Brain tissue on a chip achieves voice recognition

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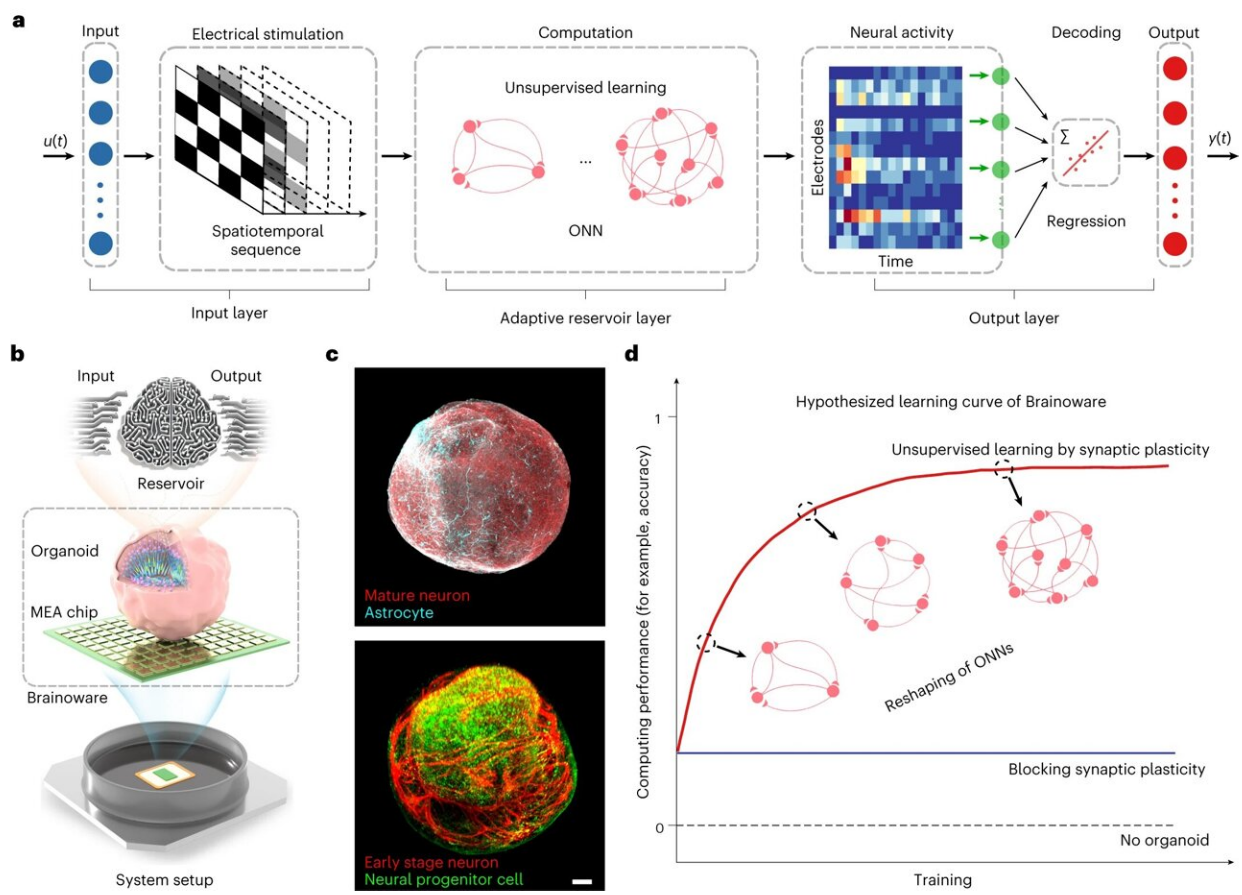

Brainoware with unsupervised learning for AI computing. **a**, Schematic of an adaptive reservoir computing framework using Brainoware. **b**, Schematic of the paradigm of Brainoware setup that mounts a single brain organoid onto a high-density MEA for receiving inputs and sending outputs. **c**, Whole-mount immunostaining of cortical organoids showing complex three-dimensional neuronal networks with various brain cell identities (for example, mature neuron, MAP2; astrocyte GFAP; neurons of early differentiation stage, TuJ1; neural progenitor cells, SOX2). **d**, Schematic demonstrating the hypothesized, unsupervised learning of Brainoware by reshaping the BNN during training, and the inhibition of unsupervised learning after synaptic plasticity is blocked. Scale bar, 100 µm. Credit: *Nature Electronics* (2023). DOI: 10.1038/s41928-023-01069-w

Clusters of lab-raised brain cells connected to a computer are capable of elementary speech recognition and math problems.

Feng Guo, a bioengineer in the Department of Intelligent Systems Engineering at Indiana University, Bloomington, said his study is a major step in demonstrating how brain-inspired computer neural networks can advance artificial intelligence capabilities.

Guo and his team grew bundles of specialized stem cells that developed into neurons, the main component of the brain. A typical brain consists of 86 billion neurons, each neuron connected to as many as 10,000 other neurons.

The ball of neurons, known as an organoid, created in Guo's lab is less than a nanometer wide. It was connected by an array of electrodes to a circuit board, where machine-learning algorithms decoded responses from the organoid.

The researchers dubbed their creation Brainoware.

After a brief training period, Brainoware was able to distinguish between the voices of eight subjects based on their varying pronunciation of vowels. The system achieved an accuracy rate of 78%.

Brainoware was also able to successfully predict a Henon map, a mathematical construct in the field of chaotic dynamics, with greater accuracy than an artificial network.

"This is a first demonstration of using brain organoids [for computing]," says Guo. "It's exciting to see the possibilities of organoids for biocomputing in the future."

A key advantage of biocomputing is its energy efficiency. Currently, artificial neural networks consume several million watts of energy a day. The human brain, on the other hand, requires only about 20 watts to function for a day.

Brainoware is "a bridge between AI and organoids," Guo said. "Organoids are like 'mini-brains.'"

"We wanted to ask the question of whether we can leverage the biological neural network within the brain organoid for computing. This is just proof-of-concept to show we can do the job," Guo said.

A future application for biocomputing systems is studying neurological diseases such as Alzheimer's. The potential to tap into cellular activity also opens the door to decoding brain wave activity during sleep and possibly recording dreams.

Challenges remain. Among them will be the task of keeping organoids healthy and well-nourished, a 24/7 task.

And there are other concerns as well.

"As the sophistication of these organoid systems increases, it is critical for the community to examine the myriad of neuroethical issues that surround biocomputing systems incorporating human neural tissue," Guo said.

"It may be decades before general biocomputing systems can be created, but this research is likely to generate foundational insights into the mechanisms of learning, neural development, and the cognitive implications of neurodegenerative diseases."

"We do have a long way to go," he added.

The study was published in *Nature Electronics*.

More information: Hongwei Cai et al, Brain organoid reservoir computing for artificial intelligence, *Nature Electronics* (2023). DOI: 10.1038/s41928-023-01069-w

Lena Smirnova et al, Reservoir computing with brain organoids, *Nature Electronics* (2023). DOI: 10.1038/s41928-023-01096-7

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