https://doi.org/10.1038/s41928-023-01041-8

The year of brain–computer interfaces

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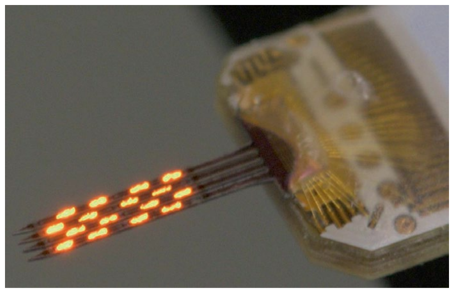
With advances in capabilities coming hand in hand with calls for regulation, 2023 is proving to be a critical year for brain–computer interfaces.

Back in February, we announced that brain–computer interfaces were our technology of the year for 2023. The interfaces, which provide a direct communication link between the brain and an external device, can record, decode and stimulate neural activity. They are of potential use in a variety of profound applications — from treating neurological disorders to enhancing human capabilities — and they have been the topic of a series of powerful research demonstrations in recent years.

These capabilities have continued to develop throughout 2023. In August, for instance, two reports were published in *Nature* on brain–computer interfaces that can translate neural signals into sentences at speeds close to that of normal conversation (around 150 words per minute)[1,2]. In one approach, intracortical microelectrode arrays were used to collect signals, which — with the help of a recurrent neural network and a language model — could be decoded at an average rate of 62 words per minute, and with a word error rate of 23.8% for a 125,000-word vocabulary[1]. In the other approach, an electrocorticography electrode array was used to collect signals, which — again, with the help of a recurrent neural network and a language model — could be decoded at a median rate of 78 words per minute, and with a word error rate of 25.5% for a 1,024-word vocabulary[2]. (See also our Research Highlight on the two papers.)



Photograph of an optical probe developed by Malte Gather, Kenneth Shepard and colleagues with 512 of the 1,024 OLEDs illuminated.

Developments in the underlying devices have also continued. In this issue of *Nature Electronics*, for example, Baibhab Chatterjee, Shreyas Sen and colleagues at Purdue University report a wireless communication technique for neural implants. In this approach — which is termed biphasic quasistatic brain communication — the implants transmit information to a wearable headphone-shaped hub, and this hub sends power and programming bits to the implant; all of which is done using fully electrical signals that should avoid transduction losses.

In a Comment article back in our February issue, Rikky Muller and colleagues at the University of California, Berkeley argued that the future of brain–computer interfaces could be entirely optical[3]. For now, and in an Article elsewhere in this issue, Malte Gather, Kenneth Shepard and colleagues report device developments focused on creating optical probes for neural stimulation. The researchers — who are based at Columbia University, the University of Cologne, the University of St Andrews, the Massachusetts Institute of Technology and Stanford University — have integrated organic light-emitting diodes (OLEDs) with silicon complementary metal–oxide–semiconductor (CMOS) control circuitry. The resulting implantable probes incorporate 1,024 OLEDs with two different colours and can be used to selectively activate individual neurons in mice. (See also the accompanying News & Views article on the work.)

Our decision to select brain–computer interfaces as our 2023 technology of the year was also based on the fact that we felt this was a critical moment to consider the potential consequences and direction of the technology. In July, the United Nations Educational, Scientific and Cultural Organization (UNESCO) released a report on neurotechnology[4], a field that brain–computer interfaces lie at the heart of. The organization also called for global regulation for the technology and proposed to develop a universal ethical framework for it[5], similar to what it has done in the past for the human genome (in 1997), human genetic data (in 2003) and artificial intelligence (in 2021)[6]. Such developments are likely to be as important for the future of brain–computer interfaces as the technological advances themselves.

Published online: 25 September 2023

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