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CAN ELECTRICITY HELP OUR BRAINS LEARN FASTER?

Rachel Donaldson, Sicong Liu and Lawrence Gregory Appelbaum *

Human Performance Optimization Lab, Department of Psychiatry and Behavioral Sciences, Duke University School of Medicine, Durham, NC, United States

YOUNG REVIEWERS

DILWORTH MIDDLE SCHOOL

AGES: 12–14

Have you ever been frustrated when you miss a shot in basketball, or when your drawing comes out differently on paper than you pictured in your head? Would not it be nice if there was a way that we could speed up learning, to help our brains and hands work together better? People who are training to be surgeons feel the same way. Before they get good enough to do real operations, they must practice drills using a pretend setup, called a simulator, that feels like surgery without risking patients' safety. Because the brain uses electricity to communicate with the body, we tested whether we could help people get better faster by applying electricity to their brains while they practiced these drills. We found that it worked! This means that electricity can help people's brains learn quicker, especially for skills that use the eyes and hands together.

HOW CAN SURGERY HELP US UNDERSTAND SKILL LEARNING?

Doctors help us stay healthy and fix our bodies when something is wrong. Sometimes this means checking to see if we are sick, and other times it means fixing body parts that are hurt or broken. Surgery is when a doctor cuts into the body to repair a part that is hidden under the skin. There are lots of different types of surgery. Some types involve making big cuts in the skin, while others involve making small cuts and inserting a camera and tools into the opening. This type of surgery is called **laparoscopic surgery** (Figure 1A) and it is very useful because patients can recover much faster from small cuts than from big ones.

LAPAROSCOPIC SURGERY

A type of surgery in which a tiny camera and instruments are inserted into the patient's body through small cuts in the skin.

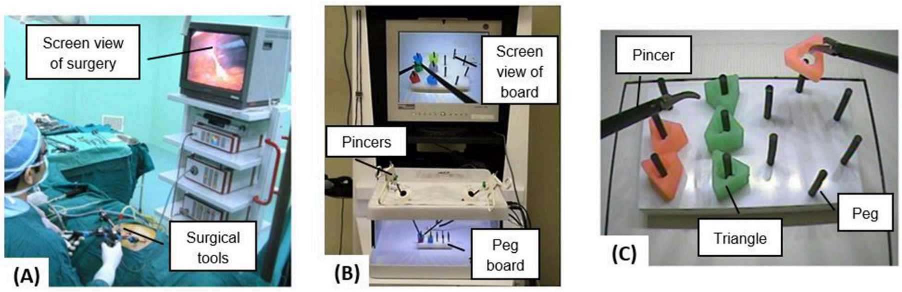

Figure 1

Figure 1

(A) A laparoscopic surgery. The screen shows what the camera sees inside the body. **(B)** View of the peg transfer task simulator setup, used by doctors to practice laparoscopic surgeries. **(C)** A different view of the peg transfer task.

If you have ever threaded a needle or painted a portrait, you can probably appreciate how hard it is to make our hands do exactly what our brains want them to do. Surgery is challenging in the same way, because it takes very good coordination between what doctors see and what their hands do (called **eye-hand coordination**). Surgery is also hard because small mistakes can lead to big problems for patients. For these reasons, doctors must practice before they can operate on real patients, just like you might have practiced riding a bike with training wheels at first, to avoid getting hurt. Because surgery uses some of the same skills we use every day, it can help us understand how we learn how to do new things.

EYE-HAND COORDINATION

Is the ability to do activities that require the simultaneous use of vision to guide hand movements.

HOW DO DOCTORS PRACTICE?

The same way that you might practice drills to get good at sports, doctors spend a lot of time practicing drills on a **simulator** to get good at surgery. A surgery simulator is a machine that makes doctors feel like they are practicing real surgery but does not involve an actual human body. An example of a drill that a surgeon might practice on a simulator is called the peg transfer task (Figures 1B,C). The goal of this drill is to use pincers to move six small triangles from one peg to another. This task teaches surgeons how to move things quickly with the same tools they use in real surgery.

SIMULATOR

A device that allows people to practice a complex activity in a realistic way, like surgery, driving a vehicle, or flying an airplane.

Doctors know they have practiced enough when they pass a challenging test that requires them to perform the drills they practiced, like the peg transfer task or other tasks, like tying knots or cutting shapes. To pass, the doctor must be very fast and cannot make any mistakes. The test is important because it has been shown that doctors who do better on the test perform better surgeries on their patients [1].

NEURON

A specialized cell that carries electrical impulses; a nerve cell.

COULD ELECTRICITY HELP US LEARN NEW SKILLS FASTER?

PRIMARY MOTOR CORTEX

The part of the brain that is most directly connected to muscles and a major source of the control of movement of the body. Also called "M1" for short.

You probably know that we use electricity every day, to turn on the TV or flip on a light switch, but you may not know that we have electricity inside our bodies, too. Our brains are made of lots of really tiny cells called **neurons**. Neurons are unlike most of our other body parts because they can use electricity to talk to each other. They help us do things like talk, breathe, and see. One special group of neurons helps us move our bodies, and is called the **primary motor cortex**, or M1 for short. Without your M1, you could not move your hands to make a sandwich or move your legs to run around. Doctors use their M1s during surgery because they move their hands to operate.

TRANSCRANIAL DIRECT CURRENT STIMULATION (TDCS)

When electricity is applied to the brain to help neurons communicate with each other more easily.

Because the M1 uses electricity to tell the body how to move, it makes sense that adding electricity to the M1 could help a person learn new skills that involve movement. One way that scientists can do this is called **transcranial direct current stimulation** (**tDCS**) (Figure 2A). "Transcranial" means, across (trans) the skull (cranium), which is exactly where the electricity is going.

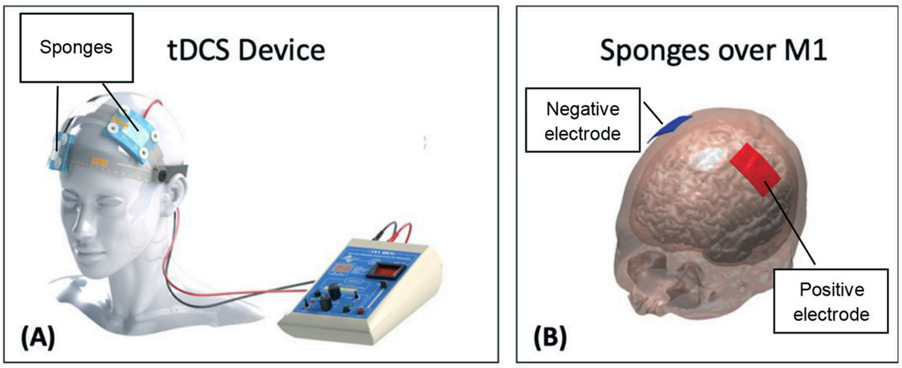

Figure 2

Figure 2

(A) A tDCS device with sponges. Tiny amounts of electricity flow from the negative sponge to the positive sponge, through the brain. **(B)** Image of a head, facing the bottom left corner of the box, showing the brain inside the skull with positive (red) and negative (blue) sponges on the outside of the skull, over the M1.

tDCS works by adding tiny amounts of electricity to the brain through wet sponges on the head [2]. Two sponges are needed to guide the flow of electricity. The electricity flows from a negative sponge to a positive sponge, passing through the brain on its way. tDCS does not hurt—it feels like a light tingling. Even though tDCS uses only very weak electricity, some of it gets to the neurons and helps them talk to each other. By making it easier for neurons to communicate, tDCS could help the brain to learn new skills[1].

[1] WARNING: Do not try this at home! tDCS is always done under careful conditions in a laboratory to make sure that the electricity is not harmful.

CAN TDCS HELP US GET BETTER AND FASTER?

So, you may be wondering whether tDCS can make you better at using your hands to play video games or piano. Past experiments have shown that tDCS can be used to speed up learning of tasks that use just one hand [3], but we decided to test whether tDCS could also help speed up learning for two hands. We tested this by adding electricity to people's brains while they practiced the peg transfer task on the surgical simulator. While they practiced, we measured how fast they were at moving the triangles and how many mistakes they made. Everybody wore sponges over their M1s, as shown in Figure 2B. One group of people practiced with the electricity turned on to a very low intensity, which they could barely feel. The other group practiced with electricity turned off. This is called sham stimulation. "Sham" means "fake" because people cannot tell that the electricity is off, but it is. A sham stimulation group helps us figure out how fast people learn *without* any help from electricity, so that we have a baseline to use to judge whether adding electricity actually helps with learning.

We found that the group who practiced with electricity delivered to their M1s learned faster and got higher scores than the sham group (Figure 3). This shows that people practicing with electricity got better at the task, and got better at it faster, than those without electricity.

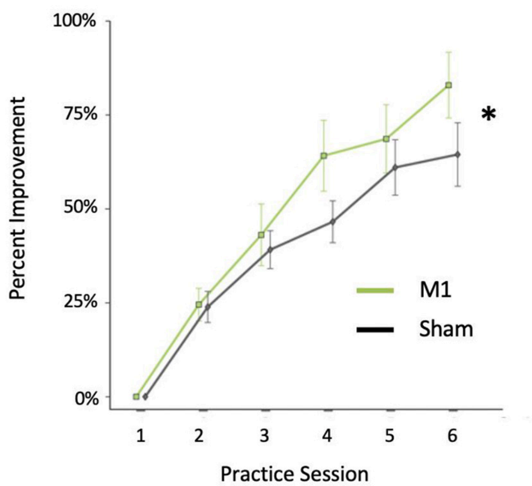

Figure 3

Figure 3

Electricity can help with learning. The green line shows the M1 group, which practiced with the electricity. The black line shows the sham group, which practiced without electricity. As you can see, the green line goes up more and faster, meaning that electricity helped people learn better. The thin vertical lines on each data point are called "error bars" and they show that there is some unavoidable uncertainty in the data. This "*" indicates that there is a significant difference between the M1 and the Sham data

WHY IS THIS RESEARCH IMPORTANT?

The results of this study tell us that adding electricity to the brain can help people learn eye-hand coordination skills faster. This finding could be used to help doctors while they practice to become surgeons, or may be used to help people learn other types of skills. Because good eye-hand coordination is important for activities like playing sports, music, or video games, it is possible that adding electricity to the brain could also help speed up learning of these activities, too. The tDCS technique may also help other types of learning, like problem solving or memory, but further research is needed to figure out whether this is true. So, stay tuned to discover exactly what kinds of learning can be aided by adding tiny amounts of electricity to the brain!

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ORIGINAL SOURCE ARTICLE

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

DILWORTH MIDDLE SCHOOL, AGES: 12–14

This article was reviewed by Mrs. Ellis and her wonderful eighth grade science students at Dilworth Middle School in Sparks, Nevada. The students were fascinated that electricity can help us learn faster. The class took a poll of how many of them would get a permanent device, if such would exist: 11 yays, 6 nays. They agreed that this technology seems too cool to pass up!

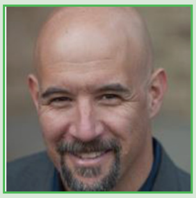
AUTHORS

RACHEL DONALDSON

Rachel Donaldson is a 2020 graduate of Duke University. She majored in neuroscience, completed a graduation with distinction, and was vice president of the Neuroscience Major's Union.

SICONG LIU

Sicong Liu, Ph.D., is a research associate in the Annenberg School of Communication at the University of Pennsylvania. He has a Ph.D. in sports and exercise psychology and master's in measurement and statistics from the Florida State University.



LAWRENCE GREGORY APPELBAUM

Lawrence Gregory Appelbaum, Ph.D., is a professor at the University of California, San Diego, where he heads OptiLab, a cognitive neuroscience laboratory dedicated to research testing approaches to speed up learning and improve performance.
*lg.appelbaum@gmail.com