Project 2: Understanding the neural code for human visual cognition with large-scale brain recordings

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Summary:

How do fundamental cognitive phenomena like attention and decision-making emerge in the human brain? Current non-invasive recording technologies like electroencephalography (EEG), magnetoencephalography (MEG), functional MRI (fMRI) and functional near-infrared spectroscopy (fMRI) allow us to answer this question by recording from the human brain to a certain extent. However, even these state-of-the-art techniques are relatively noisy, which makes it hard to decode relevant information from the recorded neural activity.

In this project, we will employ some new technologies that allow us to record directly from the brain of human patients. These include invasive methods such as electrocorticography (ECoG) and stereo-EEG (sEEG) that enable high-resolution measurements by directly recording neural activity from the brain's surface or tissue. sEEG involves the precise placement of depth electrodes in the brain via burr holes in the skull whereas ECoG uses a grid of electrodes placed on the cortex over the dura. These recordings will be made in epileptic patients who are surgically implanted for seizure localization. But we will record from the patients' brains when they are seizure-free and performing perceptual or cognitive tasks, like viewing videos or playing video games. We will then employ state-of-the-art machine learning and deep learning algorithms to decode patients' cognitive states (e.g. attention or decision-making) based on their brain activity. We will also electrically stimulate particular brain regions and study how the signal propagates to other brain areas and affects behavior. Over the long term, this project aims to develop indigenous sEEG and ECoG electrodes tailored for human brain mapping, thus enhancing the ability to record inexpensively, and at scale, with patients in India.

Additional reading:

https://www.nature.com/articles/s41562-024-01852-5

https://www.nature.com/articles/s41467-024-46013-4