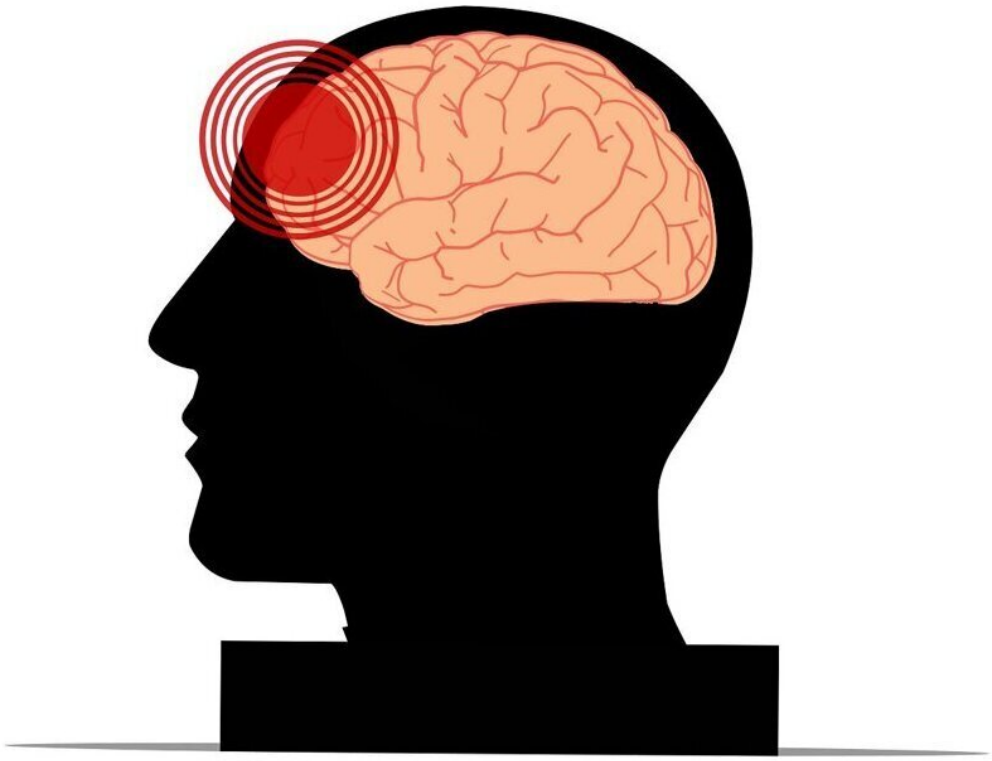
AI-guided brain stimulation aids memory in traumatic brain injury

July 18 2023, by Erica Moser



Credit: Pixabay/CC0 Public Domain

Traumatic brain injury (TBI) has disabled 1% to 2% of the population, and one of the most common disabilities among patients is problems with short-term memory. Electrical stimulation has emerged as a viable

tool to improve brain function in people with other neurological disorders.

Now, a new study in the journal *Brain Stimulation* shows that targeted electrical stimulation in patients with traumatic brain injury led to an average 19% boost in recalling words.

Led by University of Pennsylvania psychology professor Michael Jacob Kahana, a team of neuroscientists studied TBI patients with implanted electrodes, analyzed neural data as patients studied words, and used a machine learning algorithm to predict momentary memory lapses. Other lead authors included Wesleyan University psychology professor Youssef Ezzyat and Penn research scientist Paul Wanda.

"The last decade has seen tremendous advances in the use of brain stimulation as a therapy for several neurological and psychiatric disorders including epilepsy, Parkinson's disease, and depression," Kahana says. "Memory loss, however, represents a huge burden on society. We lack effective therapies for the 27 million Americans suffering."

Study co-author Ramon Diaz-Arrastia, director of the Traumatic Brain Injury Clinical Research Center at Penn Medicine, says the technology Kahana and his team developed delivers "the right stimulation at the right time, informed by the wiring of the individual's brain and that individual's successful memory retrieval."

He says the top causes of TBI are motor vehicle accidents, which are decreasing, and falls, which are rising because of the aging population. The next most common causes are assaults and head injuries from participation in contact sports.

This new study builds off the previous work of Ezzyat, Kahana, and their

collaborators. Publishing their findings in 2017, they showed that stimulation delivered when memory is expected to fail can improve memory, whereas stimulation administered during periods of good functioning worsens memory. The stimulation in that study was open-loop, meaning it was applied by a computer without regard to the state of the brain.

In a study with 25 epilepsy patients that was published the following year, they monitored brain activity in real time and used closed-loop stimulation, applying electrical pulses to the left lateral temporal cortex only when memory was expected to fail. They found a 15% improvement in the probability of recalling a word from a list.

But the new study specifically focuses on eight people with a history of moderate-to-severe TBI, who were recruited from a larger group of patients undergoing neurosurgical evaluation for epilepsy. Seven of the eight are male, and Diaz-Arrastia says 80% of people who get hospitalized for traumatic brain injury overall are male.

Kahana emphasizes the importance of addressing TBI-related memory loss, noting, "These patients are often relatively young and physically healthy, but they face decades of impaired memory and executive function."

The researchers' primary question was whether stimulation could improve memory across entire lists of words when only some words were stimulated, whereas prior studies only considered the effect of stimulation on individual words. Ezzyat says this development is important because "this suggests that an eventual real-life therapy could provide more generalized memory improvement—not just at the precise moment when stimulation is triggered."

The study notes that more work remains before this kind of stimulation

can be applied in a therapeutic setting, and scientists need to study physiological responses to stimulation to better understand the neural mechanisms behind improved memory performance. Diaz-Arrastia says, "these are still early days in the field."

"I think eventually what we would need," he says, "is a self-contained, implantable system, where you could implant the electrodes into the brain of someone who had a brain injury."

More information: Michael J. Kahana et al, Biomarker-guided neuromodulation aids memory in traumatic brain injury, *Brain Stimulation* (2023). DOI: 10.1016/j.brs.2023.07.002

Provided by University of Pennsylvania