Article

Quantum Human & Animal Consciousness: A Concept Embracing Philosophy, Quantitative Molecular Biology & Mathematics

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Abstract

Biology and culture, consciousness and the world, subject and object, inner and outer have continuity and find, in the "creative transcendence" of consciousness and its experiences, a privileged degree of understanding. The aims of this paper are: (1) to stress the validity of the phenomenological approach to consciousness and the subsequent interpretation of memory, expression of the "ego" as a continuous narrative of "self"; (2) to show that a molecular structure, such as tubulin, can effectively modulate the state of consciousness through the changes that occur within it; (3) to formulate a plausible hypothesis about the existence of different levels of consciousness in animals; (4) to introduce a hypothesis concerning the involvement of membrane viscosity and serotonin as regulatory agents in different levels of consciousness such as mood disorders and hallucinations. It is suggested that consciousness persists even in the face of minimal conditions, perhaps even in traumatic brain injuries. Such a suggestion is justified at the bio molecular level through introduction of the hypothesis that Schrödinger proteins (i.e. tubulins) are the biological interface from quantum to classical computation, underlying quantum/classical consciousness processes and at the crossroad of memory and learning capacities.

Keywords: intentional consciousness, animal consciousness, cell membrane viscosity; Gsα protein, tubulin.

Consciousness: a phenomenological interpretation

Each consciousness is intentional consciousness, "*consciousness of*", "*look towards*" a world, whether it be, of "*naked thing*" or matter of sense and evaluation, says Husserl (Husserl 1950). Consciousness, therefore, performs the work of unmasking, finalized to the evidence of the world, to its explanation (*zu den Sachen Selbst*).

Any experience to which we refer is always an experience of something that is in the world, caught in its flow, into the living embodiment of its things that are "*here for me, they are within my reach [...] whether I am paying or not paying attention to them, whether or not I take care of them in my thinking, in my feeling, in the will* "(Husserl 1950).

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In short, consciousness is "*life that experiences the world*", the world-of-life, of lived experience (*Lebenswelt*): at the beginning there is the intuition, the perceptive and bodily dimension of feeling, moving, observing, real previews of the subsequent theoretical time.

The origins of objective science send back to the world-of-life, of the original evidence, of the lived experience, pre-logical, constantly experienced, whose "peculiar scientificity" founds the same logic-theoretical science, its logical meaning located underneath experiencing.

Every process of abstraction, idealization, scientific research, each of its historical senses starts from that original pre-science construction that is, precisely, the Lebenswelt, the world of life, the real life of consciousness intuitively immersed in the history of a world not yet objectified, theoretical.

The world-of-life is the beginning, (the "Vergessenes Sinnesfundament der Naturwissenschaft") (Husserl 1954) of any scientific question; categories and scientific instruments should not emphasize their strangeness, their formalism with respect to reality, but must constantly nurture the relationship with it.

In the Paragraph of the Krisis entitled "Die positivistische Reduktion der Idee der Wissenschaft auf bloße Tatsachenwissenschaft. Die "Krisis" der Wissenschaft als Verlust ihrer Lebensbedeutsamkeit" ("The positivistic reduction of the idea of science to the idea of a science of facts. The 'crisis' of science as a loss of its meaning for life) reports: "The mere facts of science create mere men in substance (*Bloße Tatsachenwissenschaften machen bloße Tatsachenmenschen*)". Husserl's thought wants to remind science not to confine the knowledgeable world, in a material way, because, by doing so, those problems that are the most pressing for man, who, in our restless times, feels at the mercy of fate; it would exclude "on principle"; the problems of the meaning or meaninglessness of human existence as a whole (*die Fragen nach Sinn oder Sinnlosigkeit dieses ganzen menschlichen Daseins*)", that is, those issues that "relate to man 's behavior towards the surrounding human and non-human world, man who must freely choose and who is free to rationally model himself and the world around him.

What should this science say on reason and unreason (*Vernunft und Unvernunft*), what should this science say about us, human beings as subjects of this freedom (*Menschen als Subjekte dieser Freiheit*)"?

All sciences, the Geisteswissenschaften also, seem to confine themselves up in their specialized fields and fences, within a *substantial factualism* which rejects as unscientific, or even as anti-scientific, irrationalistic, the essential problems concerning freedom, reason, happiness, and the sense of life.

Consciousness, in other words, has a transcendent active character (Merleau-Ponty 1945) of understanding of the existing: consciousness "*takes along*" (cum-prehendere) itself and the world not as a mere factual but intentional registration (tension of consciousness with the object of giving it a soul, to make it understandable).

The conscious awareness on itself and the world is not limited to a "*path with an intended destination*" (*Erfahrung*), that is, the difference between subject and object with verification by the first of what is true or false in the second, but configures, primarily, as an experienced inclusion of the object in the transcendence of consciousness (*Erlebnis*).

Fruitfulness of the phenomenological approach to consciousness

If we assume that consciousness, *ab origine*, is intuitive, a vital look on the world, its perceptions (biologically related to tubulin and to the cell membrane viscosity) will not be simple facts, but lived concreteness. The man would say Hidegger (Heidegger 1977) as human being - in the world - (*In-der Welt-sein*) has a relationship with his ways of being and with other lives (Binswanger 1946). Well, this lived, perceived, internalized concreteness, could be retained by tubulin as a mnemonic expression of consciousness, to configure the man as a continuous narrative, that is, as always active consciousness, even to minimal levels, oriented to continuously stitching and mending itself.
An English study, however, has found "*evidence of consciousness*", that is, responses to stimuli, albeit in a small percentage, in patients who have suffered traumatic brain injury (Monti 2010).

The uninterrupted narrative of self is embodied in the memory, understood as a succession of experienced feelings, thoughts, events, otherwise unrelated, that is, as openness to the sense (Nietzsche 1958).

Locke himself, who didn't found the personal identity in a vertical direction (metaphysical continuity of the individual) but in a horizontal one, recognized, specifically in memory, the thread capable of stitching together, and then connecting, all the events of our lives, even being aware that memory, which is open to the sense, but also to the 'implosion of every sense, that is to say death (Galimberti 1999), is an expression of human frailty (according to a line of thought that from Locke and Hume reaches Parfit or Dennett).

This so fragile self, according to Ricoeur (Ricoeur 1990), is idem identity, continuity of the same (méméte) and ipse identity, narrative identity; permanence in time, topographic identity and dynamic uniqueness, ever renewing itself; formal identity, substantial, "be himself" statically, and dynamics that keeps faith in herself as a promise, and that tells its action without interruption, under a language that has a pragmatic force (Austin's locutionary and illocutionary acts) and not just a semantic one. Right in the illocutionary force, Ricoeur (Ricoeur 1999) finds the notion, dear to the personalist tradition, of commitment and self-esteem, "where at the level of semantics the person was only one of the things in respect of which we speak, at pragmatic level the person is immediately designated as self, to the extent that the speaker designates himself every time that specifies the illocutionary act in which he engages his word."

Here we are at the heart of the person and of the so-called personism: mind - body relationship, typical of analytic philosophy, should be replaced with the person-body relationship, because the world and the person belong to different ontological geographies.

In other words, the physicalism, according to which every object is made by and reducible to physical analysis should be replaced by the phenomenology (De Monticelli 1995; De Monticelli 1998; Rudder-Baker 2000). In this context, consciousness is conceived as a "creator of reality": it would be interesting to deepen, in a phenomenological sense, some quantum models of consciousness (Herbert 1987; Hameroff 1998; Hameroff 2007; Hameroff and Penrose 2003; Stapp

1999), starting, for Stapp, from the affirmation of Von Neumann, claiming that the universe is the objective result of subjective observational states.

Consciousness levels

Recently it was shown (Cocchi 2008; Cocchi and Tonello 2010) that, according to the molecular parameters investigated in humans (platelet fatty acids), by which it has been possible to obtain a classification of the depressive disorder (Cocchi 2010a, b), in some animals can be found the same bio-molecular characteristics evidenced for human depression (Cocchi 2009d). This finding led to a reflection on the state of consciousness about human psychiatric condition and has, once again, raised the *quaestio* of consciousness in the animal world.

The acquisition that consciousness is a fundamental element involved in psychiatric illness (Cocchi 2010c) creates a fertile ground to identify the mechanisms that, through various experiential activities, lead to an hypothesis of molecular approaches to psychiatric illness, with a possible "continuous" between cell membrane viscosity, protein Gsα and Tubulin.

To provide a precise definition of consciousness is not easy, however. Personal thoughts, theories and behavioral experiments on humans and animals, have involved many intellectual resources with the intent to understand whether the animals have consciousness or not and which kind of consciousness in comparison with man.

In recent decades the progress of the biochemical, molecular and quantum computation knowledge has, in recent decades, has allowed the opening of hypotheses that have shown chinks of light on the delicate and complex problem of consciousness.

A strong proposal, not yet fully shared by the entire scientific community, has been put forward by Penrose and Hameroff with the Orch OR Theory. It's the first time that consciousness is substantiated and is part of a biological domain, opening, in fact, to a complex series of researches aimed to find links and connections between the cytoskeleton and the molecular expression of the cell, which involves membrane viscosity, Gsα protein and tubulin.

We believe that consciousness is a complex system, interactionist and organismic, in which the parties can be explained only if they refer to the whole. In detail, the ordinary states of consciousness or ego can be represented as a set of communicating levels (Figure 1):

1. Pure biological level or primordial ego: the proto self of Damasio (Damasio 1999), attributing in a rudimentary form to his own ego, feelings of hunger, thirst, pleasure, pain;
2. Bio-eco-logical level: on the conscious interaction between subject and environment, but set only the "hic et nunc" with no extension project.
3. Extended mnemonic level: belonging to a consciousness that, while expanding "back and forth, "does not yet embody in a language its being continuous narrative, preserved by the memory as a place of meaning of life.
4. Level of identity sense: from its original roots in biology the ego has gradually expanded to the ecological dimension or mnemonic short-range, is then passed to the mnemonic long-haul dimension, and now, through language, produces an accomplished culture.

5. Mysteric level of consciousness or abyss of consciousness (Cocchi et al. 2009). The presence in humans of a prophetic intuition, of an abyss of consciousness opens the way for intellectual freedom as liberation from the outer limits (subject, "obstacles" to overcome in pursuit of their projects) and internal (indefinitely biological determinism or panbiologism).

In other words, the ego produces articulations of sense about himself and the world that incorporates into his experiences and his acting out, in a narrative, intellectual and emotional, irreducible to any other, world views, social stress, scientific and cultural expressions.

Altered states of consciousness (ASC) are states of consciousness that differ significantly from baseline or ordinary consciousness. ASC are brain states wherein the sense of identity with one's body or with one's normal sense of perceptions, is lost. The ASC can be achieved through trauma, sleep disturbance, sensory deprivation or sensory overload, neurochemical imbalance, epileptic seizure, or fever. They may also be induced by social behavior, such as frenzied dancing or chanting and may be induced by electrically stimulating parts of the brain or by ingesting psychotropic drugs (Vailt 2005). Man is rooted in biology, but does not solve it in its entire existence. In short, it is reductionist to identify the personal self in a simple chain of neurons or, in other words, to explain the mind, and thus indirectly the soul/consciousness, only on neural basis: e.g. on neuro-psychoanalysis and on Freud old dream of reducing the mental to the neural, see the contributions of Heinrich (Henrich 2010) and Semenza (Semenza 2010).

On the other hand is, obviously, ontologically nonsensical undock the ego from his flesh, from its biological dimension. There is, in short, a carnal “self”, but also a “self” whose nature is immaterial, a-quantum, mysterious, chaste guardian of freedom and openness to a transcendent sense:
"On the idea of soul we must say the following. To explain what it is, would be task of a divine exposure in all directions, and long; but, to say what it looks like is a human exposure, and relatively short“. (Plato, Phaedrus, 246 A it. tr. G. Reale; see also Heraclitus, fr. 45; compare also the intuition of Heraclitus' *logos*, which increases itself: fr. 115 and the pace of the Platonic Phaedo, 99 A-B).

In light of the above, we believe that consciousness is in memory that makes itself language and narration, the identification process for excellence, which cultural or existential nature intercepts,in tubulin its biological marker, the sign of continuity between biology and culture. In this context, as can be inferred from the subsequent molecular biology argument, the dialectic among tubulin, brain and synapses, governed by serotonin, could be the privileged herrmeneutical key to determining the different levels of states of consciousness.

In our case, the animal consciousness (Dennett 1996; Griffin 1992; Wilder 1996; Bekoff and Allen 1997; Gozzano 2001) could be incorporated at the pure organic and bio-eco-logical levels. Bekoff (Bekoff 2002; Bekoff and Peirce 2009) even believe that the animals show a wide range of moral behavior, including sense of justice, empathy, trust and reciprocity: a hypothesis that would lead us to an even higher level of consciousness, to the extent that morality would be understood as an evolutionary trait that humans share with other social mammals.

Quaranta et al. (2007) argue, on the other hand, that the lateralization, appeared before language, is not just a prerogative of man but also of very different organisms (i.e. dogs). Mascalzoni et al. (2010), studying the chicks (chicken), concluded that in the brains of vertebrates there is an innate neural mechanism underlying the recognition of animate objects (along with physical causality, the distinction between animate and inanimate objects constitutes a kind of Kantian genetic a priori).

Accordance with these studies, depening the concept of "animal potential memory", one could hypothesize a sort of proto level of animal consciousness (extended mnemonic proto level). Figure 1.

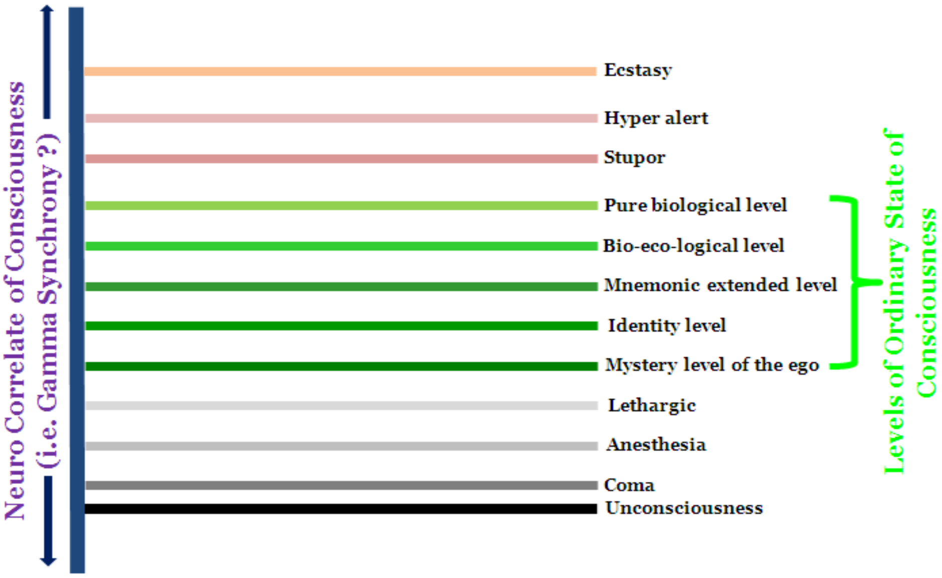

Fig 1. Description of consciousness levels

Even in the world of plants one could speak of a first level of consciousness. Tryptophan, in fact, together with some plant intermediates (oxygen and reduced cofactors), forms serotonin: the role of all these is to ensure the utilization of light, essential for life (Azmitia 2001). In fact, as a proto-self exists in animals and humans, linked to the fulfillment of basic living needs (hunger, thirst, pleasure, pain), so there is a sort of pre - proto-self plant, expression of the dialectic-tryptophan-intermediate substances-serotonin-light, which guarantee a biological life.

Serotonin, with all its dynamics, would thereforeconstitute the principle of identity of the plant: the plant lives because the serotonin guarantees the light. In other words, you could also split the pure biological level:

- primordial consciousness plant or pre-proto-self
- primordial animal and human consciousness or proto-self.

The Spinoza conatus sese conservandi, the power that every natural expression has to expand its power, in primis the existence, is therefore, trasversal to the whole nature and seems to impose itself as an original marker of consciousness in its original announcement, that is, to say from and in the very moment we start talking about that.

Quantum Consciousness

The definition of consciousness is not universally shared, even worse is the definition of quantum consciousness. For the purposes of this study is very useful the Efstratios Manousakis approach which describes the nature as grounded on the framework of the operation and on the primary ontological character of consciousness, rather than describing consciousness as grounded on the laws of physics. The word consciousness usually means "experienced awareness". A person is "conscious" or "has" consciousness if he is experiencing a "flow" of conscious events. The stream of consciousness consists of the conscious events that constitute this stream. Manousakis supposed that all human beings and the other living organisms have their own streams of consciousness and postulated the existence of the Universal/Global stream of consciousness, as the primary reality that contains all of our individual streams. Therefore, he postulates the primary ontological status, the oneness, and the universality of consciousness. The term "oneness" means that there is only one stream of conscious flow with various sub-streams, the individual streams of consciousness, such as those which we are experiencing as human beings, but all connected to one Universal conscious flow (Manousakis 2006).

According to Stuart Hameroff: "*Consciousness involves phenomenal experience, self-awareness, feelings, choices, control of actions, a model of the world, etc. But what is it? Is consciousness something specific or merely a byproduct of information processing? Whatever it is, consciousness is a multi-faceted puzzle. Despite enormous strides in behavioral and brain science, essential features of consciousness continue to elude explanation"* (Hameroff 2006).

We need, at this stage, to spend some words about the reasons which induce us, and many other researchers, to choose quantum theories as the main conceptual framework to model consciousness phenomena. These reasons have been already discussed in detail way by many authors, such as, for instance, Penrose (1994). However, without entering into technicalities, we should help biochemists, physiologists, philosophers and clinicians to understand the convenience of using very abstract and mathematically difficult theories (such as the quantum ones) to account for phenomena whose macroscopic features are, after all, easily accessible to everyday observations. This convenience stems from the following considerations:

1) all physical phenomena underlying consciousness are based, at the microscopic level, on the behaviours of molecules, atoms and elementary particles; the latter, as evidenced by more than one hundred years of experimental research, must be described in quantum terms;

2) only quantum theories allow the existence of robust global coherence effects (Anderson and Stein 1985; Umezawa 1993; Vitiello 2001); the latter have been observed in a huge number of cases, scattered among all scientific disciplines (consciousness phenomena are highly representative in this regard) and generally difficult to accounting for by resorting to traditional classical physics; within the latter, of course, coherence effects are allowed, but they cannot be robust, being strongly dependent on initial conditions, special arrangements, and like; moreover, they are subjected to an unavoidable decay dictated by the laws of classical thermodynamics.

These reasons must not induce us to forget that the actual state of quantum theories is far from being perfect. Namely the latter have been initially formulated with the purpose of describing only simple atomic phenomena. Their application to biological processes is, thus, still marked by a number of conceptual and technical difficulties (Pessa 2008). However, the findings, so far obtained, point to a increasingly better integration of quantum theories within the world of biological modelling.

In the last decade many theories and papers have been published concerning the biophysical properties of Microtubules (MTs) including the hypothesis of MTs implication, in coherent quantum states in the brain, evolving in some form of energy and information transfer.
A plausible motive force for objective collapse in the brain needs to be identified, and it is conceivable that MTs or the tubulin subunit, that compose them, have something to offer to this concept. Tubulin, acting as qubits that communicate with one another via quantum entanglement induced by physical interactions, performs quantum computations that would be influenced by synaptic activity, and other neuronal conditions, to orchestrate the collapse that gives rise to cognitive events.

MTs and Actin filaments can be viewed as computationally relevant nanowire networks that operate within neurons providing the connection of the cell nucleus with the postsynaptic density interactome (Woolf et al. 2010). Potential computational modes for MTs and actin filaments are beginning to be understood, with two main quantum models proposed for MTs information processing. The Hameroff-Penrose model (Hameroff and Penrose 1996) which suppose that quantum-superposed states develop in tubulins, remain coherent and recruit more superposed tubulins until a mass-time-energy threshold, related to quantum gravity, is reached up to 500 msec. (Libet et al. 1979).

In figure 2 is synthesized how the quantum mechanisms of unconsciousness are processed to reach the conscious mind.

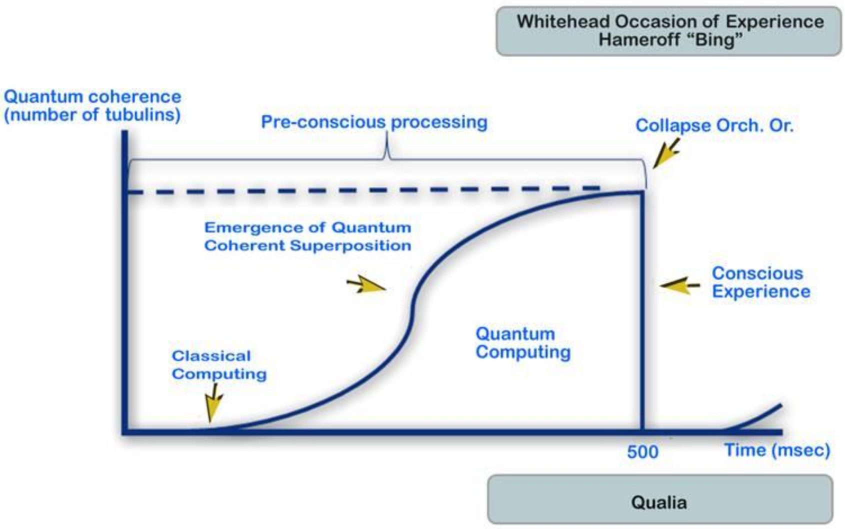

Fig 2. Consciousness and Unconsciousness. The unconscious, endowed with global knowledge, (the truth-observable) is rich enough to originate creativity. Quantum information is processed by the unconscious and then is made available to our conscious mind as classical information. (From Hameroff and Penrose 1996: modified)

This model predicts dendritic webs of approximately 100,000 neurons for discrete conscious moments, or frames, occurring every 25 ms in gamma synchrony (Hameroff and Penrose 1996). More recent is the Craddock and Tuszynski model which describes classical and quantum information processing in MTs based on a double-well potential in the interior of the tubulin dimer. (Craddock and Tuszynski 2010; Craddock et al. 2009).

Within each dendrite's cytoplasmic interior, microtubules are connected by microtubule-associated proteins. Many possible fine-scale processes e.g. electromagnetic fields, calcium ion gradients, molecular reaction–diffusion patterns, actin sol-gel dynamics, glycolysis, classical microtubule information processing, and/or microtubule quantum computation with entanglement and quantum coherence can extend through gap junctions. Networks of gap junction-linked neurons (and glia) have been termed hyper-neurons (John et al. 1986). Thus, dendritic integration webs may unify, on a brain-wide basis, fine-scale processes comprising consciousness. Gap junction circuits of cortical interneurons in adult brains mediate gamma EEG/coherent 40 Hz and other synchronous activity (Dermietzel 1998; Draguhn et al. 1998; Hormuzdi et al. 2004; Bennett and Zukin 2004; Lebeau et al. 2003; Friedman and Strowbridge 2003; Buhl et al. 2003; Rozental et al. 2000; Perez-Velazquez and Carlen 2000; Galaretta and Hestrin 1999; Gibson et al. 1999).

Serotonin, Membrane Viscosity and Post-synaptic Interactome

The aspect of neuron and platelet cell membrane viscosity (Tonello and Cocchi 2010) is often missed, as responsible of the central goverment of that bio molecular intracellular complex, called interactoma, and that is defined "as the whole array of molecular interactions that take place in an organism and allow the cascade of regulatory molecules including the mechanism of action of enzymes and metabolic reactions".

These findings agree with Heron (Heron et al. 1980) who described the correlation between serotoninergic cell membrane viscosity, due to the fatty acids pattern, and serotonin receptor binding capacity, capable of constraining the serotonin availability and Lee (1985) who reviews and discuss the role of lipids and cholesterol on neuron membrane viscosity and serotonin receptors. The researches, anyway, didn't explain the link brain-platelet-serotonin. After 30 years it has been possible to demonstrate, with a mathematical model for the classification of the depressive disorder, that platelet membrane viscosity rhythms the depressive disorder and finds in Arachidonic Acid the main element of criticality when it is too high in platelets. The high concentration of Arachidonic Acid in platelets is a step limit to its mutual exchange with the brain and, as a result, the Arachidonic acid increases its neuronal concentration, since brain receives Arachidonic Acid also from other sources (Cocchi et al. 2009a, b)

Three essential points constitute the issue about the relationship between the cytoskeleton molecular structure and the psychiatric disorder:

1. Serotonin levels
2. Platelet and neuron membrane viscosity
3. The Interactome-Consciousness relationship

Concerning the first two points, the hypothesis of the link between platelet-brain and serotonin is that in subjects with Major Depression (MD) the high platelet membrane concentration of arachidonic acid (highly unsaturated fatty acid) and then, the decreased viscosity, reduces the serotonin platelet receptors uptake, thus favoring a decrease of the serotonin concentration within platelets (Heron et al 1980; Cocchi et al. 2008). This would explain the similarity (low serotonin concentration) between neurons and platelets in depressive disorder (Takahashi 1976; Edwards et al. 1978; Marangos et al. 1980; Kim et al. 1982; Rotman 1983; Dreux and Launay 1985; WirzJustice 1988; Camacho and Dimsdale 2000; Plein and Berk 2001; Maurer-Spurej et al. 2007). Increased brain and plasma phospholipids arachidonic acid concentrations have been found, respectively, in depressed rats (Green et al 2005) and humans (Tiemeier et al. 2003).

About the third point, protein Gsα increases in neuronal membrane (Lipid Raft Microdomain), according to the degree of viscosity, in suicides (depressive disorder) when compared to death due to other causes as demonstrated by Rasenick group (Donati et al. 2008). As a part of the post-synaptic interactome connection Popova et al. (2002) report about the interaction of tubulin with protein Gsα, influencing the dynamics of microtubules in the cytoskeleton. These interactions determine a close link with the Hameroff–Penrose Orch OR theory and it is possible to hypnotesize that, through this mechanism, is possible to modify the consciousness state (Hameroff and Penrose 1996, Hameroff 2010). According to the experimental findings a very suggestive molecular depression hypothesis was built and the link, embracing normal and altered membrane viscosity, platelet-brain fatty acid transfer, serotonin levels and the levels of consciousness has been described (Cocchi et al. 2010a,b).

The Membrane Receptors – Interactome Relationships

Tubulin, with its microtubules, is the complex of functional material most represented among all cytoskeleton elements, and, this aspect, according to the logic of biology, can not be underestimated if compared to the mass-function relationship. The correlation-tubulin synapses, being tubulin needed for growth and maintenance of synapses and neurites, makes a first observation plausible, i.e., that synapses are based on the mass of tubulin and microtubules (Cronly-Dillon and Perry 1979) and that it affects the brain mass, particularly, the cortex (Bond and Woods 2006).

It is, however, to be taken into account that a complete conceptual framework enabling to describe the behaviour of the principal actors playing the consciousness game – tubulin, serotonin, neurons, cytoskeleton, cell membranes, synapses – appears to be still lacking. The picture is complicated by the complex pattern of (chemical) interactions involving these actors. Here, by adopting a strongly reductive approach aiming to capture only the essential aspects of these interactions, we will try to sketch a possible logical scheme of their effects. This scheme could be used as a basis for more detailed mathematical models which, in part, have been already built. In any case, within the context of the present paper we will avoid any reference to their technical aspects.

Let us, now, start from the first actor of the consciousness game: the tubulin. On the properties and the structure of this protein there is a wide literature, both of experimental and theoretical kind (Tuszynski and Kurzynski 2003; McKean 2001; Tuszyinski et al. 2005; Low et al. 2001; Craddock and Tuszynski 2010). It leads to a picture of tubulin as a molecular system, consisting of a heterodimer, in which valence electrons are forced to lie within double-well electrostatic potentials without the possibility of jumping to the conduction band. A quantum-mechanical description of the behaviour of an electron within this system shows, once adopted suitable approximations, that there are two available energy states: a ground state and an excited state. Such a result is obtained by assuming that the electron is not localized, being in superposition between the two wells. Then, if we focus our attention on the tubulin electron, the tubulin dimer itself can be viewed as equivalent to a qubit. It is to be remarked that, from a quantum-mechanical point of view, the superposition between the two wells would not be eliminated by assuming the electron localized within a specific well, owing to the possibility of quantum tunnelling between one well and the other.

But, the knowledge of tubulin properties is not enough. Namely tubulin is only a component of polymerized aggregates of tubulin molecules, the so-called microtubules, which constitute one of the fundamental components of cell cytoskeleton. The latter, as it is well known, can be considered as the main cell component responsible for cell organization and operation (Kandel et al. 2000). Microtubules have a cylindrical form, which seems to suggest that each one of them could act as a sort of channel for vehiculating the quantum information stored in the tubulins. Unfortunately the things are not so simple. First of all, each tubulin dimer is characterized by an electric dipole moment. This implies that, by adopting suitable assumptions, each microtubule can be described as an Ising-like network of spins (Slyadnikov 2007). The latter could correspond to the single qubits of the different tubulin dimers, so that models based on network qubits (Trugenberger 2001; Trugenberger 2002; Pessa 2010) could be suited to describe the behaviour of a single microtubule.

The problem with these models is that, in general, they allow three different kinds of phases (i.e. ferromagnetic, antiferromagnetic, and glassy), whose occurrence depend on the features of the distribution of tubulin dimers coupling factors. The three phases correspond to very different dynamical behaviours of the whole microtubule. In turn, the conditions granting for the occurrence of these phases depend on the concentrations of chemical substances present within the cell during the polymerization originating the microtubule itself. The latter circumstance forces us to focus our attention on the interactions between the microtubules and the environment as well as on the interactions between the microtubules themselves. Even if this topic is still poorly known, we can roughly assert that a network of microtubules looks very different from a traditional neural network (Karp 2008; Wade 2009).

First of all, there is no direct communication between different microtubules, contrarily to neurons which are connected by synapses. There exist microtubule-associated proteins (MAP) whose major role, however, seems to be the one of granting the mechanical stability of the microtubule system. In fact, there is no evidence that they support some form of information transmission. The input and output of each microtubule, therefore, consists of a direct communication with the intracellular environment. This not precludes, of course, some form of communication between a microtubule and another which, in any case, is mediated by this environment. As regards the input and output of each microtubule, the most known one seems to be related to proteins which are transported along the microtubule owing to the action of kinesin and dynein motor proteins. A number of researchers, however, hold that microtubules emit also electric pulses (the main proponents of this thesis are Hameroff and Tuszynski, together with their coworkers; their papers have been already quoted elsewhere in this paper; here we will limit to add (Hameroff 2002; Priel et al. 2006; Tuszynski 2006; Priel 2010; Faber 2006). The characteristics of these latter depend, in a crucial way, on the interactions between the qubits associated to the single tubulin dimers.

It would thus be possible to assert that within microtubules occurs some form of quantum computation, whose output, however, is strongly dependent on the details of physical conditions holding within each microtubule. This dependence leads us to take into consideration the main difference between the microtubule system and neural networks: microtubules are not stable objects. Namely they can assemble (undergoing polymerization) and disassemble (depolymerization), grow and shorten. All these processes (and whence the whole cytoskeleton structure) are controlled by the concentrations of chemical substances present in the intracellular environment. The microtubule dynamics is therefore very complicated and, so far, there have been very few attempts to model it (Shpil'man and Nadezhdina 2006). In any case, within such a dynamics a major role is played by cell membrane. Not only there is a direct connection between microtubules and membrane, but the properties and the dynamics of the latter are just the controlling factors which act on the concentrations of the chemical substances influencing the dynamics of microtubules and cytoskeleton. The reciprocal interactions membrane-cytoskeleton (Luna and Hitt 1992; Kusumi and Sako 1996; Helmreich 2003) thus let us individuate a very complex system which could be, on one side, self-regulating, and, on the other side, could constrain the macroscopic activities of multi-cellular organs, like, for instance, the ones constituting the human or animal bodies.

As regards membrane dynamics modelling, there is a consolidated tradition of studies, lasting to the celebrated Hodgkin-Huxley paper (Hodgkin and Huxley 1952) and to the pioneering papers of Delbrück (Saffman and Delbrück 1975). Actually this modelling activity makes use of the most sophisticated tools of mathematics and theoretical physics (Diederichs 2006; Chen and Mikhailov 2010). The results so far obtained evidence how the membrane could be the seat of very complex dynamical phenomena, including spatial pattern formation and travelling waves. The practical application of these findings requires, however, focusing on specific kinds of cells, where theoretical models could be directly related to experimental data. In this regard it seems that the best strategy would be to concentrate our attention on the neuron, the cell which many feel to be at the basis of mental processes and consciousness. While it is still unclear whether the neuron is the only cell responsible for the phenomena associated to consciousness, the high number of experimental researches, devoted to it, makes this cell as the ideal candidate for sketching a general model of the interactions between the different players of the consciousness game. Such a model relies on the latest findings of biochemistry and theoretical physics.

Before starting we must warn the reader that the scope of this model is not to account for the detailed phenomenological aspects of consciousness or mental processing. Consciousness and mind are emergent entities which are endowed with an inner coherence and autonomy which cannot be reduced only to some details of neuronal interactions. And, even without resorting to philosophical or physical theories of emergence (Minati and Pessa 2006; Corradini and O'Connor 2010), we could accept the idea that the human mind processes can influence or control the neural activity. The problem is another: if the autonomous operation of consciousness and mind requires, in usual conditions, the occurrence of a delicate equilibrium among the different actors of the consciousness game, what happens when, for some reason, this equilibrium is broken? Of course, we feel that, potentially, the mind could remedy for this breaking, but under what conditions? And how much time would be required?

To make a trivial example, if my head has been severely injured, my mental faculties will be partly impaired. In other words, I will be in a pathological state, at least for some time, despite the potentialities of my mind and the fact that it cannot be reduced only to neural activity. In an analogous way, when the equilibrium between the players of consciousness game is altered, we can assume that this alteration will give rise to a psychopathology, like, for instance, the depression. This does not mean that trying to re-establish the equilibrium through the administering of some drugs will automatically eliminate the psychopathology. Namely, in a so complex game and in presence of the high flexibility of mental processing, it is a naïvety to think that a simple external action can control a system which, instead, undergoes changes only through self-organization processes. But, in any case, we need to know the physical and biochemical conditions underlying the non-pathological conditions, as well as the psychopathological effects deriving from a change of these conditions. And the model we are sketching has just this scope.

Serotonin receptors and G proteins

Let us, now, start by considering a generic neuron, whose skeleton microtubules, besides influencing many cellular processes, appear to exert a fundamental control action on neurotransmitter signalling, thus regulating the dendritic and synaptic operation (Gardiner et al. 2011). The action of this skeleton is strongly dependent both on the coherence (of quantum nature) of electric pulses emitted (typically under the form of solitons) by the single microtubules, and on the momentary configurational state of the microtubule system. As regards the latter, two opposite possibilities can occur: or this state is more or less stable for some time, or it undergoes very fast changes on time scales comparable to the ones of neuronal refractory time. As many studies have evidenced, the main control on the cytoskeleton configuration is due to the action of the neurotransmitter serotonin (Azmitia 2001).

The seven recognized families of serotonin receptors are termed 5-HT1 through 5-HT7. With the exception of the 5-HT3 receptor, a ligand-gated ion channel, all other serotonin receptors are G protein-coupled receptors that activate an intracellular second messenger cascade to produce an excitatory or inhibitory response. Receptors 5-HT1A to 5-HT1F and 5-HT5A-B are coupled to the protein Giα, which inhibits the cAMP-dependent pathway by suppressing production of cAMP from ATP. Receptors 5-HT2A to 5-HT2C are coupled to protein Gq/11α, stimulating membrane bound phospholipase C, which then cleaves PIP2 (a minor membrane phosphoinositol) into two second messengers, IP3 and diacylglycerol. Receptors 5-HT4,6,7 are coupled to protein Gsα, which enhances the production of cAMP from ATP via direct stimulation of the membrane-associated enzyme adenylate cyclase; cAMP acts as a second messenger that goes on to interact with and activate protein kinase A, which can then phosphorylate myriad of downstream targets (Raymond et al. 2006).

It suffices, here, to remember that the serotonin action is mediated by second messengers produced by G proteins; the most notable are the Giα and the Gsα. While the action of Giα favours the depolymerization of microtubules and the steady state of neuroelectric activity, the Gsα favours polymerization and instability of neuroelectric activity. The relative proportion of these two proteins in neurons is poorly known and, in any case, is not constant from a neuron to another. What are now the possible macroscopic behaviours of a neuron whose membrane contains Giα and Gsα activated by serotonin coming from the extracellular space? It is possible to argue that, if the single microtubules are responsible for the generation of electric-dipole quantum-coherent solitonic states in absence of very fast decoherence phenomena (as regards the conditions granting for this circumstance see Mavromatos 2010), then the whole microtubule cytoskeleton can be assimilated to a probabilistic Boolean network able to act as a sort of quantum computer (Mavromatos et al. 2002).

This implies that, from a macroscopic point of view, a single neuron can be modelled as an input-output system endowed with an inner (quantum) computational subsystem. It is then evident that, if Giα predominate over Gsα, in presence of serotonin this computational system has a poorer structure which, on the other hand, can be considered as fixed on neural computational time scale. The simplest picture of such a kind of system is the one of a McCulloch-Pitts neuron or, in more general terms, of a spiking neuron with fixed parameters. On the contrary, if Gsα predominate, our neuron will behave like a system whose structure changes with time, that is, in a first approximation in which the only macroscopic parameter is given by its threshold, as a neuron whose threshold is variable with time as a function of the previous activation states. This kind of neurons attracted the attention of researchers since the end of the Eighties after the proof that they were behaving as chaotic deterministic systems (Horn and Usher 1989; Horn and Opher 2000; Sussillo and Abbott 2009).

We can thus come to a first conclusion, consisting in the fact that the two kinds of serotonin receptors are associated to two different kinds of neuronal behaviour, normal and stable, and chaotic and unstable. Why is this conclusion, useful? In essence, because of the existence of a famous conjecture, which states that the most effective way of living is characterized by structures and behaviors that seem to be on the border between order and chaos.The reason for such a conjecture, first formulated by Langton (Langton 1990), can be easily understood: the vicinity to order grants, on one side, for the stability and efficiency in solving routine problems within a stable environment, while the vicinity to chaos allows, on the other side, the growth of new ideas and strategies (owing to the high sensitivity to small disturbances, typical of chaotic systems) in presence of fast changes in the environmental conditions (Kauffman 1993). It is not so easy to test the validity of this conjecture (Mitchell et al. 1993). In any case there is a lot of experimental evidence that human brain could just be a system living at the edge of chaos (Kitzbichler et al. 2009). The fact that one of the two serotonin receptors allows for normal, ordered, neural behaviour, while the other allows for chaotic neural behaviour, evidences that the presence of both is just what is required for having a neural system operating at the edge of chaos. It is useful, in this regard, to underline that all psychopathologies are, in a way or in another, associated to some form of leaving the edge of chaos towards a more ordered (and psychotic) state.

We can even conjecture that there is an interaction between two classes of G proteins associated to serotonin receptors, due, for instance to a dynamical relationship between their concentrations on the membrane. If we denote by x and y the concentrations, respectively, of Giα and the Gsα, a possible dynamical system describing their chemical kinetics could have the simple form:

$$\frac{dx}{dt} = -a\,x + b\,x\,y + x_0 \quad , \quad \frac{dy}{dt} = c\,y - b\,x\,y + y_0$$

This system is very similar to the Lotka-Volterra system describing predator-prey interaction. As it is well known from standard textbooks (Davis 1962; Glendinning 1994) for suitable choices of the values of parameters a, b, c, x_0, y_0 the system allows an oscillatory solution, whose amplitude and centre of oscillation depend on parameter values. The parameters x_0 and y_0 have been introduced to avoid the vanishing of the equilibrium value of one concentration when the other is exactly zero (as it appears to be the case in some kinds of neurons).

If the system parameters are kept constant, they can describe the oscillation between order and chaos which should grant for the occurrence of a normal psychological answer to the environmental demands. What happens, however, if they change their value? An easy mathematical analysis shows that the amplitude of the oscillation, or its centre, could change in such a way as to shift the values of concentrations out of the physically allowable region, so that only one of the two receptors can survive. In this case a psychopathological behaviour of the neural system, at all levels, is to be expected, either because we have a too ordered and rigid configuration of mental processes, or because we have an unpredictable dynamics, too sensitive to any perturbation. It is to be remarked that the former case is the less likely to occur, owing to the fact that the noise always present in the neural system can effectively counteract the chaos so as to produce ordered behaviours. This is evidenced, for instance, by experimental observations about the behaviour of the olfactory bulb. The most important contribution is the one due to the studies of Freeman (Freeman 1992; Freeman 1994; Freeman 1996; Freeman 2000). The influence of noise on ordered behaviours is, instead, lesser and more subtle (Horsthemke and Lefever 1984).

In order to understand the cause for the changes of parameter values in the dynamical system described above, we must resort to membrane dynamics, and in particular to changes in membrane viscosity resulting from the interactions with external molecules. Without entering here in a detailed discussion about this subject, partly dealt with elsewhere within this paper, we will limit here to list the variables whose values, according to the model sketched before, could be critical in driving the transition from the normal to the psychopathological state, in particular the depressive one. Among these variables the most important ones appear to be the quantities of serotonin and tubulin available. Low levels of both preclude, on one hand, the operation of microtubules and whence of the cytoskeleton, and, on the other hand, the existence of a correct interplay between chaotic and ordered neural dynamics which keeps the mind processing at the edge of chaos [as regards the crucial role of these variable in depression (Crespi 2010)]. But we cannot forget the crucial role of Giα and the Gsα concentrations, as well as the one of cell membrane viscosity. The latter, in turn, calls into play the concentrations of fatty acids. It is known that they have an important role in neuronal membranes, influencing the physico-chemical properties of the latter (Yehuda et al. 1998).

According to our previous considerations, therefore, they should play a role in depression. And this is just what clinical research evidenced: some fatty acids (n-3) can help to reduce symptoms of major depressive disorder (Logan 2004), while Arachidonic Acid is involved in major depressive disorder. The Arachdonic Acid induces a lower viscosity than the omega 3 fatty acids, because of the major length of the saturated part of the n-3 fatty acids carbon chain. This gives a major contribution for a higer melting point, if compared to n-6 one and corresponds to a major membrane viscosity, which can increase the serotonin receptors uptake. Of course, all the evidence so far collected does not authorize to think that, by supplying in some way a chemical substance whose concentration could be lower than the critical one, we should induce a remission of depressive symptoms.

With reference to the model outlined and above illustrated, the reasoning you have to do is more complex, since the equilibrium between the different components of the game underlying consciousness and mental processing is a delicate affair: to change even a single chemical concentration could induce a chain of disturbances difficult to control. Human and animal consciousness is the result of a self-organization process and we still lack a theory helping us to influence, in the wanted way, the dynamical and metastable equilibrium states resulting from this process. Further, being in presence of very complex systems, it is to be suspected that such a theory is, in principle, impossible to build owing to intrinsic and logical limitations imposed by the complexity itself.

The Interactome-Consciousness Relationship

Neuroscience hypothesizes that consciousness is generated by the interoperation of various parts of the brain, called the neural correlates of consciousness, or NCC. The best measurable is γ-synchrony EEG, coherent field potential oscillations in the range from 30 to 90 Hz (prototypical 40 Hertz), γ-Synchrony, along with consciousness, apparently moves and evolves through various global distributions and brain regions (Hameroff 2010).

If tubulin is involved in the generation of consciousness and its modifications (Hameroff 1994; Tuszynski et al. 1997; Hameroff 2007), if γ-synchrony is the brain wave that represents the best correlate of consciousness and the cell membrane viscosity is conditioning the serotonin receptor availability correspondingly to different psychopathological conditions, in which the γ synchrony frequencies are modified (Flynn et al. 2008) we must ask ourselves about the influence of membrane viscosity on cytoskeleton (Doherty and McMahon 2008), in general, and tubulin, in particular, in relation to the assessment of interactome (Tubulin)-consciousness quantum computational steps and of the interpretation of the phenomenon in its variables.

As a consequence we must also raise the question whether a total detachment from consciousness is possible, or if the venue of the physiological changes of consciousness, namely tubulin, is the repository of a memory of consciousness itself such as could be hypothesized also in animals. “Single celled animals such as amoebas and paramecium have no nervous system. However, they are obviously capable of sensing and responding to the presence of food, danger, and obstacles and appear to be capable of learning from their mistakes. The cytoskeleton is thought to be the mechanism through which their awareness is structured. This would imply that not only our neurons but every single cell in our body has its own ‘nervous system’ capable of independently processing information” (Minsky 1986).

Tubulin, therefore, could become the critical crosslink between the external (perception) and the internal (viscosity of the membrane) environment that is expressed in a modulation of consciousness according to the molecular principles that govern the phenomenon in its determination through a quantum assessment. In all this, we must understand how to consider the quantum computation in relation to the tubulin state.

As Woolf (Woolf et al. 2010) has documented, antidepressants and antipsychotic drugs take 2–6 weeks to diminish psychotic symptoms. The lower end of this time interval (2 weeks) is the same time interval over which reorganization of the cytoskeleton in neurons occurs after learning, suggesting that neuropharmacological agents may exert their therapeutic effects via the cytoskeleton and as is argued, e.g., whether is to be considered an initial condition of the tubulin state compared to the quantum computation changes, which will govern the state of consciousness. We should see the whole phenomenon as a "continuum" modulator of a consciousness state which, likely, leaves traces of himself (itself) even in conditions, normally, considered in lack of consciousness.

Animal Consciousness Embracing Serotonin System and Quantum Nanowire Cytoskeleton Network

The existence of serotonergic neurons has been demonstrated in Drosophila (Lundell et al. 1996), in humans (Chugani and Muzik 2000) and in vertebrates. Serotonin (5-HT) plays a role for several bodily functions, such as sleep (Carley and Radulovacki 1999; Portas 2000), food intake, mood (Wurtman and Wurtman 1995) and mammalian body temperature regulation (Cronin and Baker 1977; Myers 1981; AbdelFattah et al. 1997).

Diminished serotonin production has a well established association with depressed mood, while increased formation of kynurenines might contribute to development of late-onset depression via their apoptotic, neurotoxic, and oxidative effects and through up-regulation of inducible nitric oxide synthase, phospholipase A2, arachidonic acid, prostaglandin, 5-lipoxygenase, and leukotriene cascade (Oxenkrug 2010).

The interesting work of Maurer Spurej (Maurer-Spurej 2005) draws a strong correlation of serotonin to the animal evolution. Maurer-Spurej refers, in the light of experimental evidence, that the presence of serotonin as a circulating factor of thermo-regulation indicates the turning point of evolution between reptile species and warm-blooded animals, which may, in fact, coincide with the rise of “endothermy” (Figure 3).

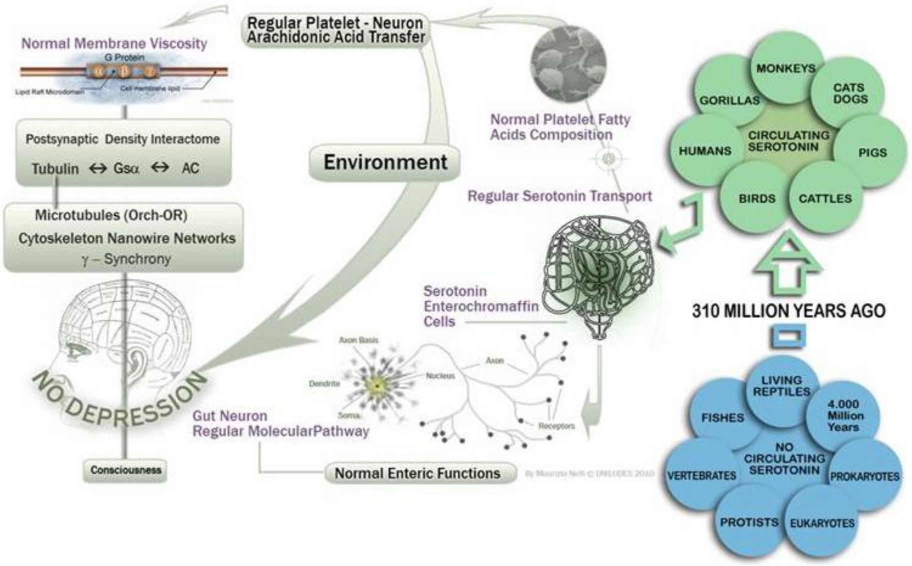

Fig 3. The figure (left) shows the serotonin pathway in its connections with the interactome under normal conditions compared with depressive disorder in which the serotonin transport to platelets and neurons could be modified by the viscosity of the membrane and, therefore, consciousness (Cocchi et al. 2010b). The phylogenetic comparison of animals with and without circulating serotonin, (right), makes it plausible,

even for animals, the molecular and quantum hypothesis of consciousness, although for different levels of expression.

Assuming that consciousness occurs through the quantum nanowire cytoskeleton network, we should state that a potential consciousness can be expressed by any cell containing a cytoskeleton network, in any animal species, and this could represent the biological interface supporting the Manousakis (2006) view of consciousness.

Therefore, different potential expression of consciousness levels might occur according to the evidence mentioned above. This statement must, however, take into account certain considerations. The Orch OR theory provides at least the presence of 300 neurons as the minimum level to express consciousssness states which corresponds to 100 milliseconds of quantum coherence, then it seems very unlikely that in paramecium is possible to speak of " true consciousness", in addition, the paramecium certainly does not have a mature but a primitive form of cytoskeleton (tubulin-based circuits) (Hameroff 1998a). A sort of "pre-conscious protein-based quantum computation" could represent a state of evolutionary continuity among living organisms. The scientific debate on the Orch OR Theory has never mentioned the role of serotonin in living species, possessing or not serotonin. Human and animal consciousness, therefore, should be considered and discussed with respect to the pre-and post-serotonin era (Figure 4).

Serotonin should be considered as a modulator of the intensity of mood disorders and of the different types of psychotic disorder (Jackman et al. 1983; Mann et al. 1992; Kovacic et al. 2008; Fujii and Nagamine 20001; Blardi et al. 2002) and therefore, could be the subtle regulator of the neuro correlate of consciousness through the receptor-interactome-cytoskeleton network connections. Figure 4 compares the assumptions of the border between quantum consciousness and classic consciousness. In animal models, according to the anatomical and physiological characteristics of organisms and for the presence of circulating serotonin, you can think that only at the transition from cold-blooded and warm-blooded animals (Maurer Spurej 2005) consciousness begins to take on characteristics of increasing complexity. From Drosophila to Humans has been well documented the presence of serotonergic neurons (Lundell et al. 1996; Chugani and Muzik 2000; Moore et al. 2003) of early phylogenetic origin (Jacobs and Azmitia 1992; Azmitia 2001).

The first evidence for the presence of serotonin is in thrombocytes of birds and of three reptilian species, the endothermic leatherback sea turtle, the green sea turtle and the partially endothermic American alligator (Maurer Spurej 2005). Available evidence suggests that, in vertebrates, 5-HT-containing enterochromaffin cells are lacking only where there is an innervation of the gut mucosa by nerve fibres containing high concentrations of 5-HT (Anderson and Campbell, 1988). At this point a reflection arises, is it, really, the late appearance of circulating serotonin the watershade between quantum consciousness and classic consciousness?

This could confirm the hypothesis of the existence of a watershed in the evolution of consciousness, in essence, giving properties of continuity to the molecular mechanisms of consciousness with the Orch OR Theory, from the most primitive conditions to the most evolutive conditions.

A submerged animal consciousness that sees, probably, within tubulin and microtubules, the self-determination of a consciousness state, limited to what is necessary to exist without emotional expressions and that faces a growing neuro-related consciousness event (classic information) with expressions of emotional consciousness, more complex and differentiated, to the progress of a critical mass ratio among tubulin, synapses, cortex and serotonin.

In practice, this would generate the circumstances that give shape to the molecular phenomenon of "consciousness", to those aspects that interface the human being with its environment and its perception, in a complexity that, from the human being goes back to the animals that have marked the endothermic turning point, to the most primitive forms of the cytoskeleton.

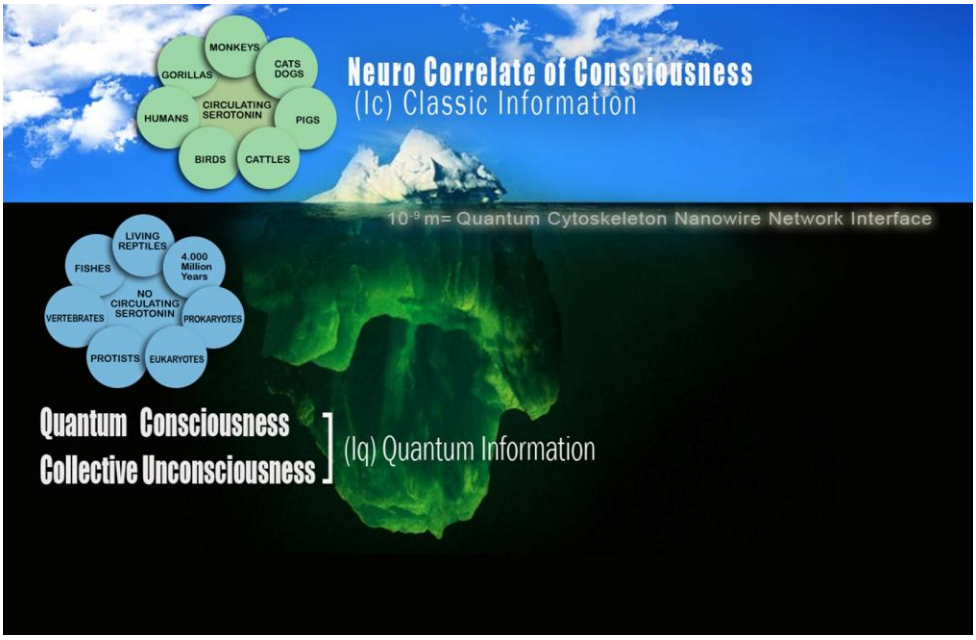

Fig 4. Figure shows the border between classic and quantum consciousness according, also, to the appearance of serotonin.

Conclusion

Consciousness occurs, according to the most recent acquisitions, among linear and not linear mathematics and quantum computation, open to the interpretation of psychopathological phenomena. It would be interesting, then, as further of ways of research, understanding the biological dynamics of microtubules with the "catastrophe theory", while the difficulty to explain highly complex phenomena (with more than five variables) remains. In nature, as in biological systems, chaos, seems a more common order and from chaos a multitude of forms are created: abrupt changes among structurally stable states, conflicts that produce new stability, always subject to new changes in state. René Thom (1983, 1989, cf. Even the critical position of Zaheler and Sussmann, 1978) presents the "catastrophe theory" as an attempt to explain the natural forms, of their state of maintenance, of their genesis and of the conflicts which are in their origin. The universe is more a cosmos than a chaos, and catastrophe theory tries to explain its forms, regardless of the substrate: any form owes its origin to a conflict.

Already Heraclitus of Ephesus said: "War is the mother of all things and queen of all things" (DK 22 B 53), and again, in fragment 8: "Where there is opposition there is reconciliation and the most beautiful harmony rises from differences and everything is generated by contrasts."

In our case, we could see the tubulin as a "form", "site of catastrophe," which corrects the conflict between consciousness and trauma (that is, simultaneously, also the origin), as well as the edge between two surfaces, a desk placed on a horizontal plane and the vertical wall, is "a place of catastrophe."

Indeed, the edge originates from the conflict between the piece of wood and the metal saw which has drew a boundary line in the wood board. Ultimately, from the comparison among philosophy, molecular biology, higher mathematics, can originate a new approach to the traumas of the consciousness and to the problem of memory and identity.

In a few words it seems to be consistent the hypothesis that Schrödinger proteins interactoma and in particular the cytoskeleton nanowire network is the best biological interface for potential expression of consciousness, being typical and specific for each animal species and that consciousness is always a potential. It's very fascinating to think that every animal possess a primary Schrödinger proteins complex (cytoskeleton) and even in the absence of circulating serotonin there is a potential of consciousness that is essential to the behavior of some life forms, while other species such as invertebrates, procariotes and even archea possess expertise in their own domain probably mediated by their own Schrödinger proteins interactoma.

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