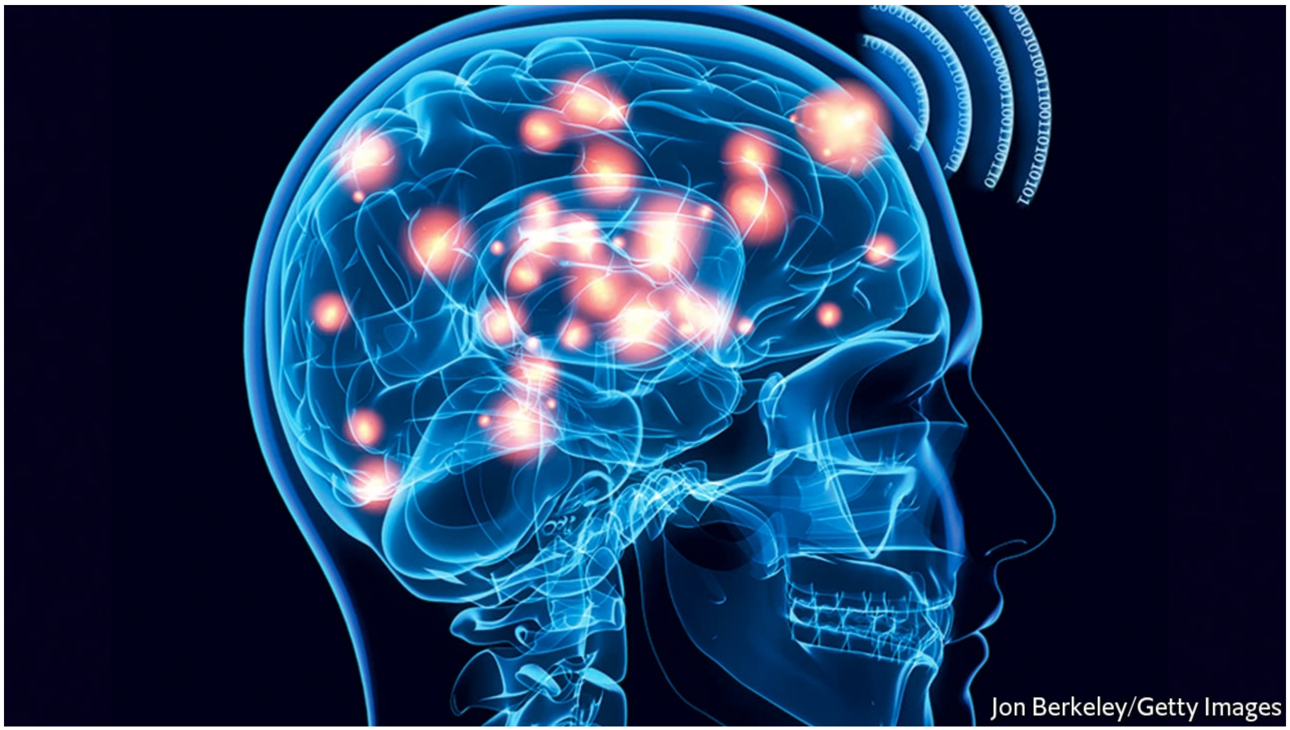
The next frontier

Using thought to control machines

Brain-computer interfaces may change what it means to be human



Print edition | Leaders › Jan 4th 2018

TECHNOLOGIES are often billed as transformative. For William Kochevar, the term is justified. Mr Kochevar is paralysed below the shoulders after a cycling accident, yet has managed to feed himself by his own hand. This remarkable feat is partly thanks to electrodes, implanted in his right arm, which stimulate muscles. But the real magic lies higher up. Mr Kochevar can control his arm using the power of thought. His intention to move is reflected in neural activity in his motor cortex; these signals are detected by implants in his brain and processed into commands to activate the electrodes in his arms.

An ability to decode thought in this way may sound like science fiction. But brain-computer interfaces (BCIs) like the BrainGate system used by Mr Kochevar provide evidence that mind-control can work. Researchers are able to tell what words and images people have heard and seen from neural activity alone. Information can also be encoded and used to stimulate the brain. Over 300,000 people have cochlear implants, which help them to hear by converting sound into electrical signals and sending them into the brain. Scientists have "injected" data into monkeys' heads, instructing them to perform actions via electrical pulses.

As our Technology Quarterly (https://www.economist.com/technology-quarterly/2018-01-06/thought-experiments) in this issue explains, the pace of research into BCIs and the scale of its ambition are increasing. Both America's armed forces and Silicon Valley are starting to focus on the brain. Facebook dreams of thought-to-text typing. Kernel, a startup, has $100m to spend on neurotechnology. Elon Musk has formed a firm called Neuralink; he thinks that, if humanity is to survive the advent of artificial intelligence, it needs an upgrade. Entrepreneurs envisage a world in which people can communicate telepathically, with each other and with machines, or acquire superhuman abilities, such as hearing at very high frequencies.

These powers, if they ever materialise, are decades away. But well before then, BCIs could open the door to remarkable new applications. Imagine stimulating the visual cortex to help the blind, forging new neural connections in stroke victims or monitoring the brain for signs of depression. By turning the firing of neurons into a resource to be harnessed, BCIs may change the idea of what it means to be human.

That thinking feeling

Sceptics scoff. Taking medical BCIs out of the lab into clinical practice has proved very difficult. The BrainGate system used by Mr Kochevar was developed more than ten years ago, but only a handful of people have tried it out. Turning implants into consumer products is even harder to imagine. The path to the mainstream is blocked by three formidable barriers—technological, scientific and commercial.

Start with technology. Non-invasive techniques like an electroencephalogram (EEG) struggle to pick up high-resolution brain signals through intervening layers of skin, bone and membrane. Some advances are being made—on EEG caps that can be used to play virtual-reality games or control industrial robots using thought alone. But for the time being at least, the most ambitious applications require implants that can interact directly with neurons. And existing devices have lots of drawbacks. They involve wires that pass through the skull; they provoke immune responses; they communicate with only a few hundred of the 85bn neurons in the human brain. But that could soon change. Helped by advances in miniaturisation and increased computing power, efforts are under way to make safe, wireless implants that can communicate with hundreds of thousands of neurons. Some of these interpret the brain's electrical signals; others experiment with light, magnetism and ultrasound.

Clear the technological barrier, and another one looms. The brain is still a foreign country. Scientists know little about how exactly it works, especially when it comes to complex functions like memory formation. Research is more advanced in animals, but experiments on humans are hard. Yet, even today, some parts of the brain, like the motor cortex, are better understood. Nor is complete knowledge always needed. Machine learning can recognise patterns of neural activity; the brain itself gets the hang of controlling BCIS with extraordinary ease. And neurotechnology will reveal more of the brain's secrets.

Like a hole in the head

The third obstacle comprises the practical barriers to commercialisation. It takes time, money and expertise to get medical devices approved. And consumer applications will take off only if they perform a function people find useful. Some of the applications for brain-computer interfaces are unnecessary—a good voice-assistant is a simpler way to type without fingers than a brain implant, for example. The idea of consumers clamouring for craniotomies also seems far-fetched. Yet brain implants are already an established treatment for some conditions. Around 150,000 people receive deep-brain stimulation via electrodes to help them control Parkinson's disease. Elective surgery can become routine, as laser-eye procedures show.

All of which suggests that a route to the future imagined by the neurotech pioneers is arduous but achievable. When human ingenuity is applied to a problem, however hard, it is unwise to bet against it. Within a few years, improved technologies may be opening up new channels of communications with the brain. Many of the first applications hold out unambiguous promise—of movement and senses restored. But as uses move to the augmentation of abilities, whether for military purposes or among consumers, a host of concerns will arise. Privacy is an obvious one: the refuge of an inner voice may disappear. Security is another: if a brain can be reached on the internet, it can also be hacked. Inequality is a third: access to superhuman cognitive abilities could be beyond all except a self-perpetuating elite. Ethicists are already starting to grapple with questions of identity and agency that arise when a machine is in the neural loop.

These questions are not urgent. But the bigger story is that neither are they the realm of pure fantasy. Technology changes the way people live. Beneath the skull lies the next frontier.

This article appeared in the Leaders section of the print edition under the headline "The next frontier"