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The Promise and Peril of Emerging Technology for Brain Enhancement

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Abstract

Today's emerging technologies provide possibilities for radical therapy for human diseases and disabilities, as well as radical enhancement and alteration of human abilities. This article discusses both the positive and negative possibilities of three current emerging technologies for therapy and bioenhancement—brain-computer interfaces, prosthetic memory, and transcranial direct current stimulation—as well as fictional narratives that prefigure these innovations. The author argues that the particular dangers of current radical emerging technologies that could enhance brain processing speed, alter or enhance memory, and affect mental states are prefigured by fictional stories that anticipate these real innovations.

Keywords: *Emerging technologies; BCI; tDCS; Prosthetic memory; Science fiction*

Introduction

Most journal articles about the implications of emerging technology generally focus on theory, but I am going to focus in this paper more on the practical and applied implications of emerging technology, and of its literary instantiations. I also want to preface this article by making it clear that I think that our emerging technology has done some amazing and good things, as my examples will show, and that I am in favor of its continued development. However, I am also in favor of its *careful* development. Right now, there is not much regulation of developing technologies, and as a result the development of emerging technologies is haphazard and uncontrolled. Consequently, some very dangerous things are happening, as my examples will *also* show.

A number of fictional accounts that I will discuss later, such as the film *Total Recall,* have been made about the possibility of enhancing the human brain through various scientific means. These older fictional imaginings are now in the process of being realized via pharmaceutical, genetic, and technological means. In this article, I'm going to discuss two particularly new digital methods for brain enhancement and a relatively new way of using electric current to enhance the brain. The digital techniques are "Neural Lace," a type of Brain-Computer Interface (BCI) ultimately meant to speed up human cognition and communication, and a "prosthetic memory" that is being developed by a team at the University of Southern California. The technique of using electricity to enhance brain activity is called "transcranial direct current stimulation" (tDCS), which is the non-invasive passing of a weak electric current across the brain via the scalp; this relatively recent technique has been shown in clinical studies to enhance memory, attention, and certain motor skills. It has also been shown to help with depression. I will also discuss how these emerging technologies are

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prefigured in fiction, and how such fiction foreshadows some of the downsides of this kind of technology.

Neural Lace: a new type of Brain-Computer Interface

Neuralink, a company founded by Elon Musk about five years ago, is the most notable of several companies developing a new type of Brain-Computer Interface (BCI)—notable because of its ambitions. Neuralink aims to create a wireless implement not only for helping patients recover from injury and disease, but also to *enhance* humans—to give them superhuman abilities, such as thinking as fast as computers, and communicating telepathically. Neuralink's plan is to make what is essentially a Wi-Fi antenna for the brain: specifically, a direct, two-way, digital system that would be robust, compact, and wireless, and that can be easily inserted in the brain, where it will incorporate itself with the neurons; from there, it will be able to communicate via Wi-Fi with external computers, the Web, and so forth. They already have a prototype for this that I will discuss below. But first, some general information about BCI. BCI is already being used therapeutically to allow paralyzed people to control their artificial limbs and to help those who, like the late astrophysicist Stephen Hawking, cannot communicate physically. It is also being used to reduce seizures in severe epileptics, resolve tremors in Parkinson's patients, and to stabilize mood disorders in psychiatric patients. But the devices used to do this are bulky and hardwired, causing difficulty of use for patients and requiring invasive surgeries and large incisions in the skull to implant them. So, researchers have been trying to make these devices more compact, easier to implant, and wireless.

There are a number of companies working on improving BCI, such as Kernel and Synchron, but Musk's company is receiving the greatest share of publicity. A big reason for this, besides Musk's own notoriety, is the radical nature of Musk's goals. He has stated that his long-term aim for such devices goes beyond current therapeutic uses of BCI; he wants to use it to enhance the human brain in order to make it competitive with AI, especially in the workplace, and perhaps eventually to allow the merging of humans with AI (Knapp, 2019). This is because he sees AI as an existential threat to humanity, particularly in the realm of jobs, and sees neural lace as something that could make humans able to compete with ever more powerful AI (which is ironic, given his financial support of OpenAI and the attendant dangers of its product, ChatGPT). As he says, using neural lace in a bi-directional manner with computers "could make us smarter, improve our memory, help with decision-making and eventually provide an extension of the human mind" (Marsh, 2018). It could also allow us to communicate, he believes, at lightning speed with each other via a form of wireless communication similar to telepathy. The sociocultural implications of all this is interesting, as I will discuss later.

In 2021, Neuralink successfully implanted a monkey with a version of the BCI transmitter and then used that to have an AI learn from the monkey's brain input how to successfully play the old video game Pong. Eventually, the monkey could play the game just by *thinking* about his hand movements, with the machine making moves based on what it had learned of the monkey's brain patterns (Shead, 2021).

A Literary Prefiguration of BCI

A notable fictional prefiguration of BCI is Philip K. Dick's novel *Do Androids Dream of Electric Sheep?*, originally published in 1968 and known more famously by the name of its film version, *Blade Runner* (1982). In the novel, there are two notable forms of BCI: a machine called a Mood Organ, and another called the Empathy Box. The Mood Organ is a machine that characters in the story use to instantiate emotions in themselves. If they want to experience happiness, for instance, they simply dial in a particular number and the machine instills that feeling. The Empathy Box is for a much more specific purpose—the instantiation of a feeling of empathy and thus connection to fellow humans in general. It is what we would now call a virtual reality game. People in the story use it when they feel lonely and destitute, partly because there are few people left on earth to befriend, and partly because people have trouble being friendly. To use it, one grabs hold of two handles and the machine jacks the person into a virtual world by a sort of brain-machine interface; the machine puts the person into a sort of trance that causes a 3-dimensional experience that elicits empathy with a vague personage in the game known as Mercer, a humanoid who is cloaked in a sort of hooded robe. This happens when the gamer shares the sensory experience with this personage as he tries to ascend a steep, rocky slope while stones rain down on him from outside of his perceptual field—presumably thrown by anonymous people who are watching him. The scenario in this virtual experience—a simultaneous echo of the Greek myth of Sisyphus and of the suffering of Christ carrying his cross to Golgotha—shows us how Dick sees technology as a means of alienation of humans from each other, as a means of attenuating human interconnections rather than solidifying it. It also reflects badly on Musk's ambitions for a technology-based human telepathy, as the telepathic connection established via the fictitious technology here is dystopian.

Prosthetic Memory

I will come back to Dick's story and its implications shortly, but first I want to talk about prosthetic memory. A related cognitive enhancement to neural lace has been developed by a team at the University of Southern California led by Theodore Berger: a prosthetic digital memory that can be implanted in the brain. It holds the possibility not only to replenish lost memories for those who have memory problems, such as Alzheimer's patients, but also to artificially enhance the memories of healthy people. Berger and his team have had successes with long-term memory re-generation (and generation) by using implanted chips to replace damaged parts of the hippocampus in rats, monkeys and, more recently, in humans.

The way this device works is that a chip containing a biomimetic program mathematically simulates or enhances the actions that the damaged hippocampus would have performed when transforming a short-term memory into a long-term one. Aimed at therapy for dementia, strokes and other causes of memory loss, this technology has been under development by Berger and his team for about the last ten years, and is now backed by a corporation called Kernel, which is trying to commercialize it. The upside of such technology for those suffering from memory impairment is clear. However, there is reason to be careful about developing it because there are some indications that it could be used for negative purposes—to implant false memories, for instance. In the studies with rats, Berger's team found that individual rats' brains used codes common to all rats to form some types of memories. Although testing with humans and apes has been limited so far, if there is what the team terms "a generalized memory code" for those species too, then the possibility for using this technology to implant false memories is significant (Strickland, 2016).

Other developments with emerging technology for the brain reinforce this possibility. In 2013, MIT neuroscientists Steve Ramirez and Xu Liu were able to manipulate brain cells in a mouse to give it a false memory—that is, a memory about something it had never experienced (Gibbens, 2018). Similarly, another scientist at the University of Toronto, Sheena Josselyn, was able to selectively eliminate a memory in a mouse, by making the specific cells that memory occupied susceptible to a certain toxin (Gibbens). The hope of all these scientists is that the ability to implant or delete specific memories will benefit those who have been mentally traumatized, such as "those suffering from PTSD or depression" who "could have their memories altered…so that they don't have a strong emotional response to painful recollections" (Gibbens). However, the negative, even dystopian possibilities of this ability to manipulate memory are also clear: creating false memories or deleting memories represents the chance that people's privacy and personal integrity could be threatened. To illustrate this let us look at the dangers of this that have appeared in fiction.

Prosthetic Memory in Fiction

The social and ethical implications of technology that allows manipulation of human memories are illustrated in another Philip K. Dick story: the 1966 short story "We Can Remember it for You Wholesale" (Dick, 2002), made into a movie in 1990 titled *Total Recall*, starring Arnold Schwarzenegger. In that movie, the main character, Daniel Quaid, accidentally finds out that everything he remembers—basically, his whole past life—is a false memory that has been implanted in his brain by a technological procedure somewhat like those discussed above. Eventually, Quaid finds out that the people who have implanted those memories did it to benefit themselves, and now that he has discovered their plot, his life is in danger. This narrative laid out in the movie and the short story touches on questions of how our memories are tied to our sense of self and on how their manipulation affects our sense of privacy and agency. It also implicitly comments on how readily we get seduced into using potentially invasive technology that can have significant consequences, especially if we cede too much of our own agency to it. These same issues come up with regard to the current emerging technology I have been discussing, making these stories—mostly from the 20th century—predictive. In both real-life cases and in the case of Dick's story, we can see that memory implantation or deletion can alter the sense of what people think they have experienced, and therefore who they conceive themselves to be.

Transcranial Direct Current Stimulation (tDCS)

Transcranial Direct Current Stimulation (tDCS) is a non-invasive technique for enhancing various brain functions by passing a very weak electric current through the scalp and into the brain, usually by way of a cap containing electrodes. These currents are only about 2 milliamperes (2mA) in strength, about the strength of a large flashlight battery. The only side effect that most people experience is a slight tingling sensation across the scalp. In fact, an advantage of tDCS is that this technique rarely has any negative side effects—at least so far; however, there is much that is still unknown about the long-term effects of tDCS, as I will discuss below. This technique of neuromodulation has been investigated since the 1990's but has been most intensely explored over approximately the last decade, 2010 to 2023. The most salient result of work with tDCS has been increased memory in human subjects (Grafman et al., 1994; Nitsche et al., 2003; Dockery et al., 2009; McKendrick et al., 2015).

More recent studies have focused on which specific areas in the brain yield the best results for increasing memory for particular purposes: for instance, some studies found that stimulating the dorso-lateral prefrontal cortex (or DLPFC, near the front of the head) boosted memory for complex tasks like learning how to fly a plane (Choe et al., 2016). Other studies found that stimulating the temporal lobes (just around the ears) improved verbal memory (Kuczewiz et al., 2018); while still others have found that stimulating the DLPFC also caused a significant increase in long-term memory, while energizing the parietal lobe (near the middle-top of the head) increased short term memory perhaps better than stimulating the DLPFC (Grover et al. 2022).

The memory gains in all kinds of circumstances have been significant enough to cause scientists to see tDCS as a significant potential treatment for memory loss that comes with age or dementia. The recent study by scientists at Boston University mentioned above (Grover et al. 2022) showed that elderly patients treated with tDCS for about 20 minutes at a time over four days experienced a 50-65% improvement in memory, and that this effect lasted at least a month. Dr. Gregory Worrell, a neurologist at the Mayo Clinic who heard of these results, noted that they are highly significant, even "quite remarkable" (Lovelace).

In addition to these huge gains in memory, tDCS has also been shown to be effective for increasing attention to a task (Choe et al., 2016), treating depression (Jog, et al., 2023), management of chronic pain (Pinto et al., 2018), rehabilitating physical movement in stroke victims (Schlaug et al., 2008), and for reducing cravings and improving outcomes in addiction treatment (Kooteh et al., 2020).

But although in virtually all of these clinical studies there were no discernible side effects, there has been concern that not enough work has been done to determine if negative side effects exist—particularly over the long term. For example, how often over a long period can a person inject electricity into the brain, even a weak amount, before harm is caused? At what amperage does it become dangerous? There have already been injuries suffered by people trying to do tDCS at home (scalp burns, brain injuries from using too strong a current), which have happened because the basic technique is so simple: at minimum, all you need to do tDCS at home is a couple of sponges wetted with salt water attached to your head with a headband, and a large flashlight battery with two wires attached to the sponges. One can buy these things easily at a hardware store for a few dollars. How do we regulate that? Indeed, the difficulty of regulating this is evident if one just does a quick online search for "tDCS kits." The results show numerous kits being sold online for home use. And there are ethical issues to think about here as well. For instance, as with other brain enhancements, there is the issue that if people begin to enhance their memory and attention span and motor skills with tDCS, others will be left behind, or they will feel compelled to also use tDCS too, even if they are worried about doing it.

A small example of how this might happen is illustrated by what happened when I discussed the results of tDCS research with my university classes. My students were very impressed by the significant increases in memory and attention caused by its use. They immediately mentioned that this would be great for studying. In fact, many said they were eager to try doing this at home, even after we discussed the unknown long-term effects and possibly undiscovered downsides of this relatively new technology. Some of them immediately did internet searches to find do-it-yourself kits for doing tDCS. Would this be an easy form of "cheating" by using brain enhancement to improve one's memorization by 50-65%, as in the experiments I have cited above? Would it coerce other students to risk harm to themselves to keep up?

A literary example related to tDCS

There are not many stories in which the use of simple electricity affords cognitive enhancement, but there is one that provides a sort of analogue. The story of *Frankenstein* springs to mind because the movie version of Shelley's story makes prominent use of electricity—but to enliven the creature, rather than to enhance its intelligence. In Shelley's story itself, electricity is an implied cause of cognitive enhancement—a phenomenon we will return to. First, we need to note that electricity is explicitly mentioned in just two places as an implied factor in Victor Frankenstein's making of his creature. The first of these is in Shelley's introduction to the book's second edition, where she herself discusses how Galvanism influenced her conception of Frankenstein's enlivening of his creature.

She says that, in her discussions late at night with Percy Bysshe Shelley and Lord Byron, they had touched on Luigi Galvani's experiments with using electricity to make dead animals move. As she says, "Perhaps a corpse would be reanimated; galvanism had given tokens of such things: perhaps the component parts of a creature might be manufactured, brought together, and endued with vital warmth" (5).

The second place in the novel where electricity is implicitly mentioned as integral to the creature's birth is at the point in the story where Frankenstein witnesses the power of lightning. When a tree in his family's yard gets hit by lightning, he notes that it changes the whole course of his studies. The intimate brush with electricity shifts his attention from the ancient writings of Paracelsus and Agrippa (who both claimed to be able to use alchemy to create small humans called homunculi) to the more modern science of Shelley's day. Victor particularly mentions experiments in Galvanism (Shelley 40). Frankenstein's experiments with electricity do not end well: in the 1931 film, his monster rampages through his community; in the book, the implied use of electricity does have the effect of cognitive enhancement, which does not end well either. The enhancements that Frankenstein gives the creature not only cause superhuman strength, but also superhuman intelligence, which it unfortunately uses to plot its maker's downfall.

Conclusion: the stories reflect poor human judgement about scientific advances

Overall, the stories we have looked at anticipate not only some revolutionary technological human enhancements, but they also warn against mankind's poor collective judgement regarding their use. They all pointedly imply that we will become victims of our own ingenuity because we will fail to regulate our ambitions; we will allow ourselves to believe that just because we can create an innovation, we should. Moreover, the stories show that we will fail to anticipate and to regulate problems stemming from our inventiveness. Arguably, the innovations I have been discussing enact rather accurately the anticipatory worries of the fictional stories we have looked at.

We can see this more easily if, keeping in mind our examination of the fictional stories already presented, we review the ethical problems inherent in the real innovations discussed above. First, I will quickly outline the ethical concerns projects such as Musk's BCI project, tDCS, and Berger's (and Kernel's) prosthetic memory raise, and then delve more deeply into the details. The chief questions that projects such as these raises are those of safety, distributive justice, privacy, and human autonomy and agency—many of which questions arise with any effort to use advanced technology to provide a transcendence of our species' limits. To be more specific about this list of ethical issues, the questions here are: First, how closely is safety being monitored, given the speed of these developments? Second, will the benefits of any enhancements be evenly distributed through society, or will they be reserved just for the rich? How would fair distribution be done, and who would pay for the distribution of benefits to people other than the wealthy? Also, and not least in importance: If our thoughts become easily transmittable digitally (as Musk envisions), what does that mean for the privacy of those thoughts?

Furthermore, a profoundly disturbing question scratches at the door of possibility: If our brain is connected with the Internet or other networks, wouldn't it be theoretically possible in the future to hack people's digitally connected brains?

What about the issue of coercion? As others, such as Adam Briggles in his edited collection *A Rich Bioethics* (2010) have pointed out regarding human enhancement, if some people choose to use implantable BCI, for instance, to make themselves more competitive with machines, then they also become better competitors with other humans for jobs, as well as for other pursuits. Consequently, others will feel compelled (coerced) to get the implants too, whether or not they really want them.

Ultimately, personal privacy and autonomy remain big issues, because the basis of neural lace is that a Wi-Fi antenna implanted in a subject's brain would have technology connected to it to allow two-way translation—from brain waves to code, and from computer code to brain waves. This would eventually crack the digital-brain barrier as part of the process of providing the sort of telepathy that Musk, among others, hopes for. In other words, such technology as he envisions entails making a subject's brain data directly accessible via digital devices, and that in turn causes even greater risks for privacy and personal autonomy than already exist today. One's most personal data—what is going on in the brain—would increasingly become mere tools for use by entities such as corporations and governments, threatening individual privacy and autonomy to an unprecedented degree. As all of these stories indicate, we cannot afford to let this and the other ethically threatening issues grow unchecked.

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