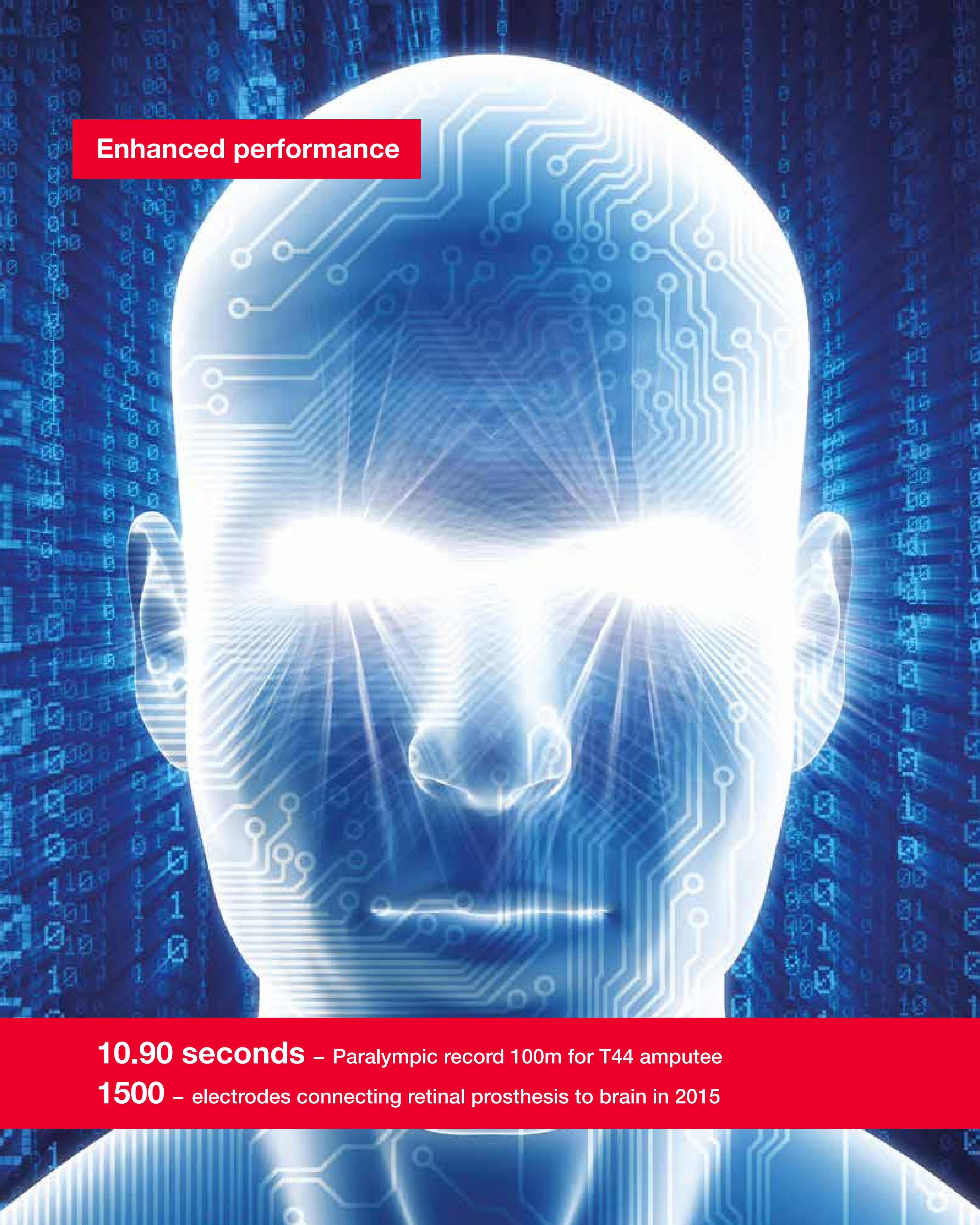
Enhanced performance



10.90 seconds – Paralympic record 100m for T44 amputee

1500 – electrodes connecting retinal prosthesis to brain in 2015

Enhanced performance

We are developing key technologies that could integrate humans and data to make us safer, more informed and potentially super-human in performance - but should we?

The idea of human enhancement is not new. For years now we have variously been seeking to improve our cognitive, emotional and physical capabilities using training, drugs or technology. What we are now seeing however is the convergence of a whole series of pharmaceutical, biological and mechanical developments from different arenas coming into view. Whether from DARPA-sponsored military programmes aimed at creating the super-soldier; medical projects looking to overcome blindness, Parkinson's or Alzheimer's; or advanced prosthetics aiming to replace functionality of limbs and organs lost in accidents or on the battlefield, a host of proven technologies are passing out of the R&D lab and getting ready to enter the mainstream. Some will take decades to gain widespread acceptance but others are just around the corner.

Within the world of enhanced performance, many people are now aware of cognitive enhancing drugs, hearing aids and retinal implants that improve our senses, and even bionic limbs that restore mobility. Most of these have been developed to bring the disabled and the injured back towards full functionality, but many are now being used to take us that little bit further towards supra-human performance - more Iron Man or Batman than Superman. Technology is being used on, within and around the body that can take our eyesight, hearing, memory, stamina, pain thresholds and even cognition beyond the norm. We will work longer, both in years and hours; work harder and operate in more hostile environments; but also work smarter, accessing and using our own and others knowledge and skills more effectively. While they have emerged from a number of areas including neuroscience, computing, engineering and biotechnology, the issues that are now being raised by their further evolution are touching the political, social, ethical and regulatory worlds.

Developments in neuroscience and pharmacology have led to a host of drugs that used to treat patients with neurological and neuropsychiatric disorders but are now being trialled with healthy people to enable them to perform with enhanced cognition. Cognitive enhancers now in common use (e.g. methylphenidate, atomoxetine and modafinil) variously increase alertness, prevent sleep, overcome jetlag, improve productivity and raise motivation. Add on integrated implants and wireless-data connectivity, and we enter the world of brain stimulation via both invasive and non-invasive trans-cranial technologies.

Advances in molecular biology, neurology and material science are all leading to implants that will be smaller, smarter, more stable and energy efficient. For example, the Wellcome Trust in the UK is trailing a silicon chip that sits directly on the brain of Alzheimer's patients, stimulating them and warning of imminent episodes. Scientists and Brown University's BrainGate programme are experimenting with using implants to translate thoughts into actions for people with neurological impairments, inserting a small chip with 100 needle-like wires into the part of the neocortex that controls movement, feeding signals to external robotic devices. The same technology, it is argued, could be used to allow people to control machines and devices outside the body through thought alone.

Implants that will be smaller, smarter, more stable and energy efficient.

While in the past we have created add-on devices such as hearing aids, cochlear implants, glasses, infrared goggles and prosthetics in a bid to correct or improve our physical capabilities, recent advances in bioengineering, microelectronics and computing are all moving the art of the possible forward. Bionic limbs and exoskeletons developed by DARPA for the US military have not only enabled injured soldiers to regain functionality but also provide better-than-human performance. Most significantly wearable is becoming implantable. Outside the research labs, amateurs are bio-hacking their bodies. Starting a decade ago with the insertion of RFID tags between fingers and electromagnets into fingertips, data is now being generated, accessed and manipulated by humans. DIY cyborgs are upgrading their bodies without waiting for corporate bodes or authorities to say okay.

As well as providing enhanced cognition, the US military is looking at how similar approaches can be used to diminish sensitivity to pain and tiredness. While the Geneva and Hague conventions prohibit the use of torture, ethical questions are being raised about what you do with enhanced soldiers who feel little pain and don't need sleep or food. As we change human biology and seek to create a super soldier, some are asking whether we will have to change the laws of war.

Most significantly wearable is becoming implantable.

Retinal implants are another area of fast change. We are no longer talking about blurred black and white images but sharp, full colour and even high-resolution video. US firm Second Sight gained FDA approval back in 2013 for a bionic eye implant that wirelessly feeds data from a digital camera to a chip implanted on the retina that decodes the data into human vision. Over the next decade researchers expect to develop retinal chips that enable seeing in the dark. There are clearly risks when matching hard technology to soft tissue and brain-cells – from infection to toxicity – and therefore to date a lot of focus has been on external or replaceable technologies. Going forward however the material constraints of metal and silicon are being overcome.

Tissue engineering and stem cell research has already allowed us to grow and replace simple organ parts and tissue such as found in joints. Regeneration of body parts is happening in the lab and moving into medical facilities; 3D printing of biological tissue is allowing us to redesign nature. The ability to grow a whole organ means that we can start to design in the functionality we want rather than that others are born with. While the growth of cosmetic surgery and laser eye surgery has changed social perceptions about external physical enhancement, how the options for internal enhancement plays out will be more down to regulation and medical ethics.

3D printing of biological tissue is allowing us to redesign nature.

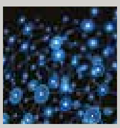
It used to be that enhanced performance was down to education and fitness - to add nurture to what nature had provided. With the advances that have been made to restore natural capabilities to those born with, developed or acquired disability, it is clear that we are able to give many more a longer and more productive life. However, as we push the boundaries of what is natural and deploy the same technologies on the able-bodied to enter the world of cyborgs and super-humans, it is clear that science fiction is fast becoming fact. How far we go in the next decade will inevitably depend a lot on the development of technology and clinical practice; however it may just as much be moderated by ethics, regulation and a view of what society will accept.

Related insights

Affordable healthcare

The escalating cost of healthcare is further stressed by the need to support the old and the chronically ill. Spending 20% of GDP on healthcare is seen as unsustainable so hard decisions are taken around budgets and priorities.

Everything connected



Over 1 trillion sensors are connected to multiple networks: everything that can benefit from a connection has one. We deliver 10,000x more data 100x more effectively but are concerned about the security of the information that flows.

Ethical machines

Automation spreads beyond trading and managing systemic risk. As we approach technology singularity, autonomous robots and smarter algorithms make ethical judgments that impact life or death.

Working longer

People are having to work for to support longer retirements. Flexible working practices and policies are emerging, but some employers continue to remain ambivalent about older workers.