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Proceedings of the 2018 and 2019 summer schools on brain and gut neuroscience: from molecules to mood

The objective behind this collection of papers is to present an integrated view of the human brain in terms of both its hierarchical structural organization and functional complexity. Through the contributed articles that reflect the lectures given in Turin, Italy, our objective is to develop an overview of modern neuroscience in a multi-scale approach starting with molecular aspects and ending with psychological, psychiatric and pharmacological aspects. The assumptions of cognitive neuroscience employ abstractions from the theoretical constructs of 19th century physics. Specifically, neural network models of "emergent conscious experience" rely on analogies to relations among molecules in crystals, fluids, and gases and employ chemical hypotheses regarding the emergence of thoughts, moods, and perceptions from chemical modulation of synaptic interactions among neurons. However, 20th and 21st century science offers probabilistic perspectives from which to view the mind-brain nexus. Quantum mechanics and quantum field theory have given physicists extra "degrees of freedom", radically multiplied beyond thermodynamics. A relatively new offshoot of quantum physics is quantum information theory, quantum cryptography and actual quantum computation. Quantum logic formally upgrades the classical concept of a "bit" into the notion of a "qubit". Quantum interference permits vast computational parallelism. Cognitive paradigms drawing upon wave-like quantum logic have recently spawned a new psychological literature. In 2013 Emmanuel Pothos and Jerome Busemeyer advanced an argument that quantum modeling captures many empirically known relations among human perceptions, including mutual interference, order-dependence, and non-localized links, more accurately and completely than does classical neural network theory. Gregory Engel's laboratory and other researchers after him in the last decade demonstrated experimentally that photosynthesis entails intrinsic quantum components giving rise to the field of "quantum biology." Werner Loewenstein extended quantum biology to include cognitive neuroscience. Hence, it is high time to reconsider new quantum neuroscientific approaches developed over the past three decades as alternatives to traditionally dominant non-quantum paradigms. The way for this has been paved by the work of physicists like Hiroomi Umezawa, Kunio Yasue, Giuseppe Vitiello, Jack Tuszynski, and Travis Craddock, mathematicians like Roger Penrose, and biomedical investigators like Stuart Hameroff and Gustav Bernroider, some of whom will give lectures at this school. These innovators, by plumbing the depths of the brain's "quantum underground" and its amplifications across diverse scales of the "connectome" have laid a foundation for a possible rapprochement between material substrates and human cognition. In the past few years, quantum-psychological and quantum-neurodynamical ideas have also provided alternative hypotheses concerning the genesis and nature of mental illness. Several efforts in this direction were undertaken by members of the QPP (Quantum Psychopathology) initiative, an effort led by Massimo Cocchi to develop viable quantum paradigms of psychopathology.

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Nancy Woolf suggested possible links between psychopathology and anomalous quantum computation in cytoskeletal proteins. Paavo Pylkkanen hypothesized a relationship between diffuse physical substrates of mental illness and quantum "pilot waves" gone awry. Massimo Cocchi and his collaborators identified via membrane biophysics possible quantitative correlations between phospholipid composition, serotonin and quantum properties of the cytoskeleton in depression and psychosis. Massimo Pregnolato suggested wave-like quantum logic as a possible non-Boolean algebra underlying primary process in thought disorders. Ursula Werneke reinterpreted the content of "impaired" reality testing in the context of Hugh Everett's many-worlds ontology. Eliano Pessa proposed a mathematical structure for psychiatric disease nosology based on symmetry breaking. These ideas may guide future explorations of quantum paradigms of psychopathology. First, shifts from coherent to incoherent quantum brain states may, when aberrant, flag neural correlates of psychotic perception. Second, persistently mismatched phase relations among "parallel channels" of quantum information processing may shed light on clinical thought disorders. Third, bulk properties of brain states emerging from scaled-up quantum-statistical aspects of neural matter may include subjective experience, including normal and abnormal variation of moods. Fourth, resonances across the connectome, readjusted to account for quantum uncertainty effects, may inform us about effects of psychotherapeutic interventions, including electromagnetic brain stimulation. An important emerging topic of the gut-brain axis via microbiota has been extensively covered in these lectures. In this advanced course on neuroscience we have collectively explored the strengths and weaknesses of quantum-cognitive and quantum-neurodynamical perspectives on normal and pathological mentation in comparison to mainstream non-quantum paradigms through lectures, exercises and discussions. Emphasis has been placed on the evolution and content of novel paradigms and their empirical correlates while technical details will be kept to a minimum. The audience was introduced to historical, theoretical, and empirically oriented material and then encouraged to synthesize their own sets of conclusions regarding the possible practical relevance of quantum psychology and quantum brain models to neuroscience and psychiatry.

This collection of papers is dedicated to the memory of Dr. Kary Mullis (Nobel Prize, 1993) who was an active participant in QPP Meetings, a friend, mentor and colleague to all of us.

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