The science, drugs and tech pushing our brains to new limits

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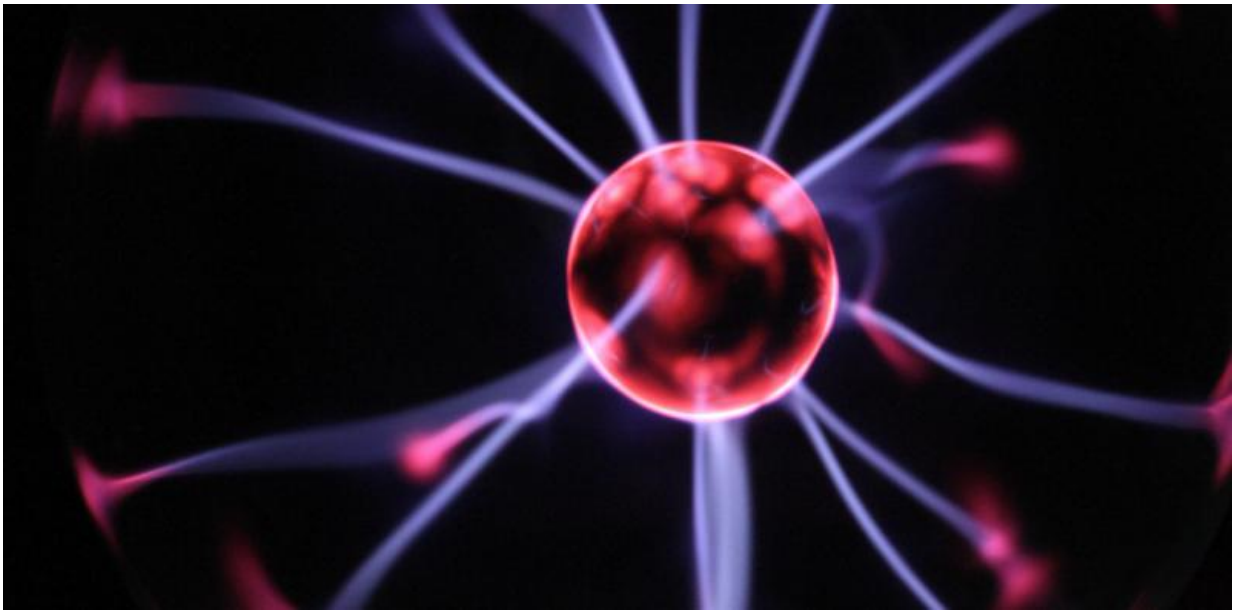

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A recent explosion of neuroscience techniques is driving substantial advances in our understanding of the brain. Combined with developments in engineering, machine learning and computing this flowering has helped us enhance our cognitive abilities and potential. In fact, new research into the extraordinary machine in our skulls is helping us keep pace with the rapid rise of artificial intelligence.

Exciting new advances are everywhere, but worth putting front and centre are findings made in the relatively new area of social neuroscience. Research by Molly Crockett at Oxford University has demonstrated how we might influence the social brain and examine the effects of neurotransmitters, such as serotonin, and hormones, such as oxytocin, on social cognition and social interactions. This includes the most fundamental aspects of our daily lives: trust, punishment, moral judgement, conformity and empathy.

Crockett and colleagues used experiments looking at cooperation, and moral dilemmas such as the "trolley problem" where participants must decide who to save from an onrushing railway cart (a similar puzzle was posed in the 2015 Helen Mirren film Eye in the Sky). Among their findings was evidence that serotonin increased an aversion to harming others. This clearly suggests that this brain chemical can promote positive social behaviour.

Recently developed computerised tests, such as EMOTICOM, which assesses a range of cognitive functions, will also make it easier to combine state-of-the-art neuroscience techniques with objective measurement of social and emotional concepts.

Shared knowledge

One amazing feat of combined neuroscience, engineering and computing was achieved by Edda Bilek, Andreas Myer-Lindenberg and colleagues from the Mannheim Central Institute of Mental Health in Germany. They invented a way to study information flow between human pairs during real-time social interaction, using functional magnetic resonance imaging (fMRI), which measures changes in blood flow in the brain. They were particularly interested in studying joint attention because it arises in early development and is important for social learning.

Their study allowed immersive, audio-visual interaction of two people in linked fMRI scanners, and identified the flow of information between the sender's and receiver's temporoparietal junction, a key brain region for social interaction. Not only did the study show that specific social brain systems are drivers of interaction in humans, it demonstrated the strength of integrated research across biological and physical sciences.

In future, this will allow us to study in real time the neural networks involved in other forms of joint social interaction, such as defeat, trust and mutual attraction.

Rapid development of these fMRI techniques, and of neuroimaging, will continue to transform the field of neuroscience. Experiments have tackled topics such as unconscious racial bias, "mind reading" and lying. It is work which helps to pull back the curtain on our understanding of the human mind – and might make us wonder if this glimpse into our thoughts crosses an ethical line in terms of privacy and profiling.

To see the power of fMRI techniques, look to the futuristic experiments by Jack Gallant and colleagues at the University of California. They have developed a method for reconstructing movie segments that a person is watching purely based on fMRI recordings, which track brain activation patterns. More recently, the Gallant laboratory mapped the semantic atlas of the brain. These semantic networks are a sum of our verbal knowledge and how we understand the relationship between words and concepts.

The drugs might work

Outside of the lab and academia, there is an increasing use of so-called lifestyle drugs to enhance cognition, creativity and motivation in the workplace. Drugs such as modafinil, which has effects on noradrenaline, dopamine and GABA/glutamate in the brain, can boost cognitive

functions, especially in flexibility of thinking and complex planning.

Such drugs are used to seek a competitive edge at university or work. The Care Quality Commission reported that over a six-year period from 2007 to 2013, there had been a 56% rise in prescriptions for methylphenidate in the UK. London City workers and traders use them to stay awake and alert for long periods of time. German workers use them in jobs where small mistakes might have large consequences. American academics travelling to international meetings use them to counteract jet lag.

Modafinil has been known to reduce accidents in shift workers, thereby increasing safety. In a similar fashion, aniracetam is used by Silicon Valley entrepreneurs to boost cognition. One of the original drugs in the same class is piracetam, which increases brain metabolism, while aniracetam has been shown to modulate the receptors in the brain that are thought to enhance cognition.

In parallel, there is a boom in demand for nootropics. These "microdosed" psychdedelics are increasingly a phenomenon in which small amounts of psilocybin mushrooms, LSD or mescaline are taken to enhance perception and creativity. Cognitive processes, including attention, learning and memory, have also been targeted through evidence-based games such as the brain training programme and the Wizard memory game developed by University of Cambridge and Peak. These academia-industry collaborations help to translate neuroscience discoveries into the real world.

AI, AI, Go

At present, the magnificent human brain is superior to artificial intelligence (AI). Computers have to dedicate themselves to playing chess or Go in order to beat us humans. In contrast, we can play chess or

Go or perform many other activities and behaviours, often multi-tasking, and we can create new ideas and inventions. We are also social beings and our social and emotional cognition allows us to have "theory of mind". In other words we can understand and empathise with the thoughts and emotions of others.

However, with the rapid advances in machine learning and computing technology – including face and voice recognition – the potential for artificial intelligence may be limitless. By contrast, there will likely remain limits to the extent to which we can enhance human intelligence.

Nonetheless, the amazing achievements made by basic and clinical neuroscientists will not only help us understand the healthy brain but also improve brain health for everyone, including those with neuropsychiatric disorders, such as Alzheimer's disease, and brain injury.

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