My hand shook as I reached for the silver switch on the little black box sitting in my lap. If everything went as planned, flipping that switch would send electricity racing up wires and through two saline-soaked sponges pressure-fitted with headbands to my skull. And hopefully through my brain. Prudence urged me to check the output of the machine at least one more time, make sure there were no missed solders, no loose or crossed wires.

The risks are low, but when a plan involves running electricity through one’s body and brain, it’s better to err on the farthest side of caution. The machine I’d built was direct current and not nearly as dangerous as the alternating current coming out of a household electrical socket. That said, there’s still the possibility that when I turned it on, the entire charge would belch up the wire all at once to dump directly onto my skin. Instead of adding IQ points, I’d have electrically branded my bad idea right onto my stupid, dumb forehead. The hand tremor was a manifestation of my lack of faith in myself.

Brain Hacking | Neuromodulation
Interest in neuromodulation is growing among researchers and do-it-yourselfers. The more we learn about the inner workings of the brain, the more scientists are focusing mental health study and research towards treating the brain like any other physical organ, rather than obscuring that fact through concerns into the nature of self. Technology now provides professionals the diagnostic tools to suss out what's wrong with a brain through physical examination, then deploy interventions informed examination and target treatment to fix the underlying problems. These same techniques could go beyond treatment, and straight to enhancement. Better our brains through the application of science.
In 2013, we spent nearly $2 billion globally on supplements like Omega-3, gingko baloba, and ginseng largely because of the claims those supplements increase thought performance. ADHD drugs, including Focalin and Concerta, contribute $13 billion to big pharma, and a good portion of those proceeds are forked over by Silicon Valley programmers and college students looking for a mental leg up. Brain-training games like Lumosity, Cognifit, and Brain Fitness Pro still rake in millions each year in spite of the fact that the science behind their claims is dubious at best.

TDCS is the newest hotness in a collective lust to get smart quick and easy. Consumer-facing products run the gamut from clearly startup up to some pretty slick designs.

The Brain Simulator is almost DIY as far as machine form factor and design. It’s a simple box with some knobs and wires, and its simplicity speaks to the baseness of the circuitry required. All-in, a 2.0 Travel Model runs about $120 to get everything needed for the first session. This requires the black box with the circuit controls, the wires running from the box, the sponges with the contact points, and a headband to hold them in place.

Halo Neuroscience, on the other hand, has an actual marketing team. Founded by Bret Wingeier and Daniel Chao in 2013, the company produces Beats-By-Dre-looking electric stimulating headphones. Prior to starting Halo, they both worked at NeuroPace, a company specializing in the manufacture of deep brain stimulators for epilepsy sufferers.
The electrodes on Halo’s tech rest in the middle of the headphone band in order to stimulate the regions of the brain that control coordination and reflexes. To train like the pros costs around $700. The slickness of the design, the high-end nature of the interface, the integration of an app is all necessary.

The US Ski Team, the Golden State Warriors, and more than a few athletes competing in last year’s Olympics are clients of Halo’s, and Wingeir has them dedicated to training better through current. Wingeier told me that athletes training with Beats-by-Halo regularly have seen up to a 14 percent performance improvement. Those kind of gains that encourage anti-doping agencies to be at the finish lines with jumper cables ready to test for athletes’ current levels. “If someone were to use our device and sit on the couch, the only thing they’d learn how to do better is sit on the couch,” he said. It’s not cheating, it’s superior training. Practice is important when using TDCS for betterment; it’s not a silver bullet to an improved you, you still have to put in the work.

The commercial TDCS market is still in its infancy, but it’s quickly gaining steam. There are twice as many companies out there as there were two years ago. For an idea of demand, consider this: The Brain Simulator, which started as a device manufactured out of a parents’ garage, Version 3.0, is now accepting pre-orders. And as for Wingeier and Halo? Last summer, Halo had sold out of their next two deliveries, and had signed a major sports team from every major american sport.

Add to that that there’s decades-worth of reputable research pointing to the fact that TDCS may actually help our brains, and in a variety of ways: new business, promising scientific research, enthusiastic hobbyist– this may be a trend.

The Center for Discovery and Innovation

Dr. Bikson’s assistant was busy placing two, two-by-two inch thick sponges into a plastic harness consisting of a horizontal strap meant to go around a head, and another, vertical half-moon strap that goes over the top. His assistant pressed down on the sponges and I could feel the saline solution–there to aid in conducting the electricity through my hair– wet my hair. One sponge was just above my left eye, the other on top of my head in between the vertical midpoint and my right ear. This montage, a fancy TDCS-world term for electrode placement, has shown promise in helping mood enhancement, treating depression, and even helping memory retention. TDCS is so exciting because there are many more montages aside from this one and each has the capacity to improve a different area, aid in another way.

Bikson’s lab at the City College of New York is on a middle floor in the centerpiece structure among a collection of all glass, modern and shiny semi-circular buildings.
The complex sits atop a hill surrounded by an iron gate and looks down. Tall grass plants dot the grounds and break up the winding paved walkways lined by sterile steel benches leading the way up from 6th Ave. The complex looked like an effort by researchers to quantify art, to systemize beauty, a scientific approach to the ineffable.

Dr. Marom Bikson is at the forefront of TDCS research. He’s a biomedical engineer who studied out of Johns Hopkins and Case Western and a serious researcher. In spite of sounding like something out of *Metropolis*, The Center for Discovery and Innovation is a serious institution.

“Our brains are electric,” Bikson told me while his assistant was setting me up with the machine. “It makes sense that we can affect change in them by introducing more electricity, we’re speaking to it in its language.”

“TDCS is often a measure of last resort, but it’s proven invaluable in helping people who’ve tried and failed every other treatment for depression, anxiety, and some cases of epilepsy.” He spoke in the precise, matter-of-fact, staccato language indicative of a person who is happily dedicated to a single, specific pursuit.

Mathematical equations littered the frosted glass walls of Bikson’s office. The biggest letters read, “Electromechanical Neuromodulation.”
Mercifully, almost 70 percent of epileptic patients can find relief through medication. Classic tranquilizers such as diazepam, lorazepam, and clonazepam are system-deadening enough to effectively quiet the electrical storms that surge through a sufferer’s head at the moment of seizure.

There are also newer drugs, drugs that still allow the user to drive a car or operate heavy machinery. For the most part, patients are able to achieve some kind of normalcy. Unfortunately there’s still 30 percent of suffers for whom big pharma can’t help.

The next, best option for these people is something called deep brain stimulation. These devices are implanted and sense the mounting mental maelstrom that precedes and intensifies during an epileptic seizure. When a storm is imminent, the device delivers a shock to specific areas and “resets” the brain into normal function.

One program of Bikson’s lab is creating software to simulate the rods on these devices, the ones that deliver significant but short-lived current into the inner recesses of a patient’s brain. The software simulates the current, resistance, and flow to test whether or not the imbedded rods will get hot enough when delivering its medicine, to burn the patient’s brain.

That’s not a worry with TDCS, its main advantage being that it is much milder than other electroceuticals. As a point of comparison, an ECT or electro-convulsive session, similar to the procedure immortalized in One Flew Over the Cuckoo’s Nest, pulses at 70 to 400 volts and 1600 milliamperes. The treatment causes convulsions so violent, so offensive, that modern application of the procedure requires the patients be under anesthesia. The TDCS charge should never exceed 2 milliamperes.

Milder or not, it’s still electricity, so I wanted Bikson to explain exactly what was about to happen to my brain. His response, “We don’t really know how the brain works, so it’s hard to say exactly what’s going on that’s making things better,” did not fill me with confidence.

Bikson reminded me that the same could be said of Prozac, Lexapro, or Lithium, common popular drugs that have been used for decades to treat depression. We still don’t know exactly how the chemicals affect our bodies, in the short or the long term. There are theories, but testing those theories would require the type of ethically dubious methods reserved for mad scientists and criminals.

We know the resting power of an individual neuron, the cell that makes up our brains, is around 70 millivolts, or .07 volts. Even something as small as 9 volts will put a neuron into a heightened state, or what Bikson referred to as hyper plasticity, a flow state.
In this state, the action potential, or the neuron-to-neuron communication process, is readied, but not fired. Action potential fires and the neuron releases neurotransmitters: a little serotonin here, dash of dopamine there, and just a pinch of adrenaline, and we’re getting sleepy. There are at least 100 different neurotransmitters, and millions of potential outcomes. Researchers are just starting to understand how it all may work, but for some reason, some combinations go on to be a thought, others a movement, others a series of learned responses.

The 9 volts of TDCS travels from the anode (positive contact point), through the brain, to the cathode (negative contact point), washing over any neurons along that path. In ECT the sheer volume of current sends the neurons straight into action potential; all neurochemicals, all the time. ECT resets the brain, reboots it to get things working in the right direction. The uncertainty that comes with a flooding of all possible outcomes prevents any sort of targeted control or intentional result. Bikson explained that TDCS pushes neurons right up to the edge but not over; this is the big difference, this allows for targeted intervention.

At the end of a session, the neurons are primed and ready for some of that action potential, hyperplastic and ready to shoot off in whatever direction the stimulus dictates. Bikson thinks that in this primed state, the biological engine of learning is more efficient, more effective. It’s not a reset, it’s a revving up. Spinning up the RPMs so the throttle can open up on green, the neurons are ready for whatever task or information comes next.

The actions a subject takes immediately following treatment are paramount. Maybe it a concerted effort for some happy thoughts, or it’s learning a new language, maybe even something like playing basketball or skiing.

Once I was all hooked up and strapped in, Bikson’s assistant placed the machine in my lap. Bikson pointed to a lit horizontal dial on his machine, which showed that the electrodes on my head were producing good conductivity and we’d reached an optimal state to turn on the juice.

Once it was turned on, I felt the tingle almost immediately. It was somewhere in the middle of small ants crawling around just under my skin at each of the contact points, and getting the world’s lightest tattoo from a needle not quite sharp enough to pierce the skin. Bikson showed me the timer on the machine and explained that with each passing second the amperage, or the volume of electricity, would ramp up. It would peak around the end of the first minute and for the remainder of my 20-minute session I would be receiving the total recommended 2 milliamperes, no more or less.

Bikson explained that direct current is stable, polarized—it reliably and efficiently travels from anode to cathode, from positive to negative, in a precise and predictable
path. Alternating current changes, wanders, and because of this, researchers believe it fails to have the same polarizing effect on the neurons, doesn’t let them come to rest right in that sweet spot of readiness.

Bikson’s assistant reached out for the machine on my lap, apparently 20 minutes of TDCS goes rather fast, my time was up. I was a little bummed that I didn’t feel completely different.

Logan’s Run
Logan studied psychology in college but turned away from the field after graduating. He had heard an episode of RadioLab touting the benefits of TDCS, and confident of his grasp of his baccalaureate material, he felt prepared to test the waters on his own.

He says he’s not a depressed person. In fact, he’s always been rather happy, if also always a little overweight. He attributed his struggles with his size to that fact that he’s got little impulse control when it comes to sugar or eating in general. “It’s kind of like someone with a cigarette. If I had nothing to do, if I was bored, I’d be at the fridge looking for what to eat without realizing it.”

Logan turned to TDCS to help him with impulse control and a general feeling that that the world lacked a place for him. He said he was able to achieve a measure of both of his goals, simply by building a machine to take the juice out of a nine-volt and run it through his skull. The treatments allowed him to finally get ahold of his negative self-
speak, and achieve dominance over the impulses leading him to eat whenever the boredom of life set in.

“I was doing it daily. And I can really say it helped me talk louder than the voice in my head telling me to eat. It helped me be the boss again.”

You won’t find Logan’s machine for sale on the internet; he’s not even sure it’s safe to use. Out of curiosity, he cranked it up to double the top recommended output, which he said made his head feel like it was on fire. His machine is built into an Altoid box, and a repurposed multi-meter is rewired to measure flow. Logan is one of thousands of people who have been experimenting with this at-home enhancement for years.

Speaking to him gave me high hope; I hadn’t started this journey with the idea that it would work, but the confidence of Bikson and Logan, the surety of inventors like Wingeier, and the excitement of researchers like Dr. Okano, who studies how TDCS can affect athletic performance, were really starting to persuade me. What they said started to make perfect sense. Of course we could mold our brain with a battery. Throughout history we’ve been missing the perfect timing of necessary ingredients. Easy mental improvement was finally here, just turn up the current. This is the first moment in time where technology, curiosity, and just the right amount of turning a blind eye to the rational allowed for this life changing option to show itself.
Science or Snakeoil?

Mankind has a long sordid history of using electricity to treat ourselves for ailments. The ancient Egyptians and Greeks used to take bio-electric fish out of the water and place them on the foreheads of those suffering from headaches or dementia.

We were forced to harvest the electricity of nature until we learned how to create our own current.

Like so many eureka moments, humanity’s deeper understanding of the bioelectric nature of all living things began by accident. Towards the end of the 18th Century, Luigi Galvani exposed a frog to some static current through his scalpel during a dissection, and the frog moved. Galvani dedicated the rest of his career to investigating that phenomena. His nephew, Giovanni Aldini, carried on his uncle’s work, and practiced a very rudimentary version of TDCS when he applied current to his patients’ heads in an effort to treat their “melancholia.”

A superficial understanding of a thing, coupled with public demonstrations of seemingly otherworldly characteristics and abilities, makes for a lovely boondoggle, a perfect panacea. Aldini practiced real science, but at the time, the macabre spectacle of electrically animating the corpse of Newgate prisoner George Forster, to the delight of a sizable audience, was accepted as valid practice. The mystical-seeming nature of harnessed lightning made it ripe for quackery, intended and incidental.

Enlightenment physicians saw the current as a revolutionary treatment for any ailment, and felt the validation of the volts could benefit any and all willing to ride the lightning. Before long charlatans recognized electricity’s value as poorly understood but awe-inspiring, a perfect theme for separating fools from their money.

Erasmus Darwin, grandfather to Charles, a brilliant and respected thinker, prescribed in his 1794 opus *Zoonomia*, “frequent, almost hourly” electrical shocks to the head to treat *hydrocephalus internus*, or water on the brain. He also postulated that “electric shocks through the duodenum greatly assist the operation” to remove a tapeworm. Throughout the following century, for every Erasmus Darwin, there was at least one Dr. George A. Scott. Nearly a hundred years after Erasmus, Scott patented and sold electrical devices like brushes and curlers, claiming that they could help with ailments ranging from diseases of the blood to paralysis. Scott’s malfeasance was written right on his packaging: “In no case should more than one person use the brush. If always used by the same person it retains its full curative power.” Sharing would mean less products sold, less profits for Scott.
A few years before the US patent office granted Scott a patent for a health-giving electric corset, Richard Caton used a galvanometer to observe bioelectricity in the brains of animals. Building on that foundational research, in 1924 Hans Berger developed EEG, or electroencephalography. The current was now more than an exterior force of nature to be bottled and doled out, it was part of us. This blew wide open the door to serious and not-so-serious scientific inquiry into what electricity could do for our brains.

If a little current could help, then a lot of current could help all the more, and by the early 20th century, ECT had largely eclipsed its weaker cousin, TDCS, as a cure-all. It wasn’t until the 1960’s that things came full circle. D.J. Albert out of the University of Michigan conducted experiments showing that he could improve or reduce memory retention in rats simply by reversing the polarity of the treatment. If the flow went in one direction, the mice would improve and get through the maze quicker. If Albert reversed that flow, it was harder for the mice than if there were no flow at all.

It wasn’t until a decade ago that scientists began investigating TDCS as a possible avenue of research for treating depression. It didn’t take long for the general public to catch wind of cost benefit analysis. People quickly started to ride the mind lightning provided by homemade machines, and companies were founded to build machines for those who couldn’t.

**Did it Work?**

It’s been more than a minute now– if I were going to commit these cards to memory, it’d already have happened. I started to flip them face down, one by one, then waited another 30 seconds before starting to flip them over again, trying to recall where the matches were, trying to beat my best time. This was the first time I’d done it right after a session with my homemade machine, which I’d affectionately dubbed the Brainiator.

I’d played a couple of games of memory prior to doing any of the treatments, and had gotten what I thought was a fairly good score. I’d finished in around two and a half minutes and taken around 50 tries. But now I’d had three sessions, four if you count my visit to Bikson’s lab, and I’d been super careful to find the right montage for memory by doing my usual more-than-necessary amount of research.

There were a couple of options, but in the end I decided to go with one suggested to me by Andrew Westphal out of the Rissman Memory lab at UCLA. His placement wasn’t like the others, but I’d worked for him, and his research indicated a more than 10% increase in episodic recall, the kind that specifically references a picture in the mind’s eye, exactly the kind of skill that would help in a game of Memory. So far
though, I was 0 for 2 in my augmented memory flips. As far as starts go, this one wasn’t all that inspiring.

But let’s be clear, nothing is going to make anyone smarter. People are pretty much born limited by the makeup of the matter in their heads. The blueprints of our being, DNA, limits the scope and size of our greatest heights; no amount of electricity, drugs, or herbs yet discovered can raise the ceiling on what our minds are capable of at peak performance.

After about 3 weeks of daily treatments, my memory score hadn’t improved, but my mood and overall outlook on life could not have been better. Every time I prepared for a treatment session, I would pull my phone out of my pocket and turn it off. I would make sure all of my computers, gadgets and gizmos were set to silent and that none of them were within eye line of where I was strapped in for my memory medicine. Since I took the time to build the machine, I’d like to think that effort had something to do with my newfound lust for life, experience, and adventure. But the truth is, there’s a chance I could have achieved the same results with or without the intervention of the current, the validation of the volts, because the practice of sitting each day for at least twenty minutes, away from the screens, sans their bells and whistles, sights and distractions, was an experience absent from my life that I didn’t even realize I missed. Time alone to think.