

Minds, Membranes, Microtubules and Madness. Current Progress in QPP-Related Research.

Quantum Paradigm of Psychopathology Group

Abstract

The QPP conference in Palermo has marked a definite turning point in the foundational perspective of many of the group's participants regarding the study of psychopathology, particularly mood disorders. One reason for this turning point stems from a realization that two of the most common forms of psychopathology, major depression and bipolar disorder, may be recognizable by means of biomolecular markers. Long years of theoretical study by independent investigators have finally culminated in a convergence of their insights via quantum paradigms that now promise to illuminate, through the empirically tangible route of such new biomolecular markers, pathological phenomena of the conscious brain, thus potentially both confirming in fact and further harmonizing the diverse prior contributions of these conceptually innovative psychiatrists, biochemists, molecular biologists, philosophers and theologians.

Key Words: Brain Neuron, Platelets, Membrane Viscosity, Tubulin, Serotonin, Depression, Artificial Neural Network, Human finitude, Original structure.

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Introduction.

Quantum Mind has been an ongoing field of study since the final decades of the last century. Pioneers like the physicists Hiroomi Umezawa, Kunio Yasue, and Giuseppe Vitiello, mathematicians like Roger Penrose, and biomedical investigators like Stuart Hameroff, Gordon Globus, and Gustav Bernroider have plumbed the depths of subatomic structure and its macroscopic amplifications in search of substrates for quantum computation and other capabilities that may match attributes of the normal human psyche better than models advocated by conventional cognitive neuroscience.

In the domain of psychopathology, Gordon Globus has gone on to propound a highly original concept of schizophrenia linked to the "tuning" of quantum vibrations suffusing the brain. Nancy Woolf, along with co-authors including Jack Tuszynski, has offered credible links

between psychopathology and quantum-computational dysfunction within the skeletal proteins giving shape to brain cells. Paavo Pylkkanen has related the physical substrates of mental illness to quantum "pilot waves." Donald Mender has proposed ways of comprehending the neurophysiology of disordered thinking and emotion in terms of quantum "phase transitional" analogies to the freezing and melting of ordinary matter; he has also contributed to a reframing of psychiatric disease nosology in light of the anthropic principle. Ursula Werneke has complimented this anthropic reconsideration through her examination of psychotically "impaired" reality-testing in the context of Hugh Everett's many-worlds ontology. Massimo Cocchi, Lucio Tonello, Fabio Gabrielli, Massimo Pregnotato, Paola Zizzi, Eliano Pessa, and their collaborators have forged links between serotonin and quantum

phenomena via membrane biophysics in depression and psychosis.

The above honor roll of seminal QPP theoreticians is surely not exhaustive, but these brief remarks are not intended as a complete historical review. Rather the purpose is an opening into the possibility of turning today's theoretical potentialities into experimental confirmed reality. It should be recalled and emphasized as a guiding principle that the cohesion of a convivial multidisciplinary group operating without the winnowing constraints of competing, mutually exclusive ideas may not remain true to the epistemic rigors of science. QPP can minimize this sort of hazard by maximizing, in the spirit of Karl Popper, exposure of its most cherished conjectures to a fair risk of experimental refutation.

A number of participants in the Palermo conference have signed a theoretical manifesto, aptly called "*The Declaration of Palermo*," whose text follows:

The Declaration of Palermo

On this day of April 27, 2013 a core international group of investigators, offering expertise in the fields of psychiatry, biochemistry, physics, computational neuroscience, mathematics, philosophy and theology, gathered in Palermo, Sicily under the auspices of the global QPP initiative with the aim of assessing the potential relevance of quantum physics and quantum chemistry to the mapping of mind-brain relations in normal and abnormal states of consciousness applicable to humans and non-human animals. Positions taken by members of the Palermo Group have argued that: recent progress of a restricted kind in mainstream consciousness research has proceeded rapidly due to dramatic technical improvements in relevant empirical research tools. Classical biophysics, which provides the paradigmatic foundation of mainstream consciousness research, has offered bountiful correlations between subjective reports of qualitative human experience and quantitative measurements of

objective physical processes. However, these merely correlative advances have not at all addressed what David Chalmers has termed the "Hard Problem" of mind-brain relations by bridging what Joseph Levine has called the "Explanatory Gap" between qualitatively subjective phenomenal experience and quantifiably objective physical events. So far no explanatory bridge between consciousness and corporeal neural tissue has issued from the classical biophysics of mind and brain in homo sapiens, and, in research on non-human subjects precluding self-reports via human language abilities, even correlations have remained substantially elusive. Quantum approaches may offer greater latitude in addressing these classical deficiencies, to the extent that at least some latent links formally exist between the qualitative dimensionality and quantitative measurability of canonically conjugate quantum observables, whereas no such formal links are required with reference to the possessed observables of classical physics.

Moreover, at least one interpretation of quantum measurement as formulated by John Von Neumann casts the measuring agency itself as subjectively conscious per se, in contrast to an absence of any such classical notion.

Quantum generalization of classical biophysics opens up the possibility that relevant brain processes may reach both beneath the scale and beyond the boundaries of discrete neurons separated by synaptic clefts. Quantum-germane structures and dynamics within the brain may include superposed dimeric tubulin conformations in the microtubular cytoskeleton spanning both intraneuronal and interneuronal spaces, ordered water in relation to cytoskeletal proteins, membrane channels and lipids together with their second messenger pipe lines to neuronal interstices, and solitons communicating along cytoskeletal routes between classical and quantum aspects of brain function. Max Tegmark's objections to the thermodynamic feasibility of such quantum structures and processes surviving thermal decoherence at

biological temperatures entailing orders of magnitude comparable to those within the human skull have been thrown into doubt by the recent work of Gregory Engel's group, which has demonstrated non-trivial quantum computation in photosynthesis.

The ubiquity of water, cytoskeletal tubulin, membrane lipids, and second messengers in non-human life suggests that a new biophysics, accounting for quantum-generalized processes in living tissue, may lead to future predictions about consciousness not only in human beings but also in organisms lacking any semblance of human brain architecture at the level of organized neuronal networks or "higher."

Emmanuel Pothos and Jerome Busemeyer have presented abundant empirical evidence that properties of normal mental life may be more parsimoniously modeled by abstract quantum formalisms than by classical computational algorithms. The quantum wetware outlined above is more compatible with these formalistic findings than is any classical model of neural biophysics. Both quantum-logical and quantum-physical cartographies of mind and brain also promise to generate avenues for improved comprehension of neurophysics in psychopathology.

Explanatory and even psychotherapeutic opportunities may emerge from considerations of superpositional logic and malattunement in primary process thinking by schizophrenic patients, of Everett's quantum ontology in the "alternate worlds" of psychotic perception, and of membrane and second-messenger interfaces between serotonin biochemistry and quantum-microtubular nanowire dysfunction in mood disorders.

Aberrations of scale-dependent emergence in quantum thermofield phase transitions and problematic barriers to Bohmian holism may be important in multiple forms of mental illness. We declare the following:

Even the absence of highly complex synaptic connections among neurons does not preclude the presence of at

least rudimentary phenomenal experience in organisms endowed with superposed microtubular dimers, ordered water, membrane ion channels, and/or crucial lipid raft assemblies connected to selected second messenger systems. In addition, quantum-biophysical aspects of these and/or other yet unmapped structures and related processes may prove to be potent factors in the deeper etiologies and improved treatments of psychiatric disorders.

The above strong theoretical statement invites an opening into possible experimental models that will test the accuracy of the group's hypotheses by identifying, starting from precise molecular reference points characterizing major depression and bipolar disorder, a non-trivially quantum pathway of relevant biomolecular changes conditioning brain processes through the most intimate aspects of neuronal, transneuronal, and subneuronal function. In particular, membrane viscosity and its role within the interactome may prove to figure centrally in quantum-chemical transduction of normal and pathological neural signals.

The Declaration of Palermo, through its support for the plausibility of a quantum basis of consciousness offers phenomenological conclusions phenomenologies crucial to both human beings and other creatures. Homo sapiens and non-human animals share a core of conscious awareness that is nevertheless expressed differently for each kind of organism at divergent levels, overseeing management of disparate needs and actions and realized through behaviour in relation to concrete variations of the external environment. The dimension of "self-consciousness" hence can be understood to have evolved, step by step, in phylogenetic progression according to an admirable order promoting the survival of each unique life form with respect to the particular tasks which it has to perform.

Today we are equipped with many high-end tools in our attempts to understand all the steps in the evolution of consciousness, but only through intuition will we achieve an adequate interpretation of consciousness itself, that most complex

and extraordinary end product.

Pending such “intuition”, some members of the QPP group have decided to submit to classical experimental testing those insights independently adduced by each contributor through theoretical inquiry, that is, through the construction of an empirical map laying bare the most germane transneuronal, neuronal, and subneuronal molecular changes with an eye toward the possibility of inducing and measuring changes in membrane viscosity correlated with in vivo manifestation of mood disorders. As far as we know this is the first time that such micro-molecular events will be tied rigorously to molar cognitive phenomena.

The resulting experimental data may offer an enduring empirical anchor in contrast to the intersubjective vagaries that have afflicted those various psychiatric disease nosologies, most recently DSM V, issuing from the hollow consensus of committees and cultural contextual fashion. If the experimental program planned by QPP succeeds, the goal of psychodiagnostic validity, heretofore sacrificed by DSM to mere “inter-rater reliability”, may at last be achieved.

Molecular and Quantum Approaches to Psychopathology. An Interdisciplinary Dialog with Psychiatrists

The Cunning of the Observable

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This work attempts to pose, address, and then apply to an understanding of psychopathology a question which will be called Heisenberg's Hard Problem. The issue can be stated as follows: Can the “explanatory gap” between quantities and qualia, famously afflicting the philosophy of mind, be narrowed by a deepened understanding of the reasons that

quantifiably observable qualities appear naturally to be grouped in sets of two distinct types, i. e. 1) canonically conjugate operators displaying fourier duality and 2) all others?

We might speculate that the answer is yes, given two considerations. First, the Von Neumann-Wigner interpretation of measurement encompassing latent physical observables offers strong parallels with the crucial nexus of practical agency and risk in Heidegger's post-metaphysical penetration of subjectivity. Second, some psychologists (Pothos, 2013) have recently proposed expanding the qualitatively open set of possible “possessed” observable dimensionalizations to include “qualia” lying outside the standard physical domain of causally complete dynamics.

The established scientific success of Heisenberg's uncertainty principle warns us that any new psychophysically promising bridgehead across the latent/possessed divide must eschew retrograde retreat into exclusively classical, possessed, commutative notions of canonically conjugate observables. A unified quantum-psychophysical approach should instead more progressively posit novel theoretical conduits through which non-conjugate qualia may aggregate as sets whose internal relations harbor an occult fourier duality, distinctive insofar as this non-conjugate fourier duality dynamically “hides in plain sight” and appears in a misleadingly “possessed” guise under conditions of traditional physical measurement. One might require the “cunning” of such non-conjugate pseudo-possessed qualia to maintain their disguise of apparent mutual compatibility through seeming conformity with classical and unitary determinism and commensurately with known measurable behaviors of neurophysiologically localized and behaviorally proximate assays entailing mainstream notions of physical cause and effect. In addition, the hidden fourier-dual latency of the “cunning” non-conjugate qualia would be required not to boomerang, in any locally obtrusive manner detectable by standard experimental means now in use, as an anomalous back door influence on

canonically conjugate constraints under principles of quantum mechanical uncertainty.

The preliminary outlines of a possible model (Mender, 2013) for such crypto-causal hiding in plain sight by non-conjugate pairs of quantifiable qualities will be advanced in this talk. The postulated model will seek to enlist a set-theoretically reframed ensemble of conceivable "floppy" manifolds to which in toto the skew-symmetric vector space of fourier-dual canonical conjugation may be considered "probabilistically" tangent (Penrose, 2005). It will be suggested that the set-theoretically reframed manifolds might be configured toward two "metaphysical" ends: a) compensatory gauge-like "curvature" which could "warp" non-conjugate sets of qualia into canonically conjugate observables and b) extrinsic rather than intrinsic behavior of that curvature, whose expected physico-topological manifestations could thereby "hide" locally while emerging "in plain sight" across a global perspective.

Probability-valued aspects of the above set-theoretic revisions open up possibilities that statistical interrelationships among acts of measurement may depart from their traditionally understood behavior, which is known to occur in the limiting case of discrete experimental observations.

It might then be theorized that, as the density of observational acts radically increases toward "flicker-fusion" within an effectively continuous stream of consciousness, statistics interrelating those subjectively generated acts of observational agency (rather than governing merely the wave-functional probabilities of observed physical objects) may diverge into Bose-Einstein and Fermi-Dirac components. Sources of potential torsion inherent within transformations from tangent skew-symmetry to fully arrayed ensembles of manifolds also raise the question of a subjective measuring agent's possible association with novel spin-like moments.

Such spin-statistical considerations in the contexts of supersymmetry and the diffusely distributed character of

gravitational negentropy (Penrose, 2005) may point toward a new conceptual platform for psychophysical causation. Radicalized psychophysics might bridge the phenomenal "explanatory gap" by escaping causal locality and finding empirically accessible expression not in local neural generators but instead, more subtly and cryptically, through diffuse scalar fields.

Those Higgs-like, quasi-quintessential entities, insofar as they extend in global topological relationship to extrinsic curvature, may in turn delimit the homeomorphic signposts, including genus-like properties, of relevant manifold ensembles. Inserted topological "genus" values might thereby impose on the affected manifold ensembles tunable boundary conditions. Hence, it is also in problematic bicontinuities of such disseminated scalar fields, rather than focal neurological lesions, that evidence may be found for postulated malattunements (Globus, 2010), deviating from hyper-anthropic (Mender, 2011) resonances, as highly correlated physical expressions of aberrant qualitative experience.

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Orthótes as metaphysical violence. Major Depression and Bipolar Disorder: from ideology to biology

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The accuracy of the metaphysical viewpoint resulting from an original cognitive desire (Gabrielli 2009, 2013), epistemic reflection on the becoming seen as anthropological anguish – implodes into ideology, when it turns into violent interpretation of reality, the primacy of words over things, arbitrary and interested manipulation of facts (macro and micro power).

The metaphysical ideology finds a privileged breeding ground in mental diseases, when social and cultural conditioning takes on a metaphysical value because of the often faded match between classification and natural object, nosology and actual disease reality.

Hence the danger that such a strong medical ideologism could flares up into diagnostic imperialism. In our opinion, the weakness of DSM classifications, particularly as to the distinction between MD and BD, results from the lack of a strong and real biological equivalent, capable of proving diagnoses which are merely narrative, based on literature or apparent only in the psychotic onset (Cocchi, 2012a,b). In light of these considerations, we believe we have identified during our experimental path (Paolo Sotgiu Institute) the biological markers which provide the MD and BD diagnoses with an extremely real foundation to be used for establishing a DSM free from pseudophenomenology or, even worse, ideology, and focused on the here and now of consciousness in its real biomolecular flesh (Cocchi 2011, 2012c-h, 2013a-b; Gabrielli, 2012).

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A dialogue between ethics and neuroscience

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The neurosciences have ranked genetics as a leading sector of the medical scientific research. Their development is due to new diagnostic technologies (PET, SPECT, MRI, fMRI, EEG, MEG, ERP). These tools can help establish correlations between physical events and mental events, to the point that some people think that the mind is only a secondary phenomenon of the brain, and that every mental state is in principle reducible to the physical dimension below. Another position asserts that mental states while being tied to specific configuration of the brain are, however, "emerging", id est they have their own originality.

An examination of the relationship between neuroscientific data and philosophical interpretations of the relationship mind brain is the first point of ethical evaluation. A second point is constituted by the possibility of pharmacological interventions able to induce very specific functional changes (Farah and Volpe, 2004).

These two aspects are important for our understanding of ourselves as beings with a life mental and spiritual. Hence the birth of neuroethics.

Several elements enter in the definition: Study of the neural correlates of emotions and moral decisions, and Reflection that deals with the implications of the right and wrong treatment or enhancement of the human brain. In this case it would be just a chapter of bioethics. Another position asserts that the more deeply it comes to

producing a philosophy of life based on the brain. The position of Gazzaniga can have two meanings: that knowledge of the brain mechanisms is necessary for the understanding of ourselves, and, more radically, that the neuroscientific point of view should be the decisive one in the definition of bioethical issues. Based on this, the embryo has no value before the formation of the brain, because we are our brains. Thesis is not new (Green and Wikler, 1980) which also involves the release by the human species of patients victims of dementia. Leaving aside the criticism that they can turn to this simplistic approach, interest in neuroethics is another: Is it ethical problems resulting from the use of current or future scientific tools that allow you to learn more about the cerebral phenomena, and to take action to change them? Are the therapeutic and application radically new acting on the brain alter the experience and behavior of people? There are two aspects to be considered (Farah , 2005): the practical application of neuroscientific knowledge, the theoretical aspect that affects our self-interpretation, to the point of subverting the ordinary conception of ethics. There are many possible applications, all with ethical implications. Read minds? The neuroimaging techniques seem to allow direct access to the personality of the individual, or at least to the physical structures that allow the expression. There is therefore the question of individual privacy. It seems that we can measure what people think, the propensities of stable behavior (McClure, 2004), the tendency to violence or to racist attitudes. It can thus assume fingerprint brain predictive of the future. Remarks: is not at all certain that these detection systems of the brain activity may never become sufficiently reliable (Farah and Volpe, 2004). The brain imaging data provides fascinating, not incontrovertible evidence. For example, the predisposition to antisocial behavior does not necessarily translate into concrete actions. Improve the performance of the mind? Another area of application is the enhancement of cognitive performance and the psychological and emotional state.

Think of the selective serotonin reuptake inhibitors (SSRIs), which have side effects modest compared to the benefits in the symptoms, self-esteem and social relationships of individuals with mental disorders are not clearly diagnosable (Knutson, 1998).

Research is ongoing on medicines that improve sleep, appetite and sexual activity (Flower, 2004). But the most important is that of cognitive activities, such as attention and memory. In this context, they spread off-label uses of existing drugs (Diller, 1996). This raises questions of safety in the use of these drugs, but also ethical issues. Exceeding the natural limits is not perhaps a new form of eugenics? In which individual freedom is only theoretical, since there is a push to not lag behind, such doping in sport? (Rose, 2002). So we introduce a subtle coercive mechanism, especially in schools and the military, as happens in the USA. A more theoretical problem is the effect of these changes in mental abilities of personal identity and individual autonomy. The person whose memory and whose cognitive abilities and emotional have been profoundly altered is still the same person? yet the author of himself, his actions and personality (Degrazia, 2005).

The question that is posed by the decision neuroscience is that of the naturalization of the mind and consciousness, namely the reduction of spiritual phenomena to their material bases and settlement of moral experience which we have known so far. Brain functioning and eclipses of freedom. Gazzaniga argues that the brain is 1) a physical entity subject to the deterministic laws of the physical world, and 2) a specialized mainly in the formation of beliefs, thanks to the activity of the left hemisphere, which interprets the external inputs, a modular system, in which the different parts operating in parallel and independently, without constituting an integrated structure and parallel. From this vision leads to some important consequences for the ethical: A) there is no central I in the strong sense, the Cartesian cogito. The unity of consciousness would be a construction of the left hemisphere .

B) The conscious mental states, beliefs and decisions that we believe are our only posthumous awareness of what happened to the different parts of the brain. C) the most important consequence is that the mind becomes nothing more than a "product" of the brain, ie an appearance epiphenomenal no causal efficacy. In fact, we tell ourselves stories to feed the illusion of free and rational decisions. The ego is nothing but the press officer of the various agencies cognitive brain, not their president. In this way it gets rid of free will. The moral as conservation of the species. The abolition of free will not lead to the disappearance of moral behavior, indeed. Since it is necessary for social life, it is stated that evolution would have selected some forms of instinctive response, for the protection of human survival. These forms would have been progressively integrated into the mechanisms of brain functioning. In this way, we would face a universal morality. Marc Hauser tried to test this hypothesis through the study of moral dilemmas. What people sacrifice, whether to stop to rescue a wounded man, etc. It has been found that non-personal moral dilemmas activated areas similar to the non-moral and practical dilemmas that moral dilemmas relating to persons who require more time. In the same line ranging research related to mirror neurons, which would be the basis of empathy among humans, an essential element to their cohabitation. An universal natural ethic. The study of the neural basis of moral judgment and behavior seem to be able to conduct a proper naturalization of ethics. The moral systems would be variations of a universal system of rules and reaction devices innate in our species, who work for the survival of the species. As we have seen Neuroscience bring into question some essential elements of our self-understanding.

Relationship models mind brain. The most doubts are not the individual techniques and the actual practical achievements, as the theories of interpretation that these techniques are suggested. You must always remember that for a description of reality, science

adopt reductive models. This methodological aspect must become incorrect when it becomes ontological claims concerning that is the whole of reality. In fact, every phenomenon can be investigated by other methods and knowledge with other intentions. Although scientific knowledge is, in principle, a fallible and partial knowledge, which always requires to be corrected and supplemented. Particularly important is the assumption of some research that there is a neural basis for the emotions and the only reasons why we are moral agents. Now this assumption is not shown: it is not proven causality between brain events and mental events. In addition, we may wonder why the causality cannot act in reverse: that a certain area of the brain is activated because the individual has taken a certain decision. The causal interpretation that interprets the relationship between physical and mental health depends on implicit bias in many studies, that the reduction of all that we belong to a higher level (spiritual or cultural) to its biological basis is only a matter of time. Gazzaniga says: we are the only large animals. All other explanations that give us comfort are just stories. But there is no Santa Claus. The thesis is unproven that science explains everything there is to explain, and that still does not explain who will explain it in the future.

Moral pluralism. Research by Hauser and Greene indicate the possibility of intervening on the neural processes with an override, so the education and culture act themselves on the neural mechanisms. To respond immediately overwrites the neural response of a different type of values. So there are utilitarians, emotivists and theorists of virtue, Kantian, etc. How come? Really this difference would be written in neurons? We are born with a brain Kantian or utilitarian? What if the moral neural responses serve to save the species, how can we explain the behavior radically amoral or immoral? We can legitimately think that research on mental correlates of moral experience lie on the floor of a descriptive analysis, but they cannot explain moral experience, much less provide prescriptions for how we

should judge or act. In substance between the "is" neural and "must" morale there is a jump that can only be filled by individual freedom, supported by education and by the influence of moral theories (Greene, 2003). The human being is a spring of individual decisions. Neuroethics can tell us how the brain conditions can influence subjective decisions, but it cannot tell us why those decisions are made.

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New developments in quantum field theory modeling of the brain and living matter

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We have devised a thermodynamic model of cortical neurodynamics expressed at the classical level by neural networks and at the quantum level by dissipative quantum field theory (Freeman, 2004-2006; Vitiello 1995, 2001; Freeman and Vitiello 2006, 2008; Capolupo, 2013). Our dissipative model is based on features in the spatial images of cortical activity newly revealed by high-density electrode arrays. We have incorporated the mechanism and necessity for so-called dark energy in knowledge retrieval (Capolupo, 2013). We postulate that the extremely high density of energy sequestered briefly in cortical activity patterns can account for the vividness, richness of associations, and emotional intensity of memories recalled by stimuli.

The dissipative quantum model (Vitiello, 1995) enables an orderly description that includes all levels of the microscopic, mesoscopic, and macroscopic organization of the cerebral patterns. By repeated trial-and-error each brain constructs within itself an understanding of its surround, the knowledge of its own world that we describe as its *Double* (Vitiello, 2001). The relations that the self and its surround construct by their interactions constitute the *meanings* of the flows of information exchanged during the interactions. In such a dialog of the self with his Double resides the act of *consciousness* (Vitiello 1995, 2001). The perception-action arc in the Merleau-Ponty's phenomenology of perception finds its representation and formal description in the frame of the dissipative model. In the dialog with the Double, the continuous attempt to reach the equilibrium shows that the real goal pursued by the brain activity is *the aesthetic experience*, the perfect "to-be-in-the-world", the *aesthetic dimension* characterized by the "pleasure" of the perception (Vitiello, 2001).

The aesthetical experience arising from the search of the perfect fitting of the self in the world through the "active response" of the self to the world and the reciprocal action of the world on the self, continuously renews itself since the dialog of the self with his Double is of dynamical origin, never concluded or terminated, always opening new horizons to be explored. Active responses imply responsibility and thus they become moral, ethical responses through which the self and its Double become part of the larger social dialog. Aesthetical pleasure unavoidably implies disclosure, to *manifest* "signs", artistic *communication*. An interpersonal, collective level of consciousness then arises, a larger stage where again the actors are mutually dependent, each one bounded (entangled) in his very existence (including any sort of physical needs) to the other ones, simply non-existing without the others.

The coherent structure of the brain background state, or minimum energy state, manifests itself in the auto-similarity properties of fractal structures (Vitiello, 2009; Freeman and Zhai, 2009; Gireesh and Plenz, 2008; Petermann, 2009) which are observed to occur also in a large number of natural phenomena and systems. This leads us to a unified physical understanding at the ecological scale (Vitiello 2009, 2012). The conception of Nature split in closed, separated domains is replaced by the vision of Nature modulated and unified by laws of form implied by the underlying quantum dynamics of the coherent vacuum. Any distinction or antinomy between structure and function is dissolved in such an integrated ecological vision.

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A quantum brain theory of dreams

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Freud (1990) thought that the interpretation of dreams would provide the *Via Regia*, the royal way, to the unconscious mind and hence to an understanding of psychopathology. Dreams provide a window into how the illogical mind works, since the dominating influence of sensory input is inhibited and the functioning of the freed mental apparatus comes into view.

The issue to be addressed here is not what the dream *means* but what it *shows*

about the underlying brain mechanisms. It is remarkable that *sans* sensory input, yet dream worlds can be indiscernable from the worlds of waking life (Globus, 1987). How might authentic worlds be formed by the sleeping brain? Compositions of memory traces will not do. The shifts in dream scene (when we say amazedly in recounting the dream, “and the next thing I knew ...”) are especially instructive. A theory of dream formation will be offered in terms of thermofield brain dynamics (Globus, 2009).

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Founding our mathematical description of our perception of nature on the properties of consciousness

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In this presentation, I will argue that quantum theory can be founded on the framework of consciousness, in contrast to earlier suggestions that consciousness might be understood starting from quantum theory. Contrary to the idea that consciousness is an emergent property of matter, we postulate that consciousness is primary and the material universe emerges as an epiphenomenon (Manousakis 2006, 2009, 2012).

The notion of streams of consciousness, usually restricted to conscious beings, is extended to the notion of a Universal/Global stream of conscious flow of ordered events. The streams of conscious events which we experience constitute sub-streams of the Universal stream. We will discuss that consciousness can be either in a potential or unmanifested state or in an actual state

which leads to the stream of conscious events.

Our postulated ontological character of consciousness is operational, namely, it acts on the state of potential consciousness to create events or modify the likelihood for later events to occur and become part of the Universal conscious flow. A generalized process of measurement-perception is introduced, where the operation of consciousness brings into existence, from the state of potentiality, the event in consciousness.

This is mathematically represented by (a) an operator acting on the state of potential-consciousness before an actual event arises in consciousness and (b) the reflecting of the result of this operation back onto the state of potential-consciousness for comparison in order for the event to arise in consciousness. Beginning from our postulate that the ontological status of consciousness is primary and from its elementary and basic contents, such as perception of periodic change and motion, quantum theory follows naturally as the description of the conscious experience. The presentation will include simple demonstration of these ideas as well as examples of their applicability.

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Quantum logic, the collective unconscious and the biological basis of psychopathology

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The logic of the normal unconscious mind and of schizophrenic consciousness may be Lq, the logic of quantum information (Zizzi, 2010). The Penrose-Hameroff Orch OR model of consciousness was first proposed in 1995 and more recently revised in 2011. Orch OR asserts that microtubular protein polymers inside brain neurons act as quantum computers. Tubulin components of microtubules are understood to constitute a “Schrodinger’s protein” existing in quantum superposition of different states and hence encoding quantum bits, or qubits of information (Hameroff 1995, 2007).

The Penrose-Hameroff model argues that quantum-superposed states develop in tubulin, remain coherent, and recruit progressively more superposed tubulins until, over a time interval lasting up to 500 msec, a mass-time-energy threshold, related to quantum gravity, is finally reached. This model predicts dendritic webs of approximately 100,000 neurons subserving discrete conscious moments, or frames, occurring every 25 ms in gamma synchrony.

For a healthy mind passage from the unconscious state to the conscious state is marked, according to the Orch-OR model of Penrose and Hameroff, by a decoherence of tubulin qubits. This may be comprehended in terms of very fast switches from the quantum logic of the unconscious to the classical logic of consciousness.

In Lq, propositional syntax is configured in qubits, i. e. quantum information units, which are linear superpositions of classical bits. It is in this sense that the unconscious mind may be formally interpreted as quantum-

informational. The quantum concept of truth within L_q is different from that of classical truth, insofar as classical truth is single-valued and deterministic while in contrast quantum truth manifests itself as many-valued (fuzzy) and probabilistic (Zizzi, 2012a).

Physical interpretation of quantum logical coherence should take into consideration concepts of quantum coherence not only in non-relativistic quantum mechanics (QM) but also in relativistic quantum field theory (QFT) (Zizzi, 2012b; Vitiello 1995, 2001). Quantum coherence in QM is a property of pure states, whose linear superposition is also a pure state, whereas the concept of coherence is different in QFT, for which coherent states are eigenstates of the annihilation operator (Zizzi, 2009; Pessa, 2009). The above-described coherent framework lends meaning and potency to quantitative perspectives on psychopathology.

Whereas in mental health L_q is used for very short time intervals, in the case of schizophrenia L_q becomes dominant and long lasting. This predominance of L_q in schizophrenia might well stem from flaws in the quantum metalanguage (QML), those flaws entailing perhaps a dearth of requisitely configured assertions (Zizzi, 2012c). Because of strict relations between the QML and the brain's dissipative quantum field theory (DQFT), one may hope to find within the QML's flaws those pathological quantum dissipative brain processes which are responsible for schizophrenia. If, for example, the reversibility of "quantum logic gates" for some reason were to become blocked so that it was no longer possible to perform inverse operations such as decoherence and disentanglement, the mind would remain trapped in the quantum-computational unconscious.

It should be said that these quantum logic gates are indeed material structures, formed by atoms, ions, etc. Hence, it is plausible to hypothesize that the drugs currently used to ameliorate schizophrenia may somehow reset at least partially and temporarily damaged quantum logic gates in the brain (Zizzi, 2012d).

Is there any correlation between hallucinations and molecular interactions within the cell or any cause of conscious state change that may be detectable by measuring gamma synchrony, which is well correlated with consciousness and has already provided response variability in different psychopathological conditions and in meditation?

Apart from recently identified neurochemical, physiological, and classical functional manifestations, and apart from the logical issues raised by the term "formal thought disorder", schizophrenia is broadly known as a state of being "out of touch" with reality. In this context, hallucinations experienced by patients suffering from schizophrenia and other psychoses are commonly considered to represent a perceptual subset of detachments from reality with nonperceptual detachments categorized separately as delusions (Flynn, 2008; Cocchi, 2011).

To better understand the implications of hallucinatory phenomena linked to schizophrenia also at the molecular level, many studies using Lysergic acid diethylamide (LSD-25) have been done. LSD has been dubbed a "consciousness-expanding drug." Recreational doses of LSD can affect 5-HT_{1A}, 5-HT_{2A}, 5-HT_{2C}, 5-HT_{5A}, 5-HT_{5B}, and 5-HT₆ receptors, and the psychedelic effects of LSD are attributed to its strong partial agonist effects at 5-HT_{2A} receptors.

Does additional LSD binding to tubulin alter the conformational structure of microtubules and consequently their quantum computations? To explore the potential binding of different psychoactive drugs we first performed the Ascalaph Molecular Dynamics and Conformation optimization in water medium of several drugs' molecule structures.

We then started to study LSD binding by using HEX Protein Docking (Ritchie, 2010), based on research with rotational electrostatic evaluation, accelerated through FFT (ie using the so-called Spherical Polar Fourier Correlations). At the end of the computation HEX collects the best results in spatially arranged clusters. We chose the best energy

solution, corresponding to the first cluster. These procedures were compared to the docking performed on tubulin structure and taxol with the bovine taxol-tubulin 1JFF downloaded from RCS PDB. We also confirmed that taxol, at the best binding energy produced by HEX, is in the same position it has in the crystallographic PDB source. We then extended the binding studies on microtubules portions. Preliminary results of LSD and Heroin show a specific binding site in tubulin and microtubule portions. The study will be extended to all the structures previously optimized, and the conformational changes of the protein-drug complex will be evaluated. These *in silico* studies should be indicative of the *in vitro* behavior of the microtubule in solution as determined by electron paramagnetic resonance (EPR) spectra of selected spin probes to obtain structural and dynamical information in the presence of the psychoactive drug (Ottaviani, 2012).

Data in the recent literature and from our experiments seem to be consistent with the hypothesis that interactome Schrödinger proteins and in particular the cytoskeleton nanowire network comprise the best biological interface for potential expression of consciousness, being typical and distinct for each animal species, and that consciousness in animals is thus always a possibility. A deeper study of consciousness-altering drugs and their binding to tubulin and microtubules may help us to understand the complex biological interface between conscious and unconscious states and to better understand the various forms of psychopathology in a deeper physical and meta-physical framework. Scientific research in this field should focus on the study of quantum mind and the quantum brain, which are psychiatrically crucial instantiations of quantum logic and quantum physics, respectively.

In addition, scientists should directly assay behavioral aspects of thought-disordered subjects and analyze the results from a quantum-paradigmatic viewpoint in order to design and appropriately individualize quantum technologies for purposes of therapeutic clinical

communication. These considerations notwithstanding, the possibility of building a different approach for information is also within our horizons of expectation. The two potential ways - quantum gates on qbits and Licata's Hamiltonians with constraints - are complementary. Qbits are more useful when we are interested in individuating a specific state and shows a natural affinity for the problems typical of nanotechnologies.

A geometrical means of handling quantum information is more fruitful when we endeavor to study the global evolution of a system without forcing its nonlocal nature in any way. This latter mode of investigation clearly requires new formal tools based on dissipative quantum field theories (Licata, 2012).

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G proteins and lipid rafts as regulators of both microtubules and mood

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Background. Lipid rafts are specialized membrane domains rich in cholesterol and intimately associated with cytoskeletal components. G protein signaling is influenced by lipid rafts, but, depending upon the receptor, G protein, and effector enzyme, signaling components are either brought into close association or driven into separate membrane microdomains (Allen 2007, 2009). The former facilitates signaling and the latter attenuates signaling. We have demonstrated that, for Gs and Gs-coupled receptors (β -adrenergic, VPAC and 5HT-4, -6, -7), lipid rafts attenuate signaling by sequestering G α and adenylyl cyclase in separate membrane compartments. Experiments from several different laboratories suggest a post-synaptic effect of chronic antidepressants and a possible postsynaptic target for these drugs. Data from rats, cultured neural and glial cells, all suggest that the localization of the G

protein, G α , in lipid rafts is modified by chronic treatment with a number of antidepressant compounds (Donati and Rasenick, 2005; Zhang and Rasenick, 2010), and this can be screened rapidly by Fluorescence Recovery After Photobleaching (FRAP). Antidepressants facilitate translocation of G α from lipid rafts while post mortem studies show increased G α in raft fractions from several brain regions of depressed suicide subjects relative to controls (Donati, 2007). Antidepressants also concentrate in lipid raft fractions (Eisensamer, 2005). In this study, we sought to determine whether raft fractions prepared from platelets of depressed subjects showed enrichment of G α in lipid raft fractions and learn the manner in which antidepressants reversed this. We also hoped to determine whether the association between G α and tubulin that results in increased microtubule dynamics (Dave, 2011) and increased neuroplasticity (Yu, 2009) was altered by chronic antidepressant treatment.

Methods. Blood from volunteers (n = 9) or newly diagnosed MDD subjects (n = 15) was collected at the Marche Regional Psychiatric Clinic (Ancona Italy), separated into component fractions (Platelets, RBC and WBC), coded and shipped to Chicago for assay. Platelet G α was extracted, sequentially with Triton X-100 (non-raft fraction) and Triton X 114 (raft fraction) and G α was identified and quantified by immunoblotting. C6 cells were transfected, stably, with a monomeric version of a fluorescent G α fusion protein (Yu and Rasenick, 2002) and clones were selected by fluorescence cell sorting. Cells were treated chronically with a variety of antidepressants and FRAP was conducted on a Zeiss LSM710 confocal microscope.

Results. G α in the lipid raft fraction was significantly ($p < .0001$) greater in platelets prepared from depressed subjects than those from normal controls. Chronic antidepressant treatment of cells revealed increased recovery time after photobleaching. Related compounds like chlorpromazine or lithium did not have this effect. Finally, G α , internalized via lipid raft vesicles, was released from those

vesicles and increased both microtubule dynamics and neurite outgrowth. The molecular interface between tubulin and G α was revealed, and 15 amino acid peptides corresponding to this interface were effective at promoting microtubule dynamics.

Conclusions. This suggests the possible development of a simple blood test to indicate the presence of depression and may also serve as a rapid indicator of antidepressant response. Fluorescent G α may also serve as a screening tool for development of antidepressant compounds as well as a personalized profile for antidepressant selection. The interface between G α and tubulin may play a role in communicating neurotransmitter signals to the process of synaptic rearrangement.

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A quantum psychopathological account of anorexia nervosa

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Anorexia Nervosa (AN) is a mental disorder characterised by a refusal to maintain body weight at or above 85% of the minimally normal weight for age and height, an intense fear of gaining weight and a disturbance in the way in which one's body is perceived such that the sufferer is often unable to see that s/he is underweight (DSM4, 1994). Contemporary psychodynamic (Bruch, 1973; Lawrence, 2001; Krueger, 2002; Lemma, 2009; Curiel-Levy, 2012), feminist (McKinley, 2002) and neuropsychological (Klump and Gobrogge, 2005; Duvvuri, 2010) accounts of AN present only partial and sometimes conflicting accounts of this disorder.

A quantum psychopathological account of AN might therefore enrich our understanding of this disorder by providing links between the social and the neural explanations for AN while at the same time adding substantially to their depth. In this vein, this talk follows and builds on the recent work of Donald Mender, who has suggested that Quantum

Paradigms of Psychopathology (QPP) might be preferable to the currently prevalent biopsychosocial model of mental illness, and who has more specifically suggested that Quantum Theories of Mind might offer a way to render psychoanalytical accounts of mental illness scientifically falsifiable (Mender, 2010).

The first part of this talk will provide a brief yet thorough account of the psychodynamic, feminist and neuropsychological accounts of AN; the second will consider how Quantum Theories of Mind (Jibu and Yasue, 1995; Hameroff, 2007; Stapp, 2012) might be useful in our understanding of AN, examining specifically their impact on neuropsychology, their impact on psychotherapy and finally the possibility of developing a Quantum Object Relations (QOR) account of AN, based on Mender's suggestion that "sociable" bosons might account for the impact of internalised 'objects' on a patient's mental health, as identified in the psychoanalytic literature.

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Neural d-separations and transient brain dynamics: unraveling the causal chain from brain space to mind

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I attempt to demonstrate the skeleton version for a causal structure that links brain dynamics with subjective experience. Brain states seem to switch between two opposing characteristics and this switch is accompanied by phenomenal signatures.

The defining properties of these characteristics can be described by two sets of tightly interwoven conceptions. Directed cyclic causal relations (DCG)

among the variables involved and their related statistical independencies on one hand and the topological characteristics (dimensional excess) of the transients between variables, providing a transition algebra that can be mapped into the state matrix of an underlying (quantum)-physical system on the other. Thus the combined conception units causality, statistics, dimensionality and physics (CSDP). Several highly relevant and testable predictions emerge from these conceptions. For example, brain states that involve d-separated causal states should be detectable by their conditional independencies among the involved variables and these in turn are realized across dimensionally discordant (i.e. fractal) structures, combining lower and higher resolution processes and involving the quantum physical scale. I will provide a list of recent experimental evidence that is highly supportive for the predictions emerging from this theory.

Experience is at the center of all life forms. This seemingly basic property of our organization remains remarkably resistant to a causal relation to the processing architecture of our brain. A main reason that seems to nurture this neglect is the lack of a convincing causal relation of the regulatory elements behind brain signaling to the subjective-phenomenal states associated with these elements. In fact, we do not even know the precise nature of these regulatory elements and their target variable, the agent's mental state, is not well integrated within the traditional domain of physicalism. As can be expected, the commonalities of these limitations result in rather vague conceptual definitions (e.g. 'cognition') and give rise to inevitable problems in the understanding of concepts such as life, conscious experience, intelligence and social cognition, the experience of free will and the sense of agency and finally, the control of mood and affect. To understand the adaptive recruiting of these abilities into the personality of the experiencing subject may well be a prerequisite for a progress in our understanding of mental health and psychiatric disorders in general. Given the recent explosion of

highly demanding biophysical brain studies and the resulting amount and heterogeneity of complex data, the present situation unmistakably calls for a theoretical framework that can integrate network dynamics with mental states.

The outline I propose is inspired by theories of statistical causal inference as the ones developed by Pearl (1988), Spirtes, Glymour & Scheines (2001) and Shiple (2004). The focus of these concepts is the relation of causal structures to theories of conditional independence, i.e. probability theories and measurements. However, the defining properties of the theory suggested here differ in several important aspects from a standard causal path analysis. First, directed acyclic graphs (DAGs) of causal relations as suggested by Spirtes et al. (2001) are replaced by directed *cyclic* graphs (DCGs), graphically demonstrated within their natural frame in 2-dimensions. This aspect opposes the frequently held prejudice against circular reasoning but renders acyclic directed causation as special sample sections, one dimensional pieces cut out from a cyclic structure, that would be required to fully capture the phenomenon. Cyclic causation, as demonstrated here, provides the formal structure for positive and negative feedback loops in brain dynamics. It allows for the type of reciprocal causation that lays at the core of most regulatory elements in biological signaling, ranging from cellular signals, as reviewed by Brandman and Meyer (2008), to recent models of evolutionary processes, as for example reviewed by Laland et al. (2011).

Yet, there is an important additional aspect that adds the spices to the present outline. This aspect connects quantum mechanical concepts to causal brain dynamics, a connection that is still a matter of debates, unresolved and controversial, but gaining grounds by the recent developments in quantum biology (Bernroider, 2012a,b). Regarding causation and statistics, it has been demonstrated (Spirtes, 2001) how causal hypotheses translate into structured statistical models, eventually allowing for inferences from statistics to causal

structures. But these relations go much further. D-separations between variables not just map into statistical models of independence, but also into the dimensional characteristics of their connections. The presence of a causal d-separation in DCGs adds a part of an additional dimension to the topology of it is outline. The emerging fractality can then be mapped into the density matrix of the underlying (quantum-) physical system. I therefore finally argue that the seek for causal relations between neural dynamics and the phenomenology of experience most probably entails a visitation across different spatio-temporal resolutions of the underlying dynamics. The brain states switch between dimensionally concordant and physically coherent states and dimensionally discordant and physically de-cohered states. This switch is causally related to experience.

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Consciousness from animals to humans: quantum and molecular pathways

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As a result of quantitative molecular evaluations, concerning the fatty acids of platelets in human subjects with mood disorders (Cocchi 2008, 2010), and through the use of complex mathematical functions such as artificial neural network (Self Organizing Map) (Kohonen 1982, 1998, 2001), and a mathematical index (B2) (Cocchi and Tonello, 2010), it was possible to achieve a classification of subjects with unipolar depression (MD) and bipolar depression (BD) and the recognition of molecular steps that affect the serotonin response in relation to mood disorders.

The evidence arising from the study of these biological markers has raised the intriguing hypothesis of the existence of a state of consciousness in the animal world, as, moreover, recently discussed in the document known as the "Declaration of Cambridge". A similar path has been realized, in a comparative way, for some animals: sheep, cat, horse, donkey and cattle are arranged in the SOM on the opposite side to that found for human pathological cases, while rat and guinea pig and pig are in the pathological subjects areas. Dogs that are placed in the area due to the DM have a biochemical profile of platelets fatty acids most similar to humans, with all the implications resulting from its molecular interpretation. The obtained results may be considered particularly interesting with respect to possible new interpretations of animal consciousness and behavior.

Awareness is a global phenomenon that happens everywhere in animals seen as cellular aggregation that is

phylogenetically differentiated. Awareness is not relegated only to the nervous system of complex organisms but is rooted in cellular awareness that originates most likely from an awareness of individual primordial living entities, simplified to single cells. In it are associated the rapid response of non-neural adaptation to the environment, that has allowed individual free-living cells to navigate and select in their environment, or even have some sort of memory or learning. We think that it is, therefore, within the microtubular network that gives rise to the first memory and the evolution of aggregating systems is what we now call instinct (Craddock, 2012). This would provide an explanation for the instantaneous operation of our brains in evoking instinctive and stereotyped (rigid) reactions, in which the information is retrieved from a container devoid of previous recordings, in an amount of time between 100 and 1,000 meters / second - a rate that exceeds the capacity of any known connection already existing between axons and dendrites of neurons (Kraus, 1969; Jibu, 1994). The brain becomes simply the mechanism of recovery and extraction by means of basic storage.

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Paradigm shifts in mental health

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Psychiatry, as a discipline has relied traditionally on many other fields of enquiry for insights and methods of investigation. These include from purely philosophical, such as phenomenology, to purely mathematical, such as statistics (Schwartz, 2005). The inferential process for psychiatry is traditionally based on classical Newtonian mechanics. Thus Freud based his theories of Instinct on a hydraulic model essentially drawn from Newtonian physics. The operative definitions (basis of DSM system) and the algorithmic approach incorporated in various treatment and psychotherapy models are perhaps best explained by the Boolean logic. This is a deterministic model, which presupposes the prediction of a later state if all the coordinates of a previous state in the system are known. There is an implicit expectation to predict complex human behavior such as violence. This becomes even more difficult as we try to fit complicated phenomena such as psychotic states to the simplistic cause and effect models, in part to fulfill certain societal expectations and in part to follow a deterministic medical model.

With the prevalent so called “biological model”, it is assumed that brain mechanisms will ultimately suffice to explain all psychologically described phenomena. This assumption originates from the idea that the brain is made up entirely of material particles and electromagnetic fields. It is further assumed that all causal mechanisms relevant to neuroscience can therefore be formulated solely in terms of properties of these elements. Thus, experiential content (experience of feelings, free will, knowing

etc) is not included as primary causal factors.

However this worldview in psychiatry (and the neurosciences in general) is based on an outdated paradigm in physics. Contemporary understanding of quantum physics fundamentally differs from classic physics about the role of consciousness observer that enters into the structure of empirical phenomena (Bohm, 1986; Bohr, 1958, 1961).

These new principles are in direct contradiction with the deterministic idea that local mechanical processes alone can account for all observed empirical phenomenon (Kuhn, 1978; Libet, 1992). This talk highlights the need to adopt a “quantum paradigm” in the field of psychiatry and will attempt to provide evidence (both theoretical and empirical) for such an assertion. It will be shown that allowing for the quantum phenomenon at neuronal level provides an alternative conceptual framework for describing neural processes. The new theoretical framework, unlike its classic predecessor, is rests directly upon, and is compatible with, the prevailing principles of physics (Porter, 1989).

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Towards an integrated model of cytoskeletal quantum dynamics

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The last years have been characterized by a growing interest of the scientific community in the cytoskeletal dynamics. Such an interest has been fostered by Hameroff and Penrose theories, which attribute a prominent role to quantum processes concerning the microtubules in explaining most phenomena related to cognitive activity and, in general, to consciousness (Penrose, 1994; Hameroff 1994, 1996). Owing to the difficulties encountered when trying to obtain some experimental evidence about the validity of these theoretical proposals, we need to build suitable models of cytoskeletal dynamics, allowing to make experimentally testable predictions. Actually the concrete building of such models appears as a very difficult enterprise owing, on one side, to the high complexity of cytoskeletal structure, and, on the other side, to the limitations regarding the computer simulations of quantum processes. All models so far introduced describe the cytoskeleton as a network of biopolymers including three main kinds of filaments (Pullarkat, 2007): actin filaments, microtubules, and intermediate filaments. The latter are often neglected, because they seem to play a passive reinforcement role. Almost all models are based on classical descriptions of cell macroscopic hydrodynamics and are mostly focused on the rheological aspects of cytoskeletal activity. The latter, as it is well known, are related to the role played by the cytoskeleton in determining the cell mechanical properties (Levine and MacKintosh, 2009; Ramaswamy, 2010). Some models belonging to this category are inspired by a general theory of biological matter, known as tensegrity theory, introduced since the eighties by Ingber (2000). This theory assumes that all biological structures, on whatever scale, ensure the stability of their form, as well as their ability to move in a coordinate way,

owing to the combined action of local tension and compression forces. In particular, within the cytoskeleton the tensions would be supported by actin filaments, whereas the microtubules would be responsible for the compressions. For an example of a cytoskeleton model based on tensegrity theory see Cañadas (2002).

Within this theoretical framework we propose a new model of cytoskeletal dynamics which, being based on the dynamics of a network of reciprocally interacting quantum microtubules, derives the mechanical properties of the cytoskeleton itself from the global output of this network. The latter can be viewed as a set of molecular motors, a circumstance which allows to resort to already existing models, relating the global behaviour of actin filaments to the frequency spectrum of the forces produced by these motors (Levine and MacKintosh, 2009). Our model has been designed to describe the cytoskeleton of neural cells, where the microtubules give rise to coherent assemblies, characterized by a common direction of all microtubules, often parallel to the direction of cell membrane (typically in the axonal zone). This allows to restrict our considerations only to 1-dimensional or 2-dimensional networks. In conformity with the results obtained in the fundamental researches of Tuszynski et al. about the quantum processes occurring within microtubules (Tuszynski, 2005; Craddock and Tuszynski, 2010), the activity of each microtubule has been described through a continuous-time quantum Markov process (Mülken and Blumen, 2011), ruled by the interactions with the outputs of others spatially neighbouring microtubules. Moreover, the output signal produced by the microtubule under consideration becomes available only after a time depending on the length of the microtubule itself. This length is variable with time, as observed in real microtubules, according to laws of change already found in other researches (Deymier, 2005; Baulin, 2007). Moreover, our model includes also the interaction between the microtubules and the intracellular liquid. Namely, this

interactions could be responsible for the formation, within this liquid, of coherent domains which could support a 'temporary memorization' of the information transmitted by the microtubules. This induced us to represent the liquid as a system of interacting spins (related to the electric dipoles it contains), with neighbour-neighbour interactions.

Instead, we neglected the tubulin molecules lying isolated within the cytoskeleton after the disruption of a single microtubule, because some recent models (Glade, 2012) evidenced that these molecules have a marginal role in the dynamical evolution of microtubule system.

The computer simulations of model dynamics, so far performed on systems including some hundreds microtubules, evidenced two critical aspects: 1) the cytoskeletal rheological properties so far observed can be reproduced only through a very accurate choice of model parameter values (are these properties devoid of enough generality?); 2) the quantum character of microtubule dynamics does not seem to have a significant influence on the cytoskeleton dynamics, except for the case in which the interactions between the microtubules and the intracellular liquid are very strong. These circumstances suggest, on one side, the need of a critical reflection on the theories, so far proposed, about the role of the cytoskeleton, and, on the other side, the advisability of an extension of this model which can avoid the excessively rough approximations of a complex biological realm. In any case, the performed simulations and the critical assessment of their outcomes are a necessary step towards the building of an integrated model of cytoskeletal quantum dynamics.

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Quantum cognition: analogies between quantum and cognitive phenomena

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In their recent article “Can quantum probability provide a new direction for cognitive modeling?”, Pothos and Busemeyer (PB) make a convincing case that there are empirical results concerning human decision making and judgment that can be elegantly accounted for by quantum probability (QP) theory, while classical (Bayesian) probability (CP) theory fails (Pothos and Busemeyer, 2013). In particular, they point out that human judgment and preference often display order and context effects, violations of the law of total probability and failures of compositionality, and that in such cases QP - with features such as superposition and entanglement - provides a natural explanation of cognitive process. More generally, they suggest that QP is potentially relevant in any behavioral situation which involves uncertainty.

Such success in modeling raises the question of how can it be that QP which was developed to account for quantum physical phenomena could possibly be able to account for cognitive phenomena. PB do not discuss this issue at great length, but suggest that the reason is because some cognitive phenomena are analogous to quantum phenomena. But, one can then ask, why are they analogous? This analogy could be a mere coincidence, but one radical possibility is that the physiological correlates of cognition involve quantum effects in such a way that some cognitive processes have literally subtle quantum mechanical aspects.

The idea that there are analogies between cognitive processes and quantum processes is an old one, going back to at least Niels Bohr, as PB indeed acknowledge. However, perhaps the clearest early account of such analogies – and also an attempt to explain them in physical terms - was given by David Bohm

in his 1951 textbook *Quantum theory* (Bohm, 1951).

Following Bohr, Bohm is led to speculate that there are, generally speaking, two different kind of levels of physical activity in the brain, one of them describable in terms of classical physics, while the other needs to be described in a quantum theoretical way. He is tempted by the idea that the physical correlate of the logical thinking process (where clearly definable concepts dominate) is at the classically describable level of the brain, while what he calls “the basic thinking process” (which involves indivisible non-logical steps) is at the quantum theoretically describable level. At the very least, Bohm argues, there is a strong analogy between these aspects of thought and the quantum-classical structure of physics, thus clearly anticipating some ideas in the current field of quantum cognition (Aerts 2009).

The implications of Bohm’s speculations are potentially groundbreaking. I interpret him to be saying that part of what it is like to be a thinking human being is to have a direct experience of the effects of the quantum theory (Pylkkänen, 2004). For if thought involves quantum effects in the way he suggests, it might be the case that all of us are directly familiar with some quantum-mechanical aspects of matter in virtue of being familiar with the behavior of our thought processes. Quantum effects are typically assumed to lie in some mysterious domain that only physicists have access to, but they may lie much closer to home than we thought! This, I think, is an intriguing possibility which few philosophers (of mind) have thus far considered. The speculations – still controversial - that the physiological aspects of cognitive processes may involve quantum effects have developed a great deal during recent decades, and Bohm’s (1951) thoughts can be seen as an historically important early formulation of the basic idea (Atmanspacher, 2001).

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Stream of consciousness: quantum and biochemical assumptions regarding psychopathology

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The actual mainstream state of the art in neuropsychiatry seems to be inconsistent and shows equivocal evidence. On the other hand, a growing number of other approaches have arisen and are developing. In particular, quantum theories of mind, brain and consciousness seem to offer a promising way to change profoundly the present approach (Hameroff and Penrose, 1996a-b; Vitiello, 2001). Unfortunately these quantum paradigms harbor two problems: firstly, they are “just” models, theories, and assumptions, with no convincing experiments supporting any of them; secondly, they are estranged from mainstream views psychiatric illness as understood today.

Hence this paper suggests a possible way to integrate experimental neuroscience with quantum models in order to address outstanding issues in

psychopathology (Tonello and Cocchi, 2010). A key role is played by the “stream of consciousness” seen as a phenomenon linked to the so called EEG “Gamma Synchrony”(GS) (Hameroff, 2010).

From this proposed new viewpoint, unipolar depression is considered: from the perspective of GS, it is inferred that a depressed patient could be seen as a subject with an alternate stream of consciousness (Imas, 2005; Siegle, 2010; Velasques, 2010; Dzirasa, 2011; Özerdem, 2011). In particular, some clues seem to suggest that depression is linked to some species of “increased power” stream of consciousness so that a depressive subject might be understood as hyper-conscious (Strelets, 2007; Wahlund, 2009; Lee, 2010; Liu, 2012). It is additionally suggested that the above approach to depression might be extended to psychopathology in general. In this sense, it is finally conjectured that suicide by depressed patients could be viewed as an effect of extreme hyper-consciousness.

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Towards nanoneuroscience: the potential of nanotechnology for the treatment of neurological disorders

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The discovery of novel ways in which the internal structures of neurons contribute to information processing necessitates a new perspective on neuron

function or “a new electronics of mind.” Because of recent technological advances at the nanometer scale, scientists have at their disposal increasingly better ways to study the brain and new ingenious ways to engineer specific parts of neurons. The name of this emerging field is “neuronanotechnology” (Woolf, 2010). During the past century the focus in neurobiology had been on the neuron and its synapses (Nicholls, 2011). The computer analogy of higher mental function, in which each neuron acts as a processing unit with weighted synaptic connections, was our only quasi-realistic model and it served us well for decades.

The usefulness of this model may have run its course—today it is overly simplistic and needs updating to account for biophysical molecular interactions inside neurons. Neuronanotechnology exponentially expands the mind-brain computer analogy by endowing each neuron with the processing capability potentially reaching that of a supercomputer (Craddock, 2010). Synapses feed information into this massively powerful intraneuronal matrix of cables and conduits of information.

What happens inside the neuron is, arguably, as critical to higher cognitive processing as whether a message is transmitted to the next neuron. Neuronanotechnology has the potential ability to identify intracellular events most closely related to higher cognitive function because it can access the molecular machinery that enables neurons to operate at nanoscale dimensions. A central theme of my talk is that cytoskeletal filaments found in neurons are nature’s nanowires. I will present some recent research in support of this basic tenet with evidence that naturally occurring nanowires are not only basic to intracellular transport, but also to learning, memory (Craddock, 2012a), and possibly even higher consciousness. How do we know that the interiors of neurons, in particular the cytoskeletal filaments, play a role in higher cognitive function? F

or one, the cytoskeleton undergoes structural change during learning. Second, an abnormal cytoskeleton appears to be a

primary etiological factor contributing to neurological disorders, such as Alzheimer’s disease (Craddock, 2012b), as well as to mental disorders (Perez Velazquez, 2010), such as bipolar affective disorder and schizophrenia—disorders associated with deficits in memory function or impaired mental state. Finally, I will discuss ideas regarding therapeutic possibilities emerging from these new concepts.

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Intuition, counter-intuition and medical judgement

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Psychiatrists, as many other clinicians, find it difficult to come to terms with the concept of “uncertainty”. Hence, it comes to no surprise that many psychiatrists, contrary to most physicists, will experience difficulties to accept quantum paradigms (Werneke, 2011). After all, whilst

physicists are used to working with the counter-intuitive, physicians are not. Ways of reducing uncertainty in medicine include reliance on scientific evidence, medical experience and clinical intuition. Relatively little is known about how well particularly intuition performs in clinical practice, because this is not easily measured. It is likely that clinical intuition relies on common psychological mechanisms people unconsciously employ to reduce perceived uncertainty. Such mechanisms include perceptual denial, attempts to reduce cognitive dissonance, conjunction fallacy and overconfidence, to name a few (Plous 1993; Kahneman, 2001). Perceptual denial implies that we see what we expect to see rather than what is really in front of us, because the brain constructs a perception from a few significant clues considered representative.

Cognitive dissonance is a psychological mechanism that brings our beliefs in line with our behaviour instead of our behaviour in line with our beliefs. Conjunction fallacy arises when a conjunction of events is erroneously rated as more probable than one of its constituents. This occurs when a constituent is highly representative so that it distorts our perception of likelihood (Tversky and Kahneman, 1983). Overconfidence enables us to construct a coherent story although we know only little or to uncritically accept such a seemingly coherent story. Thus, increasing the acceptability of quantum paradigms will most likely remain an uphill struggle since such paradigms increase rather than reduce the amount of perceived uncertainty. Ways to overcome this inherent bias against uncertainty in psychiatrists include the introduction of more sociological training in the under- and postgraduate curriculum and the development of cognitive tools taking account of an uncertain reality.

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The Mind and the Quantum

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All of us can answer what a brain is, but what a mind is... that is a more difficult question. But not only for the infamous mind-body debate... asking this question is a personal commitment. We think that everyone should define his own personal philosophical approach before talking about the mind.

Our approach is very simple: the mind, to us, is the logic used by the brain. A quantum mind is then the quantum logic of the brain, when quantum effects become relevant in some particular physical processes occurring in the brain.

A logic is a formal language, and then the mind is the formal language of the brain. The mind (either classical or quantum) can then be compared to a computer (classical or quantum respectively). The classical computer is the conscious mind, while the quantum computer, much faster, is the unconscious mind, which “prepares” the job to its classical counterpart.

However, there are some aspects of the human thought, which are not computable. The existence of a non-algorithmic side of the mind was conjectured by Penrose (Penrose, 1989) on the basis of Godel’s first incompleteness theorem. Then in this case, the concept of the mind as a logic fails. In fact, the non-algorithmic “mind” (Zizzi and Pregnotato, 2012) is a metalanguage. The physical interpretation of the quantum “meta-mind” (the quantum metalanguage of the brain) is Quantum Field Theory (QFT), dealing with systems (the fields) characterized by an infinite number of

degrees of freedom and allowing creation and annihilation of particles.

In other words, the non-computable mind is the language of the brain when the physical processes which occur in the brain are described by a Quantum Field Theory. In this regard we quote the introduction of a generalization of QFT, named “Dissipative QFT” (DQFT) (Vitiello, 2001; Blasone, 2011). It appears as the most convenient tool, so far introduced, for dealing with quantum effects in biological matter.

On the other side, the quantum computable mind, or the quantum logic of the brain (or simply, the quantum mind) is the language of the brain when the physical processes occurring in the brain can be described by Quantum Mechanics (QM), which deals systems made by a finite and fixed number of particles.

It is to be now recalled that, in general, within QFT the phenomenon of Symmetry Breaking, consisting in a phase transition leading to a new solution of evolution equations (i.e. to a new kind of behavior) no longer fulfilling the invariance properties owned by the equations themselves, gives rise to the appearance of new (typically zero-mass) particles acting as messengers working to preserve the new solution (the less symmetrical one) against external perturbations. It is known from longtime that these particles, originally called “Nambu-Goldstone Bosons” (NGB), can, under some circumstances, undergo a sort of condensation, giving rise to collective entities endowed with macroscopic properties. Now DQFT opens the possibility of generalized kinds of condensation of NGB, which can behave as entirely autonomous entities, fully independent from the matter originally undergoing the phase transitions themselves. In other words, these condensations are to be considered as living (even if for a limited amount of time) within a world very different from the one of molecules and characterized as belonging to a “logical” level. The latter, however, must retain part of the quantum character of processes which initially produced it, so the logic ruling the new

level must be a Quantum Logic (QL). In turn, it is to be supposed that the interaction with the environment can induce decoherence processes, so that we can predict the occurrence of a new logical level, described by Classical Logic (CL) and responsible for the physical outcomes of mental processes.

DQFT thus allows to relate, through bottom-up and top-down interrelationships, the processes occurring within brain, at the different levels, with a very interesting logical scheme of the whole mental activities. Such a scheme, already proposed (Zizzi, 2010a-b), is based on three different levels: the one of (quantum) metalanguage (QML), the one of (quantum) object language (QOL), and the one of classical language. The quantum metalanguage represents the non-computational aspects of mind and is related to DQFT underlying the brain processes. It reduces to quantum object language and the process underlying this reduction parallels the one which allows to reduce QFT to QM. The level of QOL is the logical level of (Quantum) computational Mind. Finally the level of classical logic, produced by decoherence process, is the one of (classical) computational Mind, like the one taken in consideration by traditional Psychology and standard Artificial Intelligence. The latter is the seat of consciousness, while the Quantum Mind coincides with the unconscious. This description has been possible owing to the introduction of a new form of Quantum Logic, in which QML atomic assertions carry assertion degrees which are complex numbers, interpreted as probability amplitudes. It is to be noticed that a quantum computer (QC) has a QOL, whose physical counterpart is QM. Therefore a QC will never be able to have a QML because it is impossible to go from a theory with a finite number of degrees of freedom, like QM, to one with infinite number of freedom, like QFT (while the reverse is possible).

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