Researchers develop 'wireless' activation of brain circuits

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Traditionally, stimulating nerves or brain tissue involves cumbersome wiring and a sharp metal electrode. But a team of researchers at Case Western Reserve University is going "wireless."

And it's a unique collaboration between chemists and neuroscientists that led to the discovery of a remarkable new way to use light to activate brain circuits with nanoparticles.

Ben Strowbridge, an associate professor in the neurosciences department in the Case Western Reserve School of Medicine and Clemens Burda, an associate professor in chemistry, say it's rare in science that people from very different fields get together and do something that is both useful and that no one had thought of before. But that is exactly what they've done.

By using semiconductor nanoparticles as tiny solar cells, the scientists can excite neurons in single cells or groups of cells with infrared light. This eliminates the need for the complex wiring by embedding the light-activated nanoparticles directly into the tissue. This method allows for a more controlled reaction and closely replicates the sophisticated focal patterns created by natural stimuli.

The electrodes used in previous nerve stimulations don't accurately recreate spatial patterns created by the stimuli and also have potential damaging side effects.

"There are many different things you'd want to stimulate neurons for- injury, severed or damaged nerve to restore function- and right now you have to put a wire in there, and then connect that to some control system. It is both very invasive and a difficult thing to do," says Strowbridge.

IIn principle, the researchers should be able to implant these nanoparticles next to the nerve, eliminating the requirement for wired connections. They can then use light to activate the particles.

"We believe it has a lot of applicability," they said" Hopefully, the same thing can happen in the brain."

The researchers' paper, "Wireless Activation of Neurons in Brain Slices Using Nanostructured Semiconductor Photoelectrodes," is the first report of brain stimulation using light-activated semiconductor nanoparticles. This research study was published in *Angewandte Chemie*, a premier chemistry journal. The journal also highlighted the study as a "hot paper."

This study used brain slices to show that light can trigger neural activity. The next step is to see if this innovative technology can be used to stimulate longer pathways within the intact brain. Clinical development of the technology could lead to new methods to activate specific brain regions and damaged nerves.

"The long-term goal of this work is to develop a light-activated brain-machine interface that restores function following nerve or brain impairments," Strowbridge says. "The first attempts to interface computers with brain circuitry are being done now with complex metal electrode stimulation arrays that are not well suited to recreating normal brain activity patterns and also can cause significant damage."

Currently light is being used in the study to drive neural activity in a minimally invasive manner, without requiring electrical wires.

The pair credits Pamela Davis, dean of the School of Medicine, for introducing them several years ago. "It is great to have a medical school dean who knows not only what her own faculty are doing but also closely follows the research programs in other colleges," says Strowbridge. Campus geography played a role as well. "This project would not have happened without the close physical proximity between the two departments," says Burda. "Case Western Reserve is unusual in having its medical school located on the same campus as the rest of the University."

When they aren't brought together for this collaboration, the two labs pursue vastly different research programs. Strowbridge's laboratory is interested in how groups of neurons are wired together in both the brain regions responsible for the sense of smell and in the hippocampus, a critical brain area for both memory and epilepsy.

Burda's laboratory uses chemically synthesized nanostructures to study renewable energy conversion schemes, including solar cells. He also investigates nanoparticles for targeted drug delivery and therapy.

"It took a lot of extra hours above and beyond their regular projects for our students to complete this project," Burda says. "Fortunately, we have great students who were really excited about the potential applications of this technology from the beginning and found ways to make this project work,"

Phillip Larimer and Todd Pressler, from Strowbridge's group, and Yixin Zhao, from Burda's team, worked on the project outside of their primary lab responsibilities, conducting tests and recording data, creating software and measuring their results. The three graduate students are co-authors on the paper with the two researchers.

"Our findings may open up a whole new world of research possibilities Now all we have to do is get real funding for this project to take it to the next level," Burda says.

The researchers point out that it is often challenging to get federal funding for this type of interdisciplinary research. Traditional grant review panels are specialized to review either chemistry or neuroscience proposals, but not proposals at the interface between the two disciplines.

Fortunately, both laboratories are established and well funded for their primary research programs. "We were able to jumpstart this project using our existing grant support because of the potential impact this work may have for our long-term research programs," says Strowbridge.

Source: Case Western Reserve University

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