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Near-infrared deep brain stimulation via upconversion nanoparticle-mediated optogenetics

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Abstract

Optogenetics has revolutionized the experimental interrogation of neural circuits and holds promise for the treatment of neurological disorders. It is limited, however, because visible light cannot penetrate deep inside brain tissue. Upconversion nanoparticles (UCNPs) absorb tissue-penetrating near-infrared (NIR) light and emit wavelength-specific visible light. Here, we demonstrate that molecularly tailored UCNPs can serve as optogenetic actuators of transcranial NIR light to stimulate deep brain neurons. Transcranial NIR UCNP-mediated optogenetics evoked dopamine release from genetically tagged neurons in the ventral tegmental area, induced brain oscillations through activation of inhibitory neurons in the medial septum, silenced seizure by inhibition of hippocampal excitatory cells, and triggered memory recall. UCNP technology will enable less-invasive optical neuronal activity manipulation with the potential for remote therapy.

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