New form of brain analysis engages whole brain for the first time

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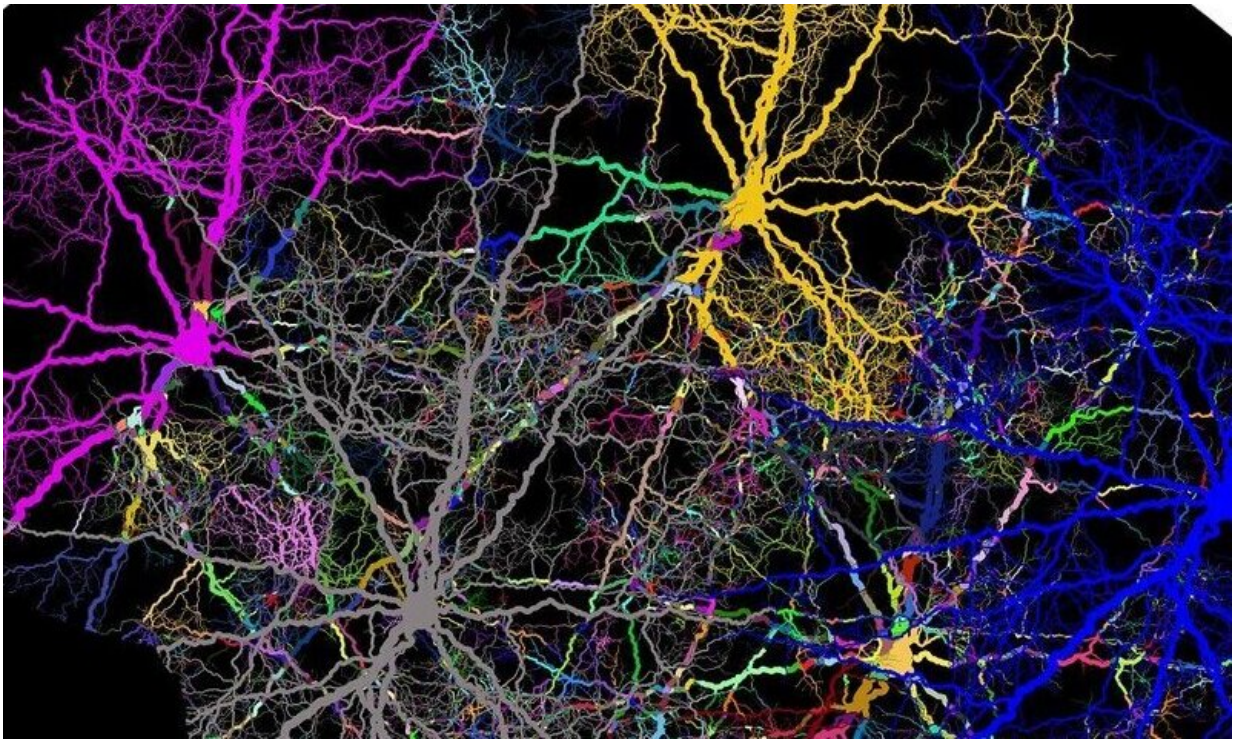

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A new method of brain imaging analysis offers the potential to greatly improve the effectiveness of noninvasive brain stimulation treatment for Alzheimer's, obsessive compulsive disorder, depression, and other conditions. Duke researchers developed the new method, which for the first time analyzed the whole brain network rather than a single region of

the brain. This new method identified brain areas that exert the most control on network function.

The study, published in the *Journal of Neuroscience*, has direct implications for improving the benefits of transcranial magnetic stimulation, which is currently used for major depression and obsessive compulsive disorder, and may soon lead to therapeutic treatment for memory disorders such as Alzheimer's and dementia.

Researchers at the Duke Brain Stimulation Research Center (BSRC) developed a method of analysis that relies on the concept of controllability, a network principle that helps to predict how one area of the brain influences a whole network involved in regulating behavior.

The authors measured controllability using functional magnetic resonance imaging (fMRI) to determine how much change TMS would induce as participants did a working memory task. In this task, individuals had to keep bits of information briefly in their memory and manipulate this information in their mind before answering questions about it. This task was used because of the importance of working memory in everyday life (like ordering your shopping list in your mind before walking through the grocery store) and because it is highly impacted by aging, particularly in conditions like Alzheimer's and dementia.

"Essentially, we look at the brain not as a set of discrete islands, but as a dense web of connections that have lots of mutual influence," said lead researcher Dr. Simon Davis, Ph.D., Assistant Professor of Neurology at Duke. "Controllability allows us a framework for identifying which nodes in this web are most likely to be influenced by brain stimulation, and for that reason likely to show plasticity and improvement after TMS treatments."

The controllability measure, which is based on a static, structural image of the brain, was used to predict dynamic activity. "Brain activity is like the spatial pattern of traffic in a city. Although the traffic pattern is ever-changing, it is always confined by the topology of the road network," said Lifu Deng, a Duke graduate student in the Department of Psychology and Neuroscience, and co-lead on the paper. "Controllability links the stimulation at one location to the global pattern of brain activity. In our study, for instance, this is the activation patterns signifying better working memory."

Previously, there has not been a systematic way to identify which brain areas are the most likely to produce global chances, because most studies have focused on just one region. This study, however, advanced the field by considering the whole brain network.

While healthy adults participated in the study, the research likely has implications for memory disorders. "Memory dysfunction as a network phenomenon that relies on multiple brain regions operating under coordinated dynamics. The typical focus on the TMS response at a single site represents a fundamental limitation in the approach of neurostimulation therapies because it neglects global impairments in whole network that underlies memory dysfunction," said Lysianne Beynel, Ph.D., a postdoctoral associate in the BSRC and first author on the study.

Ultimately, this non-invasive brain stimulation method will be used to promote healthy brain activity patterns and eventually enhance memory function, which has potential to enhance the efficacy of brain stimulation treatments for a range of cognitive disorders.

More information: Lysianne Beynel et al, Structural controllability predicts functional patterns and brain stimulation benefits associated with working memory, *The Journal of Neuroscience* (2020). DOI:

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