New technology could inspire brain implant for detecting and treating seizures

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(Medical Xpress) -- Tiny electrodes have been coated with a drug-loaded polymer in an attempt to design an implant capable of detecting a number of neurological symptoms, such as those associated with an epileptic seizure, and treating them simultaneously.

In a study published today, 2 June 2011, in IOP Publishing's Journal of Neural Engineering, researchers have developed a novel technology to precisely modulate individual neurons in rats, allowing the molecular, neuronal, and circuit functions to be analysed with unprecedented precision.

Based on the electrical conducting properties of the polymer Polypyrrole (PPy), the researchers, from the University of Pittsburgh, have demonstrated a novel way of loading specific drugs onto an array of

electrodes and triggering their release into cultured neurons, allowing for a more precise insight into the cellular mechanisms of neuronal networks .

On top of this, the researchers have also demonstrated how the release of drugs could be informed, in real-time, by the recording of activity in neurons, a step essential for creating a closed-loop system that both diagnoses and treats symptoms simultaneously, creating several potential applications.

Co-author Professor X Tracy Cui said, "We envision an implanted device in the future that will monitor the brain activity, detect or predict an onset of epileptic seizure, and send the command to the electrode at the most appropriate location, releasing an anti-convulsive drug to prevent the seizure."

Multielectrode arrays (MEAs) — small devices that can control or record the electrical circuitry in neurons — have long been used as a way of measuring neuronal activity and transforming this into an action; technologies such as ear implants and cardiac pacemakers have benefited from them.

Recent advances, however, have allowed MEAs to be coupled with devices that release specific drugs in order to test how neural circuits function, as well as investigating the underlying mechanisms within neuronal cells.

The researchers coated PPy, containing all of the necessary neurochemicals, onto an MEA. Whilst positioned on the cultured rat brain, the polymer was electrically stimulated, causing the neurochemicals to dissociate and diffuse away to the necessary locations.

Results showed that the drugs retained their activity and function with

spatial and temporal precision.

Current state-of-the-art drug delivery methods, such as picospritzer and ionotopheriesis, give researchers a greater understanding of cellular mechanisms of neural dynamics; however, both of these techniques are limited to a few sites and face the risk of drug leakage.

By having the required neurochemicals dissociate from the polymer, this technique avoids the need for an external reservoir containing the drug, which would greatly increase the size of a potential implant and could cause tissue damage.

Professor Cui continues, "By directly loading a drug of interest onto an individual electrode site and using an electrical signal to trigger its release, we can precisely control the drug delivery site with ease. Additionally, our technology can be used for a combination of exogenous chemicals such as subtype-specific receptor antagonists, thus potentially allowing for more precise dissection of neural circuit function at the molecular level."

More information: "Rapid modulation of local neural activity by controlled drug release from polymer-coated recording microelectrodes" by Stauffer et al. 2011 *J. Neural Eng.* **8** 044001. iopscience.iop.org/1741-2552/8/4/044001

Abstract
We demonstrate targeted perturbation of neuronal activity with controlled release of neurochemicals from conducting polymer-coated microelectrodes. Polymer coating and chemical incorporation are achieved through individually addressable electrodeposition, a process that does not compromise the recording capabilities of the electrodes. Release is realized by the application of brief voltage pulses that electrochemically reduce the polymer and dissociate incorporated

neurochemicals; whereby they can diffuse away and achieve locally effective concentrations. Inhibition of evoked synaptic currents in neurons within 200 μm of a 6-cyano-7-nitroquinoxaline-2,3-dione releasing electrode lasts for several seconds. Spiking activity of neurons in local circuits recorded extracellularly near the releasing electrode is silenced for a similar duration following release. This methodology is compatible with many neuromodulatory chemicals and various recording electrodes, including in vitro and implantable neural electrode arrays, thus providing an inexpensive and accessible technique capable of achieving sophisticated patterned chemical modulation of neuronal circuits.

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