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Editorial

Neuronal Connectivity and Non-Classical Brain Functions

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Many research workers have spent prolonged periods mapping connections between neurons in a wide variety of nervous systems [1-6]. The pathways of sensory inputs and motor outputs have been localised as have central processing areas e.g. in the spinal cord, brain and cerebellum of vertebrates, greatly enhancing our understanding of nervous function in health and disease. However, studies on neural connectivity do not tell us everything about the innermost workings of nervous systems.

To further complicate things, action potentials themselves have three functions within nervous systems: communication, modulation and computation [7], and are now believed to use using phase ternary, rather than binary computation [8,9]. The whole point is that nervous systems are likely to prove to be much more complex than circuit diagrams or hormonal and neurosecretory actions can predict, particularly as there is also accumulating evidence that brains may function as quantum phase computers [10], exhibiting quantum entanglement [11]. These are important concepts which will eventually have a bearing on our understanding of Neuroethology and the organization of animal behaviour.

Non-classical brain functions

In parallel with detailed studies on neural connectivity, a separate argument about the nature of consciousness has been going on for decades among philosophers, physicists, and quantum logicians. In 1994 Francisco Ventriglia [12] stated that "*..a great number of neurophysiologists retain the view that much of neural modeling has only a metaphorical value, having no connections with brain activity*" and suggested that there was "*..an ignorance of what is fundamental for the expression of superior neural activity*". This is still the case today, but evidence is accruing around the idea that consciousness may be "*a manifestation of quantum processes in the brain*" [13]. Furthermore, Cynthia S. Larson [14], provides compelling evidence for the primacy of quantum logic in the cognitive sciences, particularly when human decisions and deductions involving unknown connected variables are involved. However, Horgan and Tienson [15] had argued against a computational framework for cognitive science, but that *"At the physical level, the dynamical system is subserved by a neural network of some sort"*. They also accepted that connectionist networks (parallel processing networks) were of great importance. These seem to be contradictory viewpoints since in real neural networks individual neurons appear to act as computational elements and to participate in parallel processing using phase ternary computation [7-10]. In our view, the brain acts as a quantum phase computer and would be expected to generate multiple non-classical brain functions in terms of connectivity across a nervous system. Whether this would be the case in less complex nervous systems is currently unknown, but a possibility to be considered in future studies. However, direct evidence for such connectivity is only just beginning to emerge.

Evidence for quantum entanglement between interacting systems within the human CNS

In their recent paper Kerskens and Perez [11] suggested that, in human volunteers, non-classical brain functions exist due to quantum entanglement, thus supporting our view that the brain might use quantum computation [10] through frequency changes. Kerskens and Perez adapted an idea, based on experiments to prove the existence of quantum gravity, postulating experiments in which a known quantum system might interact with an unknown system. If those systems entangle, then the unknown must also be a quantum system. In their experiments at Trinity College, Dublin, Kerskens and Perez suggested that proton spins of bulk brain water could act as quantum systems. They demonstrated in conscious human volunteers at rest that, in the absence of classical neural signals, what appeared to be heartbeat evoked potentials were evoked in most parts of the brain using nuclear magnetic resonance (NMR) detection, and the volunteers were conscious of them. However, such signals are not normally detectable with magnetic resonance imaging (MRI) suggesting that non-classical brain functions are involved in consciousness. These observations obviously require detailed verification, but clearly suggest that there may be quantum entanglement between systems, not previously observed directly.

In conclusion, classical connections between neurons clearly exist in nervous systems, but we are in an exciting era whereby the first direct evidence that consciousness may be based on quantal entanglement between systems is beginning to emerge. We look forward to further developments in this emerging experimental area of neuroscience.

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