THE DISSIPATIVE QUANTUM MODEL OF THE BRAIN: HOW CONSCIOUSNESS (OF THE OTHER) ARISES FROM THE INTERACTIVE PROCESS OF THE BODY-BRAIN AND ENVIRONMENT. *OUR IGWEBUIKE-NESS IS QUANTUM*

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Executive Summary

It was Boethius who defined person as an individual substance with a rational nature, pointing out three important aspects of the nature of the human person, namely his individuality, his rationality and his being a substance. The rational nature of man is not just limited to the use of logic in his dealings, it is not merely reduced to the fact that man thinks or reasons before and even after undergoing an action. It also comprises the fact that man is conscious of all that he does, he is aware of his rationality. The human person is not the only substance in the animal kingdom with consciousness, for all animals have a certain level of consciousness, but the human person is the only animal whose consciousness comes with an awareness; that is to say that the human person is conscious of his awareness or is aware of his consciousness (to put in tautological terms, he is conscious of his consciousness and aware of his awareness). The issue of consciousness only gained

momentum in the 19th/20th century, although some put it in the mid 20th century. The debate as to how man is conscious and as to how this power arises in him has awed greatly the scientific world, with some holding that the validly accepted explanation to this resides in the homunculus, which is original dated to the 16th century alchemist Paracelsus. This theory is presently rejected, using the infinite regress argument. With the dawn of the quantum field theory, which is relativity applied to quantum mechanics, applied to the field of Neuroscience, the issue of how consciousness arises from the brain has resurfaced. Applying Quantum Field Theory (QFT) to the thought about the brain and consciousness has paved the way for the quantum model of the brain. How much can we know of our conscious state using QFT? Is it even possible to dabble into the matter of consciousness whose matter is absent, yet whose effect is seen, using scientific theories that depends on the availability of matter? The Igwebuike ideology speaks of two strong tenets, solidarity and complementarity (and even togetherness). What this paper will address is that these two main tenets of Igwebuike depend on consciousness, for it is the consciousness of the other, that is the foundation of Igwebuike's trends of solidarity and complementarity. With this being said, can it be proposed that the Igwebuike gospel has not just macroscopic underpinnings but it also has quantum?

Keywords: Consciousness, QFT, Kanu Ikechukwu Anthony, Brain, Neuroscience, Igwebuike, Other (Environment)

What Is Consciousness?

Consciousness is a scientific problem that is unlike any other. Our own consciousness, as Descartes noted, is the most indubitable feature of our existence. It is the most precious one, as well: consciousness is

life itself, and for most people having their bodies kept alive in a vegetative state is no better than dying. The major religions are defined by their theories of consciousness: whether a person's essence consists of his consciousness (his soul) or his body; how that consciousness ultimately fares as the result of its choices in life (whether it goes to a special place, or melds into a global mind); and whether the world contains forms of pure, disembodied consciousness in the form of gods, demons, angels and spirits. And the conviction that other people can suffer and flourish as each of us does is the essence of empathy and the foundation of morality.[1] Consciousness consists of inner, qualitative, subjective states and processes of sentience or awareness. Consciousness, so defined, begins when we wake in the morning from a dreamless sleep - and continues until we fall asleep again, die, go into a coma or otherwise become "unconscious." It includes all of the enormous variety of the awareness that we think of as characteristic of our waking life. It includes everything from feeling a pain, to perceiving objects visually, to states of anxiety and depression, to working out cross word puzzles, playing chess, trying to remember your aunt's phone number, arguing about politics, or to just wishing you were somewhere else. Dreams, from this definition, are a form of consciousness, though of course they are in many respects quite different from waking consciousness.[2] This definition is not universally accepted, and the word consciousness is used in a variety of other ways. Some authors use the word only to refer to states of self-consciousness, i.e. the consciousness that humans and some primates have of themselves as agents. Some use it to refer to the second-order mental *states about other mental states;* so according to this definition, a pain would not be a conscious state, but worrying about a pain would be a conscious

[1] D.M. Rosenthal, *Concepts and Definitions of Consciousness*, in The Encyclopedia of Consciousness, W.P. Banks ed, Academic Press, Elsevier Inc, Oxford, 2009, v.
[2] J.R. Searle, *Consciousness*, Originally published October 8, 1999 as an academic paper at the University of California at Berkeley, Posted on KurzweilAI.net August 13, 2001.

state. Some use "consciousness" behaviouristically to refer to any form of complex intelligent behaviour.[3] The term 'conscious' is used most frequently to refer to the condition of people and other creatures when they are awake and responsive to sensory stimulation. A creature lacks consciousness in this first sense when it is asleep, anaesthetized, in a coma, and so forth. The main concern with this kind of consciousness is to explain in biological terms the difference between creatures' conscious and unconscious conditions. Because consciousness of this sort is a property of creatures, it is convenient to refer to it as creature consciousness.[4] This pertains to all sentient and animate creatures. A second important phenomenon we call consciousness is a creature's being conscious, or aware, of something. There are two ways creatures are conscious of things. A person or other animal is conscious of an object by seeing, hearing, or touching it, or sensing it in some other way. But one is also conscious of something, even without sensing that thing, if one has a thought about it as being present to one, that is, a thought that represents that thing as being in one's immediate environment. Because we describe this phenomenon by reference to a grammatical object, we may call it transitive consciousness. Explaining transitive consciousness consists in explaining what it is for a thought to be about something and what it is for a perception or sensation to be of something. A third phenomenon is more controversial in nature, and is the subject of much recent scientific and philosophical literature. We are conscious of various things by virtue of our having perceptions of them or thoughts about them. But those perceptions and thoughts can themselves be conscious or not conscious. Subliminal perception is an example of nonconscious perceiving, and it is widely accepted that many thoughts occur nonconsciously as well, that is, outside our stream of consciousness. Since this phenomenon is a property of mental states, rather than of creatures that are in those states, it is

[3] Ibid.
[4] D.M. Rosenthal, *Concepts and Definitions of Consciousness*, in The Encyclopedia of Consciousness, W.P. Banks ed, Academic Press, Elsevier Inc, Oxford, 2009, 157

convenient to call it state consciousness.[5] Consciousness refers to individual thoughts, memories, feelings, sensations and environment. One's consciousness is one's awareness of yourself and the world around you. This awareness is subjective and unique.[6] Consciousness, thus, refers to experience itself. Rather than being exemplified by a particular thing that we observe or experience, it is exemplified by *all* the things that we observe or experience. Something *happens* when we are conscious that does not happen when we are not conscious—and something happens when we are conscious *of something* that does not happen when we are not conscious of that thing. We know what it is like to be conscious when we are awake, as opposed to not being conscious when in dreamless sleep. We also know what it is like to be conscious *of* something (when awake or dreaming) as opposed to not being conscious of that thing.[7]

The Quantum Model of the Brain

The quantum model of the brain makes use of excerpts from QFT. So, it would be better to let a little about QFT before delving into the quantum model of the brain.

Why QFT? QFT is physics,[8] as it seeks to uncover that which is fundamental to existence, and it owes a lot to classical physics. Classical physics is physics that does not make use of quantum mechanics or the theory of relativity. Newtonian mechanics, thermodynamics, and Maxwell's theory of electromagnetism are all examples of classical physics. Many theories in classical physics break down when applied to extremely small objects such as atoms or to objects moving near the speed of light. In spite of all its

[5] Ibid.

[6] K. Cherry, *Consiousness is the Psychology of Awareness*, in VeryWellMind online journal, February 24th, 2020, https://www.verywellmind.com/what-is-consciousness-2795922, Received 12th May, 2020.

[7] M. Velmans, *How to Define Consciousness and How not to Define Consciousness*, in Journal of Consciousness Studies, 16(5), 2009, pp 139-156

[8] Physics deals with the behavior and composition of matter and its interactions at the most fundamental level

achievements, classical physics proved itself to be incapable of handling further fundamental issue of reality, like the photoelectric effect, the Compton effect, to name a few.

- The photoelectric effect: This is the emission of electrons by a metal when light falls on it. According to classical physics, electrons require some energy to escape from the surface of the metal. This amount of energy is called the work function and is given the symbol, ϕ. According to the wave theory of light, the energy of the incident light is spread over the whole surface. Electrons should, therefore, only be emitted if the intensity of the light, given by:

  Intensity = Power absorbed by surface/Area of the surface.

  The maximum kinetic energy of the electrons and the number of electrons emitted are also predicted to depend on the intensity of the light. The frequency of the light should not matter, apart from being included in the intensity of the light:

  $$\text{Intensity} \propto \text{Frequency}$$

These predictions are clearly at odds with the experimental evidence seen.

It was Einstein who assumed that 'light consists of quanta of energy, called photons.' In fact, Planck had introduced the concept of material resonators possessing quanta of energy nhν, where n is an integer, while Einstein assumed that each quantum of light possesses the energy hν. The absorption of a single photon by an electron increases the energy of the electron by hν. Part of this energy is used to remove the electron from the metal. This is called the work function. The remaining part of the energy imparted to the electron increases its velocity - and consequently its kinetic energy. Thus if hν, the energy of a photon incident on a metal, is greater than the energy E required to separate the electron from the metal, and v is the velocity of the emitted electron, then the following relation must hold:

$$hv = E + 0.5mv^2$$

The above formula shows that if the energy of the incident photon is less than the work function, the electrons cannot be separated from the surface of the metal and, therefore, will not be emitted. For a particular metal, the work function E being constant, the relationship between the energy of the incident photon and the kinetic energy of the emitted electron is linear. It is also clear that a more intense source of light will cause photons to be emitted at a greater speed, and this will produce a stronger electron current. Thus, Einstein was able to provide a completely satisfactory picture of the photoelectric effect by using the concept of the quantum nature of light.[9]

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9 M. Saleem, *Quantum Mechanics*, IOP Publishing Ltd, 2015, 3. Einstein saw that the experimental evidence was explainable if it was assumed that light comes in discrete 'quanta' or packets of energy, which became known as photons.

- Each photon has a specific energy ($E=hf$), and only collides with one electron. The probability of two photons colliding with one electron is very low. Thus an electron can only absorb a specified amount of energy for light of a specific frequen*cy.
- If this energy is insufficient to allow an electron to escape the surface of the metal, no electrons will be emitted. This creates a threshold frequency, above which a photon will provide an electron with enough energy to leave the surface, and below which the electrons cannot escape. The minimum energy required to remove an electron from the metal is the work function, Φ. If a photon provides more energy to the electron than this, the rest will be seen as kinetic energy.

Thus:

$$K.E_{max} = hf - \Phi = hf - hf_o = h(f - f_o)$$
$$K.E_{max} \propto (f - f_o)$$

where $K.E_{max}$ is the maximum kinetic energy of the electrons, Φ is the work function of the surface, h is Planck's constant, and f_o is the threshold frequency.

- Increasing the intensity only affects the rate of electrons being emitted, but does not affect their maximum kinetic energy. This is because increasing the intensity while keeping frequency constant increases the number of photons hitting the metal per second, and so increases the number of electrons which absorb them. It has no effect below the threshold frequency, because even if a huge number of electrons absorb photons, none of them have the energy to escape the surface.

- The Compton Effect: This is also referred to as Compton scattering. The **Compton Effect** is the term used for an unusual result observed when X-rays are scattered on some materials. By classical theory, when an electromagnetic wave is scattered off atoms, the wavelength of the scattered radiation is expected to be the same as the wavelength of the incident radiation. Contrary to this prediction of classical physics, observations show that when X-rays are scattered off some materials, such as graphite, the scattered X-rays have different wavelengths from the wavelength of the incident X-rays. This classically unexplainable phenomenon was studied experimentally by Arthur H. Compton and his collaborators, and Compton gave its explanation in 1923. The experiment exhibits that the change in the frequency of incident radiation is independent of its initial frequency and depends only upon the angle of scattering. This can be satisfactorily explained by the quantum theory of light by making use of relativistic expressions for various quantities.[10] To explain the shift in wavelengths measured in the experiment, Compton used Einstein's idea of light as a particle. The Compton Effect has a very important place in the history of physics because it shows that electromagnetic radiation cannot be explained as a purely wave phenomenon. The explanation of the Compton Effect gave a convincing argument to the physics community that electromagnetic waves can indeed behave like a stream of photons, which placed the concept of a photon on firm ground.

Other areas in which classical physics failed to give explanation to included the Heisenberg Uncertainty Principle, the correspondence principle, Schrodinger's wave equation etc.

The advent of the quantum theory gave better explanation to these happenings, as science could further understand that what was earlier

[10] M. Saleem, *Quantum Mechanics*, IOP Publishing Ltd, 2015, 3.

considered as the fundamental element of all that is, yet had others more fundamental, and that these resided in a world known as the quantum world. From the above failures of classical physics, it is apparent that what led to such failure was the deterministic way in which classical physics conceived of reality, and reality proved itself again and again to not be as deterministic as classical physics claimed it to be.

To add to the above-mentioned, the course of this write-up is aimed at arriving at richer insights when it comes to the study of the brain. QFT and its elements of study provide the basic work tools to undergo this study. According to Jibu and Yasue:

> …physicist H. Umezawa in the early 1960's (wrote for, *addition mine*) the necessity of emergence of quantum field theory in describing and investigating the typical physical aspect of living matter, because complex systems of atomic ingredients with strong mutual correlation like living matter cannot be treated by quantum statistical mechanics but only by quantum field theory.[11]

***What Is QFT*?** There is no rigidly acceptable definition of QFT, it can thus only be described. It is the mathematical and conceptual framework for contemporary elementary particle physics. It can also be considered as an extension of Quantum Mechanics (QM), which deals with particles, over to fields.[12] QFT deals with and seeks answer to the most fundamental questions to life and to the origin of all that is. If we were to account taxonomically for the organism known as the human being, using him as a means of questions and answers we would say:

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[11] M. Jibu-K. Yasue, *Quantum Brain Dynamics and Quantum Field Theory*, in Brain and Being: At the Boundary Between Science, Philosophy, Language and Arts, G.G. Globus, K.H. Pribram and G. Vitiello eds., John Benjamins Publishing Company, Amsterdam/Philadelphia, 2004, 273.

[12] M. Kuhlmann, *Quantum Field Theory*, in the Stanford Encyclopedia of Philosophy, Sept 27th, 2012, https://plato.stanford.edu/entries/quantum-field-theory/ retrieved 12th May, 2020.

> *What are people made of*? People are made of muscles, bones, and organs.
> *Then what are the organs made of?* Organs are made of cells.
> *What are cells made of?* Cells are made of organelles.
>
> *What are organelles made of?* Organelles are made of proteins.
> *What are proteins made of?* Proteins are made of amino acids.
> *What are amino acids made of?* Amino acids are made of atoms.
> *What are atoms made of?* Atoms are made of protons, neutron, and electrons.
> *What are electrons made of?* Electrons are made from the electron field.
> *What is the electron field made of?…*

To the best of our present ability to perceive and to reason, the universe is made from fields and nothing else, and these fields are not made from any smaller components.[13] At the fundamental physical level, this is expressed by the quantum foundation of the notion of extended mind in QFT (Quantum Field Theory). It was formerly held that matter and particles are the fundamental building blocks. Yet, the deeper truth is that the basic building blocks of Nature are not discrete particles at all; rather, they are continuous fluid-like substances that spread throughout all of space, and they are called fields. A very good example of fields are the electric and the magnetic fields. These fields, nonetheless, like other areas of nature, have laws that they must obey and these laws are inquired by quantum mechanics (QM). Quantum field theory (QFT) is the current paradigm of fundamental physics. It emerges from the convolution of quantum physics and relativity, the

[13] B. Skinner, *A Children's Picture-Book Introduction to Quantum Field Theory*, in Ribbonfarm Online Journal, 20th August, 2015, https://www.ribbonfarm.com/2015/08/20/qft/ retrieved 12th May, 2020.

two major theoretical revolutions of the 20th-century physics.[14] While quantum field theory reverts back to quantum mechanics for its mathematical representation, it nonetheless admits of relativism in reality than does QM. Quantum field theory deals with systems with infinitely many degrees of freedom. For such systems, the algebra of observables that results from imposing canonical commutation relations admits multiple Hilbert-space representations that are not unitarily equivalent to one another. This differs from the case of standard quantum mechanics, which deals with systems with finitely many degrees of freedom. For such systems, the corresponding algebra of observables admits unitarily equivalent Hilbert-space representations.[15] One thing that makes QFT so special is that it provides a unified framework where the quantum theory and the theory of relativity become consistently integrated out. Sometimes, field theory is identified as the theory of particle physics. This is not completely correct. Field theory is a framework which goes beyond particle physics. In fact, there are field theories where there is no particle interpretation of the states of the theory. But it is also true that most of the successful field theories admit a particle interpretation. That means that there are states which can be correctly interpreted as particle states and in those cases field theory provides a causal framework for particle interactions where action at a distance is replaced by local field interactions. Although this can also achieved by classical field theory, the difference between the classical and quantum theories resides in the fact that in the quantum theory, the interaction between the particles can be interpreted as a creation and destruction (also known as creators and annihilators) of messenger particles process. The association of forces and interactions with particle exchange is one of the most interesting features of QFT. The

[14] M. Asorey, *A Concise Introduction to Quantum Field Theory*, in International Journal of Geometric Methods in Modern Physics, October 2018, 1-45.

[15] M. Kuhlmann, *Quantum Field Theory*, in the Stanford Encyclopedia of Philosophy, Sept 27th, 2012, https://plato.stanford.edu/entries/quantum-field-theory/ retrieved 13th May, 2020.

particles that appear in field theory are very special: they are all identical. This means that the electrons in the earth are the same as the electrons in Alpha Centauri because all of them are excitations of the same electron field in quantum electro dynamics (QED). Another essential characteristic of relativistic field theories is that when the field theory admits particle states, they are accompanied by antiparticle states; that is, the theory requires the existence of antiparticles.[16]

Areas To Note When Representing QFT: A quantum field theory is a quantum theory which is relativistic invariant, and exists where there is a special type of quantum operators which are associated with the classical fields. In the case of a real scalar field $\emptyset$, a consistent theory should satisfy the following principles.

- P1 Quantum principle: The space of quantum states is the space of rays in a separable Hilbert space $\mathcal{H}$.[17]
- P2 Unitarity: There is a (anti)unitary representation U(Λ; a) of the Poincare group in $\mathcal{H}$, where time reversal T is represented as an antiunitary operator U(T).
- P3 Spectral condition: The spectrum of generators of space-time translations P_u is contained in the forward like cone:
$$\vee_+ = \{P_u; P^2 \geq 0; P_0 \geq 0\}$$
- P4 Vacuum state: There is a unique state $\Psi \epsilon \mathcal{H}$, satisfying that $P_u \Psi_0 = 0$.[18]
- P5 Field Theory (real boson): For any classical field f in the space $S(\mathbb{R}^3)$ of fast decreasing smooth $C^\infty(\mathbb{R}^3)$ functions there is field operator $\emptyset(f)$ in $\mathcal{H}$ which satisfies that $\emptyset(f) = \emptyset(f)$. The field operator can be considered as the smearing by f of a fundamental field operator $\emptyset(x)$
$\emptyset(f) =$

[16] Ibid.
[17] A Hilbert space is an abstract vector space that possesses the structure of an inner product which allows length and angle to be measured.
[18] The vacuum state also known as the ground state is that at which the quantum energy level is at its lowest.

$$\int \quad d3xf(x)\emptyset(x)$$

The subspace spanned by the vectors $\emptyset(f_1)\emptyset(f_2)\ldots\ldots\ldots\ldots \emptyset(f_n)|0\}$ for arbitrary test functions $f_1; f_2; \ldots\ldots f_n \epsilon S(\mathbb{R}^3)$ is a dense subspace of $\mathcal{H}$.

- P6 Poincare covariance: Let $\dot{f}\epsilon S(\mathbb{R}^4)$ be a test function defined in Minkowski space-time[19] and $\emptyset(\dot{f}) = \int_{R4} d^4x \emptyset(x)\dot{f}(x)$;

Where $\emptyset(x) = \emptyset(x; t) = e^{itP0}\ \emptyset(x)e^{-itP0}$.

Then

$$U(\Lambda;a)\ \emptyset(\dot{f})U(\Lambda;a)^{\square} = \emptyset(\dot{f}_{(\Lambda;a)}),$$

with

$$(\dot{f}_{(\Lambda;a)})(x) = \dot{f}(\Lambda^{-1}(x-a))$$

- P7 (Bosonic) Local Causality: For any f, $g\epsilon S(\mathbb{R}^3)$ the corresponding field operators $\emptyset(f)$; $\emptyset(g)$ commute

$$[\emptyset(f); \emptyset(g)] = 0.^{20}$$

Commutators pertains to Bosonic particles, while Anticommutators pertains to fermonic particles.

Quantum Brain Dynamics

[19] Minkowski Space-time, is a combination of 3-dimensional Euclidean Space and time into a 4-dimensional manifold, where the interval of spacetime that exists between any two events is independent of the inertial frame of reference. The Minkowski spacetime coordinate system has axes given as (*x, y, z, ct*). It can also be written as (x_1, x_2, x_3, x_4). The differential for arc length in spacetime is given by the equation: $ds^2 = -c^2dt^2+dx^2+dy^2+dz^2$.

[20] When it is said that operators in the quantum realm commute, what is implied is that they are identically zero. As seen above. Let us consider that we have a state Ψ and two observables (operators) *A, B*. when these operators are simultaneously diagonalised in a given representation, they act on the state Ψ just by multiplication with a real number either a or b, or an eigen value of the operator ($A\ \Psi=a\ \Psi$, $B\ \Psi=b\ \Psi$). Imagine that this were real numbers, a and b, this will hold like $ab-ba=0$ (signifying identicality) or in the operator form ($AB-BA$) $\Psi=0$ or ((A,B) $\Psi=0$). Thus the expression AB-BA= [A,B] indicate that they commute. Commutators are used for Bose particles (bosons). There is also the expression anticommutators, and these are used for fermion particles. When talking about fermions, the commutators have to be adjusted accordingly (as in the case $\{\theta_1\theta_2 = -\theta_2\theta_1\}$). To ensure that identicality is recorded so that it sums up to zero, it needs to be adjusted to $(\{\theta_1\theta_2 = -\theta_2\theta_1 \rightarrow \theta_1\theta_2 + \theta_2\theta_1 = 0\})$.

QFT is all about gaining a fundamental understanding to matter. Matter can either be macroscopic or microscopic, and even quantum. What is being considered here is brain matter. The use of QFT, in what concerns matter, has proven insightful in blazing new trails as pertaining to the understanding of matter in its fundamentality. Quantum Brain Dynamics is used to describe long range ordered dynamics of the quantum system of electromagnetic field, and water dipole field in the brain is proposed as a revival of the original idea developed by Umezawa in the early 1960s.[21] QBD is nothing else but Quantum Electrodynamics (QED) of the electric dipole field of dipolar solitons and water molecules with a symmetry property under the dipole rotation. The highly systematized functioning of the brain is found to be realized by the spontaneous symmetry-breaking phenomena. Memory printing, recall and decay processes are represented by the fundamental physical processes standing for the phase transition process, the symmetry-restoring process and the quantum-tunneling process, respectively.[22] The brain, as already noted, is a typical macroscopic object extraordinary in its functioning as it gives rise to highly advanced mental "objects" such as consciousness (plus unconscious), mind, memory and will. It is the custom and cognitive sciences to regard the brain as a tissue made of a huge of brain cells, and many phenomenological theories of brain functioning based on the macroscopic picture of electric and chemical circuits of cells take into account various mesoscopic aspects of the brain cell revealed by molecular biological studies.[23] Of all living matter, the brain is considered as the highest example. Thus, investigating the brain and its functionality thus pertains to the Quantum field. QBD is a completely new theoretical framework to describe the fundamental physical process of the brain dynamics that

[21] M. Jibu-K. Yasue, *Magic without Magic. Meaning of Quantum Brain Dynamics* in the Journal of Mind and Behaviour, Vol 18, No2/3, 205-227
[22] M. Jibu-K. Yasue, *Quantum Brain Dynamics and Quantum Field Theory, in Brain and Being. At the Boundary Between Science, Philosophy, Language and Arts*, 269.
[23] M. Jibu-K. Yasue, *Magic without Magic. Meaning of Quantum Brain Dynamics.*

makes man human on the basis of quantum field theoretical analysis of the fundamental system of brain tissue.[24]

The Fundamental System of Living Matter: The brain is a living matter. Thus, it will be best to investigate the essential characteristic of the fundamental system of living matter. In living matter, there is specifically two degrees of freedom to which QFT ponders; the first is the dipolar soliton (also known as the Davydov soliton), localized in each protein filament of the background three-dimensional network structure and the water molecules surrounding them. In the words of Jibu and Yasue, the first degree of freedom we are looking for in the fundamental system of living matter may be found as an internal degree of freedom of the background three dimensional network structures of protein filaments free from thermalization.[25] This degree of freedom was found by Davydov in 1979 as a coherent dipolar solitary wave propagation along the one-dimensional chain of protein molecules such as the protein filament.[26] In quantum field theory, a coherent solitary wave propagation is considered as a localized degree of freedom maintaining and carrying energy, without loss due to thermalization, and it is called the "Davydov soliton" or "dipolar soliton."[27] Namely, energy in coming from the metabolizing system of living matter through the ATP cyclic process to the fundamental

[24] M. Jibu-K. Yasue, *Quantum Brain Dynamics and Quantum Field Theory, in Brain and Being. At the Boundary Between Science, Philosophy, Language and Arts*, 279.

[25] Ibid. Thermalization is the process of physical bodies reaching thermal equilibrium through mutual interaction.

[26] A.S. Davydov, *Solitons in molecular systems*, in Physica Scripta*, 20*, 1979, 387–394.

[27] The dipolar soliton is a collective mode of many dipolar oscillations maintained by nonlocalized electrons trapped in the one-dimensional chain of protein molecules and may be regarded as the first degree of freedom of the fundamental system of living matter. It is a quantum mechanical degree of freedom representing electric dipole moment localized in each background protein filament. the dipolar soliton arises from a coherent solitary wave propagation of nonlocalized electron along each protein filament. The dipolar soliton is created at the end of each protein filament by energy gain from the metabolizing system through, for example, the ATP cyclic process.

system of living matter induces first dipolar solitons localized in each protein filament. As a specific character of soliton in quantum field theory, energy stored in soliton form is kept free from thermalization and belongs to the fundamental system of living matter, though creation of soliton is triggered by incoherent and disordered interaction with the metabolizing system. In other words, the creation and annihilation process of dipolar solitons plays the role of a gateway between metabolizing and fundamental systems.

These dipolar solitons in the human brain are referred to as Corticons,[28] but "In the general case of cell assembly, we call it simply 'dipolar soliton'".[29] The second degree of freedom of the fundamental system of living matter is the water molecule. Jibu and Yasue capture this better as they note:

> The water molecule, H_2O, is a typical molecule simple in its form but rich in its physical characteristics. The origin of richness can be found, however, in simpleness of its form. Namely, due to the spatial geometric configuration of two hydrogen atoms relative to one oxygen atom, the water molecule manifests nonvanishing electric dipole moment. Thus, the totality of enormously large number of water molecules can be well described from a physical point of view by a quantum mechanical degree of freedom of electric dipole moment moving and rotating freely. This is the second degree of freedom of the fundamental system of living matter. We call it the "water dipole moment."[30]

Finally, we have obtained a physical picture of the fundamental system of living matter. It is essentially a quantum mechanical many-body system described by two different degrees of freedom interacting with each other, that is, dipolar solitons localized in the background

[28] C.I.J.M. Stuart., Y. Takahashi, H. Umezawa, *On the stability and non-local properties of memory*, in Journal of Theoretical Biology, 71, 1978, 605–618.
[29] M. Jibu-K. Yasue, *Quantum Brain Dynamics and Quantum Field Theory, in Brain and Being*, 278.
[30] Ibid.

three-dimensional network structure of protein filaments and water dipole moments surrounding them.[31] As earlier stated, the brain is a living matter; thus, there are two major components (in the words of Jibu and Yasue, degrees of freedom) that are vital in the computing of the QBD, namely; the dipolar solitons and the water dipole moment.[32] Yet, in the brain, these solitons are referred to as Corticons, and these protein filaments are immersed in water molecules, leading to a somewhat superimposition of states. Thus, instead of having two degrees of freedom acting in the brain, as in other living matter, we have one superimposed degree of freedom known as corticons. These corticons can be described as "the fundamental system of brain tissue described by a single degree of freedom of electric dipole field spanning the spatial volume of the brain tissue."[33] According to Jibu and Yasue,

> The corticon in QBD is now fully described by the electric dipole field (of both dipolar solitons and water dipole moments) spanning the spatial volume of the brain tissue. In this sense, we may call the fundamental system of brain tissue simply as the "system of corticons," hereafter. Considering the physical background of the electric dipole field as those of dipolar solitons and water dipole moments, we may assume that the electric dipole field manifests symmetry under rotation. Namely, even if the electric dipole

[31] Ibid, 279.

[32] Permanent dipoles are found in water molecules and these occur when two atoms in a molecule have substantially different electronegativity.[32] A molecule with a permanent dipole moment is called a polar molecule. In electromagnetism, there are two kinds of dipoles: An electric dipole is a separation of positive and negative charges. The simplest example of this is a pair of electric charges of equal magnitude but opposite sign, separated by some (usually small) distance. A permanent electric dipole is called an electret. A magnetic dipole is a closed circulation of electric current. A simple example of this is a single loop of wire with some constant current through.

[33] M. Jibu-K. Yasue, *Quantum Brain Dynamics and Quantum Field Theory, in Brain and Being,* 280.

> field on each position is rotated by any spatial angle, the total energy of the system of corticons is kept invariant. In quantum field theory, the total energy of the system of any field quantity plays an important role in specifying dynamics of the field, and it is usually called the "Hamiltonian." So, we refer to the total energy of the system of corticons as the Hamiltonian of the system of corticons or equivalently the Hamiltonian of QBD. Then, we obtain the following invariant or symmetry property: The system of corticons in QBD manifests a symmetry under the rotation of the electric dipole field in a sense that the Hamiltonian of QBD is invariant.[34]

Thus, we can define QBD as nothing but Quantum Electro Dynamics (QED) of the electric dipole field with symmetry under the dipole rotation.

The Spontaneous Breaking of Symmetry: Symmetry plays a big role in physics. It often greatly simplifies the solution to a problem. Suppose we have an object shaped like the base of a wine bottle, and a marble is placed on the hump at the base of the wine bottle, even though the floor of the wine bottle after the hump is yet perfectly symmetric, the marble will not end up in the centre, where it would be sitting on a hump; it will come to rest somewhere on the circle of lowest points. This is precisely what *spontaneous symmetry breaking* is about; for the ground or lowest-energy state does not share the symmetry of the underlying physics. Instead, there is a whole family of ground states, the different points on the circle.[35] The symmetry breaking is *spontaneous* in the sense that (unless we have extra information) we cannot predict which of these ground states will be chosen. Spontaneous symmetry breaking is ubiquitous in condensed matter physics. It often occurs when there is a phase transition between a high-temperature, symmetric phase and a low-temperature

[34] Ibid.
[35] T.W.B. Kibble, *Spontaneous Breaking of Symmetry In Gauge Theories*, in Phil. Trans. R. Soc. A 373: 2015 http://dx.doi.org/10.1098/rsta.2014.0033, 1-12.

one in which the symmetry is spontaneously broken. The simplest example is freezing. If we have a round bowl of water sitting on a table, it looks the same from every direction; it has rotational symmetry. But when it freezes, the ice crystals form in specific orientations, breaking the symmetry.[36] Symmetry is said to be spontaneously broken when the Lagrangian of a system is invariant under a certain group of continuous symmetry, say *G*, and the vacuum or ground state of the system is not invariant under *G*, but under one of its subgroups, say *G′*. The ground state then exhibits observable ordered patterns corresponding to the breakdown of *G* into *G′*. The possibility of having different vacua with different symmetry properties is provided by the mathematical structure of QFT, where infinitely many representations of the canonical commutation relations (CCR) exist, which are unitarily inequivalent with respect to each other, i.e. there is no unitary operator transforming one representation into another one, and thus they are physically inequivalent as well, that is they describe different physical phases of the system.[37] In SBS theories, the Goldstone theorem predicts the existence of massless bosons called Nambu-Goldstone (NG) particles. The spin-wave quanta, called magnons in ferromagnets, the elastic wave quanta called phonons in crystals, the Cooper pair quanta in superconductors, etc., are examples of NG particles. NG bosons condensed in the ground state of the system, according to the Bose-Einstein condensation, are the carriers of ordering information out of which ordered patterns (space ordering or time ordering as, e.g., "in phase" oscillations) are generated. The condensation density of the NG boson quanta determines the macroscopic field which is called *order parameter*, e.g. the magnetization in ferromagnets.[38] The order parameter is a classical macroscopic field in the sense that it is not

[36] Ibid.
[37] W.J. Freeman-G. Vitiello, *Dissipation and spontaneous symmetry breaking in brain dynamics*, in Escholarship.org, 2008, https://escholarship.org/uc/item/5c43n596, 1-16. By contrast, in Quantum Mechanics all representations are unitarily (and therefore physically) equivalent.
[38] Ibid.

affected by quantum fluctuations. Its value may be considered to be the *code* or *label,* specifying the physical phase of the system. In the absence of gauge fields, the NG quanta are observed as realistic physical quanta, and excitations of the system ground state extend over the whole system (*collective modes* or *long range correlations*). They may scatter with other particles of the system or with observational probes. If a gauge field is present, the NG bosons still control the ground state condensation in the ordered domain, and the gauge field propagation is confined into regions where the order is absent. Through the generation of NG collective modes, SBS is responsible for the change from microscopic to macroscopic scale: crystals, ferromagnets, superconductors, etc., are *macroscopic quantum systems*. They are quantum systems, not in the sense that they are constituted by quantum components (like any physical system), but in the sense that their macroscopic properties, accounted for by the order parameter field, cannot be explained without recourse to the underlying quantum dynamics.[39]

In the words of Vitiello, symmetry "corresponds to indistinguishable points."[40] But the symmetry which gets broken in the creation of observable ordered patterns is the symmetry of the dynamical equations; symmetry is said to be spontaneously broken when the symmetry of the ground state is not the symmetry of the dynamical

[39] Ibid. When symmetry is broken, a quanta, a masseless scalar with no spin, appears, this masseless scalar according to Vitiello, is the carrier of the ordering information and therefore the quantum mediating the long range correlation among the atoms. This scalar is a boson, which means that many of them can be found in the same state with similar quantum properties (charge, energy, numbers etc). Symmetry can be restored via condensation of the bosons, one that is controlled by the Bose-Einstein distribution function (referred to as the Bose-Einstein Condensate). According to Vitiello, At conveniently high temperature, above a certain critical temperature T_c, the condensed bosons may "evaporate": condensation is destroyed and symmetry is restored. Symmetry is restored and broken by means of an occurrence known as phase transitions.

[40] G. Vitiello, *My Double Unveiled.* John Benjamins Publishing Co., Amsterdam and Philadelphia, 2001, 30.

equations.[41] This means that the symmetry is said to be broken since the vacuum state does not possess the full symmetry of the field equations (the dynamics). The "order" *is* indeed such a "lack of symmetry."[42] When symmetry is broken, "the invariance of the field equations implies the existence of quanta, the so-called Nambu Goldstone (NG) quanta."[43] These NG quanta propagate through the system and are the carriers of the ordering information, "they are long range correlation modes;"[44] in crystals, for example, the ordering information is that which specifies the lattice arrangement. The NG quanta for crystals are the phonons. Thus, not only are these NG quanta involved in informational gain, they are also involved in the dynamic ordering of the system. for instance, with magnets, the symmetry broken is that of the magnetic dipole of the electrons, thus the magnetization comprises the correlation amongst all the electrons so that they all choose, among all available directions, one particular direction of the magnetization vector (the NG quanta for magents are magnoni). The NG quanta are masseless scalar bosons. Thus, they are to be differentiated from the other type of boson involved in the different energy fields known as the gauge bosons (the photons of the EMF, the gluons of the strong field, the $W^{\pm}$ and Z bosons of the electroweak fields). The gauge bosons are mediators of the energy exchanges among the interacting elements they correlate, because they are effectively quanta of the energy field they mediate (that is the $W^{\pm}$ and Z bosons are the quantum of the weak field). The NG bosons (NGB) are not mediators of the interactions among the elements of the system. They determine only the modes of interaction among them.

[41] Ibid, 30-31. According to Vitiello, «the word "spontaneous" means that the symmetry of the dynamics can be rearranged in any one of the possible ordering patterns observable at the physical level (in other words any of the physical phases can be dynamically realized).» (G. Vitiello, *My Double Unveiled*, 31)

[42] G. Vitiello, *The Dissipative Brain*, in Brain and Being - at the boundary between science, philosophy, language and arts, Globus G.G., Pribram, K.H. and Vitiello, G., (eds), John Benjamins Pub. Co. Amsterdam, 2004, 317-331.

[43] G. Vitiello, *The Dissipative Brain*, in Brain and Being.

[44] Ibid.

Due to the masselessness of the NGB, their condensation does not necessitate a change of energy state of the system. This is because in their "lowest momentum state NG quanta do not carry energy."[45] This is needed to enable the NG quanta cut across the full system volume, sending long distance informational correlation in the system, "thus setting up an ordered pattern."[46] In living biological systems, the human body, the NG quanta are the Dipole Wave Quanta (DWQ), since they arise from "the breakdown of the electrical dipole rotational symmetry."[47]

How does symmetry breaking happen in the QBD? According to Vitiello, this happens by interaction, for the "brain is a system in interaction with the external world from which it receives stimuli carrying information. These stimuli put the brain into states."[48] The brain-body is not a closed system, but an open system that stands in physical entanglement with the environment. According to Streltsov et al., entanglement can arise from incoherent operations, provided one of the communicating systems is coherent. This can be illustrated thus:

S (incoherent) *A (incoherent)* *S (Coherent)*
A (Incoherent)

Incoherent Op. *Incoherent Op.*

S is separable from A *S is entangled with A.*[49]

[45] Ibid.
[46] Ibid.
[47] Ibid. According to G. Vitiello, «In QFT the dynamics (i.e. the Lagrangian or the Hamiltonian, or simply the field equations) is in general invariant under some group, say G, of continuous transformations. Spontaneous breakdown of symmetry occurs when the minimum energy state (the ground state or vacuum) of the system is not invariant under the full group G, but under one of its subgroups.» (G. Vitiello, *My Double Unveiled.* John Benjamins Publishing Co., Amsterdam and Philadelphia, 2001, 93).
[48] G. Vitiello, *My Double Unveiled*, 73.
[49] A. Streltsov et al, *Measuring Quantum Coherence with Entanglement,* in Physics Review Letters, Number 115, June 2015, pp1-8..

Thus, the personal unit brain-body-environment has its physical foundation in the quantum entanglement brain-body-environment. The entanglement "represents the impossibility of cutting the links between the brain and the external world;"[50] the quantum model of the brain is based on the fact that the brain "is an open system in interaction with the external world."[51] For information printing on the brain "is achieved under the action of external stimuli, which produce the breakdown of the symmetry associated with the electric dipole vibrational field." [52] Thus, emphasis is laid on the brain being entangled or "coupled to the environment."[5354]

The centrality of the brain, as constantly noticed in the foregoing lines, should not lead to a hasty consideration of the body as inconsequential in the entire dynamics that defines the human person, for the three components, of body-brain-environment, stand as integral

[50] G. Vitiello, *The Dissipative Brain*, in Brain and Being - at the boundary between science, philosophy, language and arts, Globus G.G., Pribram, K.H. and Vitiello, G., (eds), John Benjamins Pub. Co. Amsterdam, 2004, 317-331.
[51] G. Vitiello, *My Double Unveiled*, 104.
[52] Ibid.
[53] Ibid.
[54]Each personal conscious state of a human being corresponds to a complex phase-coherence among the oscillating electromagnetic force fields of some material parts (molecules) of the three components involved. That is - for instance in the personal state of me as seeing now the computer screen in front of me - some (effectively many trillions) of molecules of the neurons of a part of the visual cortex involved, many and many trillions of the molecules constituting the parts of the ocular system involved (ocular nerve, ocular muscles, cones and rods of my retina, of the crystalline membrane in front of my retina etc), many and many trillions of molecules constituting the gases forming the air between me and the computer screen, and finally the many and many trillions of the molecules of the part of the screen I am seeing and emitting the electromagnetic radiation putting in phase the molecules of screen, of airs, of my oculomotor system, of my visual cortex, on its turn influencing the oscillation in phase of my emotional system: limbic system, amygdala etc. This is a personal state unified at the material level by the electromagnetic fields, ordered and then unified informationally by the Nambu-Goldstone bosons characterizing univocally this so complex phase coherence domain of electromagnetic, oscillating force field.

to a valid comprehension of the human person. According to Capolupo, Freeman and Vitiello,

> Brains are thermodynamics systems that use chemical energy to construct knowledge from information. The oxidative metabolism of glucose provides the energy, as measured by oxygen depletion and carbon dioxide production. The sensory receptors in the body and on the body surface provide the information by absorbing energy of various types impinging from the internal and external environments. The role of each sensory receptor is to selectively convert a microscopic quantity of energy first to ionic currents (receptor potentials), then to a train of pulses (action potentials, units, spikes) on its axon.[55]

Once the external stimuli are intercepted by the body, a necessary SBS occurs, a definite ground state, from the many infinite ground states or vacua, is chosen. Masseless NGB are observed, which carry long-range correlation waves observed in the brain dynamics. As a consequence of this, the time-reversal symmetry is also broken, because the choice of a ground state entails that the information has been recorded.[56]After information has been recorded, the brain state is fixated and the brain cannot be brought to the state configuration in which it was before the information printing occurred, for before the information recording process, the brain can in principle be in anyone of the infinitely many (unitarily inequivalent) vacua.[57]

The Brain as an Open/Dissipative System

The brain is an open, dissipative system; the brain closed on the world is a dead brain, physiology tells us. Isolation of the brain (closure to the world) produces serious pathologies. Thus, the extension of the quantum model of brain to the dissipative dynamics appears to be a

[55] A. Capolupo et al, *Dissipation of Dark Energy by Cortex in Knowledge Retrieval* in Physics Life Review, Volume 10, Issue, 1, March 2013, pp85–94.
[56] G. Vitiello, *My Double Unveiled. The dissipative Quantum Model of the Brain*, 107.
[57] Ibid.

necessity.[58] The dissipation of the brain, and its inherent openness, is a mark of the interaction that exists between the brain and the environment, for the brain (/body) is not a closed system, but an open system that stands in physical entanglement with the environment. We ought to note that the entirety of the human person, as a biological system, stands in relation to other biological systems (other human persons and the environment). As a biological system, the human person is a dynamic comprising the brain and the body. The human person is an open-dissipative biological system in relation to the environment (that was why it was earlier asserted that the human person stands in relation, a relation of brain-body-environment). The human body (brain-body) operates dynamically in a phase coherent order. This macroscopic level of a high degree of coherence is referred to as order parameter. The order parameter is the macroscopic variable that characterizes the new emerging level of matter organization and is related to the matter density distribution. The emergent properties are neither the properties of the elementary constituents nor their summation. Rather, they are new properties, depending on the modes in which they are organized, that is to say, on the dynamics controlling their interaction. A point to recall is that "the ordered pattern which is actually realized is the output of the system's internal dynamics."[59] This pattern is realized through a process known as spontaneous symmetry breaking.[60]

Then, the mathematical formalism for quantum dissipation *requires* the doubling of the brain degrees of freedom.[61] The doubled degrees

[58] G. Vitiello, *The Dissipative Brain*, in Brain and Being.
[59] G. Vitiello, *The Dissipative Brain*, in Brain and Being.
[60] Symmetry breaking can also be explicit, referred to as Explicit Symmetry Breaking. In this case, the dynamical operations are modified by adding one or more terms that are not consistent with the symmetric terms.
[61] The conventional approach in introducing the QFT algebraic structure consists in assigning the canonical commutator or anticommutator relations for the boson or fermion case, respectively. However, one needs also to specify which one is the prescription for adding primitive observables such as energy, angular momentum, etc. It could seem that such a prescription does not belong to the algebraic structure

of freedom, say A˜ (the tilde quanta; the non–tilde quanta A, denoting the brain degrees of freedom), are meant to represent the environment to which the brain is coupled. The physical meaning of the doubling is the one of ensuring the balance of the energy flux between the system and the environment. The environment thus represented by the doubled degrees of freedom appears described as the "time–reversed copy" (the *Double*) of the brain.[62] The environment is "modelled" on

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of the theory. Effectively, this is not the case. In fact, in order to specify, e.g., the total energy E of two identical particles, one writes E = E1 + E2. The meaning of the labels in such a formula is that E1 refers to the first particle and E2 to the second particle. However, it is easy to realize that E1 = E × 1 where the index 1 thus refers to the first position. Similarly, E2 = 1 × E. Thus, E = E1 + E2 = E × 1 + 1 × E, and similarly J = J1 + J2 = J × 1 + 1 × J, for the angular momentum, which are nothing but the commutative coproducts of a coalgebra. Here, "commutative" refers to invariance of the coproduct under the permutation 1 ↔ 2, as it needs to be on the premise that the particles are identical. We should be able therefore to go from the algebra A for the single particle to the algebra for two of them, namely, A → A × A. Of course, we need also to be able to go back to a single particle, namely, A × A → A. The conclusion is that the basic algebra to start with, in QFT is a bialgebra, that is the Hopf algebra. We thus see that the "doubling of the degrees of freedom" (DDF) implied in the Hopf mapping A → A × A arises as a natural requirement in setting up the QFT algebraic structure. Most interesting is the case when the two systems need to be treated not on the same footing, as, for example, in thermal field theory, or when dealing with open systems in general, where the system under study and its thermal bath or environment are not exchangeable. In these cases the proper tool is provided by the q-deformed Hopf algebras with non-commutative coproducts, e.g., $\Delta aq = a\times q+q^{-1}\times a \equiv aq + q^{-1}\tilde{}a$, with a∈A, and its hermitian conjugate, $\Delta a\dagger\ q = a\dagger\times q^*+(q^{-1})^*\times a\dagger$. Of course if q is real, q* = q; if it is imaginary, then $q^* = q^{-1}$. The deformation parameter q may depend on temperature, decay constants, etc. The QFT formalism of the DDF has been introduced and used in many applications of the TFD formalism for many-body systems. The Hopf coalgebra thus describes the doubling of the degrees of freedom a → {a, ˜a} and of the state space F → F × ˜ F, with the operators a and ˜a acting on F and ˜ F, respectively. We stress that the associated Hopf algebra is, as said, a non-commutative coalgebra. (G. Basti, G. Vitiello and A. Capolupo, *Quantum Field Theory and Coalgebraic Logic in Theoretical Computer Science*, in arXiv:1701.00527v1[quant-ph], 29th Dec, 2016, 1-20).

[62] G. Vitiello, *The Dissipative Brain*, in Brain and Being. When the system under consideration is dissipative, it accepts external energy without heating up, stores the order, and can later give it up to the surrounding heat bath environment. *Umezawa's*

the brain. Time–reversed since the energy flux outgoing from the brain is incoming into the environment, and vice versa.[63] The doubling of the degrees of freedom in the dissipative model thus arises as a consequence of the irreversible time evolution.

The superimposition of the dipole soliton and the water dipole moment in the brain lead to one defined degree of freedom known as corticon. This, according to G.G. Globus, "disregards the neuron's and neuroglia's boundary membrane"[64] that is the mark of classical physics. These corticons are created when an input from the environment comes into the vacuum. But let us understand the concept of vacuum in QBD.

The concept of vaccum in QBD: Vacuum states are near-zero energy states, also called "ground states." In the case of ordered water, the momentum axes of the spinning water dipoles all point in the same direction in the θ-vacuum states upheld by the living brain.[65] As already stated, when input comes into this vacuum, corticons (dipole wave quanta) are created, they are quanta which undergo annihilation

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innovation is to treat the heat bath environment as tilde. The nontilde system exchanges energy with its ~environment, while the energy of the nontilde system + ~environment, that is, the energy of the closed system, remains constant in strict accordance with energy conservation laws. So when the nontilde system dissipates order to the ~system, its entropy increases and the entropy of the ~system in compensation decreases. The *total entropy* of nontilde and tilde systems, however, remains constant under any exchange. (G.G. Globus, G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics* 36).

[63] The quantum dissipation formalism implies that the full operator describing the system time evolution includes the operator describing the coupling between the non–tilde and the tilde quanta. At the same time, such a coupling term acts as the mathematical tool to attach the label to the vacua (and thus to distinguish among different memories). This label is time–dependent: the system states are thus time–dependent states.

[64] G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics,* John Benjamins Publishing Co., Amsterdam and Philadelphia, 2003, 22.

[65] Ibid.

and creation dynamics. This input provokes corticon dynamics. In the corticon dynamics, the energy gained can be dissipated, with the system relaxing back into a *different* θ-vacuum state than before. (The θ-vacuum transformation is called the Bogoliubov transformation, which remarkably, in Russian literally means the love-of-God transformation. So we might say that we have memory, and so our humanity, through the love of God.) Input provokes corticon dynamics and a Bogoliubov transformation to a θ-vacuum state. (Memory – hence temporality – is derived through the Bogoliubov movement).[66]

***Understanding Bogoliubov Transformation via the Hopf Coalgebra of QFT**:*

> There is one more aspect of QFT and its intrinsic algebraic Hopf structure, which is relevant from the perspective of the coalgebraic logic and computer science: the tilde modes provide the intrinsic dynamic (coalgebraic) reference (semantics) for the non-tilde modes. The coalgebra structure of the doubling both the space, and the operators, turns into a strict correspondence between each operator and its tilde-copy (the doubled operator) so that one of the two provides the address of the other one. The result is the self-consistent dynamical inclusion of the "reference term" in the logical scheme. A sort of contextual self-embedding, or dynamical generation of meaning, a "local", not "absolute", but crucially meaningful truth, singled out of the infinitely many possibilities offered by the infinitely many representations of the CCRs. The simplest example is perhaps obtained by explicitly computing the expectation value of the number operator
> $N_{Ak} = A^{\dagger}_{k}A_{k}$ in the ground state $|0(\theta)\}N$. By inverting the Bogoliubov transformations, we have $\forall k$
> $NA_{k}(\theta) \equiv N\{0(\theta)| A^{\dagger}_{k}A_{k} |0(\theta)\}N = N\{0(\theta)|A\tilde{}_{k}(\theta) A\tilde{}^{\dagger}_{k}(\theta)|0(\theta)\}N = \sinh^{2}\theta_{k}$, (1)

[66] Ibid.

> which shows that for any k, the only non-vanishing contribution to the number of nontilde modes $NA_k(\theta)$ comes from the tilde operators. In this sense, these last ones constitute the dynamic address for the non-tilde modes. Through them, the total number $NA_k(\theta)$ of the A_k condensate is determined. Of course, the reverse is also true, namely the only non-zero contribution to $NA\tilde{}_k(\theta)$ comes from the non-tilde operators, and
> $NA_k(\theta) - NA\tilde{}_k(\theta) = 0$.
> The whole condensate content of $|0(\theta)\}N$ is thus specified by the N-set $\equiv \{NA_k(\theta), NA_k(\theta) = NA\tilde{}_k(\theta), \forall k\}$.
>
> Such a N-set is called the order parameter. It provides a characterizing parameter for the θ-vacuum $|0(\theta)\}N$ and explains the meaning of the N subscript. Its knowledge constitutes the "end point" of the computation, the searched result.[67]

The corticon fields in which corticon creation and annihilation dynamics take place are of the spontaneous symmetry-breaking type. At the ground, there is sameness before difference, vacuum states without preference – degenerate θ-vacua – and difference is achieved, intrinsic to the ground, in symmetry-breaking. In non-vacuum states, the unbroken symmetry of "a uniform rotation of the electric dipole moment vectors of the H_2O molecules does not change the fundamental dynamics of the water rotational field described by the Schrödinger equation." The field entity, with its various energy levels, makes no distinctions under uniform rotation in higher energy states. But in least energy vacuum states, the rotational symmetry can be broken: a change in the direction along which the electric dipole moment vectors lineup changes the vacuum. Symmetry-breaking in vacuum states thus permits distinction. Order becomes ontological

[67] G. Basti, G. Vitiello and A. Capolupo, *Quantum Field Theory and Coalgebraic Logic in Theoretical Computer Science*, in arXiv:1701.00527v1[quant-ph], 29th Dec, 2016, 1-20.

through symmetry-breaking, without which there is only the degeneracy of uniformity.[68] So vacuum states support distinction, permit order. When input spontaneously breaks the rotational symmetry of the vacuum, the broken symmetry is specific to a particular input. However, fundamental energy conservation laws do not allow the loss of symmetry under these conditions. The "lost" invariance is in fact conserved in massless quanta known as Nambu-Goldstone (N-G) bosons.[69] The broken symmetry is preserved by the NGB. According to G.G. Globus, the NGB "in living brain tissue are none other than the "symmetrons" of the early Umezawa school, since they conserve the lost symmetry specific for input."[70]

How Does Consciousness Arise? The personal unit brain-body-environment has its physical foundation in the quantum entanglement brain-body-environment. The entanglement "represents the impossibility of cutting the links between the brain and the external world;"[71] the quantum model of the brain is based on the fact that the brain "is an open system in interaction with the external world."[72] For, information printing (this is also consciousness) on the brain "is achieved under the action of external stimuli, which produce the breakdown of the symmetry associated with the electric dipole vibrational field." [73] Thus, emphasis is laid on the brain being entangled or "coupled to the environment."[7475] The centrality of the

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[68] G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics,* 23.

[69] Ibid.

[70] Ibid. G.G. Globus refers to these symmetrons as Goldstone symmetrons, to remind all that they are massless quanta which conserve the symmetry specifically broken by input order.

[71] G. Vitiello, *The Dissipative Brain*, in Brain and Being.

[72] G. Vitiello, *My Double Unveiled*, 104.

[73] Ibid.

[74] Ibid.

[75]Each personal conscious state of a human being corresponds to a complex phase-coherence among the oscillating electromagnetic force fields of some material parts (molecules) of the three components involved. That is - for instance in the personal state of me as seeing now the computer screen in front of me - some (effectively many trillions) of molecules of the neurons of a part of the visual cortex involved,

brain, as constantly noticed in the foregoing lines, should not lead to a hasty consideration of the body as inconsequential in the entire dynamics that defines the human person, for the three components, of body-brain-environment, stand as integral to a valid comprehension of the human person. According to Capolupo, Freeman and Vitiello,

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[76] A. Capolupo et al, *Dissipation of Dark Energy by Cortex in Knowledge Retrieval* in Physics Life Review, Volume 10, Issue, 1, March 2013, 85–94.

because the choice of a ground state entails that the information has been recorded.[77] After information has been recorded, the brain state is fixated and the brain cannot be brought to the state configuration in which it was before the information printing occurred; for before the information recording process, the brain can in principle be in anyone of the infinitely many (unitarily inequivalent) vacua.[78] There is the presence of time-reversal symmetry which means that the human person assumes a present state of affairs, one that can be distinguished from the past and the future, what Vitiello calls, "NOW you know it!"[79]

According to Vitiello, "Consciousness appears to be intimately related to dissipation."[80] He adds further that "Consciousness seems thus to emerge as a manifestation of the dissipative dynamics of the brain."[81] This dissipative dynamics has to do with the coupling of A (the nontilde subject) with Ã (the tilde object), which describes nonlinear dynamical features of the dissipative model. The nonlinearity of the dynamics describes a self-interaction process for the A system. Ã thus also plays a role in such self-coupling or *self-recognition* processes. The Ã system is the *mirror in time* image, or the *time-reversed copy* of the A system.[82] It actually duplicates the A system. It is the A system's *Double,* and since it can never be eliminated, the A system can never be separated from its Double. The role of the Ã modes in the self-interaction processes leads me to conjecture that the tilde-system is

[77] G. Vitiello, *My Double Unveiled*, 107.
[78] Ibid.
[79] Ibid.
[80] Ibid, 123.
[81] G. Vitiello, *Quantum Dissipation and Information. A route to consciousness modeling*, in NeuroQuantology 2003; 2: 266-279.
[82] According to G.G. Globus, that the tilde object is a mirror image of the nontilde object, this representation is only in the mathematical sense, for There is no world running forward in the nontilde system and running backward in the ~environment, and so a metaphor of time and time-reversal as a movie run forward and backward respectively would be an inappropriate metaphor. (G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics,* 36-37).

actually involved in consciousness mechanisms. [83] Dissipation manifests itself as a *second person*, the Double or *Sosia*, to dialogue with. In this way, consciousness appears to be not solely characterized by a subjective dynamics; its roots, on the contrary, seem to be grounded in the permanent *trade* of the brain (the subject) with the external world, on the dynamical relation between the system A and its Sosia[84] or Double Ã, permanently joined to it.[85]

Consciousness is reached *through* the opening to the external world. The crucial role of dissipation is that self-mirroring is not anymore a *self-trap* (as for Narcissus), the conscious subject *cannot* be a monad. Consciousness is only possible if dissipation, openness onto the outside world, is allowed. Without the *objective* external world, there would be no possibility for the brain to be an open system, and no Ã system would at all exist. The very same existence of the external world is the *prerequisite* for the brain to build up its own *subjective simulation*, its *own representation* of the world. The informational inputs from the external world are the *images* of the world. Once they are recorded by A, they become the *image* of A; Ã is the *address* of A, it is identified with (is a copy of) A.[86] In Vitiello's formulation, the

[83] Ibid. The mathematical and physical meaning of the tilde-system is to describe the environment to which the brain is permanently coupled (linked). Since the brain is intrinsically an open system, the tilde-system can *never* be neglected. The tilde-modes thus might play a role as well in the unconscious brain activity. This may provide an answer to the question "as whether symmetron modes would be required to account for unconscious brain activity. As already observed, the tilde modes might tell us something about that fuzzy region between fragile consciousness and the obscure unconscious core of the dream activity.

[84] The "doubling" of the self is actually a very old literary metaphor. Plautus invention of the "doubling" of Sosia in his comedy Amphitruo (Plautus, 189 B.C.), or even the falling in love of Narcissus with himself mediated by his "reflection" in the water, are famous examples of such a metaphoric use of the "doubling ". On the other hand, in the ancient Vedic tradition (Kak 1996), consciousness also flows between two poles: an identity of self and an identity with the processes of the Universe. G. Vitiello, *My Double Unveiled*, 141.

[85] Ibid.

[86] Ibid.

brain is an open system exchanging energy with the external world. There is a "permanent 'trade' of the brain (the subject) with the external world." This trade is reiterated in the relation between the brain (subject) and its ∼Double.

> ...the unavoidable coupling with the external world is 'internalized' in the dialectic, permanent relation with the Double.[87]

So now there is a subject/object dialectic where subject is nontilde and object is tilde, and a subject/Double dialectic where again subject is nontilde and Double is tilde. Consciousness arises for Vitiello where tilde and nontilde come together, where nontilde subject meets a world that is "in some sense" tilde, a meeting of time-reversed mirror images, self meeting Double. Consciousness, in Vitiello's account, is the case of subject self-recognition in a ∼conjugate mirror. In his metaphor, consciousness is not on either side – neither nontilde/subject nor tilde/object, but at the tail of a mirror in which the mirror image comes up in an alter universe.[88] In Vitiello's thermofield QBD formulation, consciousness lies in the vacuum states where an interaction match takes place. Dasein's dissipative quantum brain, which supports controlled interactions in its ground states, does it all. So Vitiello's formula resolves to:

nontilde subject self-recognizing world representation → *consciousness*.

Vitiello gives no justification for thinking of nontilde as subject. It has the very same symmetry as the ∼object, only time runs oppositely in the latter. Tilde and nontilde modes here are perfectly symmetrical, so they cannot support the categorical distinction between subject and object, indeed their only distinction is the time reversal.[89] In the very mathematical formulation, the self recognition or match is *assumed*.

[87] G. Vitiello, *My Double Unveiled*, 141.
[88] G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics,* 31.
[89] Ibid, 32

Vitiello "requires" that the condensate contain an equal number of A and A~ modes, which insures "that the flow of the energy exchanged between the system and the environment is balanced."[90] The equation of subject and object here is imposed by fiat; their equality is simply postulated, in the dominating fashion typical of still metaphysical modernity.[91]

Conclusion

Consciousness, as a nonphysical entity that is pertinent to the rationality of the human person, is an issue that has for long defied any explanation. Yet, with the findings of the QBD, based on QFT, it is now seen that the age-long truth of "no man is an island" comes to bear in what has been elaborated upon thus far. Consciousness arises in the brain-body-environment interaction or, to put it in quantum terms, entanglement. The environment referred to here is all that is outside the subject, the "I", including the "other", that is the "You". That is to say that the environment is not limited to the inanimate, or the brute, or the vegetative life that resides outside the subject. It also encapsulates other subjects, who in reference to the subject under study, is the object. The mode in which consciousness arises also makes reference to the view that opposes solipsism, but speaks for interaction, community, solidarity and togetherness. These latter qualities have been championed in philosophical debates under titles such as existentialism, personalism, Interpersonalism, especially in *Igwebuike* philosophy[92]. What this goes to certify is that the human

[90] G. Vitiello, *My Double Unveiled*, 111.

[91] G.G. Globus, *Quantum Closures and Disclosures. Thinking-Together Postphenomenology and Quantum Brain Dynamics,* 32.

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person is not a closed system, but is an open system who is in continuous interaction and rapport with others (rational, animate and inanimate alike). The human person becomes a closed system when he dies; as QFT records it, this is when he attains to the state of maximum entropy. The exchange between him and the environment is cushioned under the second law of thermodynamics, such that there is a balance, even in this exchange of energy (for what is exchanged is energy). The human person is one with other, and not one with himself, his rational consciousness attests to this. That the human person is linked to the other is what makes consciousness arise, one which is rational and cognitive. What is to be said is that our solidarity and complementarity, our interpersonal interaction, our "Igwebuikeness" as human persons, is neural, it is cognitive and it is quantum.

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