NEUROTECHNOLOGY

Who we are

The Student Venture Fund (SVF) at the University of Waterloo provides hands-on training in venture capital investing with guidance from industry experts and supervision by faculty members. Students have the opportunity to make investment recommendations by conducting thorough due diligence on product-market fit, growth potential, and management team.

Each term, students teams work with faculty members to research and present an emerging technology that represent opportunities for new start-ups. Through these Technology Deep Dive presentations, the SVF aims to develop domain expertise in these new technologies.

The *SVF Technology Review* is a thought leadership initiative allowing SVF members to share our insights on emerging technologies and facilitate cross-faculty discussions on entrepreneurship, technology, and finance.

Introduction

Neurotechnology describes any tool that seeks to leverage or alter brain function. The brain's 100 billion neurons are engaged in continuous activity, allowing us to receive information from the environment and use it to make decisions (Herculano-Houzel, 2009). For example, it receives information input from the external environment through our sensory organs – eyes, skin, nose, ears, tongue – and sends outbound information controlling motor movement – limbs, muscles, vocal cords.

However, the brain does not always perform its intended functions. Psychiatric disorders, neurodegenerative diseases, and physical trauma are just a few examples of existing impediments preventing normal cognition. Neurotechnology is our response to these problems and describes the tools we use to change cognitive abilities.

Neurotechnology provides solutions to repair or enhance neural function

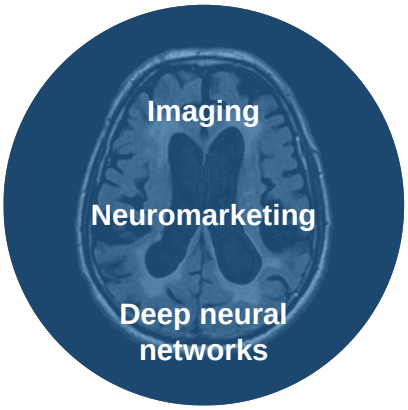
Psychiatric Disorders

Neurodegenerative Diseases

Neural Trauma

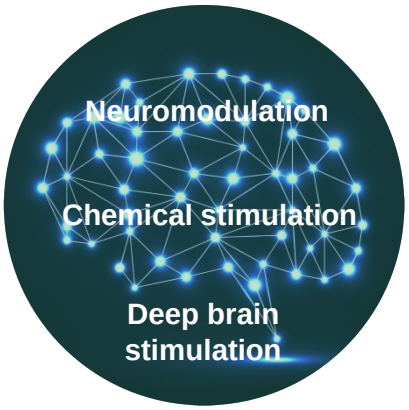
Industry Landscape

"Reading" (recording + decoding)



"Reading", as in "reading one's mind", is the process of decoding neural activity to obtain information on cognitive function (Roelfsema, Denys, & Klink, 2018, henceforth RDK). Techniques can range from non-invasive methods to capture activity at a high-level, such as MRIs, to those that produce higher-resolution images, such as electrode array implants used to monitor individual neurons (Kim, et al., 2016).

"Writing" (stimulating activity)



"Writing" describes techniques to send information to the brain (RDK). This ranges from inducing tactile sensations to controlling emotional states to communicating complex thoughts. Chemical stimulation is one such method, for example through the intake of psycho-pharmaceuticals such as antidepressants. In contrast, deep brain stimulation is a more invasive approach, requiring surgical implantation of electrodes to stimulate deep brain structures. Applications include psychiatric treatment and restoration of motor function (RDK).

However, a major limitation of reading and writing is that they only describe one-way information flow, either to or from the brain, even though the brain does both simultaneously. An area of growing interest is the brain-computer interface (BCI) or brain-machine interface (BMI), which allows adaptive interactions (RDK). For example, BCIs can predict onsets of seizures in epileptic patients and deliver stimulation to interrupt their course (Halpern, Samadani, Litt, Jaggi, & Baltuch, 2008).

Applications of neurotechnology can go beyond restoring brain function to augmenting cognition to give us superior capabilities. Leveraging our understanding of the brain, we can increase its natural abilities, such as by creating external processing units for “hybrid computations” or information retrieval (RDK). For example, what if students can extend their memory by offloading their biology notes to an external memory drive? This would change the way we think about education, or at the very least, exam proctoring.

Market Outlook

The worldwide market for neurotechnology products is predicted to reach $13.3 billion, led by growth in in healthcare and communication and control (Research and Markets, 2018) (Grand View Research, 2018). Some of the major companies are below:

kernel

Using neuroprosthetics to treat neurological diseases and future plans to work towards cognitive enhancement
Total Funding: $100 M (Seed)
Founded in 2016 (Los Angeles)

GTX medical

Developing a spinal cord implant to accelerate and augment functional recovery for spinal cord injuries
Total Funding: $40.8M (Series A)
Founded in 2014 (Switzerland & Netherlands)

DREEM BY RYTHM

Headband that improves sleep quality using sensors to track sleep and sound simulation to improve deep sleep
Total Funding: $57M (Series A)
Founded in 2014 (San Francisco)

InteraXon THOUGHT CONTROLLED COMPUTING muse the brain sensing headband

Headband that monitors brain activity to provide real-time feedback on meditation sessions
Total Funding $28.8 M (Series B)
Founded in 2015 (Toronto)

nuro

Point-of-care monitoring headband that detects when patients at high-risk are having a stroke and alerts caregivers and emergency services
Founded in 2016 (Hamilton)

HiNT Healthcare Innovation in NeuroTechnology

Point-of-care monitoring headband that detects when patients at high-risk are having a stroke and alerts caregivers and emergency services
Founded in 2016 (Hamilton)

A major driver in the neurotech industry is the baby boomer generation. By 2030, 71.5 million in the US will be over the age of 65, increasing this segment from 12.3% of the total population in 2005 to 20% (MaRS Discovery District, 2009). An ageing population will drive much of the demand for treatment, cure, and prevention for Parkinson's, stroke, chronic pain, and dementia (MaRS Discovery District, 2009). Alzheimer's disease and other dementias were the fifth leading cause of mortality in 2015 globally (Institute for Health Metrics and Evaluation, 2016), and prevalence is projected to increase.

$8.8 B
Market Size in 2018

$13.3 B
Market Size in 2022

Furthermore, neuropsychiatric disorders in the developed world are also the most prevalent disability, comprising 28% of the global disease burden (Lipsman, et al., 2017). The direct and indirect costs of mental health conditions are predicted to increase from US $2.5 trillion in 2010 to $6.05 trillion in 2030 (Bloom, et al., 2011). The demand for more effective treatment will drive funding into companies seeking to solve these pressing issues.

Ethical Considerations

The emergence of the neurotech industry has given rise to new fields such as "neuroethics" and "neurolaw" to address legal and ethical considerations (Bowman, Garden, C., & Winickoff, 2018). Given that identity and individuality are intertwined with our neurological profile, technologies that alter our cognition challenges post new challenges:

- New laws to enforce right to mental ownership and psychological continuity as tools which enable alterations to our brains become available (Ienca & Andorno, 2017).
- Consumer protection surrounding privacy and consent will have to be revised to account for techniques that allow neural data to be extracted, interpreted, and stored.
- New forms of discrimination and socioeconomic disparity, as key treatments and augmented cognition will likely not be uniformly accessible.

Key Takeaways

Neurotechnology is rapidly disrupting current industries and is expected to grow to a $13.3B market by 2022. These tools allow us to leverage our understanding of neural cognition and repair or enhance cognition, such as in treatment of psychiatric and neurodegenerative disorders. However, we must make key ethical decisions to ensure that these technologies do not encroach on privacy or promote discrimination.

Sources

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