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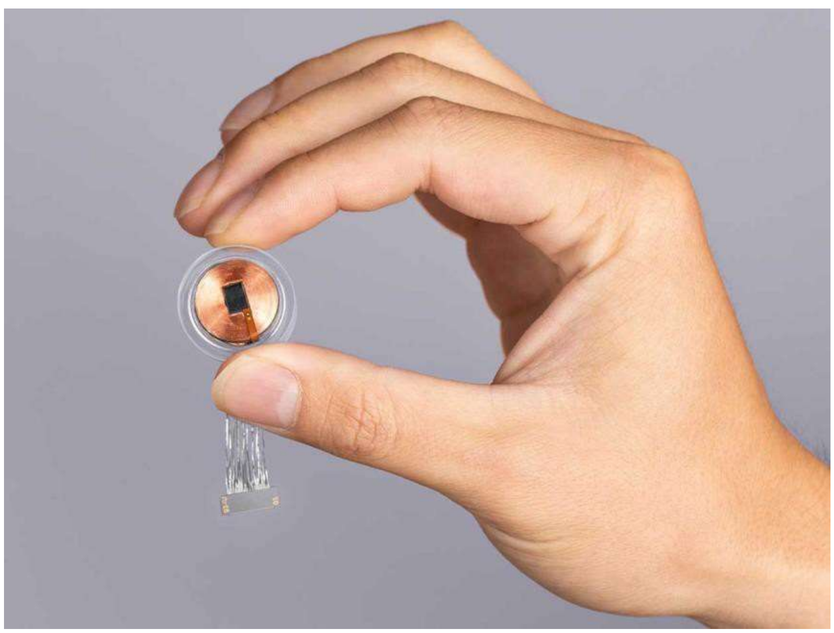
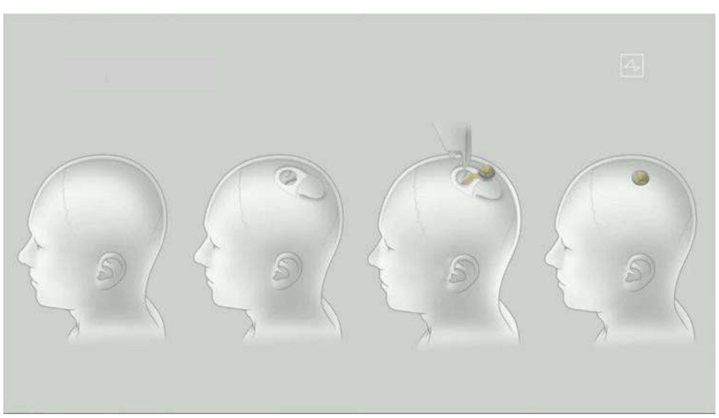
Just a couple months ago, Elon Musk, the CEO of Tesla, SpaceX, and now Neuralink, debuted his enhanced design of the Neuralink, a wireless brain implant the size of a coin, which he plans to use to ultimately facilitate the achievement of a state of symbiosis between humans and artificial intelligence. Specifically, Musk envisions a world where we can control technology with our minds by connecting the neurons of our brains to the Neuralink and hence, digitally to computers. However, for right now, Musk is focusing on more pertinent medical applications in treating epilepsy, Parkinson’s disease, and paralysis. According to Science Focus, “At the launch, Neuralink’s CEO Max Hodak stated that the first patients would be those with quadriplegia due to spinal cord injuries. These patients will have four chips implanted, connecting with up to 4,000 different neuron” .[1] According to Computers, Networking and Electronics Technology or CNET, the FDA granted Neuralink approval for “breakthrough device” testing in July of this year.



Much of the human brain still remains a mystery to even the most intelligent specialists in the field, but there are some things that we do know. The brain is responsible for controlling our organs’ functions, our thoughts, speech, memory, moods, actions, and the list goes on and on. Neurologists also have the brain mapped reasonably well, so they can pin movements and actions to particular regions of the brain. But, most importantly in understanding the science behind Musk’s new technology is the fact that everything that happens in the brain is governed by electrical signals that are relayed from one neuron to another through action potentials that travel down the neuron’s axon.

You may be wondering how exactly this micro-sized brain chip works. Well, simply put, the micro-sized wires of the Neuralink chip have multiple electrodes on their tips that allow them to record electrical signals that are fired between the brain’s neurons and transmit information to the chip to instruct external technology wirelessly through Bluetooth. According to Antonio Regalado, the speed and pattern of these signals are a basis for movement, thoughts, and memories.[3] By being able to record and read these brain signals, the Neuralink can act on that specific sequence of signals. For example, if your brain’s neurons fire a specific sequence of signals telling your hand to press a button to turn on your phone’s screen, these same signals can be read by the Neuralink and the Neuralink will turn the phone on for you without you having to lift a finger. In a sense, our brain’s activity is a code that Neuralink deciphers and acts on, on our behalf. Applications like these would be especially beneficial for people who are paralyzed and cannot perform these tasks on their own, but it would also eventually enable the human-technology symbiosis that Musk is determined to achieve. “If you can sense what people want to do with their limbs, you can do a second implant where the spinal injury occurred and create a neural shunt. I’m confident in the long term it’ll be possible to restore somebody’s full body motion."[5] Equally as fascinating is the fact that the wires of Neuralink are designed to communicate back to the brain, with computer-generated signals of their own. Each Neuralink chip is able to connect to 1,000 neurons and a maximum of 10 chips can be implanted in a brain. Just for reference, there are approximately 100 billion neurons in the brain, so as you might imagine the placement of these chips is crucial in treating the area of interest in the patient's brain. Even more interesting is the fact that the wires must be within 60 microns or .06mm from each nerve or the signal will not be detected. While this necessitates cutting a small hole in the skull, the chip is so small that it is designed to sit flush with the skull's surface so that it is not noticeable.

Although the technology behind Neuralink is not new, there are some things about the device's design that excite neurologists. Science Force explains that Neuralink's wires are thinner than a human hair and that these wires are what connect the neurons of the brain to Neuralink's 4-millimeter chip. Neuralink is implanted by the, "sewing machine," a term coined by Musk himself,referring to the surgery robot that he built for the sole purpose of implanting the ultrafine, flexible threads of his device into areas of interest in the brain with pure precision. The robot even avoids blood vessels in order to minimize any inflammatory response. Musk sees this procedure as being as simple as LASIK eye surgery in the future and would like to be able to eliminate the need for general anesthesia. Additionally, Antonio Regalado states that the link's design allows its user to charge it wirelessly through the skin at night and its small size makes it easier to remove and replace with a newer version as the technology improves.[3] In addition to this microengineering and surgical feat, Elizabeth Lopatto believes that perhaps the biggest advance is Neuralink's flexible threads which are less likely to damage the brain than the ridged spikes currently used in BrainGate, a brain-machine interface (BMI) used for quadriple- gics.[2] Specifically, the stiff needles of current BMI's are problematic for long-term functionality because the brain shifts in the skull, but the needles of the array don't, leading to damage. Lopatto explains that the thin and flexible polymers of Neuralink solvethat problem and even allow for a much higher volume of data to be collected and transferred because Neuralink's threads have more electrodes than current BMIs.



Musk boasts an endless list of benefits and applications of his medical device, but how realistic are they? He claims that eventually the Neuralink will be able to treat memory loss, hearing loss, blindness, paralysis, depression, insomnia, extreme pain, seizures, anxiety, addiction, strokes, and brain damage. According to Musk, Neuralink can measure temperature, pressure, and movement and warn you about a heart attack or stroke based on the data it collects. Musk even sees people being able to save and replay memories on demand as he states, "You could basically store your memories as a backup and restore the memories. You could potentially download them into a new body or into a robot body." Other far-fetched applications include visual prosthesis, "non-linguistic consent consensual conceptual telepathy," the elimination or minimization of pain, disease prediction and prevention, solving mental illnesses including anxiety, fear, and depression, and improving our understanding of consciousness. While these promises sound exciting or even too good to be true, it's because they are, or at least for now they are. Antonio Regalado argues that significant knowledge about what electrochemical imbalance creates each condition or disease still needs to be developed before we can attempt making these applications a reality.[3] If Neuralink is to be successful in the future, it will need to learn from preexisting BMI technologies and the challenges that they have faced in implantation and preservation. Even though the realization of these applications may be farther away than we may like them to be, they hold great potential for revolutionizing not only the way we think about the human-AI connection, but also the way in which we use technology within the medical field.

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