Army researchers develop new ways to nudge the brain

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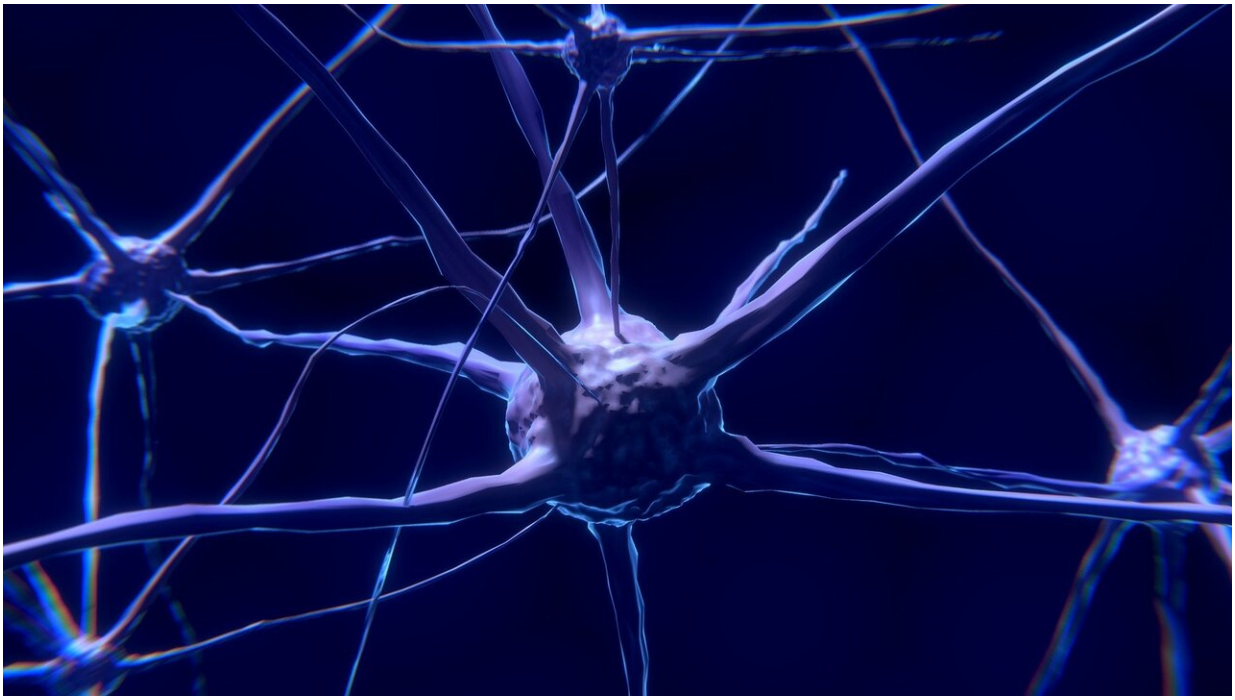

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For Army scientists, the goal of neuroscience research is pursuing the inner workings of the human brain to advance scientific understanding and improve Soldier performance.

Researchers recently applied new techniques to modify brain activity. Not only are these techniques used to characterize and study complex

networks such as in telecommunications or social networks—they describe how different nodes, or elements of the network: brain regions in neuroscience, or individuals in social networks, interact with each other.

The U.S. Army Combat Capabilities Development Command's Army Research Laboratory, in collaboration with academic partners, collaborated on a neurostimulation study, where they safely and non-invasively modified brain activity and then characterized the dynamics of the brain's response to this modification. This research provides some of the foundational knowledge for future technologies that may one day expedite cognitive processes. The journal *Network Neuroscience* published the recent discoveries.

Researchers from the lab, Drs. Javier Garcia, Steven Thurman and Jean Vettel, along with researchers from the University of Pennsylvania and the University of California, Irvine, investigated foundational questions to how local processing in the brain harmonizes with global dynamics using dynamic community detection on rapidly changing brain signals.

"A flexible brain region is one that easily engages with other brain regions and/or networks," Garcia said. "In marrying these methods and techniques, we find that there are precise and measurable local (stimulated region) and global (whole brain) effects that travel common oscillatory patterns in the brain often implicated in tasks related to vision, attention and motor control. This puts us a little closer to harnessing the power of neurostimulation for behavioral modification."

The researchers combined new and different techniques and methods to add to the novelty of their discovery.

"The first is neurostimulation, which uses simultaneous transcranial magnetic stimulation and electroencephalography," Garcia said. "[This]

is a type of neurostimulation that causes a changing magnetic field near your scalp, which in turn induces current into whatever conductive body is next to it—in this case, it's your brain."

The electrical current that is non-invasively injected into your brain then disrupts the neural firing at the stimulated region, but it is unclear what kind of downstream non-local effects this stimulation will produce, he said.

"This method and related methods are often controversial because it's often very difficult to determine what behavioral effect is actually due to the stimulation, and given the variety of stimulation protocols, it is often difficult to determine the specificity of the effect," Garcia said. "In our research, we kept it simple and pulsed four regions related to attention and visual processing every four or so seconds."

They paired this stimulation with EEG, which measures the electrical current emanating from the brain—through the scalp—and inspected the effects of stimulation.

"Effects of this specific type of stimulation do not last more than one second," Garcia said. "To look at the effects on the brain from this stimulation, we used some network science approaches, specifically dynamic community detection."

This research supports the lab's current research in Human-Autonomy Teaming and the goal of providing foundational knowledge products to enable future adaptive teaming neurotechnologies.

"As part of human basic research for the laboratory, we often look at associations between physiology and behavior, perhaps finding that a brain network may be associated with a particular behavior or optimal performance within a narrow task," Garcia said. "This type of research

will support future adaptive neurotechnologies that may be used in human-autonomy teams where behavioral missteps may be predicted and avoided or it could enable a non-human agent synthetic metacognitive abilities to know how a member of the team will perform in particular situations and assess team and individual performance."

This research goes one step beyond this and provides some foundational knowledge that may enable a robot to neurally nudge the brain to perhaps prime an individual for an upcoming task when a particular outcome is needed.

"While technologically we are pretty far from this scenario, the foundational research that measures the impact of subtle nudges of electrical injection in the brain is necessary to attain these sort of human-autonomy teaming neurotechnologies," Garcia said.

More information: Javier O. Garcia et al, Reconfigurations within resonating communities of brain regions following TMS reveal different scales of processing, *Network Neuroscience* (2020). DOI: 10.1162/netn_a_00139

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