ADVANCED HEALTHCARE MATERIALS

Supporting Information

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Electronic Neurons for a New Learning Paradigm

*Zhen Wang, Jiajia Wang, Xiang Shi, Zhengfeng Zhu, Peining Chen and Huisheng Peng**

Supporting Information
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Abstract: Learning is the cornerstone of the growth and development of human beings. However, traditional learning methods have been insufficient to meet the explosive growth of knowledge and information. Repeated training accounts for a large proportion of learning time, which greatly limits the improvement of learning efficiency. Inspired by cloud storage technology, we propose electronic neurons (E-neuron) similar with functions similar to neurons in the brain. Implanted E-neurons can form new patterns of neural activity in circuits including both E-neurons and biological neurons, which will be capable of transferring knowledge from cloud electronic devices to human beings without training. Here, the feasibility of this concept was preliminarily demonstrated. Fiber neural electrodes (FNEs) made of poly(3,4-ethylene dioxythiophene) (PEDOT) modified carbon nanotubes (CNTs) were used to form both dendrites and axons of E-neuron. After the implantation of an E-neuron in the brain of a mouse, an electrical neural connection was created between the mitral cell and dorsolateral periaqueductal gray (dlPAG). A piece of knowledge similar to "The red light stops, the green light is all right." was then passed on to the mouse.

Table of contents

1. Results and Discussions

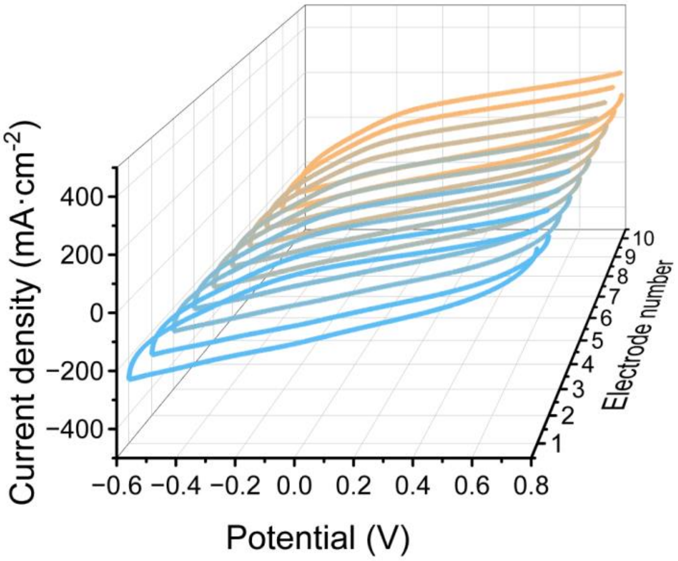

Figure S1. CV curves of ten fiber neural electrodes prepared in the same batch.

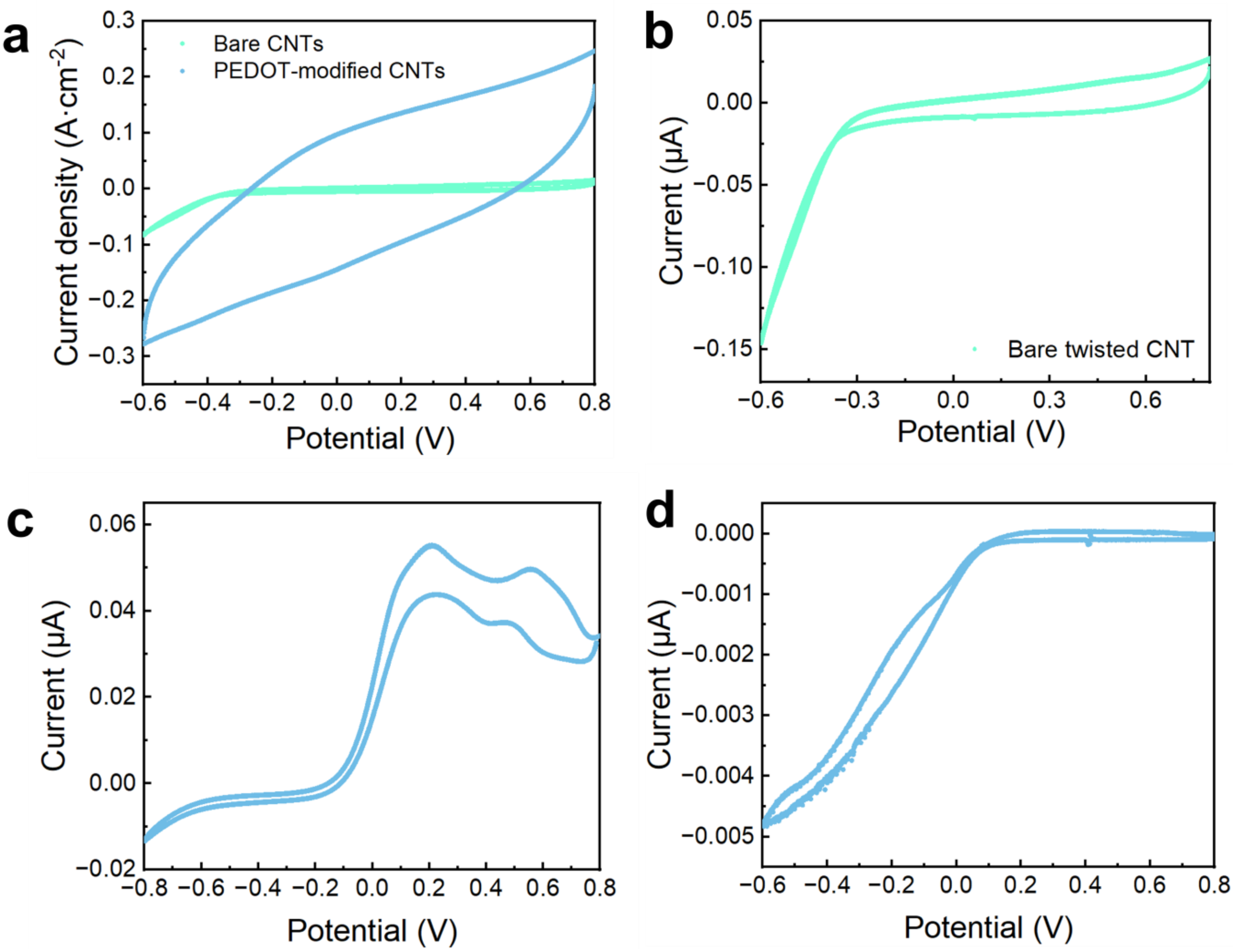

Figure S2. CV curves of different types of electrodes

Figure S2 contains the following parts: **a**, CV curves of PEDOT-modified CNT electrodes compared to bare CNT electrodes. **b**, Zoomed-in version of the CV curve of bare CNT electrodes. **c**, CV curve of stainless-steel electrodes (20 µm in diameter). **d**, CV curve of PtIr electrodes (15 µm in diameter). Our fiber neural electrodes showed a high charge storage capacity of 1808 mC·cm^{-2} (**Figure S1a**), which is much higher than other neural electrodes, such as PtIr wires (6 mC·cm^{-2}), CNT fibers (316 mC·cm^{-2}) and stainless-steel wires (231 mC·cm^{-2}, **Figure S1b-d**).

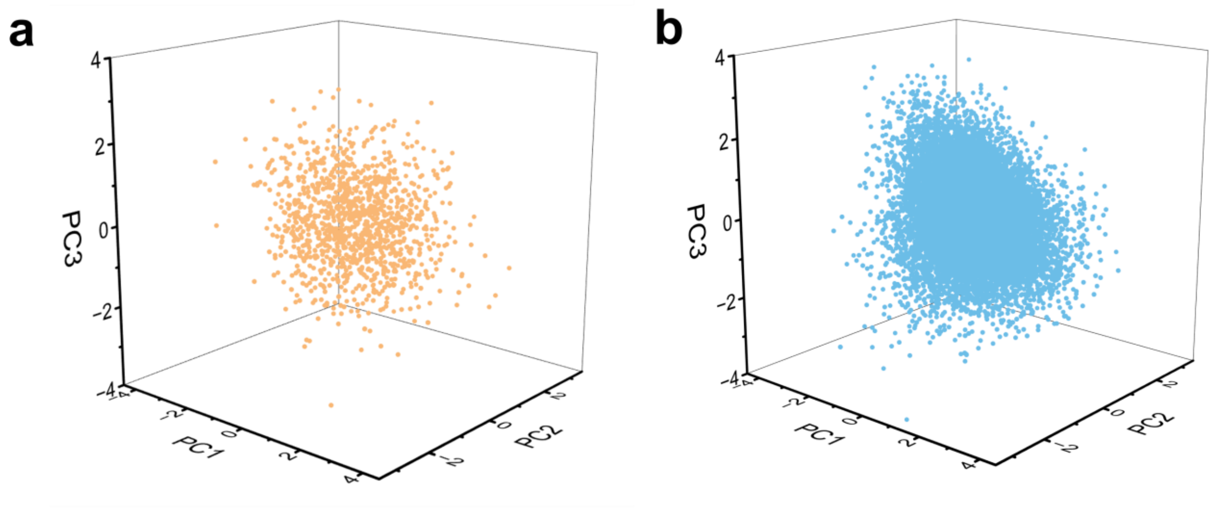

Figure S3. Principal Component Analysis (PCA) of single spike units recorded by the electronic dendrite during switching of odor stimulation.

Figure S3 contains the following parts: **a,** Spike units recorded in the anesthetized state. **b**, Spike units recorded in the awake state.

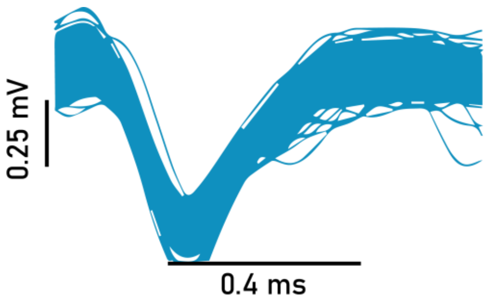

Figure S4. Waveforms from the recorded mitral cell in the awake state of mice.

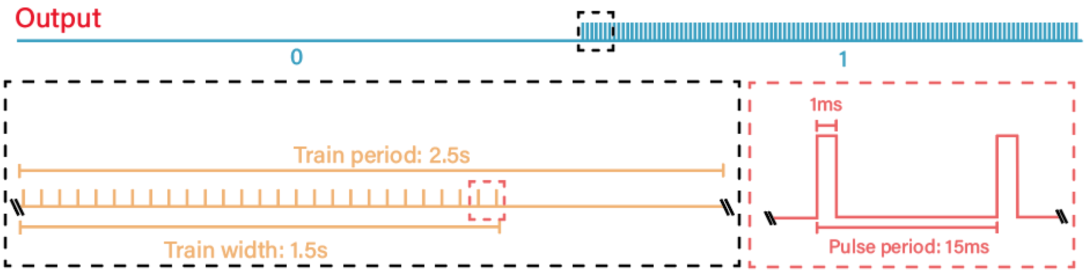

Figure S5. Waveforms of the stimulation train released by the electronic cell body.

3. Author Contributions

Z. W. and H. P. conceived and designed the research project. Z. W. and J. W. performed the experiments, and Z. W., Z. Z., X. S., and P. C. wrote and revised the manuscript.