

Not content with merely working on missions to Mars and building tunnels underneath Los Angeles, tech genius Elon Musk is now working on exploring the human mind. In July last year, Musk's company Neuralink announced plans to start human trials of its brain-hacking device, which reportedly attaches to its human host via a tiny probe filled with electrodes. This and similar technologies have the capacity to heal those who are paralysed or have conditions like Parkinson's disease, but critics wonder whether they could be co-opted or even drive us insane.

The type of technology Musk's company would employ is called a brain-computer interface (BCI). This kind of device comes in two main types – non-invasive, where the equipment to measure a person's brainwaves is attached to the outside of their head, and invasive, where the skull is drilled through so electrodes can be placed directly onto the outer layer of the brain.

Dr Kenneth Pope from the College of Science and Engineering at Flinders University works with electroencephalogram (EEG) technology to measure brain signals. He says the invasive brain-computer interface would mainly be used where medical professionals need to cut into the person's skull to perform surgery. An example would be if the patient has severe epilepsy and medication hasn't been effective, so surgery is needed to reduce their seizures.

The upside for researchers when drilling through the skull is there is less 'noise' interfering with measurements of the person's brainwaves. "If your sensors are outside the skull, which is easy to do, then you've got the problem of things like muscles that are sitting outside the skull and generate loud electrical signals, and they really get in the way of anything you can measure from the brain," says Pope.

The plan behind Musk's Neuralink technology would involve a robot, under the supervision of a neurosurgeon, implanting a 4mm-square chip into the patient's skull. This chip sends out threads finer than a human hair to various parts of the brain, recording and imparting information into the person's mind. The patient wear a device like a hearing aid hooked over their ear. At its launch, Neuralink stated the first people to receive the technology will be those with quadriplegia caused by spinal cord injuries.

SPELLING IT OUT

BCIs are already doing tremendous work for those with severe disabilities and other medical conditions. One such miraculous invention is called a P300 speller, used for patients who have locked-in syndrome, a condition where the patient becomes quadriplegic, as well as losing the ability to speak and make facial expressions. They are left with almost no way of communicating with the outside world, although their ability to think and perceive the outside world is still intact.

Pope says the P300 speller offers a way to methodically spell out messages to those in the outside world. "The common way to do it would have the letters and maybe numbers and other symbols in a grid. As you're watching this grid the first row would be highlighted, and then a bit later, the second, and a bit later, the third, and the other ones become un-highlighted as you go down. So when the row that has the letter you're after is highlighted, the P300 goes off in your brain, the system detects that, and recognises we're looking for something in the third line. It then will highlight the first column, and work its way across the columns."

In this way, the patient can spell out letters one every five or ten seconds to form a word, a sentence or a phrase to express themselves. While

Some believe that by 2060, AI could be doing most tasks humans do.

a painstakingly slow way to hold a conversation, for someone who otherwise would have no outlet for communication, these machines could be a godsend.

REACHING THE LIMITS

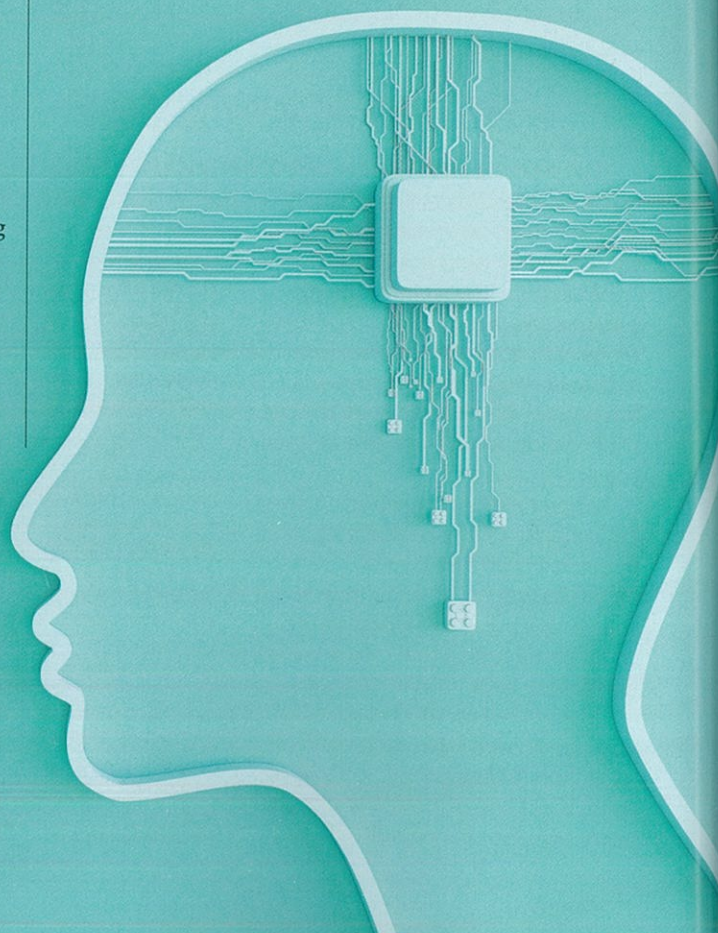
Shara Evans is a technology futurist who specialises in predicting future trends in fields such as robotics, medical technology, wearables and 3D printing. She says the field of artificial intelligence behind brain-computer interface technology has incredible potential, but we're still in the initial stages of what these machines can do. "Even though we've been working on artificial intelligence since the 1950s and over the last two years in particular we've made incredible advances, we're still in the very, very early days of AI. If I had to put even today's smartest AI on the scale and rate it next to a human being, I'd probably rate it about equivalent to a smart two-year-old."

Even then, this AI would be focussed on a narrow task rather than have a general knowledge of the world around it like a human does. BCI technology, in particular, is best at slow communication where the brain is asked to choose between two alternatives. Anything more complicated takes extra time and the answer is less certain.

HACKING THE BRAIN

Technology has the potential to tap into the brain and cure all manner of physical ailments and psychological illnesses, but should we really be messing with matters of the mind?

WORDS BY REBECCA DOUGLAS



"If you want to do something relatively straightforward that can be slow, for example someone who can't move at all attempting to communicate, to write a sentence or two, you can do that but it'll take a few minutes," says Pope. "The fundamental difficulty with BCIs at the moment is it's hard to get good, strong, confident decisions out of the brain reliably and quickly. So if you want to do something that requires reliable, fast decisions, like driving a car with your brain, I would say we're not near there yet."

Artificial intelligence has a long way to go before it can handle the complex decision-making a human goes through every day, with all the factors that affect which possibility you decide to go with in that moment.

"Psychological reason, social background, emotional state of mind at a particular point in time, your health, whether you're feeling good, whether somebody has said something five minutes ago that's upset you, all these other things come into play that impact your reaction," Evans says. "I don't think we've got that down to an algorithm that we could teach an AI how the human brain always works."

Because of the size of the collections of information an AI is often sifting through, it can be difficult to trace back how the machine has arrived at a certain result. At this stage, Evans suggests AI is best used as a tool to search through huge sets of data or analysing things the naked eye can't detect, with a human overseeing the results to ensure the computer hasn't wandered off the mark due to biases or errors in the data.

WORKING WITH AI

An example of this approach where human and machine would work in harmony in this way is in radiology, looking at an image trying to detect if a patient has cancer. The AI could detect anomalies by creating a three-dimensional model so it can analyse changes over time and see tiny defects a human might miss. The human could check the computer hasn't created a false positive. "You wouldn't want the AI to be replacing the doctor. You would want the AI to be assisting the specialist doctor or radiographer in their task so that you're getting the best of both worlds," says Evans.

What if, instead of healing the sick and assisting the disabled, we could be enhancing the abilities we were born with to become superhuman?

Fancy a flawless memory, better decision-making, or an increased ability to solve mathematical equations? Soon, this sort of upgrade might be available to us.

"The next stage is the thought that to compete with AIs and robots, we humans – all of us – are going to need to have these brain-machine chips implanted somewhere in our neocortex to connect us with whatever version of the worldwide web there is then," says Evans. "That won't be until 2030, so we are about 10 years out before this would become more commonplace."

Whether we're motivated by keeping our jobs safe from a robot replacement, vanity, or simply unlocking the potential to improve ourselves, wandering into this realm of brain enhancement raises troubling ethical conundrums. There's also a question of who we leave behind in our quest for technologically aided self-improvement, and whether upgraded soldiers might fight our wars in future.

Despite his determination to forge into this realm of discovery, Musk himself has made comments in the past warning of these dangers, and calling for greater regulatory oversight of AI technology, saying at the 2018 South by Southwest interactive media conference: "Mark my words, AI is far more dangerous than nukes."

Aside from questions surrounding how far we should take this technology, Evans says sadly security is often only an afterthought, and the devices could well be hacked, causing chaos and potentially even killing someone. "Medical devices in our bodies have already been hacked. People have hacked into insulin pumps and pacemakers and into other implanted devices. It happens. There's nothing to say somebody couldn't hack into this kind of device as well."

Another potential hiccup is the patient's brain or body rejecting the foreign object that's been inserted into it. Whether by malicious interference from a hacker or malfunction of the machine itself, what if the computer code starts issuing orders against the person's will? Could you be forced to commit murder by someone else assuming control of your mind? Your software might be commanding your limbs to pick up a gun and shoot someone while you're screaming inside your brain to stop. The ensuing battle could even drive you insane. "That would be a possibility, especially if there was an ongoing conflict

between what you wanted to do and what the chip was trying to make your body do. That could certainly cause some kind of psychosis or mental breakdown," says Evans.

Your physiology might also have a problem with being invaded by materials it recognises don't belong inside your body. Scientists are currently exploring options such as graphene, a super-strong, flexible, highly conductive material that appears to be biocompatible with our brains, and even growing nanobots out of our own DNA so they can be injected directly into the neocortex.

"There's a couple of promising directions for how we might design brain-machine interface devices that are biocompatible with the human brain so the physical device doesn't cause harm to the brain," says Evans. "We don't want to put a device in that's

A BRIEF HISTORY OF HACKING OUR BRAINS

1800s

Craniometry is used in the medical profession to determine intelligence and various other health markers by measuring a patient's skull.

1924

German psychiatrist Hans Berger records the electrical activity of the human brain using electroencephalography (EEG) technology.

1962

Joseph Altman, a scientist from MIT, discovers our brains continue to form new nerve cells into adulthood.

1970s

Scientists learn about the functioning of the human brain from CT scans, pet scans, and MRIs.

1980s

The cochlear hearing aid becomes the first widely adopted implantable brain device.

2001

The Human Genome Project maps our genes, paving the way for the simple blood test now available to detect certain hereditary neurological disorders.

2019

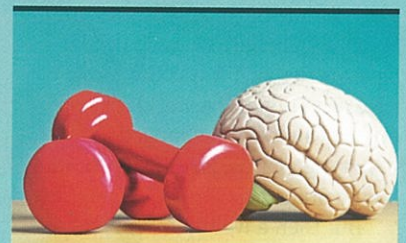
Elon Musk's company, Neuralink, announces plans to conduct human trials of brain-computer interface technology.

"ALL OF US ARE GOING TO NEED BRAIN-MACHINE CHIPS IMPLANTED IN OUR NEOCORTEX."

SHARA EVANS

going to cause all kinds of scar reactions and autoimmune reactions where your brain rejects the device and you end up with more problems than when you started."

Overall, connecting bits and bytes to the brain has wonderful potential to go even further in assisting those with disabilities. Yet we might want to wait a while before extending the technology to improving ourselves without properly thinking through the implications to our health, happiness and quality of life. **MF**



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Due to its complexity, there are many things that even doctors can't explain about the brain, and there are certainly some facts that you likely don't know about your own brain health. mindfood.com/brain-health