THE ROYAL SOCIETY

iHuman factsheet: neural interfaces

What are neural interfaces?

We interact with the outside world through our nervous system which allows us to touch, see, smell, hear and taste.

Neural interfaces are devices that interact with the nervous system. They can restore or enhance functions, and may fundamentally change how we interact with technologies and each other. In this factsheet, we describe the history of neural interfaces, outline current applications, and discuss possible future areas of development.

Timeline

While neural interfaces may sound more like science fiction than reality, they have been around for centuries. For example, Ancient Egyptians used electric catfish to treat arthritis and electric rays were used by Romans to treat headaches. As we learned more about how the nervous system works, more sophisticated and targeted neural interfaces emerged. These range from devices that measure brain waves like EEG (electroencephalography), to devices that can restore functions like cochlear implants for hearing loss, and deep-brain stimulation (DBS) to treat Parkinson's disease.

You can find more about the history of neural interfaces in the interactive timeline at: **royalsociety.org/ihuman-perspective**

Neural interfaces today

Neural interfaces are electronic devices that are placed on the outside or inside of the brain, or other parts of the central and peripheral nervous system, to record or stimulate activity – or both. The devices can be used for medical or non-medical applications.

Interfaces placed inside the brain or body are known as internal, invasive or implanted technologies. Those placed externally are non-invasive or wearable devices.

COCHLEAR IMPLANTS

Cochlear implants are the most widely used internal neural interfaces. These devices help people who have partial or profound deafness due to damage to their inner ear or cochlea. The cochlear implant acts as a substitute for the cochlea, converting vibrations received from the outer and middle areas of the ear into electrical signals that the auditory cortex decodes into the soundwaves we hear.

The figure below demonstrates the relatively low uptake of cochlear implants in the UK, due to a variety of issues. For more information, read the Royal Society's report, *iHuman: blurring lines between mind and machine*, available to download at: **royalsociety.org/ihuman-perspective**

Cochlear implants

The world's most widely used implant

- **11,000,000** people in the UK have some hearing loss
- **8,000,000** people with hearing loss are aged 60 and over
- **6,700,000** people could benefit from hearing aids
- **2,000,000** people use hearing aids
- **900,000** people are severely or profoundly deaf
- **12,000** people in the UK use cochlear implants[1]

1. Hearing Link factsheet. See https://www.hearinglink.org/your-hearing/about-hearing/facts-about-deafness-hearing-loss/ (accessed 8 February, 2019).

DEEP BRAIN STIMULATION

Deep brain stimulation (DBS) is an invasive neural interface, used in the treatment of conditions such as Parkinson's disease, epilepsy and drug-resistant depression. Electrodes are implanted deep in the brain, stimulating specific areas. This stimulation is very effective at reducing some of the more debilitating aspects of diseases like Parkinson's such as tremor or difficulty of movement.

INTERFACE-CONTROLLED GAMES

Neural interfaces are of huge interest to the videogaming industry, as they could allow gamers to play using just their thoughts. Although applications are still in the very early stages of development, there are already examples of interface-controlled games where a player wears a headband containing electrodes that connect to a virtual reality headset. The brain signals of the player are then picked up and analysed by software that controls how characters in a videogame move.

Possible future applications of neural interfaces

Neural interface technologies are in their infancy, comparable to computers in the 1970s – but they are now experiencing a wave of innovation and investment that will lead to smaller, more powerful and more widely used devices.

It is difficult to be certain about exactly what neural interfaces will look like in the future as there are several directions that researchers and companies are exploring. For example, neural interfaces may one day allow us to do the following:

- **'Typing by brain' and using a 'mental mouse'**
  A company called CTRL Labs is developing a device that reads the muscle signals on a user's wrists, the wearer can then use these signals to control a mouse on their computer. Ultimately, this kind of device could allow us to control any form of technology using just signals from the nervous system.
- **Enable immobile people with paralysis to walk again**
  Experimental treatments, using interfaces that electrically stimulate paralysed limbs when they detect a patient's intention to move, have already allowed people with paraplegia to walk again. Alternative mobility options using interfaces could take the form of mind-controlled prosthetics.
- **Communicate directly, brain-to-brain**
  One speculative, but possible application of neural interfaces is being able to send a loved one a 'neural postcard' that transmits sensory experiences. This could allow someone to share directly what they are experiencing when on holiday.
- **Monitor brain or neural activity to support health, safety and security**
  People undergoing rehabilitation have used neural interfaces to detect their muscle activity and movement during exercises. This data is then captured on a tablet, allowing users to monitor their progress. In the future, neural interfaces could be used to monitor fatigue, enabling safer roads and workplaces.
- **Enhancement of human memory, concentration, and learning**
  Early experimental research has suggested that neural interfaces could be used improve our working memory, attention, or ability to 'multitask'. Scientists have however cautioned that these applications may improve the ability to perform one task but damage the ability to perform another, and the effect may vary from person to person.

You can find more information on neural interfaces and the potential of this technology in the Royal Society's report, *iHuman: blurring lines between mind and machine*, or you can watch our short animation, *An introduction to neural interfaces* (3:11 mins), both available online at: **royalsociety.org/ihuman-perspective**