"Ecotechnology of the water molecule in the human brain"

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In the mid 1980s it was shown that water diffusion in the brain could be imaged using Magnetic Resonance Imaging (MRI). During their random displacements water molecules probe tissue structure at a microscopic scale, thus providing unique information on the functional architecture of tissues. A dramatic application of diffusion MRI has been acute brain ischemia, following the discovery that water diffusion drops immediately after the onset of an ischemic event, when brain cells undergo swelling through cytotoxic edema. With its unmatched sensitivity water diffusion MRI provides patients with the opportunity to receive suitable treatment at a stage when brain tissue might still be salvageable, thus avoiding them terrible handicaps. On the other hand, it was found that water diffusion is anisotropic in white matter, because axon membranes limit molecular movement perpendicularly to the fibers. This feature can be exploited to produce stunning maps of the orientation in space of the white matter tracks and brain connections in just a few minutes, as well as to provide information on white track microstructure and integrity. With water diffusion MRI it has been shown that some psychiatric disorders, such as schizophrenia might result from faulty brain connection. Diffusion MRI has also the potential to give clues on the cellular organization within brain cortex on an individual basis, a step forward to segregating brain areas at mesoscale level, which could reveal a neural code, as there is a genetic code. More recently, it has been shown that diffusion MRI could even be used to detect brain activation. Functional neuroimaging has emerged as an important approach to study the brain and the mind. Surprisingly, although they are based on radically different physical approaches both positron emission tomography (PET) and MRI make brain activation imaging possible through measurements involving water molecules. So far, PET and MRI functional imaging have relied on the principle that neuronal activation and blood flow are coupled through metabolism. However, a new paradigm has emerged to look at brain activity through the observation with MRI of the molecular diffusion of water. In contrast with the former approaches diffusion MRI has the potential to reveal changes in the intrinsic water physical properties during brain activation, which could be more intimately linked to the neuronal activation mechanisms and lead to an improved spatial and temporal resolution. Recent data on the physical properties of water and on the status of water in biological tissues, suggest that the biophysical mechanisms of brain activation have to be reassessed to reveal their intimacy with the physical properties of water, which could, some day, be regarded as the 'molecule of the mind'?

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