Journal of Phylogenetics & Evolutionary Biology

Cocchi et al., J Phylogen Evolution Biol 2013, 1:4
DOI: 10.4172/2329-9002.1000119

Review Article Open Access

Molecular Contiguity between Human and Animal Consciousness through Evolution: Some Considerations

Massimo Cocchi[1]*, Fabio Gabrielli[1], Lucio Tonello[1], Mauro Delogu[2], Valentina Beghelli[2], Michela Mattioli[2] and Pier Attilio Accorsi[2]

[1]"Paolo Sotgiu" Institute for research in Quantitative and Quantum Psychiatry and Cardiology, L.U.de.S. University, Lugano, Switzerland
[2]Department of Veterinary Medical Sciences, University of Bologna, Italy

Abstract

This work suggests the possibility of the existence of contiguity in the molecular evolution of consciousness, between man and animal. From the experimental point of view and in terms of hypotheses, it seems that many elements lead to considerations about a common molecular evolutionary origin of the consciousness in animals and humans. It seems, also, evident that the increasing levels of complexity of consciousness can correspond to the evolutionary process. The work discusses a scientific speculation about the possible role of serotonin and thermoregulation in the evolution of consciousness of living beings.

Keywords: Evolution; Living beings; Mood disorders; Membrane viscosity; Serotonin; Interactome; Consciousness

Introduction

Recent researches on the molecular contiguity between man and animal [1], provide strong evidence in the studies carried out by "Paolo Sotgiu" Research Institute for Quantitative and Quantum Psychiatry and Cardiology of L.U.de.S University, Lugano, in collaboration with the department of Veterinary Medical Sciences of the University of Bologna.

The research has underlined this continuity, especially in regards to the relationship between men and animals [2], both, from an evolutionary point of view and from a molecular perspective. Also the Cambridge Declaration on Consciousness[1] represents a real turning-point in the interpretation of animal behaviour: "The absence of neocortex does not appear to preclude an organism from experiencing affective states. Convergent evidence indicates that non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviours. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Nonhuman animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates".

A critical analysis of the results obtained [3-5] shows that exist molecular analogies between animal and human beings with respect to mood disorders. The results concerning the platelet markers, together with the scientific evidence of literature, seem to substantiate the hypothesis that also animals are inherently prone to mood disorders, and, as a consequence of that, to different state of consciousness.

Supposing that consciousness is the result of a quantum process of the cytoskeletal network, it should be stated that a potential of consciousness can be expressed by any cell containing a cytoskeletal network, in all animal species, and this could represent the biological interface of consciousness [4].

A hidden animal consciousness, that probably uses the complexity of the interactome (tubulin and microtubules, Gsα protein, membrane viscosity and ion channels) in order to self-determine a state of consciousness, limited to what is required to exist, without emotional expressions and which, with the development of a critical relationship between tubulin, synapses, cortex, and serotonin, form the conscious event, neuro-correlated (classic information), with expressions of a more complex and differentiated emotional consciousness [4].

It is assumed that, the consciousness survives even with basic conditions and this assumption is plausible, at bio-molecular level, referring to the hypothesis according to which the Schrodinger's protein (that is to say tubulin) is the biological interface from quantum physics to classic computation, the basis of quantum/classic consciousness processes and at the crossroad of memory and learning skill [4].

Biology and culture, consciousness and the world, subject and object, inside and outside, have continuity and find in "creative transcendence of consciousness" and in its related experiences, a special level of comprehension.

The consciousness: a pathway from animal to man

The existence of serotonergic neurons has been demonstrated in Drosophila [6], humans [7] and vertebrates (cold and warm blooded). Serotonin (5-HT) plays a role in several bodily functions, such as sleep [8,9], food intake, mood [10] and mammalian body temperature regulation [11-13]. [1]

A diminished serotonin production has a well-established association with depressed mood [14-21]. Maurer Spurej [22] draws a strong correlation in the role of serotonin with respect to the animals in the light of experimental evidence: i.e. the presence of serotonin as

[1] The Cambridge Declaration on Consciousness was written by Philip Low and edited by Jaak Panksepp, Diana Reiss, David Edelman, Bruno Van Swinderen, Philip Low and Christof Koch. The Declaration was publicly proclaimed in Cambridge, UK, on July 7, 2012, at the Francis Crick Memorial Conference on Consciousness in Human and non-Human Animals, at Churchill College, University of Cambridge, by Low, Edelman and Koch. The Declaration was signed by the conference participants that very evening, in the presence of Stephen Hawking, in the Balfour Room at the Hotel du Vin in Cambridge, UK. The signing ceremony was memorialized by CBS 60 Minutes.
As a matter of fact these evidences open a new chapter in the study of animal behaviour and, therefore, in the concept of well-being.

***Corresponding author:** Massimo Cocchi, "Paolo Sotgiu" Institute for research in Quantitative and Quantum Psychiatry and Cardiology, L.U.de.S. University, Lugano, Switzerland, Tel: +18-898-989-7586; E-mail: massimo.cocchi@unibo.it

Received March 22, 2013; **Accepted** September 23, 2013; **Published** September 25, 2013

Citation: Cocchi M, Gabrielli F, Tonello L, Delogu M, Beghelli V, et al. (2013) Molecular Contiguity between Human and Animal Consciousness through Evolution: Some Considerations. J Phylogen Evolution Biol 1: 119. doi:10.4172/2329-9002.1000119

a circulating factor of thermoregulation indicates the turning point of evolution between the last reptile species and the warm-blooded animals (Figure 1).

We have attempted to reconstruct the involvement of serotonin in animals and men through the connection of the molecular steps that lead to the consciousness hypothesis in agreement with our working hypothesis [21,23] (Figure 2).

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 all animal species, and this could represent the biological interface supporting the Manousakis view of consciousness [24].

Therefore, different potential expression of consciousness levels might occur, according to the evidence mentioned above. However, this statement must take into account certain considerations.

The Orch OR theory provides the presence of, at least, 300 neurons as the minimum level to express a consciousness state which corresponds to 100 milliseconds of quantum coherence [24-33].

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, provided or not with serotonin. Human and animal consciousness, therefore, should be considered and discussed with respect to the pre-and post-serotonin era (Figure 3).

In animal models, according to the complexity of organisms and to presence of circulating serotonin, is the transition between cold-blooded and warm-blooded animals [22] that causes an increase in the complexity of consciousness?

Available evidence suggests that in cold blooded vertebrates the enterochromaffin cells, containing 5-HT, are lacking because the intestinal mucosa is rich in nerve fibers with high concentrations of 5-HT [34]. At this point a reflection arises: is it, really, the late appearance of circulating serotonin and consequently the appearance of the mechanisms of thermoregulation the watershed between quantum consciousness and classic consciousness? Is it possible that this phenomenon plays an extraordinarily important role in the evolution of living beings?

Therefore, we can hypothesize the existence of a submerged animal consciousness limited to what is necessary to exist without emotional expressions and that modulates progressively towards a neuro-related, emotional consciousness, correspondingly to the realization of an increasing level of optimization of the relationship among tubulin, synapses, cortex and serotonin.

The molecular similarities, observed between animal and man, as concerns the conditions of Major Depression and Bipolar Disorder (Figure 4) suggest that the modulation of serotonin uptake, modified by

Figure 1: The figure describes the point of transition between the animals without circulating serotonin to animals with circulating serotonin. "Circulating Serotonin" means the hormone is transported from enterochromaffin cells to platelets. Vertebrates, in lower part of the figure are related to the cold blooded animals (fishes and reptiles).

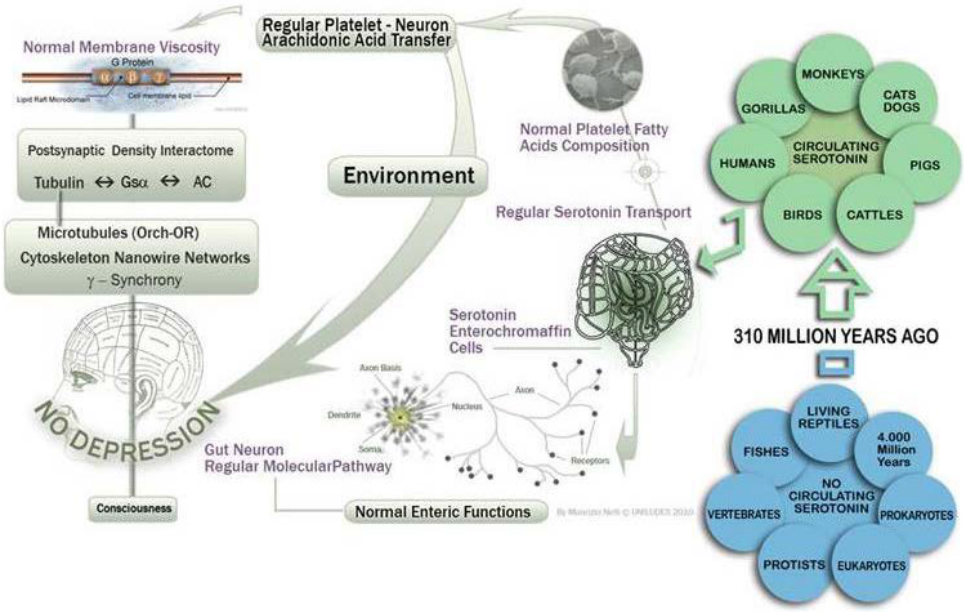

Figure 2: The figure shows the serotonin pathway in its connections with the interactome in normal conditions, where the serotonin transport to platelets and neurons could be modified by the viscosity of the membrane and, therefore, can lead to consciousness modification [23]. The phylogenetic comparison of animals provided and unprovided with circulating serotonin, (right), makes it plausible, even for animals, the molecular and quantum hypothesis of consciousness, although for different levels of complexity.

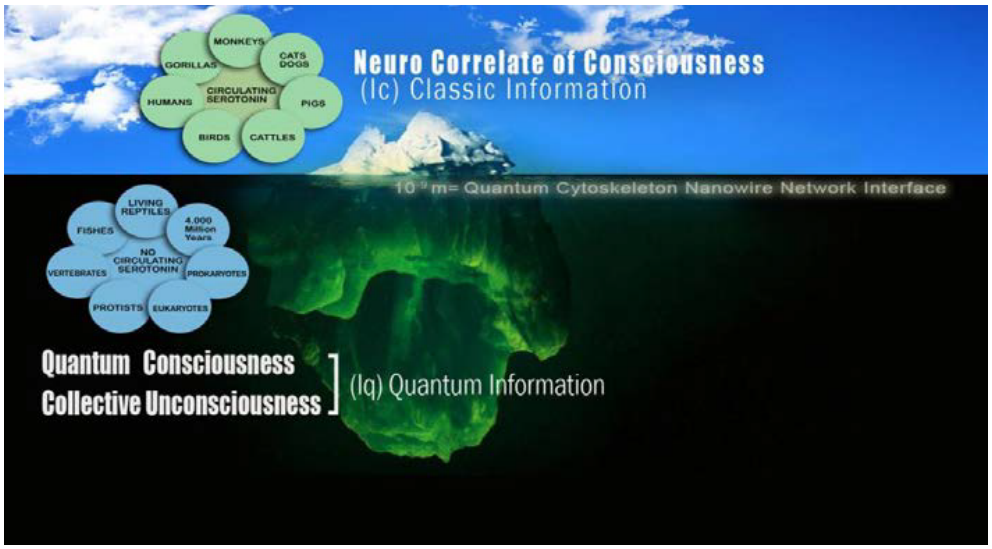

Figure 3: The figure compares the assumptions of a border between quantum consciousness and classic consciousness.

the viscosity of cell membrane (neuron and platelet), can be considered a mechanism related to evolution [35-39].

Appendix: the consciousness hypotheses

A growing number of approaches are rising and developing. In particular, quantum theories of mind, brain and consciousness seem to offer a promising way to deeply change the classic approaches. Currently, among the most notable, could be considered: the Orch OR model by Hameroff and Penrose [25-33] and the Thermo field Brain Dynamics (TBD) model [40-44] but many other should be taken into account.

Even if these models seem very promising, in the authors' opinion, they have a main problem. They are "just" models: there are no convincing experiments or demonstrations showing clear evidences supporting them.

In the mid-90s, Roger Penrose and Stuart Hameroff proposed the so called "Orch OR" model [26] continuously updated [33]. According to this well-known model, one of the main sites involved in consciousness formation is the Microtubule (MT). Therefore, the fundamental building blocks are Tubulins. They are supposed to live both in classical states as well as in a superposed quantum state (coherent state). In classical states they can express information as bits, while in superposed

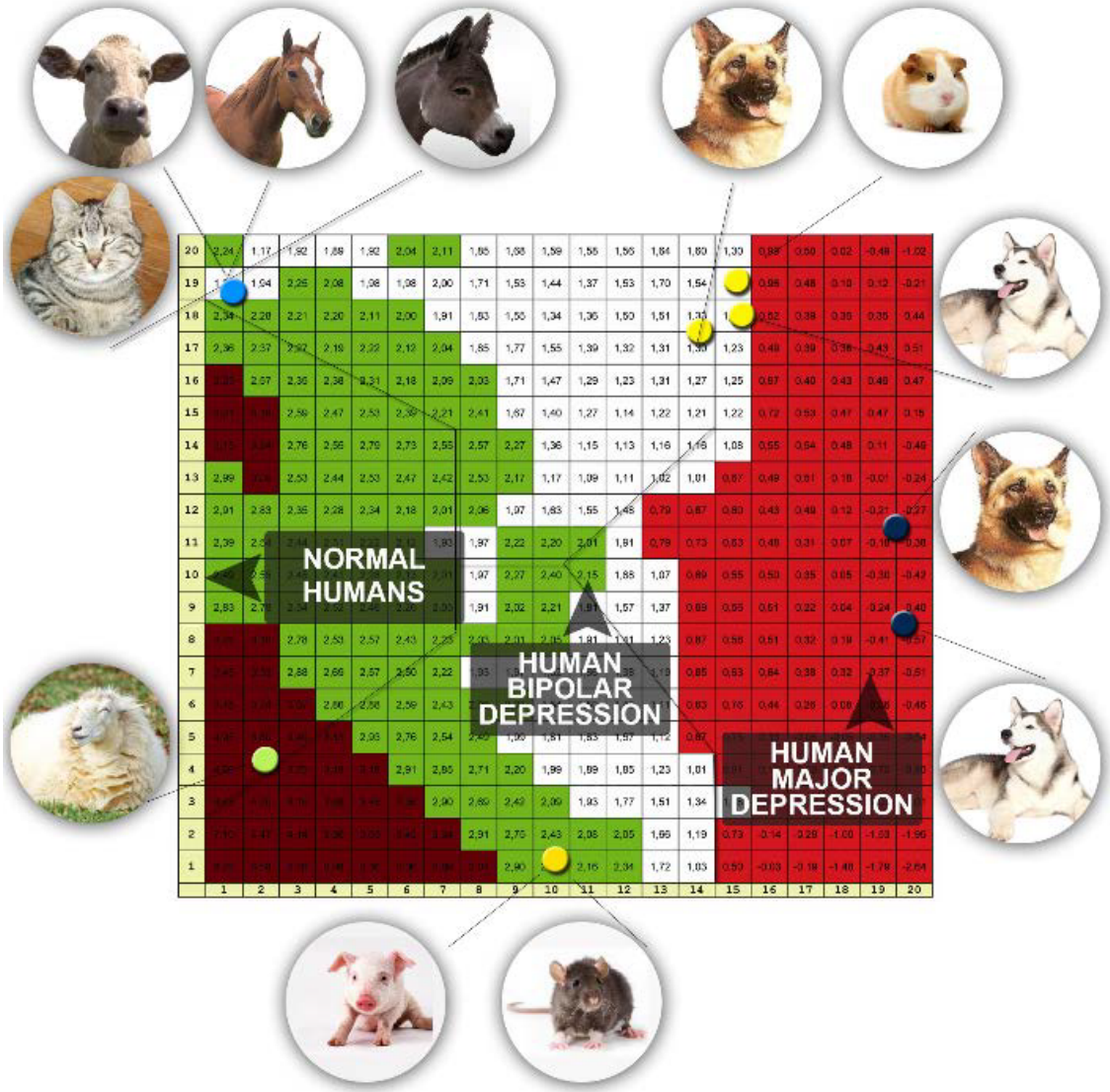

Figure 4: Positions of animals over the SOM of human depression [40].

state they can express it as qubit, so that, both, classical and quantum computation could take place.

Once the tubulin assemblies in coherent states reaches a kind of threshold, a sort of "self-collapse" (called Objective Reduction by Penrose) occurs. This self-collapse to classical states gives rise to the "conscious event", the "actual now". The stream of consciousness would be a discrete sequence of quantum "self-collapses" (O.R.). Hameroff and Penrose suggested that differences in the sequence of O.R. could be coupled with different "real life" situations.

This topic has been addressed recently by a group of world-reputation scientists belonging to the Quantum Paradigm Psychopathology Group and that is worth to report it in full description.

On 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 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 preceded 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 micro tubular cytoskeleton spanning both intra neuronal and inter neuronal 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 de-coherence 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".

The statement is a prime example of reflection between the quantitative aspects and quantum brain function and the ability to improve therapies in psychiatric disorders concluding: "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 micro tubular 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 undiscovered structures and related processes may prove to be potent factors in the deeper etiologies and improved treatments of psychiatric disorders".

The Declaration of Palermo was written by Donald Mender and Massimo Cocchi and edited by: Don Michele Aramini, Gustav Bernroider, Francesco Cappello, Fabio Gabrielli, Gordon Globus, Mansoor Malik, Efstratios Manousakis, Kary Mullis, Eliano Pessa, Massimo Pregnolato, Paavo Pylkkänen, Mark M. Rasenick, Lucio Tonello, Jack Tuszynski, Giuseppe Vitiello, Ursula Werneke, Paola Zizzi.

Conclusion

Awareness is a global phenomenon that happens everywhere in animals seen as cellular aggregation, 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 these organisms 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. Therefore, we think that it is within the micro tubular network that gives rise to the first memory and to the evolution of aggregating systems what we, now, call instinct [45]. This would provide an explanation for the instantaneous operation of our brains in evoking instinctive and stereotyped (rigid) reactions, where 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 [46,47].

Thanks to quantum and quantitative molecular evaluations on platelet fatty acids in human subjects suffering from mood disorders, and through the use of complex mathematical functions, namely the artificial neural networks (in particular the Self-Organizing Map), it has been possible to classify subjects having unipolar depression and bipolar depression [48] Figure 5.

A similar pathway has been followed, in a comparative way, for some animals, and it led to interesting results for new interpretations of consciousness and animal behaviour. The discovery of the same molecular features found in human subjects suffering from major depression raises many questions about consciousness and the hypothesis considering animals inferior to men.

From the biological point of view is a ontological hierarchy steeped in ideology.

Probably, men and animals are only two different expressions of language as also Donald Mender (Lecturer of Psychiatry at Yale) supposes (private exchange of ideas between Cocchi and Mender): "One thought that I have is to seek in wolves an olfactory (e. g. urinary pheromonal), body-kinetic, or prosodic route for the expression of mood rather than a linguistic mode. The first mode might be especially fruitful, since canines seem to live in an olfactory sensory world of which we cannot even conceive, much as these creatures most likely cannot conceive of our own human linguistic universe. Can a dog write a polyphonic symphony of subtle odors? Perhaps. Might that composition feel emotionally like a Chopin etude? Why not?"

Language introjection in the human species has undoubtedly brought about a complete change of the conscious experience [49-55]. When compared to primary or nuclear consciousness, the extended consciousness, which is crucial for personal self-building, implies a major role of language [56].

Edelmann and Tononi [57], argue, in an even more convincing way, that once the highest level of consciousness has blended with language, then the Self and all its social and affective aspects can be built. Nevertheless, the presence or lack of language does not exclude the ability of non-human animals to express intentional behaviors and affective experiences. Indeed, today the empirical evidence supporting animal consciousness is well-established (for example, the cognitive complexity of octopus) [58-60].

In our case, the animal consciousness [50,61-64] could be incorporated not only at the pure organic (hunger, thirst, pleasure, and pain) and bio-eco-logical levels, but also at higher intentional levels (consciousness limited to the "here and now", with no projection in time) [65]. As a matter of fact, Bekoff et al. and Bekoff and Peirce [66,67] even believe that animals show a wide range of moral behaviours, including sense of justice, empathy [68], 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.

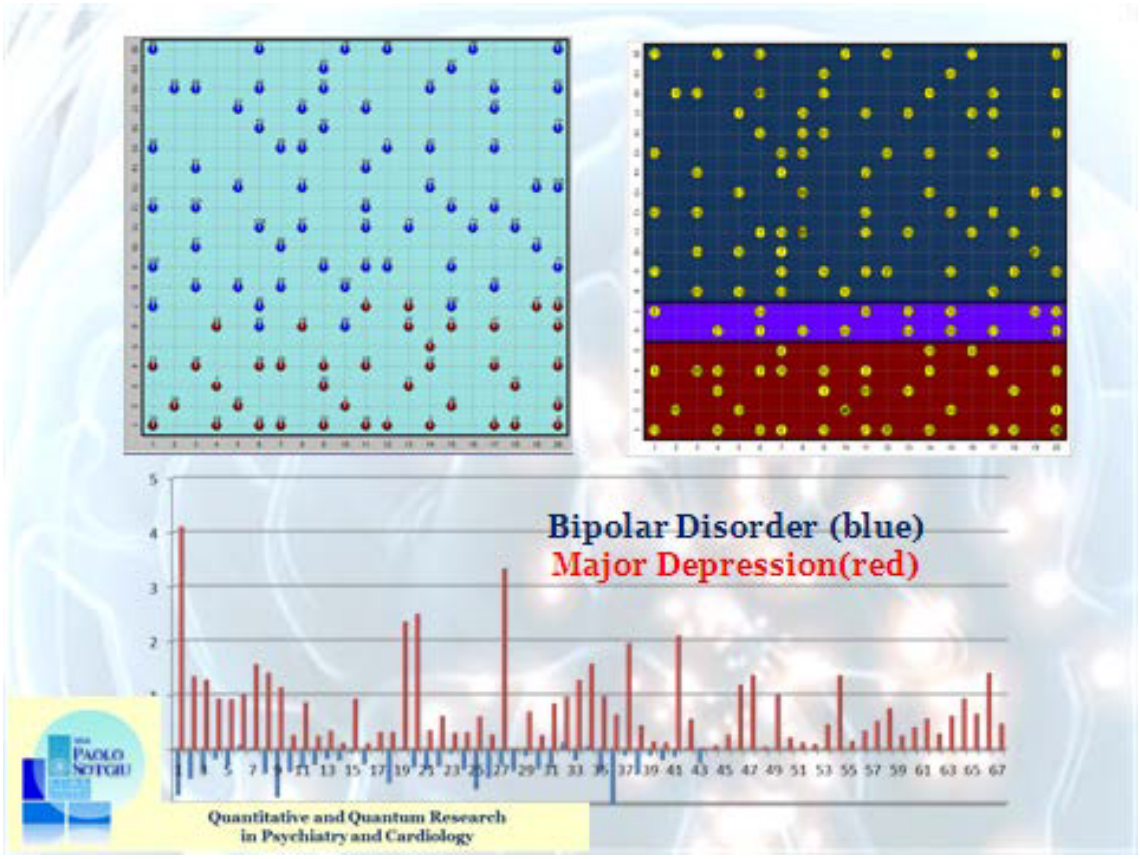

Figure 5: Separation of Major Depressive subjects from Bipolar subjects over a dedicated SOM (upper part of figure) and according to the B2 index (lower part of figure) [(B2 is the index that correlates the three fatty acids isolated by the SOM through the molecular weight and the melting point and that has been able to recognize the Bipolar subjects (B2 positive red lines) from the Major Depressive subjects (B2 negative, blue lines)].

The reciprocal interactions between membrane and cytoskeleton [69-71] represent 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, as, for instance, the ones constituting the human or animal organism.

Our data make us, also, believe that:

- Humans and animals (at least those analysed in our work, (Figure 4) share a common biological and biochemical house, which does not necessarily imply anthropocentric existential and cultural expressions.

In particular, our work shows that, by going beyond animals' ability of producing forms of socialization, having feelings and behaviours, from the biological point of view and with reference to mood disorders, animals and men share some interesting common features. We are convinced that continuity between biology and culture exists and that, this continuity is involved in the evolutionary tract of living beings.

References

1. http://nonhumanrights.net/
2. Comunicazione nella seduta della Società Italiana di Biologia Sperimentale, Sezione di Bologna, 7 Dicembre 2012.
3. Cocchi M, Sardi L, Tonello L, Martelli G (2009) Do mood disorders play a role in pig welfare? Ital J Anim Sci 8: 691-704.
4. Cocchi M, Tonello L, Gabrielli F, Pregnolato M, Pessa E (2011) Quantum human & animal consciousness: a concept embracing philosophy, quantitative molecular biology & mathematics. Journal of Consciousness Exploration & Research 2: 547-574.
5. Cocchi M, Tonello L, Gabrielli F (2011) The animal side of "mood disorders": Mood disorders between humans and animals. LAP Lambert Academic Publishing. Saarbrücken, Germany.
6. Lundell MJ, Chu-LaGraff Q, Doe CQ, Hirsh J (1996) The engrailed and huckebein genes are essential for development of serotonin neurons in the Drosophila CNS. Mol Cell Neurosci 7: 46-61.
7. Chugani DC, Muzik O (2000) Alpha[C-11]methyl-L-tryptophan PET maps brain serotonin synthesis and kynurenine pathway metabolism. J Cereb Blood Flow Metab 20: 2-9.
8. Carley DW, Radulovacki M (1999) Role of peripheral serotonin in the regulation of central sleep apneas in rats. Chest 115: 1397-1401.
9. Portas CM, Bjorvatn B, Ursin R (2000) Serotonin and the sleep/wake cycle: special emphasis on microdialysis studies. Prog Neurobiol 60: 13-35.
10. Wurtman RJ, Wurtman JJ (1995) Brain serotonin, carbohydrate-craving, obesity and depression. Obes Res 3 Suppl 4: 477S-480S.
11. Cronin MJ, Baker MA (1977) Midbrain heating in freely behaving cats (Felis domesticus): further evidence on the role of serotonin in thermoregulation. Gen Pharmacol 8: 359-363.
12. Myers RD (1981) Serotonin and thermoregulation: old and new views. J Physiol (Paris) 77: 505-513.
13. Abdel-Fattah AF, Matsumoto K, Murakami Y, Adel-Khalek Gammaz H, Mohamed MF, et al. (1997) Central serotonin level-dependent changes in body temperature following administration of tryptophan to pargyline- and harmaline-pretreated rats. Gen Pharmacol 28: 405-409.
14. Cocchi M, Tonello L, Tsaluchidu S, Puri BK (2008) The use of artificial neural networks to study fatty acids in neuropsychiatric disorders. BMC Psychiatry 8 Suppl 1: S3.
15. Cocchi M, Tonello L, De Lucia A, Amato P (2009) Platelet and brain fatty acids:

a model for the classifcation of the animals? Part 1. International Journal of Anthropology 24: 69-76.

16. Cocchi M, Tonello L, De Lucia A, Amato P (2009) Platelet and brain fatty acids: a model for the classification of the animals? Part 2. Platelet and brain fatty acid transfer: hypothesis on arachidonic acid and its relationship to major depression. International Journal of Anthropology 24: 69-76.
17. Cocchi M, Tonello L, Gabrielli F (2009) Quantum consciousness and a-quantum consciousness. New Medicine XIII 4: 114-115.
18. Cocchi M, Sardi L, Tonello L, Martelli G (2009) Do mood disorders play a role on pig welfare? Ital J Anim Sci 8: 691-704.
19. Cocchi M, Tonello L (2010) Bio molecular considerations in major depression and ischemic cardiovascular disease. Cent Nerv Syst Agents Med Chem 10: 97-107.
20. Cocchi M, Tonello L, Rasenick MM (2010) Human depression: a new approach in quantitative psychiatry. Ann Gen Psychiatry 9: 25.
21. Cocchi M, Gabrielli F, Tonello L, Pregnolato M (2010) The interactome hypothesis of depression. NeuroQuantology 4: 603-613.
22. Maurer-Spurej E (2005) Circulating serotonin in vertebrates. Cell Mol Life Sci 62: 1881-1889.
23. Cocchi M, Gabrielli F, Tonello L, Pregnolato M (2011) Consciousness and hallucinations: molecular considerations and theoretical questions. NeuroQuantology 9: 182-189.
24. Manousakis E (2006) Founding quantum theory on the basis of consciousness. Foundations of Physics 36: 795-838.
25. Hameroff SR (1994) Quantum coherence in microtubules: a neural basis for emergent consciousness? Journal of Consciousness Studies 1: 91-118.
26. Hameroff SR, Penrose R (1996) Orchestrated objective reduction of quantum coherence in brain microtubules: The “Orch OR” model for consciousness. Toward a Science of Consciousness, Cambridge, MA, USA.
27. Hameroff SR (1998) Consciousness, the brain and spacetime geometry. The Annals of the New York Accademy of Sciences 929: 74-104.
28. Hameroff SR (1998) `Funda-Mentality': is the conscious mind subtly linked to a basic level of the universe? Trends Cogn Sci 2: 119-124.
29. Hameroff S, Nip A, Porter M, Tuszynski J (2002) Conduction pathways in microtubules, biological quantum computation, and consciousness. Biosystems 64: 149-168.
30. Hameroff SR, Penrose R (2003) Conscious events as orchestrated space-time selections. Neuroquantology 1:10-35.
31. Hameroff SR (2006) Consciousness, neurobiology and quantum mechanics: the case for a connection. The Emerging Physics of Consciousness 193-253.
32. Hameroff SR (2007) Orchestrated reduction of quantum coherence in brain microtubules. Neuroquantology 5: 1-8.
33. Hameroff S (2010) The “conscious pilot”-dendritic synchrony moves through the brain to mediate consciousness. J Biol Phys 36: 71-93.
34. Anderson C, Campbell G (1988) Immunohistochemical study of 5-HT-containing neurons in the teleost intestine: relationship to the presence of enterochromaffin cells. Cell Tissue Res 254: 553-559.
35. Tonello L, Cocchi M (2010) The cell membrane: is it a bridge from psychiatry to quantum consciousness? NeuroQuantology 8: 54-60.
36. Cocchi M, Tonello L, Gabrielli F (2012) Molecular uniqueness of major depression: biological remarks and theoretical implications. Journal of Consciousness Exploration & Research 3: 380-391.
37. Cocchi M, Tonello L, Gabrielli F (2012) Possible Roles of cell membrane & cytoskeleton in quantum aspect of psychiatry. Journal of Consciousness Exploration & Research 3: 1082-1100.
38. Cocchi M, Gabrielli F, Pessa E, Pregnolato M, Tonello L, et al. (2012) Major depression and bipolar disorder: the concept of symmetry breaking. NeuroQuantology 10: 676-687.
39. Cocchi M, Gabrielli F, Tonello L, Delogu M, Beghelli V, et al. (2012) Communication to the session of the italian society of experimental biology.
40. Vitiello G (1995) Dissipation and memory capacity in the quantum brain model. Int J of Modern Physics B 9: 973-989.
41. Vitiello G (2001) My double unveiled. John Benjamins, Amsterdam, The Netherlands.
42. Vitiello G (2003) Quantum dissipation and information: A route to consciousness modeling. NeuroQuantology 1: 266-279.
43. Globus G (2003) Quantum closures and disclosures. John Benjamins, Amsterdam, The Netherlands.
44. Globus G (2009) The transparent becoming of world: A crossing between process philosophy and quantum neurophilosophy. John Benjamins, Amsterdam, The Netherlands.
45. Craddock TJ, Tuszynski JA, Hameroff S (2012) Cytoskeletal signaling: is memory encoded in microtubule lattices by CaMKII phosphorylation? PLoS Comput Biol 8: e1002421.
46. Jibu M, Hagan S, Hameroff SR, Pribram KH, Yasue K (1994) Quantum optical coherence in cytoskeletal microtubules: implications for brain function. Biosystems 32: 195-209.
47. Kraus D (1969) Concepts in modern biology. Globe Book Company, New York, USA.
48. Benedetti S, Bucciarelli S, Canestrari F, Catalani S, Colomba MS, et al. (2012) Molecular changes in mood disorders results of the marche region special project. NeuroQuantology 10: S1-28.
49. Dennet DC (1991) Consciousness explained. Little Brown and company, Boston 511.
50. Dennett DC (1996) Kinds of minds: Toward An Understanding Of Consciousness. Basic Books, USA.
51. Donald M (1991) Origins of the modern mind: Three stages in the evolution of culture and cognition. Cambridge University Press, Cambridge.
52. Clark A (1997) Being there: Putting brain, body and world together again. MIT Press, Cambridge.
53. Clark A (2003) Natural-born cyborgs. Minds, technologies, and the future of human intelligence. Oxford Universty Press, Oxford.
54. Tomasello M (1999) The cultural origins of human cognition. Harvard University Press, Cambridge.
55. Wilson R (2004) Boundaries of the mind: The individual in the fragile sciences-Cognition. Cambridge University Press, Cambridge.
56. Allen PA, Kaut KP, Lord RG, Hall RJ, Grabbe JW, et al. (2005) An emotional mediation theory of differential age effects in episodic and semantic memories. Exp Aging Res 31: 355-391.
57. Edelmann GM, Tononi G (2000) A universe of consciousness. How matter becomes imagination, Basic Books, New York.
58. Seth AK, Baars BJ, Edelman DB (2005) Criteria for consciousness in humans and other mammals. Conscious Cogn 14: 119-139.
59. Edelman DB, Baars BJ, Seth AK (2005) Identifying hallmarks of consciousness in non-mammalian species. Conscious Cogn 14: 169-187.
60. Mather JA (2008) Cephalopod consciousness: behavioural evidence. Conscious Cogn 17: 37-48.
61. Griffin DR (1992) Animal Minds. University of Chicago Press, Chicago, it. tr. Menti animali, Torino, Bollati Boringhieri, 1999.
62. Wilder H (1996) Interpretative cognitive ethology. In Readings in Animal Cognition, Cambridge MA, MIT Press,UK.
63. Bekoff M, Allen C (1997) Cognitive ethology: slayers, skeptics, and proponents. In Anthropomorphism, anecdote, and animals: The Emperor?s New Clothes?, Albany NY, SUNY Press.
64. Gozzano S (2001) Mente senza linguaggio. Il pensiero e gli animali. Roma, Editori Riunti.
65. Cocchi M, Gabrielli F, Tonello L (2011) Major depression a journey between biology and anthropology. The Research path of the Institute “Paolo Sotgiu”, Ludes University Press, Lugano.
66. Bekoff M, Allen C, Burghardt GM (2002) The cognitive animal: empirical and theoretical perspectives on animal cognition. Cambridge MA, MIT Press, UK.
67. Bekoff M, Peirce J (2009) Wild justice: the moral lives of animals. University of Chicago Press, Chicago, USA.

68. Baron-Cohen S (2011) The science of evil. On empathy and the origins of cruelty. Basic Books 180: 30.

69. Luna EJ, Hitt AL (1992) Cytoskeleton--plasma membrane interactions. Science 258: 955-964.

70. Kusumi A, Sako Y (1996) Cell surface organization by the membrane skeleton. Curr Opin Cell Biol 8: 566-574.

71. Helmreich EJ (2003) Environmental influences on signal transduction through membranes: a retrospective mini-review. Biophys Chem 100: 519-534.