Microvita and the Concept of Neuronal Assemblies

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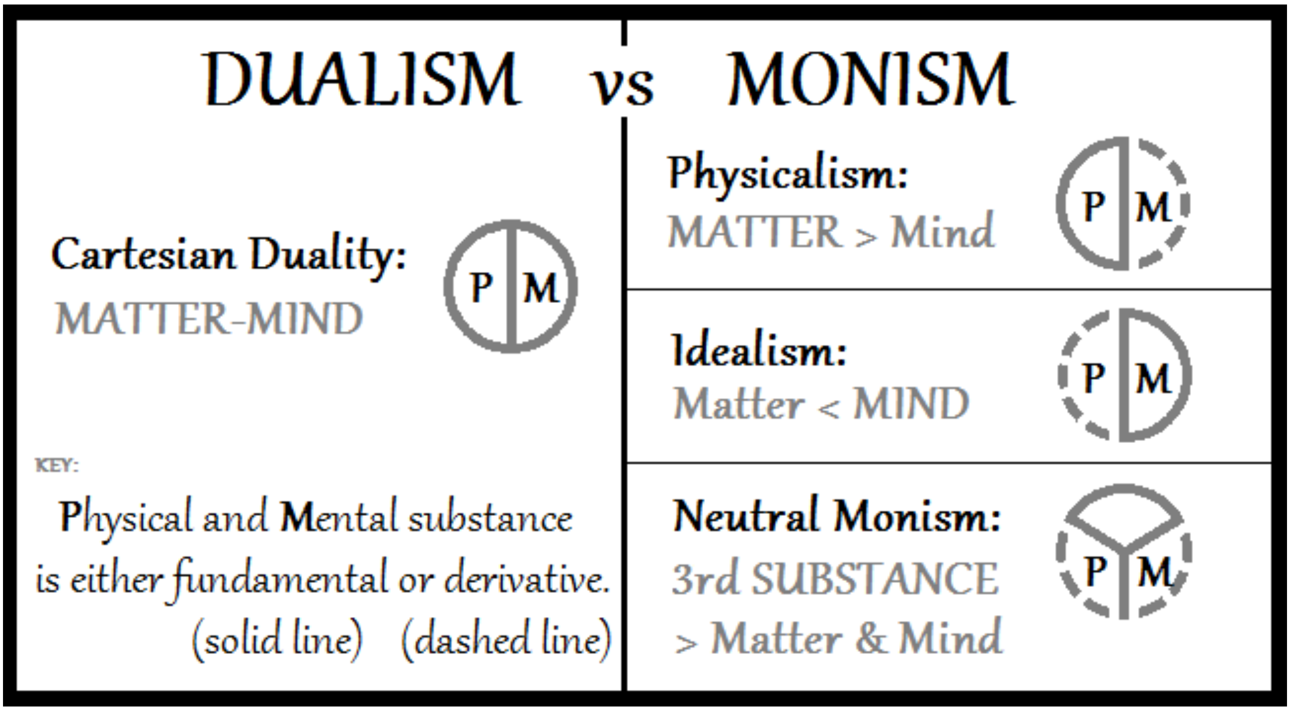
Philosophically, monism can be classified in three categories: Idealistic monism, material monism (also called physicalism or materialism) and neutral monism.

Material monism is usually subdivided in reductive and non-reductive physicalism. In reductive physicalism, all mental states and properties can be explained by scientific accounts of physiological processes and states.



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Reductive physicalism has three main types:

- Behaviourism, which states that mental states are descriptions of observable behaviour.
- Type-identity theory (Type physicalism), which states that specific mental states are identical to specific physical internal states of the brain.
- Functionalism, which states that mental states are characterized in terms of non-mental functional properties.

Type-identity theory asserts that mental events can be grouped into types, and can then be correlated with types of physical events in the brain (1). Such events are nowadays thought to correspond to the activity of networks or assemblies of neurons.

A neuronal assembly is a group of neurons that maintain strengthened synaptic connections with one another, so that they are more likely to be active all together at the same time. In these assemblies, the neurons are not necessarily all physically close to one another. They can be distributed across various parts of the brain. Moreover, a single neuron can belong to several different assemblies and can be recruited into new assemblies at any time. Thus neuronal assemblies are not stable, but dynamic, and not necessarily localized, but often distributed (2).

Now, if we combine the concept of neuronal assemblies with the described quantum Zeno effect, we are compelled to abandon the basically monistic position, as a "conscious observer" (being a non-physical entity) has to be introduced into a purely physical system. But, what we need is an unstable quantum system, associated with neuronal assemblies, and additionally responding to the quantum Zeno effect. Thereby, a non-physical (imaginary) observer could be empowered to influence the lifetime of neuronal/mental events.

Two examples:

1. Quantum brain dynamics (QBD) is a hypothesis to explain the function of the brain within the framework of quantum field theory. Large systems, such as those studied biologically, have less symmetry than the idealized systems or single crystals often studied in physics. Jeffrey Goldstone proved that where symmetry is broken, additional bosons, the Nambu-Goldstone bosons, will then be observed in the spectrum of possible states; one canonical example being the phonon in a crystal (3).

The concepts underlying this theory derive from the physicists, Hiroomi Umezawa and Herbert Fröhlich in the 1960s. More recently, their ideas have been elaborated by Mari Jibu and Kunio Yasue. Water comprises 70% of the brain, and QBD proposes that the electric dipoles of the water molecules constitute a quantum field, referred to as the cortical field, with corticons as the quanta of the field. This cortical field is postulated to interact with quantum coherent waves generated by the biomolecules in neurons, which are suggested to propagate along the neuronal network. The idea of quantum coherent waves in the neuronal network derives from Frohlich. He viewed these waves as a means by which order could be maintained in living systems, and argued that the neuronal network could support long-range correlation of dipoles. This theory suggests that the cortical field not only interacts with the neuronal network, but also to a good extent controls it (4).

2. Microtubules have a well established position in conventional biology and neuroscience. Microtubules are the main component of a supportive structure within neurons known as the cytoskeleton. In addition to providing a supportive structure, the known functions of microtubules include transport of molecules including neurotransmitters bound for synapses and control of the development of the cell. Microtubules are composed of tubulin protein dimer subunits. The tubulin dimers each have hydrophobic pockets that are 8 nm apart, and which may contain delocalised pi electrons. Tubulins have other smaller non-polar regions that contain pi electron-rich indole rings separated by only about 2 nm.

Hameroff proposes that these electrons are close enough to become quantum entangled. In the original version of his proposals, Hameroff went on to hypothesise that these electrons could become locked in phase, forming a state

known as a Bose-Einstein condensate. In his most recent paper, he has amended this to suggest that electrons within the tubulin subunits are part of a Frohlich condensate, which is a coherent oscillation of dipolar molecules.
Furthermore, he proposes that condensates in one neuron could extend to many others via gap junctions between neurons, thus forming a macroscopic quantum feature across an extended area of the brain. When the wave function of this extended condensate collapsed, it was suggested that this could give access to non-computational influences related to mathematical understanding and ultimately conscious experience that are embedded in the geometry of spacetime (5).

Hence, in both cases, the required “unstable quantum system” is located at the cytoskeleton, i.e. either in the lumen and around (➤ ordered water) or in the wall of neuronal microtubuli (➤ Frohlich condensate among the electrons of tubulin dimer subunits). It is, however, to be emphasized that these systems are not supposed to give rise to consciousness – they only allow consciousness to influence our central nervous system!

(1) Wikipedia (2013): Types of monism
(2) Neuronal assemblies and synchronization of brain activity (2013)
(3) Wikipedia (2013): Quantum brain dynamics
(4) Wikipedia (2013): Electromagnetic theories of consciousness
(5) Wikipedia (2013): Roger Penrose and Stuart Hameroff