Neural Interface and the Future of Human-Computer Interaction | Thomas Reardon

March 11th, 2019

Do not try and bend the spoon. That's impossible. Instead, only realize the truth... there is no spoon. Then you will see that it not the spoon that bends, it is yourself. – The Matrix

INTRODUCTION

Thomas Reardon is CEO & Co-Founder of CTRL-Labs, a company that builds transformative brain-machine/neural interfaces whose work spans the intersection of computational neuroscience, statistics, machine learning, biophysics, hardware, and human-computer interaction. He was previously CEO and Co-Founder of Avogadro, Inc., acquired by Openwave where he served as CTO, and creator of the Internet Explorer project at Microsoft. He's a founding Board Member of World Wide Web Consortium (W3C), has 7 patents, and was an MIT "Top 35 Young Innovator" in 2004. Dr. Reardon has an undergraduate degree in Classics from Columbia and split his PhD in Neuroscience between Columbia and Duke University. He is one of 18 siblings.

WHAT IS BMI?

Brain-machine Interface (BMI) — also known as a brain-computer interface (BCI) or neural interface, is a direct communication pathway between an enhanced or wired brain and an external device. BMI differs from neuromodulation in that it allows for bidirectional information flow. BMIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions. Research on BMIs began in the 1970s at the University of California, Los Angeles (UCLA) under a grant from the National Science Foundation, followed by a contract from DARPA. The papers published after this research also mark the first appearance of the expression brain–computer interface in scientific literature. The field of BMI research and development has since focused primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement.

WHY DO I CARE?

What interests me most about the work that CTRL-labs is doing is (1) that it addresses a fundamental problem in UI/UX design that is relevant to the entire population of the earth and (2) the team's work sits at the intersection of neurobiology, computer science and robotics, which provides an experimental tapestry for probing deeper into the how we experience material reality. Also, who doesn't find material telekinesis exciting and interesting? This is the frontier of technological futurism..

Lastly, it is valuable to point out that investors in CTRL-labs include the likes of Bill Gates, Google, and Amazon.

BACKGROUND

Reardon's background at Microsoft as the leader of the IE dev team, as well as his undergraduate work in classics interest me deeply, and I hope we can explore this in-depth during the overtime. I would like to begin, however, with a brief background into *who* he is and *how* he got to *where* he is.

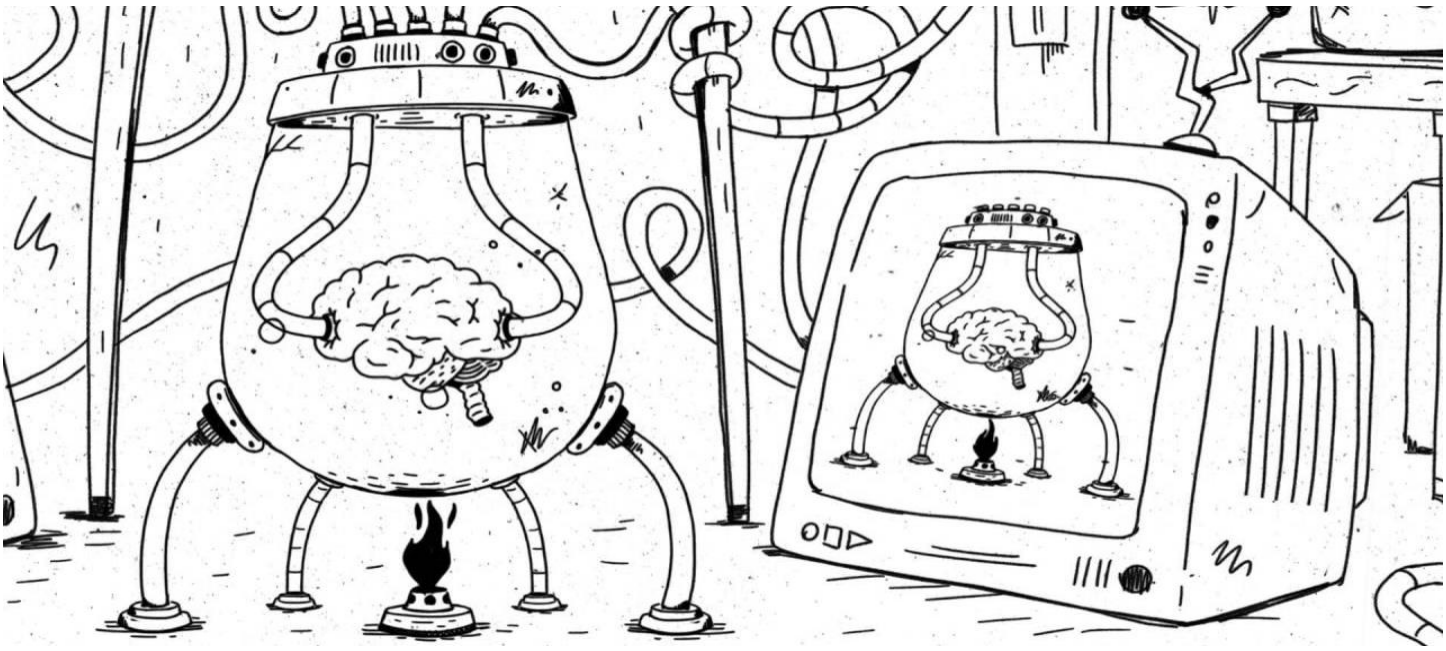
Upbringing — As I understand it, you are the youngest of a family of 10 biological siblings and 8 adopted children. I've never heard of such a thing. **Q:** Can you tell me what it was like to grow up in such an enormous, immediate family? **Q:** How did that experience shape you and how does it inform your workstyle and your effectiveness as a teammate? **Q:** How did it help prepare you for adulthood and collaboration? **Q:** Do you feel that you meet the world differently as a result of your upbringing than most of the people you know or work with?

Microsoft — You are credited with creating Microsoft Internet Explorer, and for a time, you were the only person on the project. **Q:** I would love to come back during the overtime to delve deeper into your time at Microsoft, but just generally speaking, what was that experience like? **Q:** What was it like to create a product that you were able to put into the hands of over one billion people (IE's market share in 2002 peaked at 96%!)? **Q:** Is that the sort of high that is almost impossible to replicate but that you end up chasing for your entire life? **Q:** What was it like working with Bill Gates, and what role has he played in your life since Microsoft? (I understand he is an investor in CTRL-Labs)

Classics — You left tech in 2003 to go study Classics at Columbia. You are fluent in Latin and semi-fluent in Greek. **Q:** What inspired you to study Classics? **Q:** How do you feel this experience has helped enrich your life and strengthen your abilities as an entrepreneur, developer, innovator, and leader? **Q:** Do you think more people in technical fields would benefit from studying classics or by perusing a liberal arts education?

"plurimum enim refert vitam extendat an mortem — what matters most is whether you're extending your life right or delaying your death" – Seneca

Neuroscience — **Q:** What made you decide to pursue a doctorate in neuroscience? Maybe this would be a good opportunity for you to walk me through how Thomas Reardon decides where and how to focus his tremendous intellect. **Q:** Can you walk me through the evolution of your interests and passions from Classics, to Neuroscience, to when you founded CTRL-Labs in 2015?



CTRL-LABS

CTRL-Labs is a startup that develops devices capable of translating electrical muscle impulses into digital signals. The company dedicates itself to answering the biggest questions in computing, neuroscience, and design so creators can dream. The team's work to build a transformative brain-machine interface spans research and challenges at the intersection of computational neuroscience, statistics, machine learning, biophysics, hardware, and human-computer interaction.

The Name — **Q:** Why the name CTRL-Labs? How did you come up with it?

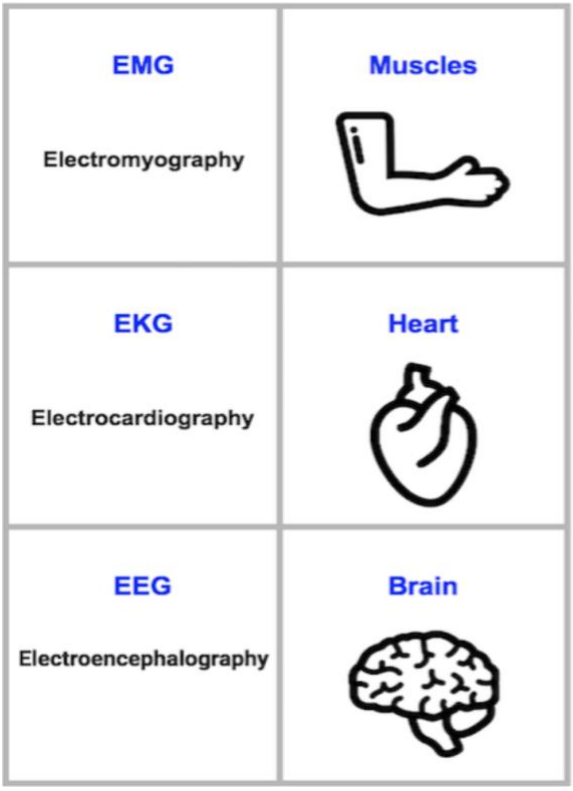
The Vision — **Q:** What was the original vision that you had? How did you come up with it? **Q:** How has that vision changed? **Q:** How do you think of yourselves and your company? **Q:** In terms of talent, experience, networks, and knowledge, what did you feel that you and your co-founders had that differentiated you from the pack of companies already in or looking to get into this space?

Competition — Many companies have been busy trying to develop viable BMI products, including Elon Musk's Neuralink, Bryan Johnson's Kernel, and even Mark Zuckerberg's Building 8 research group at Facebook. **Q:** What other companies out there are doing interesting work in this area, and how is CTRL-labs different? **Q:** What happened with Thalmic Labs and why they shut down?

Technology — When most people think of brain-computer interfaces they imagine some type of hardware or chip that is imbedded in the person's brain. Likewise, when most people think of telepathic or telekinetic-type devices, they imagine something like Dr. Xavier from X-Men – a type of helmet that sits on your head and reads your brain waves. **Q:** How does CTRL-Labs' brain-machine interfacing technology work? **Q:** What are the differences between EEG, which is what most people think of, and EMG, which is what you guys use? ***Please walk me through this distinction and why you can't translate the brain's electrical impulses as easily as you can those emanating from the spine towards the muscles.

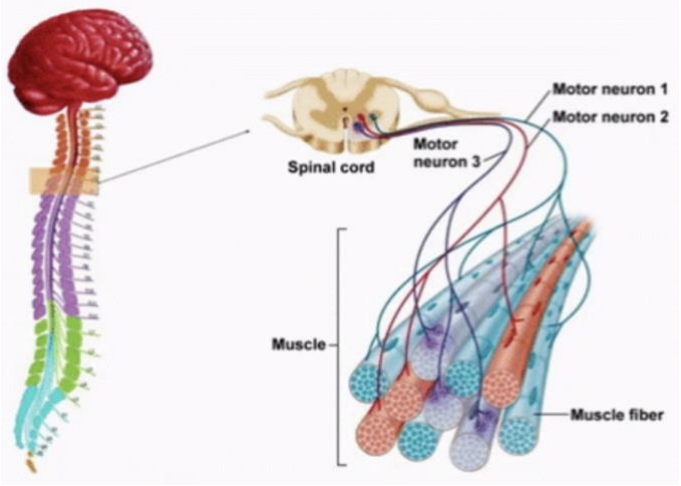
Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically noninvasive, with the electrodes placed along the scalp. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. Clinically, EEG refers to the recording of the brain's spontaneous electrical activity over a period of time, as recorded from multiple electrodes placed on the scalp. Applications generally focus either on event-related potentials or on the spectral content of EEG. The former investigates potential fluctuations time locked to an event, such as 'stimulus onset' or 'button press'. The latter analyses the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals in the frequency domain.

Electromyography (EMG) is an electrophysiological technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is performed using an instrument called an electromyograph to produce a record called an electromyogram. An electromyograph detects the electric potential generated by muscle cells when these cells are electrically or neurologically activated.



Regimes of Control — As I understand it, your neural interface has two regimes of control. One is called "Myo control" and the other is called "Neuro control."

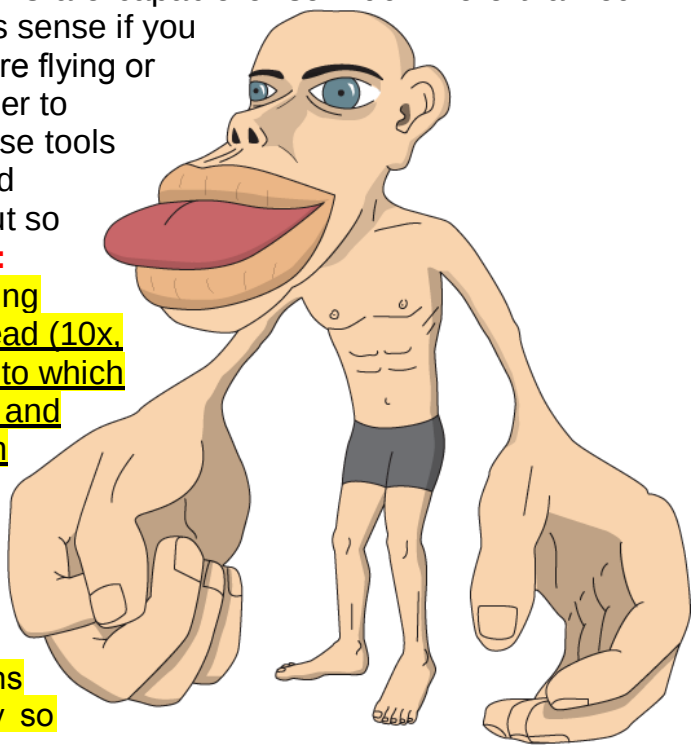
Myo Control — Let's begin with Myo control, which involve decoding the electrical input to the person's muscles that cause them to contract or relax. You do this by decoding the electrical activity that goes into those muscles even before the movement has started and even before it ends and recapitulate that in a virtual way. **Q:** Can you walk us through how myo control works? **Q:** How have you gone about turning these output signals being sent through your spin into information? **Q:** What was the most difficult part of this process? **Q:** Does this mean that you don't actually know or understand how or where intentions for physical movements reside in the brain, but are nonetheless able to capture the form their signal takes right before it reaches and stimulates the muscle? **Q:** What would that feel like if I were using the device at this very moment? Is it intuitive, just "plug-and-play?"



"This motor neuron signal evolved specifically to carry information from the brain to the hand to be able to affect change in the world, but unlike speech, we have not really had access to that signal until this. It's as if there were no microphones and we didn't have any ability to record and look at sound." – Adam Berenzweig, Lead Scientist at CTRL-Labs

Neuro Control — Q: How does Neuro control differ from Myo control? **Q:** Are these complementary modes of control or is the later the "out-of-the-box" functionality? **Q:** How do you train people at the level of individual neurons? How long does that take and what does it look like? **Q:** Does training this way alter brain plasticity and what would the consequences of this be?

Output Constrained — I've heard you remark that our brains are not input constrained, but rather, they are output constrained. In other words, our brains are capable of so much more than our bodies could ever hope to manage. This sort of makes sense if you think about what it's like to have a dream where you are flying or doing some complicated movement. Right now, in order to overcome the constraints of our physical bodies, we use tools to amplify our muscle movements. The most advanced example of this would be an industrial exoskeleton, but so would a trackpad, a car wheel, a bike's pedals, etc. **Q:** What does this mean in practice, when it comes to using your neural interface? **Q:** Is there a number in your head (10x, 100x, 1000x, etc.) that you think captures the amount to which our physical intentions could be amplified above and beyond what we have evolved to do if we give our brain access to this type of technology? **Q:** Do we have any idea of what the limit or the limiting factor might be?



Plasticity vs. Adaptation — I've heard you differentiate between "plasticity" and "adaptation." **Q:** Can you elaborate on this further? **Q:** Are you saying that we don't even need to rely on rewiring our brains because the "wiring" of our motor neurons is already so

sophisticated that we can adapt to all sorts of tasks that we never imagined ourselves doing? **Q:** When I have learned a new skill later in life, I find that it's much more difficult than something I did already when I was much younger and that I'm reacclimating myself to today. Is this an example of adaptability, and why is that steep learning curve not similar for what you are doing?

Neuroplasticity is the ability of the brain to change throughout an individual's life. A striking discovery made possible by PET and fMRI is that in intact experimental animals and humans, the motor cortex shows the same kind of plasticity as the sensory cortex. Thus, for example, the finger areas of the contralateral motor cortex enlarge as a pattern of rapid finger movement is learned with the fingers of one hand; this change is detectable at 1 week and maximal at 4 weeks. Cortical areas of output to other muscles also increase in size when motor learning involves those muscles.

Use Cases — Q: What are some of the most immediately valuable use cases for this technology that you think will be transformational and what sort of timeline are we talking about? **Q:** What are some of the non-skeuomorphic uses that you might be able to imagine?

THE BUSINESS

The Team — I'm curious about how you attract talent and staff your company. **Q:** How does a company like this go about staffing and finding talent? **Q:** Who are you primarily competing with for talent? (in neuro, robotics, and machine learning)

Philosophical Questions — I'm curious what your views are on the mind-body problem. **Q:** How is your work informed by, and how does it inform your views on the nature of consciousness?

Ethical Implications — Q: What are the ethical considerations of your work? **Q:** Do you see any ways in which this technology would be abused?