New brain mapping model could improve effectiveness of transcranial magnetic stimulation

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Brain researchers from the Perelman School of Medicine at the University of Pennsylvania have developed a new brain mapping model which could improve the success rate of transcranial magnetic stimulation (TMS) in treating conditions including depression, neuropathic pain, and stroke. The model helps pinpoint target sites during TMS, a procedure that uses magnetic fields to stimulate nerve cells in the brain to alleviate or eliminate symptoms of stroke, depression, and attention disorders. The new model will be presented at the 67th American Academy of Neurology Annual Meeting in Washington, D.C. on Wednesday, April 22.

During TMS, a large electromagnetic coil is placed on the scalp near the forehead. The device creates electric currents that rouse nerve cells in the cerebrum, the part of the brain involved in thinking, perceiving, planning, and understanding language. Through this arousal, improvements in the underlying condition have been achieved. But the technique hasn't worked for everyone.

"We know that certain genotypes reduce TMS efficacy, but aside from that we really don't understand why TMS works for some and not for others," said lead researcher John D. Medaglia, PhD, a postdoctoral fellow at Penn's Laboratory for Cognition and Neural Stimulation. "Our goal is to better understand how to appropriately model and target the neural system so that we can know with certainty whether the treatment will succeed."

"Advances in neuroscience have increasingly shown the importance of understanding brains as complex and changing networks," said Medaglia. "In this light, the use of TMS to date has not been optimal because of the relative absence of clear scientific principles for understanding how TMS affects network operations in the brain."

Medaglia says that the challenge is to identify the best possible location for placing the coil in order to generate good results. "We use a model borrowed from engineering called network control theory to suggest how information about the brain's structures and connections that can be obtained from imaging studies can be used to better understand and enhance the effects of TMS on brain networks," he said "This new way of thinking about brain networks and how they are controlled could lead to better informed, neuroscience-driven TMS therapies that optimize the effects of TMS on brain activity."

The Penn model emphasizes precision in placement as a precursor to enhanced results. It utilizes 3-D brain data inspired by the Human Connectome Project to make informed inferences about optimal placement of the coil during treatment. The Human Connectome Project is an NIH-supported initiative which includes 3-D scanning of the brains of 1,200 healthy adult subjects over a three-year span (2012 to 2015). The goal is to map the connections between neural pathways ("white matter") that link different regions of grey matter to each another. Regions of the brain need to communicate via white matter in order to carry out behavior involved in daily life.

"Placing the coil even millimeters or centimeters away from the optimal location could result in the treatment being partially or completely ineffective," says Medaglia. "Our model relies on extensive knowledge of brain neuron interconnections to guide clinicians in best situating the electromagnetic coil."

Medaglia and his colleagues focused on white matter connecting regions of the brain important for routine behavior, time-consuming behavior, and challenging mental activity. Pinpointing the most visibly robust or favorably connected (depending on the circumstances) neural connections for these areas enabled the investigators to develop a model for predicting placement locations that would likely increase beneficial TMS effects on patients with specific afflictions arising from these locations in the brain.

The Penn team plan to begin testing the model in the coming months. "We will be looking to see if patients treated under it fare better after TMS than those treated under current approaches," Medaglia said.

Other Penn researchers involved in the project are Roy Hamilton, Sharon Thompson-Schill, Shi D. Gu, and Danielle S. Bassett.

Provided by University of Pennsylvania