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"Spacetime" in the Brain

Neuroscientists at the Magdeburg University Medical Center have discovered neuronal network changes at millisecond speed in the human brain and demonstrated their significance for visual perception and recovery from optic nerve damage.

Billions of neurons in our brain communicate with each other constantly through a highly complex network of neurons and their connections. These connections can adapt throughout our lives, and they form the basis for human thought and behavior. The doctoral student Zheng Wu and neuroscientist Prof. Dr. Bernhard Sabel, Director of the Institute of Medical Psychology at Otto von Guericke University of Magdeburg, used the visual system as a model to find out how quickly functional brain networks can change in functional network structure and how this changes during visual processing.

Prof. Sabel explains: "The exact path that neuronal impulses take in the network - called functional connection - can vary greatly, depending on the current functional demand. The challenge for the brain is how it can synchronize different brain areas spatially and temporally." He states that it is the precise synchronization of neural processing in the three-dimensional “Space” and “Ttime” as the 4th dimension that is crucial for the brain´s control of thinking and acting. The authors call it "spacetime of the brain."

Prof. Sabel and his team wanted to find out how quickly the structure of functional networks can change and whether evidence could be found if rapid changes are meaningful for behavior. They studied brain activity in healthy individuals and in patients with optic nerve damage, such as glaucoma. For their studies, the researchers used electroencephalography (EEG) to record electrical brain waves on the head and compared healthy subjects and visually impaired people immediately before and after presenting brief flashes of light. "We found that during visual processing, functional networks in the brain can form and dissolve extremely quickly, in the order of few milliseconds, depending on the functional needs at that moment, to allow optimal temporal and spatial integration of human mind and behavior. In patients, these network dynamics were found to be disturbed, but using synchronizing microcurrent pulses as a novel therapy, the network´s temporal pattern was partially normalized again which led to significant improvements of visual performance," Prof. Sabel explains. The results were published in the September issue of the research journal "Scientific Reports".

For the scientist, it is thus clear: "In the brain, neuronal activities are intertwined in time and space, influencing each other by

synchronization." According to Prof. Sabel, this is not only fundamental for our understanding of the human mind, but it is also clinically relevant. This "Spacetime" concept of the brain, he said, not only helps us learn how visual processing and recovery or repair of visual performance works in people with partial blindness, but spacetime in the brain is a fundamental principle of the architecture of the human mind.

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