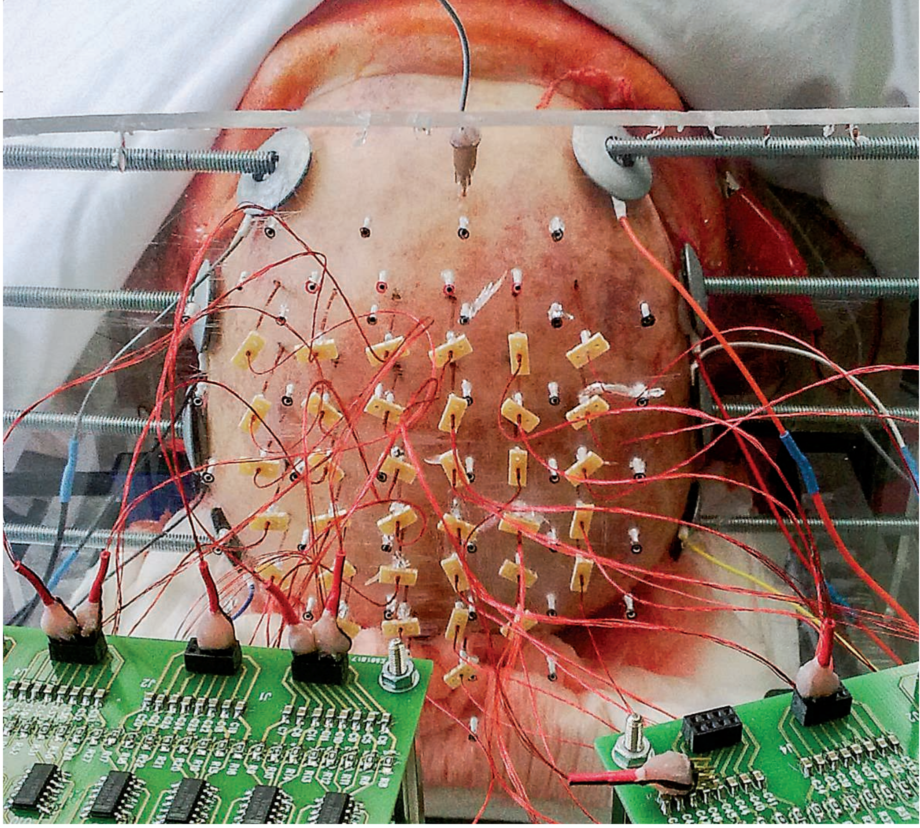

Popular brain stimulation methods can't trigger neuronal firing, a study in cadavers suggests.

PHOTO: MIHÁLY VÖRÖSLAKOS/UNIVERSITY OF SZEGED

NEUROSCIENCE

Cadaver study challenges brain stimulation methods

Unusual test of transcranial stimulation shows that little electrical current penetrates the skull

By **Emily Underwood**

Earlier this month, György Buzsáki of New York University (NYU) in New York City showed a slide that sent a murmur through an audience in the Grand Ballroom of New York's Midtown Hilton during the annual meeting of the Cognitive Neuroscience Society. It wasn't just the grisly image of a human cadaver with more than 200 electrodes inserted into its brain that set people whispering; it was what those electrodes detected—or rather, what they failed to detect.

When Buzsáki and his colleague, Antal Berényi, of the University of Szeged in Hungary, mimicked an increasingly popular form of brain stimulation by applying alternating electrical current to the outside of the cadaver's skull, the electrodes inside registered little. Hardly any current entered the brain. On closer study, the pair discovered that up to 90% of the current had been redirected by the skin covering the skull, which acted as a "shunt," Buzsáki said.

For many meeting attendees, the unusual study heightened serious doubts about the mechanism and effectiveness of transcranial direct current stimulation (tDCS), an experimental, noninvasive treatment that uses electrodes to deliver weak current to a person's forehead, and the related tACS, which uses alternating current. Little is known about how these techniques might influence the brain. Yet many scientific papers have claimed that they can boost mood, alleviate chronic pain, and even make people better at math by directly affecting neuronal activity. This has spawned a cottage industry of do-it-yourself gadgets promising to make people smarter and happier.

The new, unpublished cadaver data make dramatic effects on neurons unlikely, Buzsáki says. Most tDCS and tACS devices deliver about 1 to 2 milliamps of current. Yet based on measurements from electrodes inside multiple cadavers, Buzsáki calculated that at least 4 milliamps—roughly equivalent to the discharge of a stun gun—would be necessary to stimulate the firing of living neurons inside the skull. Buzsáki notes he got dizzy when he tried 5 milliamps on his own scalp.

"It was alarming," he says, warning people not to try such intense stimulation at home.

The cadaver research "should make the crowd nervous that favors tDCS and tACS," says David Poeppel, a neuroscientist and psychologist at NYU. Others who heard Buzsáki's talk or were informed of the results maintain that transcranial stimulation does work—and the only question is how. Neuroscientist Vince Clark of the University of New Mexico, Albuquerque, for example, has found that applying 2 milliamps of current to a person's scalp for just 30 minutes can double the speed at which they learn a game in which players must detect a concealed "threat," such as a bomb or sniper, in a video clip. Several labs have replicated those results, he says, adding that the idea that 10% or less of the current gets through to the brain is not new, and doesn't necessarily mean the methods are ineffective. "If it works, you know 10% is enough," Clark says.

Marom Bikson, a biomedical engineer at The City College of New York in New York City who uses computer models and slices of rat brain to study the mechanisms of tDCS and tACS, says that many in the field already accepted that the 1 or 2 milliamps the methods use don't directly trigger firing. It can make neurons more likely to fire or form new connections, he and others believe. Unlike techniques that rely on magnetic fields or higher current to actively trigger neurons, such as electroconvulsive therapy, tDCS and tACS likely subtly alter ongoing brain activity, Bikson says. Using cadavers to test these methods is a "complicated choice" because dead tissue conducts electricity differently from living tissue, he adds.

Buzsáki expects a living person's skin would shunt even more current away from the brain because it is better hydrated than a cadaver's scalp. He agrees, however, that low levels of stimulation may have subtle effects on the brain that fall short of triggering neurons to fire. Electrical stimulation might also affect glia, brain cells that provide neurons with nutrients, oxygen, and protection from pathogens, and also can influence the brain's electrical activity. "Further questions should be asked" about whether 1- to 2-milliamp currents affect those cells, he says.

Buzsáki, who still hopes to use such techniques to enhance memory, is more restrained than some critics. The tDCS field is "a sea of bullshit and bad science—and I say that as someone who has contributed some of the papers that have put gas in the tDCS tank," says neuroscientist Vincent Walsh of University College London. "It really needs to be put under scrutiny like this." ■

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Editor's Summary