Making people smarter through brain stimulation

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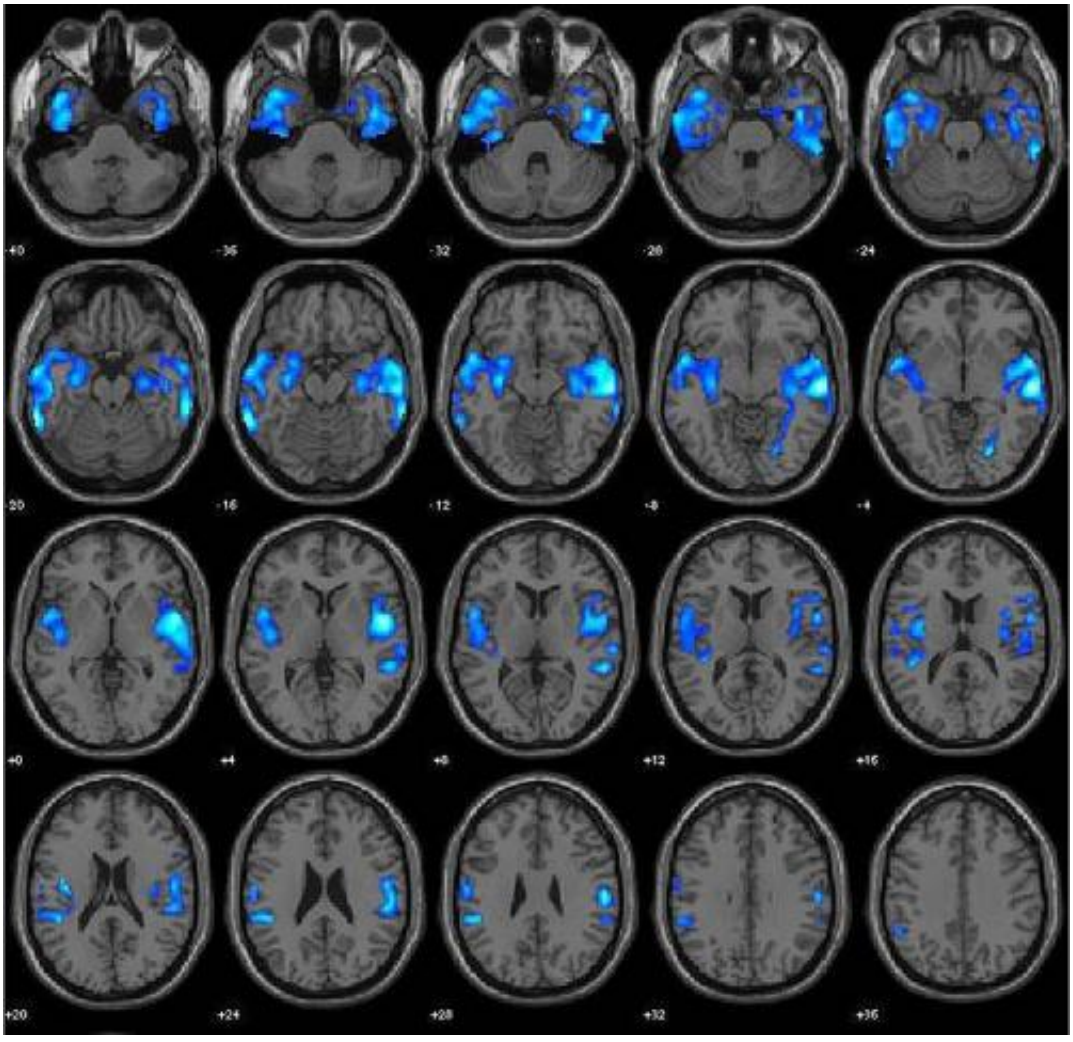

Brain stimulation used to be just a cool idea in science fiction movies, novels and other hard to believe tales when human subjects were stimulated using electrical currents and achieved near super-human feats. But now, thanks to researchers at the University of New Mexico and other collaborators, brain stimulation is a step closer to becoming a possible reality.

Mental illness and neurological disease take a huge toll on humans, both in cost and in suffering. Over the past three decades, UNM Psychology Professor Vince Clark researched the human brain and looked at basic cognitive processes in healthy people, and later moved toward examining brains of sick people, exploring how they were different from healthy people and how to make a difference in their suffering. Armed with that information, and knowing what makes someone sick, Clark and other researchers started to figure out how to change peoples' brains and make them healthy again.

Transcranial direct current stimulation or "tDCS" is non-invasive, painless brain stimulation treatment that uses small electrical currents to stimulate specific parts of the brain. Using brain stimulation technology, a constant, low intensity current is passed from a 9-volt battery through two electrodes placed over the head which modulates neuronal activity.

The idea is funded by part of a three and a half year, $12.7 million program, "Strengthening Human Adaptive Reasoning and Problem-Solving" or SHARP from the Intelligence Advanced Research Projects Activity or IARPA. It was split among multiple groups. Clark, director of the UNM Psychology Clinical Neuroscience Center, was funded through a Boston-based company called Charles River Analytics, which serves as primary contractor.

The basic goal of the project is to make people better at reasoning and problem solving. Mental illness and neurological disease take an

enormous toll in human suffering and in cost of services. Recently, over the last decade, research has been conducted using electromagnetic brain stimulation to affect how the brain operates. That's where Clark and his team focused on lately – trying to figure out how to take electromagnetism, apply it to the brain and change the brain of someone who's sick and make them healthy again. The first step is to see what electromagnetism can do for healthy people.

"What we're trying to do is to make people smarter using a combination of brain stimulation that's directed by functional brain imaging (fMRI) and combining that with two other things, one of which is meditation or mindfulness," Clark said. "The last piece includes micro-games similar to those you find on Lumosity or other commercial systems developed by our partners at Georgia Tech and a company called Charles River Analytics. The games we are using have a strong theoretical underpinning designed to improve reasoning and problem-solving on real world tasks. "They're putting these games together to help people exercise their brains and improve their memory and intellect."

The project involves three phases including the combination of brain stimulation, computer games designed to improve memory and problem solving, and mindfulness training. Research has already shown that computer games and mindfulness have both been known to help with memory and problem-solving in separate studies.

"However, no one has combined them that we know of," Clark said. "We're combining them, and on top of that using brain stimulation to enhance the effects that each one has to help people learn how to meditate more quickly and enhance the effects of the computer games, and then take all that and make people smarter – really."

In the first part of the study, researchers utilize computer games. Subjects come in and perform some standard testing in Clark's lab.

Afterward, they go home for one to two months and play specially-designed computer games designed by their collaborators for a little over three hours a week trying to increase their memory, reasoning and problem solving ability. They come back and are tested again. In the next phase of the study, researchers will perform functional brain imaging (fMRI) to see how this affects the brain as people get smarter.

"We've found that you can apply a very low electric current, about two milliamps, which is tiny," Clark said, "Many people we gave it to didn't even realize that it was turned on. They don't feel it. The current passes in through the skull and into the brain and affects how the brain functions. So you've got a tiny electric current going into the brain that alters how neurons fire, and how people respond to stimuli and how they behave."

When Clark was funded by the Department of Defense, he presented people with complex images with hidden objects in the image. Some of the objects hidden in the image were dangerous – like bombs and things like that. People had to learn what the hidden objects looked like. They could still detect them; they just weren't as obvious because they were camouflaged or hidden.

"We didn't give them much information about what they were looking for – they had to figure it out," Clark said. "We showed them a picture, and they'd have to tell us yes or no if they saw anything dangerous in the picture. If they said no, and there was something dangerous, then they would see a short movie and whatever the dangerous thing was, would happen. A bomb would blow up, a sniper would shoot someone. Things like that."

The subjects had to remember what they saw in the picture combined with what just happened to figure out what it was. They next time they saw a similar picture. They would have to think back what did I see

before that looked like maybe looked like it was a bomb there. Over time the subjects get better at finding the objects, but it takes awhile.

"When we start, it's basically chance – it's random whether or not they'll get it," Clark said. "By the end, they learn and do better at the task. People receiving tDCS do much better than those that don't, more than twice as much in some cases."

The current researchers use has a few effects including increasing chemicals in the brain that help humans encode memories. As those chemicals increase, people find it easier to learn new things. Another effect involves the applied current, which seems to alter attention so that people can attend to what they're doing better; they can pay more attention to the task at hand.

When the researchers gave people tDCS, their score went up faster. An examination of the difference before and after shows a score that goes up about 14 percent without tDCS. With full tDCS, the score goes up about 27 percent. If they wait an hour and test again, and compare no tDCS with full tDCS, it goes up even more.

"The results were really surprising to us – just shocking," Clark said, no pun intended. "We didn't believe it. It was a huge effect. So we replicated it, and now we've replicated it four times and we get the same result each time. The more attention you pay to something generally, the more you learn about it. They're attending more and their brains are better able to encode new memories and the combination of those two leads to a doubling of learning. So people's ability to do this is doubled. The effect depends on how much current we give and where we put the electrodes and things like that."

The next stage involves using professional data analysts to see if they can help them do their jobs better. The ultimate goal is to take these people

who have difficult and complex jobs and make them better at their jobs.

The other amazing thing is a measure called d-prime that is used in perceptual psychology experiments. It's a measure at how good you are at discriminating things. "So in this case, research subjects are asked to discriminate between a picture with and without the hidden objects, and d-prime more than doubles," Clark said. "Nothing does this really. People have been studying using d prime as a basic measure of perception and it shows people are twice as sensitive to what they're looking at or twice as able to identify objects. We have gotten very similar results in three different laboratories at two different universities."

Computer games and mindfulness have both been shown to help with memory and problem-solving already in separate studies. Clark feels they can use brain stimulation to increase the benefits of both meditation and playing these games to help people become smarter through those combinations of effects. And hopefully, by being smarter, they'll be able to solve problems better, which involves improving learning and memory.

"We've been working with brain stimulation to improve learning and memory for six years now and had some amazing results," Clark said. "We've replicated the results a number of times and now other groups around the country are replicating our results and getting the same huge effects."

By combining techniques and on top of that using tDCS to enhance the effects that each one of them have, we are helping people learn how to meditate more quickly and maybe enhance the effects of the computer games and then take all that and make people smarter.

"We have already used tDCS to improve learning in a really difficult

task," Clark said, and "in these tasks designed to be even more difficult, we want to use the same technology, but applied in different ways to increase people's ability to solve difficult problems."

Another of the potential benefits is the cost-savings when tDCS is compared to prescription drugs. An estimated $90 billion per year could be saved by using "electroceuticals" compared to "pharmaceuticals."

"I'd like us to develop tDCS and other cheap, safe technologies we are working on now to give doctors an alternative to expensive prescription medications," Clark says. "tDCS and other methods might offer a new way to treat many common ailments, including pain, addiction, depression, schizophrenia, motor illnesses and a host of other diseases. With a lot of hard work, this could all become a new kind of medicine, and a lot of needless human suffering could be reduced."

Provided by University of New Mexico