hints as to why such a dual mode match would correspond to an achievement of the thermofield dynamics under a minimal energy.

Two main difficulties however arise with this quantum theory. On the one hand, the quantum models of Freeman, Vitiello and Globus should necessarily behave as systems in which one maintains inner temperatures compatible with the requirements of vacuum states (as described in physical theories, the vacuum states require extremely low temperatures). Indeed, information in quantum theories of intentionality should be encoded by a physical substrate capable of encoding a message complex. Now, these theories appear to ignore this requirement. Even if it could be physically feasible to maintain a Bose-Einstein condensate in a hot wet brain, it is not easy to admit that such a state would be a substrate for intentionality. The reason is that quantum states are nearly always small and simple, because as they get larger and more complex, it becomes hard to maintain all the information in a coherent state [91]. Although a single qubit, in principle, stores an infinite quantity of information, in practice this information is difficult to exploit because decoherence increases as the complexity of the system increases, reducing the qubit to only a classical bit. Therefore, how the relatively high temperature of macroscopic objects such as molecular electrical dipoles in brain might be compatible with the quantum properties is at the present time an answerable question. On the other hand, the model of Globus links structure and function but fails to link them explicitly with experience. Recently, to address the explanatory gap between structure/function and experience, Ram L. P. Vimal [92] [93] explicitly incorporated the concept of subjective experience in the thermofield logic of Vitiello and Globus. In his theory, the fundamental subjective experiences are simply potentialities or possibilities that must exist on their own as mental aspects in the context of particular experiments or observations. Such a subjective experiences do not reject the models of Vitiello and Globus, rather they propose to complement them by providing an ontological interpretation. However, although the subjective experiences are fundamental and irreductible and hence must inherently exist, the term “subjective experience” is not clear: its meaning is the experience by subjects when they view external objects. Is subjective experience the quality of the external object or that of neuronal networks of brain? The response of Globus is as follows: 1) We always find ourselves already amidst a world of colors, sounds, and so on; 2) The fact is world-thrownness; 3) To say that we experience this world is to add something to the Heideggerian facticity (*Faktizität*) of world-thrownness, creating a duality; 4) Experience is superfluous, a manner of speaking grounded in dualistic metaphysics, a separation between experience and thing; 5) “I am amidst a world” has the same meaning as “I experience being amidst a world” in the thermofield-holoworld framework (Globus, personal communication, in ([93], p. 17)). That is, the model of Globus seems to eliminate subjective experiences, and hence bypasses the explanatory gap of materialists, whereas the model of Vimal does not eliminate subjective experiments but designes them in such a way that other various problems are bypassed. Thus, one can say that both frameworks commit bypass-mistake.

8. Discussion

The theory of Freeman has the advantage of directly addressing both to neuronal level and to quantum level to explain intentionality. His machinery of Many-Body field theory enables to model cerebral hemisphere and its hierarchy of components down to the atomic level as a fully integrated macroscopic quantum system, in the sense that some of its macroscopic properties cannot be described without recourse to quantum mechanics. The Many-Body field theory is a tool capable of making understandable both the dynamical origin of long range correlations, their rapid and efficient formation, their stability, the multiplicity of coexisting and non interfering ground states, their degree of coherence and the transition to quantum scale. In his model, Freeman maintains the classic philosophical duality between appearance and essence insofar as the neuronal networks are the true ground from which proceeds intentional action. Quantum processes enter only as a mechanism of communication between the different regions of brain. That is, contrarily to models of Vitiello and Globus, intentionality is essentially here of neurobiological nature. Since intentionality is based on spontaneously self-organized net-

works of brain, the problem then is how this dynamical system might draw us irreversibly to the future in the intentional act of perceptual experience. Freeman proposes that a self-similar hierarchy of patterns emerging from the structures of knowledge that are stored in the synaptic tissues of the brain, is continually assimilated through interactions of the brain with multiple environment of the body and world. For him, the first stage of perception is the attentive stage of hypothesis formation in an array of ground states described as an attractor landscape with multiple basins. The second stage is the testing stage of selection by input of one of the basins among these ground stages, leading to emergence of wave packets in the primary sensory areas that express the attractor. The signals conveying the selected classes of input from all sensory cortices converge to the entorhinal cortex and are unified into cortex, whereby the global state of the forebrain is updated and the action-perception is completed. But the question remains to know what is the constraint, the final cause, which draws irreversibly the successive perception-action cycles towards the future.

In contrast, the quantum models of Vitiello and Globus do not maintain the traditional phenomenology link between the subject and the object. They can be thus interpreted in terms of Being univocity. When the thought is deployment of Being-One, indeed, its element cannot be any division in Being as plurality of ontological sense, such as Being in oneself and Being for oneself: Being must say itself in only one ([94], pp. 52-55). Being-One supposes the withdrawal of any ground, the inexistence of any destinale base. In the theories of Vitiello and Globus, the Now is the world-presence of the conjugation of non-tilde and tilde modes; it marks the Present, the origin-point on the axis of times which identifies the memory with the true origin of time. Now, in the logic of Being univocity, the Present (Now) is a point of opening in the flux of the Bergsonian duration. It is a creative scission because it is duplicated in two heterogeneous directions, one springing in the future and the other in the past ([95], p. 109). In this operation, the past becomes a total memory which is the being of time as pure duration. Therefore, in the between-two of non-tilde and tilde modes of two quantum theories, time is deep-rooted in the duration as permanent action of Being-One. In this Platonic univocal sovereignty of Being-One, Being is the reserve of dissimilar productions of actuality whereas the Idea is the total pure virtuality ([96], p. 69). Let us recall that for Bergson and Deleuze, contrarily to concept of possibility that consists in thinking on the mode of production, virtuality supposes that there is a dynamic and temporal dimension of Being, appealing unceasingly future events always singular and changing. For these philosophers, virtual action is a call “to become” ([94], pp. 269-274). In the quantum theories, there is therefore an intrinsic internal telos that is the nominal virtuality/actuality couple. It is easy to show that this virtuality/actuality pair rests on fundamental principles of the quantum physics. Indeed, the strategy of quantum mechanics consists in aiming the micro-systems which are not directly perceptible but have *a priori* the potentiality to appear. The first and principal stage of this strategy is characterized by an experimental investigation (say P) that is strictly a-cognitive. Labelling P does not point here towards a micro-object not perceived whose state, apprehended at the moment of the test, would be regarded as an intrinsic property preexistent before the act of investigation. In this test, P actually points towards a micro-state which is confined out of the field of knowledge before the investigation. The objective is to make emerge an observable trace of this virtual micro-state in the continuum of reality [97]. Examined in terms of philosophies of Bergson and Deleuze, the strategy of the quantum investigation consists in choosing an experimental preparation which conceals the positive power to make appear suddenly a trace, whose actualization is always a differentiation of the virtual ground. The virtual micro-state that makes emerge a trace is *a priori* an unknowable-future which has been aimed by the past experimental cognitive act. In the terms of quantum theories of Vitiello and Globus, it can be therefore admitted that the intentional (self-tuning) and/or external world signals (tilde-mode for Vitiello, non-tilde-mode for Globus) are virtual elements that spring in the future, whereas the recognition traces of these signals (non-tilde-mode for Vitiello, tilde-mode for Globus) are actual events that preserve all the past.

In the quantum virtual/actual processes interpreted in terms of Being univocity, the actual traces are only modalities of Being-One. Actualization is not a sudden jump starting from virtuality, because if there were a jump of the one with the other, one would fall out of univocity of Being-One. Virtuality is not either the double or the preliminary phantom of actuality, it is as real as this last. Virtuality *is* the process of actualization ([96], p. 74). The reality of Being-One is to bring up to actualization new virtualities by making emerge unceasingly something new. Emergency of virtualities in the quantum process is therefore comparable to actualization process of Being-One. Consequently, in the theories of Vitiello and Globus, virtuality is as real as actuality. The thought needs only this formal distinction to support its intuition. It results from it that the objects of perception are also double: they are both virtual and actual things. To try to reconcile the rights of Being-One with the dual

nature of objects, we must adopt the thesis of Bergson on the scission of time in two symmetrical parts, future and past ([95], p. 109). Now, it is exactly what Vitiello and Globus try to do when they propose that the conjugate match occurs between: the non-tilde future (for Globus) and the tilde future (for Vitiello) approaching towards the Now, the Present; and the tilde cognitive past (for Globus) and the non-tilde cognitive past (for Vitiello) approaching towards the Now.

In sum up, the various approaches of Freeman, Vitiello and Globus offer interesting tentatives of modeling the hard problem of intentionality. However, these experimental and theoretical investigations provide ambiguous models. On the one hand, Vitiello and Globus attempt to adopt the thought of the sovereignty of Being-One, without any destinale base. Thence, the process of intentionality in their models can be regarded as immanent to the whole quantum system. As a consequence, the mere conjunction of non-tilde and tilde modes, in all likelihood, might be not sufficient to explain the functionally well defined and complex phenomenon of intentionality. On the other hand, the neurophysiological model of Freeman advantageously involves both a neuronal and a quantum level, but the quantum processes appear to be only here communication mechanisms. Moreover, the primitive process which accounts for world appearances that fulfil intentions remains unexplained. Yet, these theories integrate a common promising new notion of intentionality which, in my opinion, should be defended as potentially serious. Indeed, their hypothesis amount to implicitly assume that intentionality is a permanent and irrepressible attraction which draws us irreversibly towards the future by a kind of fundamental force. Based on this assumption of permanent tension between the mind and the world, it should be possible to reformulate a naturalistic model which would involve two complementary poles: a pole object which would work as “attractor”; and a pole subject (or cognitive), which would choose some aspects of the reality according to strategies of intentional behavior. Thus, this reformulated model would be structured both around of constraints as final cause due to physical world, and around the activities of human agents who to freely probe the reality in any one of many possible ways. The intriguing question then is to know what is the ultimate final cause of this attraction process. The simplest idea would be that the final cause is the cosmological and psychological arrow of time (the duration). Still, it is known that instantaneous quantum transitions of the physical micro-world are features which are imposed to us as ontological statut [98]-[100]. An alternative idea might therefore be that the final cause is the irrepressible connection between the spontaneous agitation of our sensorial activity (particularly the perceptual activity), always on the look out, and this ceaseless pulsatory quantum activity. Such a model rebuilds thus would avoid the problem of the difficult conciliation of thermofield quantum and Many-Body theories with the physiological temperature. In the present hypothesis of mind-world tension, what one calls intentionality might be an internal strength which would be anticipation of events. It would reveal the irreversible and irrepressible flow of singular aspects of reality chosen by the human agent from a myriad of signals, about how he will decide his free intentional action in a direction of fit such as beliefs, hopes, judgments, intentions, love, desire, hatred, etc. But since intentionality would be anticipation, it would not be comparable with the choice known as such: this choice would be only a reduction of uncertainly. However, how the act of choosing may be coupled to sensorial process to select intentional act is the central intriguing question. Recent neurophysiological studies have shed new light on the possible mechanisms underlying the goal-related chained organization of neural cells which are able to lead to selected actions [60]. Their conclusion supports the idea that an action is planned and organized as a whole chain of acts. That suggests that the bio-mechanical and temporal structure of motor acts embedded in the action depends on its desired final goal well before its actual onset. Today, the discovery of some visuo-motor neurons such as mirror neurons should challenge this view. Unfortunately, as mentioned above, much reserves have been expressed about the exact role of these neurons.

9. Conclusion

Early in the 20th century, Brentano and Husserl introduced the concept of “conscious of” to define intentionality. In 1960s, a revised Brentanian version based on the studies of Frege and Russel was developed by the analytic American theory of language. In 1980s, the analytic philosopher Dennett attempted even to dissolve this thesis and suggested that intentionality was only a feature of sentence. In contrast, in his neurophilosophy, Searle rejected the Brentanian mind-world cleavage and suggested that intentionality may be regarded as a biological naturalism. A more radical reject was that of eliminativists such as Churchland, which claimed that all philosophical arguments were illusory and should be replaced by neuroscientific knowledge. Unfortunately, very few works were tried during the last thirty years to explain intentionality in neurobiological models of consciousness.

Today, the issue emerging is based on a new conception of mind-world interactions. It rests on four main approaches: 1) "the intentional arc" and the "maximum grip" proposed in the philosophy of Merleau-Ponty; 2) the model of Freeman, implicating both a classical neurobiological level and a quantum level based on the Many-Body quantum theory; 3) the recent hypothesis that some visuo-motor neurons would be involved in controlling these self-organizing processes; and 4) the recent thermofield quantum theories of Vitiello and Globus. In the original model of Vitiello, intentionality results from the permanent and dynamic tension between two dual quantum modes: a mode which is a heat bath (the environment), and a mode which is the brain system, its mirror-image. In such a quantum system, consciousness is supposed to reside in quantum "entanglement" of two modes. In the model of Globus, the modes are not necessarily mirror-images, so that "entanglement" corresponds to an achievement in intentional dis-closure of the Presence as such. These contemporary theories amount to implicitly assume that intentionality is a fundamental force which draws us irreversibly towards the future. In this new hypothesis of mind-world tension, what one calls intentionality might be an internal strength which would be anticipation of events. It would reveal the irreversible and irrepressible flow of singular aspects of the reality chosen by human agent from the myriad of virtual signals. An alternative hypothesis based on this promising proposal is argued.

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