

What are some potential therapies that could be developed if we were fluent in the language of the brain?

What are potential applications of fully understanding how signal transmission works in our nervous system?

If we understand how to transmit specific messages to neurons by encoding them in action potentials, how could this be applied? What are electrophysiological experiments working toward and how can the knowledge gained from these experiments be used to minimize suffering?

Fluent in the language of the brain will enable us:

- To understand how the brain creates a representation of concept like smell, hunger, scare, depressed, sad, taste, sky from multisensory information
- Answering these questions will put us on the path in understanding higher cognitive processes such as language, reasoning, learning, or memorization.

The list of potential therapies is infinite and will take too much page space to go through it here. These are few examples on how the improvements in understanding brain communications have already delivered impressive results:

- Many patients after stroke or affected by neurodegenerative diseases such ALS lose their ability to speak (like the famed late physicist Stephen Hawking). They can use brain-computer interfaces to convert their thoughts and control machines. Researchers are developing tools to decode speech-related brain activity and convert it into words spoken by a machine. In 2019 JHM and APL Johns Hopkins laboratories created a BCI that allows a paralyzed patient to control his prosthetic limbs with his brain <sup>[1][2]</sup>.
- A study showed that people diagnosed with schizophrenia, the excitatory neurons had a diminished ability to stimulate one another: "Imagine you are trying to listen to someone speaking on the radio, but the signal is very weak; if you turn the volume up, the speech is louder—but so is all the static and background noise—and so you may mistake some of this noise for actual speech." With an understanding of the language of the neurons, we can imagine creating drugs to boost the weaker signal from these neurons <sup>[3]</sup>.
- Memory loss: researchers found that they can improve episodic memory by simulating the left prefrontal cortex: applying slow repetitive transcranial magnetic stimulation (rTMS) led to reduce power of low-frequency (beta) waves in the parietal region of the brain, known to be involved in attention and perception. Stimulation of the left dorsolateral prefrontal cortex with slow rTMS enhances verbal memory formation <sup>[4]</sup>.
- Hearing aid: Columbia researchers have deciphered the brain's natural aptitude for detecting and amplifying any voice within a crowd and designed a brain-controlled hearing aid <sup>[5]</sup>.

AP knowledge

Researchers in a genome-wide analysis of 1,331,010 individuals with insomnia, identified 202 loci implicating 956 genes involved in insomnia and investigated which brain regions, pathways, tissues and cells these genes frequently are found. These new insights are significant as similar studies have found that the same genes are implicated in depression, anxiety, schizophrenia, coronary artery disease and type 2 diabetes. Understanding if there are different types of insomnia can lead to more targeted therapies including cognitive behavioral therapy which may be more effective than current drugs which have limited efficacy, can be additive and have side effects.

<https://www-nature-com.proxy1.library.jhu.edu/articles/s41588-018-0333-3>

In the TEDx talk, Adam Cohen described that today to understand the brain is like listening to an opera with a straw. Using this analogy, if we are able to hear fully the opera and tune to the other instruments, the instruments being other individual brains, we could imagine improved communication capabilities with

enhanced social dynamics when we will be able to plug directly to the “brain network” without intermediary means like speech or vision organs.

Can we identify some sort of regional processor in the brain that we could understand deeply in the next 10 years?” There are small structures in the cortex called “cortical columns” where internal connections are dense and outward connections are sparse, making them likely candidates for being local processors.

[1] Decoding Imagined Speech and Computer Control using brain waves

<https://arxiv.org/pdf/1911.04255.pdf>

[2] Neuroprosthesis for Decoding Speech in a Paralyzed Person with Anarthria: <https://www-nejm-org.proxy1.library.jhu.edu/doi/10.1056/NEJMoa2027540>

[3] Computational Modeling of Electroencephalography and Functional Magnetic Resonance Imaging Paradigms Indicates a Consistent Loss of Pyramidal Cell Synaptic Gain in Schizophrenia: <https://www-sciencedirect-com.proxy1.library.jhu.edu/science/article/pii/S0006322321014992?via%3Dihub>

[4] <https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3001363>

[5] <https://zuckermaninstitute.columbia.edu/voice-crowd-experimental-brain-controlled-hearing-aid-automatically-decodes-identifies-who-you-want>