

NEWS | 26 May 2023

Does brain stimulation boost memory and focus? Mega study tries to settle debate

Analysis of more than 100 studies of non-invasive electrical brain stimulation probes whether the controversial technology works.

[Emily Waltz](#)

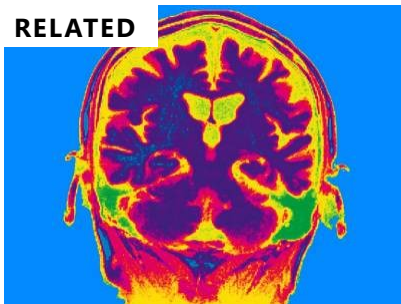




Researchers have been exploring whether zapping a person's brain with electrical current through electrodes on their scalp can improve cognition. Credit: J.M. Eddin/Military Collection/Alamy

After years of debate over whether non-invasively zapping the brain with electrical current can improve a person's mental functioning, a massive analysis of past studies offers an answer: probably. But some question that conclusion, saying that the analysis spans experiments that are too disparate to offer a solid answer.

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In the past six years, the number of studies testing the therapeutic effects of a class of techniques called transcranial electrical stimulation has skyrocketed. These therapies deliver a painless, weak electrical current to the brain through electrodes placed externally on the scalp. The goal is to excite, disrupt or synchronize signals in the brain to improve function.

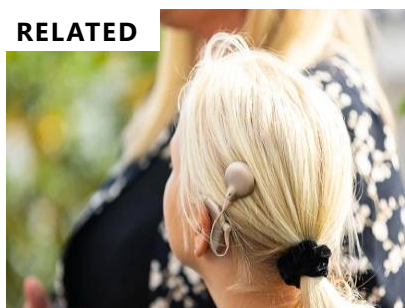
Researchers have tested transcranial alternating current stimulation (tACS) and its sister technology, tDCS (transcranial direct current stimulation), [on both healthy volunteers and those with neuropsychiatric conditions](#), such as depression, Parkinson's disease or addiction. But study results have been conflicting or couldn't be replicated, leading researchers to question the efficacy of the tools.

The authors of the new analysis, led by Robert Reinhart, director of the cognitive and clinical neuroscience laboratory at Boston University in Massachusetts, say they compiled the report to quantify whether tACS shows promise, by comparing more than 100 studies of the technique, which applies an oscillating current to the brain.

“We have to address whether or not this technique is actually working, because in the literature, you have a lot of conflicting findings,” says Shrey Grover, a cognitive neuroscientist at Boston University and an author on the paper.

Their meta-analysis, published on 24 May in *Science Translational Medicine*¹, concluded that tACS treatment brings about moderate improvements in attention, long-term memory, working memory, the ability to process new information and solve problems, and other high-level cognitive processes. The findings give researchers a reason to keep investigating tACS in humans, Grover says. The technique “does appear to bring a significant change in mental function, at least in the short term”, he says.

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“Certainly, there’s promise that further research could be fruitful,” says Sarah Lisanby, a psychiatrist who specializes in neuromodulation at the US National Institute of Mental Health in Bethesda, Maryland. “As to whether this could result in the development of a future therapeutic intervention, I would say the jury is still out.”

Importantly, the meta-analysis could help to inform the design of future studies, Lisanby says. For example, the report found that improvements in cognition were generally better after completion of treatment than during treatment, and that higher intensity stimulation isn’t necessarily more beneficial. The report also found that studies that used computational simulations to predict how the electrical current would move through the brain helped researchers to arrange the electrodes on people’s heads in more effective patterns.

An emerging technology

The biggest impact of the meta-analysis might be that it highlights significant

weaknesses in tACS research that must be improved, Lisanby says. For example, the team found that 98 of the 102 studies were not pre-registered, meaning that the investigators had not stated their hypotheses and methods on record in journals or on sites such as [clinicaltrials.gov](https://www.clinicaltrials.gov) before their experiments began. This increases the risk of publication bias – a trend in which positive results are more likely to be published than negative ones – because if a study is not pre-registered and fails, there is less chance that its findings will be shared.

But not everyone thinks the meta-analysis is so useful. “The problem I have with this paper is that it lumps together studies that are effectively different interventions,” says Alvaro Pascual-Leone, a neurologist at Harvard Medical School in Boston.



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Pascual-Leone notes that the studies included in the meta-analysis differed vastly from one another in terms of which parts of the brain were targeted, the arrangement of the electrodes on the scalp and the frequency and intensity of the electrical current. The cognitive tasks that the participants performed were different in each study, and the participants themselves varied just as widely: young and old, healthy and with

disease.

Drawing an overall conclusion on the basis of such dissimilar studies, many of which have not been replicated, risks erroneous conclusions, Pascual-Leone says. “In fact, the differences in how the stimulation is applied matter a lot,” he says. “This [report] is a comprehensive effort that provides a nice overview of the field as a whole, and that is all commendable, but it’s a mixing and matching of different things, so I’m not really sure we learn a whole lot.”

Grover responds that tACS is an emerging technology and that the team aimed to

produce an “expansive analysis” of its general effectiveness. But he acknowledges that a future analysis should focus on more specific experimental designs.

In other words, the debate doesn’t seem to be settled.

The US Food and Drug Administration has not approved a tACS or tDCS therapy for any disease, but other regulators, such as those in Europe, Brazil, China, Australia and Mexico, have approved tDCS for treatment of some conditions, such as depression or pain.

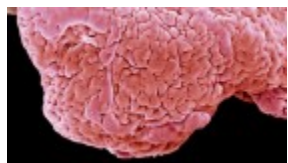
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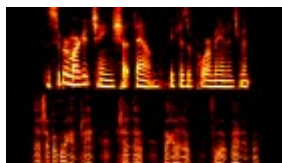
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Nature (*Nature*) | ISSN 1476-4687 (online) | ISSN 0028-0836 (print)