HUMANS AND TECHNOLOGY

With Neuralink, Elon Musk Promises Human-to-Human Telepathy. Don't Believe It.

Why the billionaire is wrong that telepathy technology will be available in a few short years.

By Antonio Regalado

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Elon Musk, seen here at Trump Tower in January, has nebulous plans to merge huma

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Billionaire entrepreneur Elon Musk, by way of blogger and cartoonis
word illustrated explainer the thinking behind his new company Neu
to directly link human minds to computers

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intelligence, says Musk.

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Musk even gives a time line. He says that within eight to 10 years healthy people could be getting brain implants as new computer interfaces.

And I say it's not going to happen.

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The problem with the post is that, despite its length, Musk does not reveal how he's going to do it. Between today's relatively crude ways of recording the brain and what Urban calls a mental "wizard's hat" is just a dotted line.

Musk is not alone in his ambitions. Last week Facebook, in its own surreal attempt to grab attention, put ex-DARPA boss Regina Dugan on stage with the claim that inside of two years the social network will have a skullcap able to transmit sentences out of your brain at a rate of 100 words per minute. In Facebook's case the cap would be meant to help you "share" your thoughts. In Musk's vision, it is actually a bunch of electrodes inside your brain to enable humans to merge with artificial intelligence. Think about how Google fills in suggestions on what you are searching for. Musk is proposing that the same kind of thing should occur in real time, inside your head.

It's not possible to assert that no future technology can make these things happen. But from what I know about brain implants, these achievements will be very difficult to attain, and the time lines are not only wrong—they're pure malarkey.

Let's deal with Musk's time line first. A brain implant is a medical device that requires neurosurgery. Proving that it works requires a stepwise series of experiments that each takes years, starting in rats or monkeys.

Here's a time line from the real world: a company called NeuroPace was started in 1997 to develop an implant that controls epileptic seizures. It actually senses a seizure coming and zaps your brain to stop it. The device got approved in 2013—16 years later. And that was for a very serious medical condition in which brain surgery is common.

Putting an implant in healthy people? That would require extraordinary evidence of safety. And that's hard to picture, because as soon as you open someone's head you put that person's life at risk. We at *MIT Technology Review* know of only one case of a healthy person getting a brain implant: a crazy stunt undertaken in Central America by a scientist trying to do research on himself. It caused life-threatening complications.

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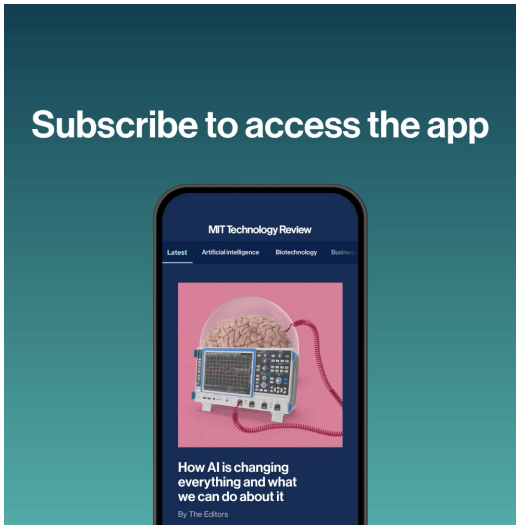
reasons. The gadget it discussed would be outside the skull, where it's much harder to pick up accurate brain

readings. Apparently, the idea is to beam photons through the skull and watch what bounces back, as it is possible to observe neural activity by measuring how cells reflect light.

In her talk, Dugan cited the work of Krishna Shenoy, a Stanford professor and part of a team that this year set a brain-typing record of 8 words a minute. But they did so only after a decade of effort and by implanting electrodes *inside* the brain of paralyzed volunteers.

"Most in the field would [ask] if non-invasive performance can even begin to approach the level of performance of implanted sensors — most would say no, and by a lot," Shenoy writes in an email. So what is Facebook even talking about? How are they possibly going to do 10 times better using a hat with lights in it? " I do not know," says Shenoy.

Again, letting people accurately think-to-text as fast as they talk *might* be possible—but only with some big advances that are unlikely to reach perfection in two years.



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In some circumstances brain-reading really does work. In 1969, when scientist Eberhard Fetz connected one neuron in a monkey's brain to a dial, the monkey learned to fire that neuron to move the dial and get a food pellet. Since then, scientists have used implants driven into the motor cortex to allow paralyzed people to move a robotic arm with substantial dexterity and, as in Shenoy's studies, to operate a computer cursor.

These devices tap into the way neurons in your motor cortex fire when you think about moving your arm or leg. It just so happens that these neurons all fire off at once when you move, but their relative speed contains vector information about your limbs. Use electrodes to record activity from a few dozen neurons and you can start to perceive the movement as a subject thinks.

So don't "diss all neurotech" and brain-reading, says Andrew Schwartz, a University of Pittsburgh scientist who helped discover the motor patterns and has hooked people up to robotic arms. However, he adds that he doesn't know what Musk and other Silicon Valley figures pursuing the technology are up to. "The idea that they know what they are after is wishful thinking on our part," says Schwartz.

Over the last couple of weeks I asked several neuroscientists and entrepreneurs about Musk. Most declined to comment because there aren't any technical details available. I got some very polite answers. Here's Gregoire

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and industry is investing resource in brain neural engineering."

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Several people said they think the great man's money and gumption may actually be what's needed to get neurotechnology out of the lab. Musk creates his advantage by tackling problems too complex for more risk-averse entrepreneurs to take on, like manufacturing electric cars (Tesla) or launching rockets (SpaceX). In both cases he also says he's pursuing a higher mission, like saving the planet from global warming or getting humanity to a back-up planet.

Brain-implant technology has been developing pretty slowly and is still mostly stuck in academia precisely because it's so complex. You need a way to record from the brain, a compact wireless chipset to transmit the signals, algorithms to know what they mean, and the medical knowledge to actually carry it off. "It's not solely reliant on just technology but also science," says Shaun Patel, a fellow in neurosurgery at Massachusetts General Hospital who researches brain-computer interfaces. "It's the execution of many facets. There is no single problem. There are many problems."

Patel told me he's enthusiastic about the possibility of human enhancement. And Musk acknowledges the most obvious point: before achieving telepathy, Neuralink will have to find a disease to treat. "Show a solution for a medical need. That is going to be a critical first step for anyone," says Patel. "But it also lets you develop the core technologies, including batteries, and the many things you need before you could imagine the futuristic idea of downloading a new skill to your brain, like being a black belt in karate. It's a foothold."

There are some indications that Musk is picking a good time to invest. The brain implant most often used—a thumbtack-size silicon device called the Utah array—is 20 years old. But recently, there's been a surge of new inventions and brain-measuring techniques, like optogenetics and schemes for recording many neurons at once in the brain. One of the co-founders of Neuralink, D.J. Seo, previously worked at the University of California, Berkeley, on a concept called "neural dust" for injecting the brain with thousands of tiny silicon motes able to record and transmit information using acoustic vibrations.

Another thing in favor of Musk's proposal is that symbiosis between brains and computers isn't fiction. Remember that person who types with brain signals? Or the paralyzed people who move robot arms? These systems work better when the computer completes people's thoughts. The subject only needs to type "bulls …" and the computer does the rest. Similarly, a robotic arm has its own smarts. It knows how to move; you just have to tell it to. So even partial signals coming out of the brain can be transformed into more complete ones. Musk's idea is that our brains could integrate with an AI in ways that we wouldn't even notice: imagine a sort of thought-completion tool.

So it's not crazy to believe there could be some very interesting brain-computer interfaces in the future. But that future is not as close at hand as Musk would have you believe. One reason is that opening a person's skull is not a trivial procedure. Another is that technology for safely recording from more than a hundred neurons at once—neural dust, neural lace, optical arrays that thread through your blood vessels—remains mostly at the blueprint stage.

So what facts am I missing? What makes it even remotely okay that Musk and Facebook are promising the public telepathy within a few short years?

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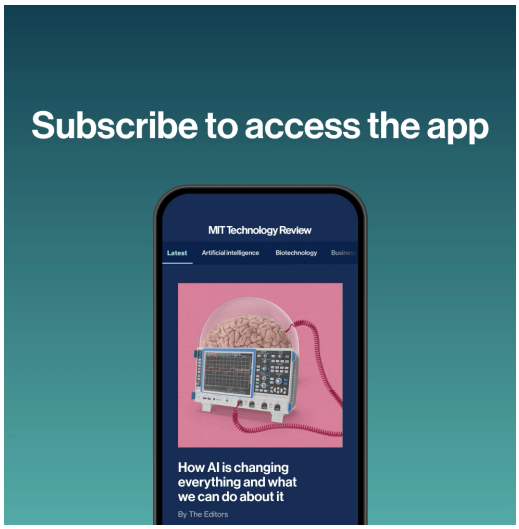

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