2023 Summer Undergraduate Research Symposium

August 16, 2023; Zillow Room (4th Floor), CSE2, University of Washington

9:00-9:03 am: Welcome (Eric H. Chudler, Ph.D.)

Program

Short Talks (5 minutes + 2 minutes questions)

1.	9:03-9:10 am:	Prithvi Krishnaswamy	(Moazeni Lab)
2.	9:10-9:17 am	Katherine Bennett	(Moazeni Lab)
3.	9:17-9:24 am	Caden S. Bourland	(Böhringer Lab)
4.	9:24-9:31 am	Emma Tran	(Smith Lab)
5.	9:31-9:38 am	Mayra Diaz-Acevedo	(Mouradian Lab)
6.	9:38-9:45 am	Maddy Hernandez	(Bruchas Lab)
7.	9:45-9:52 am	Vivian Chen	(de la Iglesia Lab)
8.	9:52-9:59 am	Alek Helgesen-Thompson	(de la Iglesia Lab)

10:00-10:05 am – BREAK

9.	10:05-10:12 am	Nila Keri	(Phillips Lab)
10.	10:12-10:19 am	Sarah Shader	(Herron Lab)
11.	10:19-10:26 am	Arshbir Banipal	(Herron Lab)
12.	10:26-10:33 am	Sara Pierce-Lundgren	(Tuthill Lab)
13.	10:33-10:40 am	Audrey Davis	(Goering Lab)
14.	10:40-10:47 am	Noah Long	(Goering Lab)
15.	10:47-10:54 am	Anthony J. Campuzano	(Stuber Lab)

10:54-11:00 am – BREAK

16.	11:00-11:07 am:	Ryan Z. Wang	(Orsborn Lab)
17.	11:07-11:14 am	Ally Williams	(Stocco Lab)
18.	11:14-11:21 am	María F. Vázquez Rivera	(Yazdan-Shahmorad Lab)
19.	11:21-11:28 am	Lucas Ritzdorf	(Rudell Lab)
20.	11:28-11:35 am	Brandon Fisher	(Mondello Lab)
21.	11:35-11:42 am	Amina A. El-Zatmah	(Steele Lab)
22.	11:42-11:49 am	Nya Martin	(Moritz Lab)
23.	11:49-11:56 pm	Penelope L. Lilley	(Moritz Lab)
24.	11:56-12:03 pm	Dominique Cunningham	(Perlmutter Lab)

12:10-1:00 pm – LUNCH BREAK

Posters

1:00-2:00 pm - Poster Session #1

Krishnaswamy, Bennett, Bourland, Tran, Diaz-Acevedo, Hernandez, Chen, Helgesen-Thompson, Keri, Campuzano, Ritzdorf

2:00-3:00 pm - Poster Session #2

Shader, Banipal, Pierce-Lundgren, Davis, Long, Wang, Williams, Vázquez Rivera, El-Zatmah, Martin, Cunningham, Lilley, Fisher

ABSTRACTS

Low-Cost Commercial CMOS Cameras for Accessible LSCI Devices

Prithvi Krishnaswamy[1], Libanh Hussein[1], Sajjad Moazeni[1]
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Laser Speckle Contrast Imaging (LSCI) is a technique used in both clinical and medical settings to quickly analyze spatiotemporal blood perfusion dynamics. By using interference patterns from the scattering lasers that are detected by a camera, we can detect the motion of scattering particles such as red blood cells. Image sensors for LSCI devices can range from a few hundred to a few thousand dollars, depending on a variety of factors, and are often times more expensive than their consumer-grade counterparts. Cheaper cameras typically result in sacrifices to the sensor's performance in a number of areas like resolution, sensitivity and frame rate. In this research project, we explore various means of reducing the cost of the device itself through a mixture of hardware and software solutions. We experimented with a low-cost OpenMV camera module that was configured with Python code to capture raw image files at speeds comparable to industry grade cameras. Furthermore, we designed a printed circuit board that is cost effective and easily integrated to work with the OpenMV camera, in addition to driving laser diodes used for LSCI operation. These approaches combined should allow us to reduce the cost of the device to a more affordable price point, making the technology more accessible to a wider range of users, including researchers, medical professionals, and health institutions.

Analog-Digital Co-Simulation Using Synopsys PrimeSim and Application in 180nm Ising Machine Verification

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EMIT Lab and other integrated circuit (IC) design labs are currently involved in IC designs with both analog and digital blocks. Analog blocks are designed in schematics, and their signals have continuous values. Digital blocks are designed in hardware description code languages such as Verilog or VHDL, and their signals are interpreted as either zeros or ones. Mixed-signal blocks can range from common design elements, like analog-to-digital converters, to more novel designs, such as EMIT Lab's SRAM compute in-memory Ising Machine. High fabrication costs and increasing design complexities necessitate realistic co-simulation of analog and digital blocks before fabrication, and EMIT Lab did not have this capability. Analog-digital co-simulator tools are also complex, so efficient co-simulation requires creating a streamlined environment to interface with the tool. As a first focus of this project, we conducted a trade study of current co-simulation tools and built a Synopsys PrimeSim-based analog-digital co-simulation environment. The environment can simulate analog and digital blocks at any stage of their design flows and can be run from the command-line via GNU Make executables. We implemented the environment for TSMC 180nm and Global Foundries 45nm technology. The second focus of this project was to verify EMIT Lab's on-chip Ising Machine, an optimizer for the MAXCUT problem. The chip has been fabricated in hardware, but it is currently non-functional, creating the need to verify the design concept and the chip's functionality in realistic co-simulation. We incrementally verified functionality of essential mixed-signal sub-blocks in the Ising Machine and performed top-level tests of the Ising operation on a 60-node MAXCUT problem to characterize the chip's behavior. Results demonstrated successful design operation, illustrating proof of concept and providing performance data. Future work will continue to investigate performance in simulation and investigate hardware-simulation discrepancy through Monte Carlo analysis and other testcases.

Deconvolution Method for Spatially Varying Point Spread Function in Real Time Imaging Applications

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Many reliable methods of deconvolution, a mathematical function to recreate a signal that has been influenced by another, have been used effectively in various applications with the assumption that the point spread function (PSF) is a given and constant across the image. A PSF is a spread function representation of a point source made necessary because of the limitations of imaging systems. Few methods exist for deconvolving an image with a spatially variant PSF. This research explores a potential solution to this problem by stitching together multiple local deconvolutions across the image to produce a sharper image. The algorithm needed to meet the constraint of a total runtime under 0.1 seconds. This methodology was compared against current deconvolution methods by evaluating how similar pixels were to an original ground truth image. Using the metrics of mean squared

error and structural similarity, this new method proved 2% better than current known methods. This could be useful in various applications such as real-time imaging of new lightweight lenses with spatially varying PSFs.

Camera Localization on Acoustically Levitated Particles

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[2]Paul G. Allen School of Computer Science and Engineering, University of Washington, Seattle, WA

In this research, multiple cameras are programmed simultaneously to localize acoustically levitated particles. With the help of OpenCV and other Python libraries, particle position can be accurately determined in addition to detecting the splitting or falling of said particles. This new camera approach allows real-time tracking, providing accurately extracted visual insights into particle behavior and can aid in improving particle manipulation in acoustically levitated systems.

Achieving Co-propagation and Co-Focus of Multifrequency Gaussian Beams

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Gaussian laser beams are necessary for building trapped-ion quantum technologies. Multiple lasers are used for different purposes like excitation and cooling where it is important to have the point of the highest radiance focused onto the ions in the trap. Gaussian beam propagation describes the nature of a laser beam where the intensity of the beam follows the shape of a Gaussian distribution. Here, we design, build, and test optical setups for complete control of a trapped-ion quantum computer. We characterize each of the lasers to determine the optimal placement of the optics outside the chamber taking into consideration the fixed placement of the ion trap within the vacuum chamber. The Gaussian beam characterization is done by capturing various images at different distances away from a fiber collimation lens. Then by processing the images we fit the expected gaussian propagation to determine the position of the beam waist. The characterization of the different lasers going into the chamber can help optimize the ideal location, even when beams of different wavelengths are combined into the same path. We will also explore full mechanical designs to ensure vibrational stability. This work will enable a well performing ion trapping and control.

Stress Induced Increases in Calcium and Dynorphin Signaling in the Claustrum

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Experiencing stress has severe effects on human functionality, that in turn, shifts behaviors and neural activity. Stress-Shaped sensory perception not only affects how we maintain our selective attention, but it has long-term health effects affecting all aspects of life. However, we still have very little understanding of how and where stress shapes sensory perception in such a broad way.–The Claustrum supports glial cells that connect the cerebral cortex to important signaling regions of the brain, such as the hippocampus, thalamus, and amygdala. This densely packed structure interconnects trillions of neurons in an intricate network that has not yet been explored due to its elongated structures and complex connectivity. However, using the technique of Fiber Photometry, an *in vivo* recording method to detect neural activities through fiber implants, we were able to see GCaMP6f (ultrasensitive fluorescent protein) in mice used to detect fluctuating signals of Calcium. Our results conclude that there is an increase in the signal of GCaMP6f responding to both tail lift and female urine under stress conditions compared to non-stressed condition, suggesting stress modulate Claustrum activities across multiple sensory domains. Along with detecting Calcium^{2+}, we also tested Dynorphin signaling, a key neuropeptide is closely involved in pain, addiction, and mood regulation and is an important factor related to stress modulation. We use a novel genetically encoded sensor Klight to record dynorphin releases in the Claustrum. Utilizing KOR-Cre mice, a Cre-Lox recombinase tool, we were able to specifically record dynorphin signaling in the claustrum-Kor+ population during tail lift and female urine stimulation. We observed an increased Klight signal during stress condition towards both tail lift and female urine, suggesting that dynorphin signal directly modulate stress responses towards multiple sensory stimulation in the Claustrum, bridging the gap in our understanding of the Claustrum and dynorphin, and how this signaling affects stress and sensory modulation.

Investigating Whether Amygdalar Optogenetic Stimulation Induces Changes in Behavior and c-Fos Expression

Vivian Chen[1], Victor Y. Zhang[1], Asad Beck[1,2], Horacio O. de la Iglesia[1,2]
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Synchronization (or *entrainment*) of circadian rhythms by external environmental cycles (*zeitbegers*) aid organisms in anticipating environmental changes. While the 24-hour light-dark cycle is the main zeitgeber, non-light cues can also entrain circadian rhythms. Research in the de la Iglesia lab shows that nocturnal fear in the form of foot-shocks administered while mice are foraging and feeding in a foraging area can act as a potent zeitgeber and entrain circadian rhythms, prompting a switch from nocturnal to diurnal behavior. To delve deeper into the circuitry underlying fear entrainment, the laboratory is currently using optogenetic stimulation of the amygdala to determine if the activation of fear centers can elicit entrainment of circadian rhythms. The use of optogenetic stimulation enables the activation of specific neuronal populations expressing light sensitive channels through light delivered through an optic fiber. After optogenetic stimulation that emulates the timing of the nocturnal fear, mice displayed freezing responses but did not flee the foraging area as they do in response to footshocks. To assess the accuracy of expression of light sensitive channels and the ability of light to stimulate neurons regionally, animals had a last exposure to optogenetic stimulation after which they were euthanized and their brains were processed for immunohistochemistry against cFos, a marker of neuronal activation. Brain sections were then examined in a confocal microscope to determine fluorescence m-Cherry, a fluorescent tag that marks neurons expressing the light-sensitive channel. Evaluating both the behavioral fear responses during the stimulation period and the presence of positive indicators of neural activity (c-Fos and m-Cherry) in the stimulated brain regions is imperative to verify the effectiveness of the optogenetic stimulation approach. In the future, we intend to build upon these findings with the aim of identifying the neural networks responsible for fear entrainment, giving valuable insight into the neuronal mechanisms underlying fear-related sleep disturbances in individuals with post-traumatic stress disorder (PTSD).

Machine Learning-Based Prediction of Seizure Stage in a Mouse Model of Epilepsy

Alek Helgesen-Thompson[1,2], Asad Beck[2,3], Glorianna Gutierrez[2], Horacio de la Iglesia[2]
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Dravet Syndrome is a rare childhood-onset form of epilepsy caused by a mutation in the SCN1A gene. It is characterized by early life seizures and resistance to common treatments of epilepsy, leading to greater frequency of uncontrolled seizures and heightened likelihood of death. The goal of this project was to develop methods of forecasting seizure onset in real-time to better develop methods to prevent seizure from occurring. Using a mouse model of Dravet Syndrome (heterozygous knockout of SCN1a gene), we implanted mice with two electrocorticography (ECoG) and one electromyography (EMG) electrodes and chronically recorded neural data to capture spontaneous seizures. Days containing spontaneous seizures were then analyzed post-hoc, dividing the data into stages of interictal, pre-ictal (using five, ten, and twenty minutes prior to seizure onset), ictal, and post-ictal, with additional data from wild-type (WT) mice included as control. A total of 98 time- and frequency-based features were extracted and used to train and compare ten algorithms for predicting seizure stage in 5-second epochs. I found that linear discriminant analysis (using singular value decomposition solver) had the best prediction time (approximately .001 seconds**)** and test accuracy (64.5%). This algorithm displayed high recall for ictal (72%) and post-ictal, (86%) stages, with most errors occurring between interictal, pre-ictal, and WT stage recall. Finally, when applied to two seizures, it generally captured the temporal progression of seizure genesis (interictal → preictal → ictal → post-ictal → interictal), suggesting this method may be a promising avenue for real-time seizure stage prediction and, thus, seizure genesis forecasting.

Investigating the Feasibility of Utilizing Fiber Photometry During Cocaine Self-administration

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The number of national overdose deaths involving stimulants in the U.S., has shown a concerning increase (CDC Wonder, 2023). However, cocaine use disorder treatment remains limited. Our goal is to understand the neurobiology of addiction in order to find treatments for addiction. For finding this, we designed an experiment to monitor neurotransmission with fiber photometry technique (new technique) in Wistar rats during one week short access (1hr) and 2 weeks long access (6hr) of cocaine self-administration. Animals had bilateral viral

injection (AAV1-CAG-dLight1.3b) and optic fiber implant in the Nucleus Accumbens prior to the self-administer cocaine training. We hypothesize for this experiment that dopamine will increase after an active response for cocaine. The results aligned with previous literature using voltammetry (old technique) reported by Phillips et al., 2003 and Willuhn et al., 2014, indicating dopamine increased following an active response for cocaine in short access and both weeks of long access cocaine self-administration. Future studies could utilize fiber photometry in conjunction with other biosensors (such as kLight) for the detection of different neurotransmitters or enabling dual recording involving two biosensors simultaneously within a single brain region; capabilities that voltammetry lacks.

Design and Demonstration of an Interface for Evoked Potential Experiments with the CorTec Brain Interchange

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An evoked potential, or evoked response, is an electrical signal recorded from a specific area of the nervous system, typically the brain, in response to a stimulus. The evoked potential result allows for characterization of connectivity between different areas of the brain, and the ability to administer and observe evoked potential activity is becoming a prominent metric to assess changes in different neurological conditions. CorTec's Brain Interchange (BIC) is an upcoming investigational device capable of high temporal processing, electrical stimulation, and neural activity recording. OMNI-BIC, an open-source software tool to interface with the BIC, enables users to design and implement customized neuromodulation therapies for clinical investigation. In this work, we used OMNI-BIC to create a Windows application for the administration of evoked potential experiments with the BIC. The application connects to the BIC and allows a user to scan a combination of parameters for an evoked potential to determine effective conditions, as well as administer specific evoked potential tests with user-defined parameters. It visualizes sensed neural activity and performs signal processing techniques in real time, including filtering and trial averaging, to display immediate evoked potential results. The application also logs all activity to allow for further offline analysis of an evoked potential experiment. In developing this evoked potential application, we hope to expand the functionality of the BIC to allow for straightforward clinical monitoring of evoked potentials that could characterize changes in neurological conditions.

Feature Analysis of Anesthetized Patient Neural Data for the Classification of Consciousness

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Emergence, or the gaining of consciousness after anesthesia, is best described as the brain restoring its connectivity and communicative abilities. Anesthetics, like propofol, dampen neural activity, especially in the thalamocortical and frontoparietal networks. Studying how neural data behaves during emergence can help design an accurate classification model that would improve the level at which we understand the gaining of consciousness. To train an accurate classification model, we studied emergence neural activity that was recorded by twelve electrodes implanted in various regions of a brain of a pediatric patient with epilepsy for 60 minutes. Before analysis, a band-stop filter was applied to remove electrical noise at 60 Hz. The Welch method was used to transform the signal to the frequency domain, where the Power Spectral Density (PSD) was visualized for minutes 5, 20, 30, 40, 50, and 58 for thirty second intervals. Aside from the noisy first ten minutes, analysis shows the neural frequency bands being the most distinct between unconsciousness and consciousness in the temporal and parietal lobes on the left side of the brain, whereas channels on the right side of the brain did not show any distinction between unconsciousness and consciousness. Noisy initial minutes and indistinct channels were removed, leaving a dataset with 3 labels: unconscious, post-limb movement, conscious. SVM (time and frequency) and LDA (time and frequency) models were then trained on the new dataset and had accuracies of 88.88%, 78.57%, 86.11%, and 92.85%, respectively, whereas models trained on the old dataset had accuracies of 78.61%, 72.72%, 74.06%, 90.64%. Seeing the LDA model that was trained on the refined frequency dataset had the highest accuracy and the LDA and SVM models trained on the refined dataset outperformed older models highlights the importance of frequency analysis when it comes to developing a classifier for consciousness.

Novel Insights into Proprioceptive Function of the Abdominal Chordotonal Organ in Drosophila Melanogaster

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Proprioception is the ability to sense limb positions as we move. Mechanosensory neurons in muscles, tendons, and joints control this sense. Proprioception has historically been studied in the limbs, but this novel experiment looks exclusively at the main body. Despite the evolutionary distance, underlying cellular mechanisms are similar among all animals, including fruit flies, *drosophila melanogaster*. *Drosophilae* are ideal for studying proprioception, as sensory neurons are in the periphery and connect to the ventral nerve cord without hard bones, like mammals, allowing observation during active behaviors. Despite being the biggest mass of one of the most widely used model organisms in neuroscience, much remains unknown about the physiology of the fly abdomen, such as the function of the abdominal chordotonal organs (AbCO). Using genetic, imaging, and computational techniques I have found the AbCO axons have a high connectivity with leg and wing associated interneurons, but not abdominal motor neurons, indicating it may be involved with flight or postural control.

Privacy and Data Sharing in Neurotechnology: A Comparative Analysis

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Today, the amount of personal information available and the pace at which it can be shared is staggering; thus, the meaning of information privacy is increasingly complicated. Most Americans are concerned with the amount and use of data gathered about them and while attitudes on sharing are more open when contextualized in the medical field, public trust is critical in furthering scientific funding and innovation.

Neurotechnology is evolving rapidly and producing huge quantities of data, without clear standards for data sharing, ownership, and privacy. This has prompted calls for “neuro rights” to protect mental privacy and cognitive liberty. For this research, a comparative analysis of biobanking data governance and emerging ideas about neurodata governance provides meaningful insights into the significance of maintaining public trust while also moving science forward. Biobanking establishes an important model of data stewardship which sets standards for the governance of open sharing, facilitating safe access, and empowering participants. There are slight differences in the privacy issues between traditional biobanking and neurodata but the approaches to addressing each could be similar. Data sharing is widely accepted as positive for scientific growth but regulations around sharing can ultimately become burdensome for investigators — both those sharing and those looking for information; still, neuroscience researchers see the need for clear guidelines. While biobanking and genetic research still face issues of a decentralized governance model and the correlated diverging regulations stemming from separate institutions, the precedent for good data governance is recognized as important for neurodata. The quick advancements within neurotechnology and the added complication of commercialization indicate the need for widespread data governance frameworks. Limitations of stewardship necessitate the implementation of independent safeguards to prevent harm. As the lines between clinical and commercial become increasingly blurred, data stewardship in both realms could help protect privacy and maintain public trust while also enabling scientific and technological advances.

Ethics, Identity Formation, and Children in Neurotechnology

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A BRAIN pioneer can be defined as an individual who volunteers for trailblazing trials or treatments in the field of neurotechnology. BRAIN pioneers take on risks related to neurological interventions to help science progress, and often with the hope of finding some individual benefit for otherwise treatment-resistant conditions (e.g., depression, OCD, epilepsy, dystonia). Pediatric deep brain stimulation (pDBS) refers to experimental treatment for children with neurological disabilities. Potential complications arise from this however, as we examine the complex nature of brain procedures in the child population. The current study explores unique and crucial ethical questions that must be addressed as part of anticipatory governance in this area of scientific inquiry.

Additionally, identity formation within children has been identified as crucial by many studies, prompting a need for more research in this area. My contribution to the conversation comes from the research I've done combining the sociological perspective on identity formation and research on the wide-ranging field of neurotechnology. My methods included a literature review, as I read several articles, interviews, and journals to approach the idea of identity as an ethical consideration in the pDBS field. As pDBS treatment rises, preventing detrimental risks unique to the child population is more important than ever.

Dopamine Signaling Across the Striatum During Consumption

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Animals must consume energy to survive, leading to varied consumption behaviors mediated in part by the dopaminergic system. The dopaminergic system and its plays a crucial role in learning and motivation through its projections to multiple downstream structures including subregions of the striatum. Previous data shows that the connectivity of the midbrain dopamine projections to the Ventral Striatum (VS), Dorsal Striatum (DS), and the Tail of the Striatum (TS). The TS shows unique dopamine release relative to the VS and DS While previous work demonstrated that the midbrain dopamine projection to the TS receives distinct input patterns, it remains to be determined if this dopamine projection exhibits unique activity patterns relative to dopamine projections to the DS and VS. Fiber photometry was performed in head-fixed mice at rest to simultaneously measure dopamine release dynamics across the striatum. Using correlations, we found the signals reflected the initial connectivity patterns, with the TS showing low correlation with the rest of the striatum. We also investigated the signaling patterns of dopamine release across the striatum during consumption. Previous findings indicate that the VS and DS show activity that is positively correlated with reward, but it is unclear if the tail of the striatum also shows these activity patterns. However, it is unknown if the dopamine signaling across the striatum is correlated with consumption. We used fiber photometry in head fixed mice and measured the consumption of various concentrations of NaCl. The results show a correlation between consumption and dopamine release in the VS and the DS but not the TS. This suggests that the dopamine release in the TS may have a different function that does not involve consumption. Together our results show how signaling across the striatum is during consumption.

Neural Decoding of Primate Reach Intention in Brain-Computer Interfaces Using a Novel Machine Learning Model

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Brain-Computer Interfaces (BCIs) establish a direct link between a user's cognitive processes and computer systems, offering avenues for restoring and augmenting human capabilities. For example, BCIs have been used to restore motor function in disabled individuals, translate neural signals to text, and facilitate control of a computer screen. Successful implementation hinges upon the accurate, efficient, and precise decoding of brain signals. Neural decoding algorithms typically use supervised machine learning models, which require explicit labeling of desired output based on neural input signals. This labeling can be challenging with large datasets and prone to human error. Recent research has introduced self-supervised decoding models for BCIs, which generate their own pseudo-labels during the training process (Peterson 2022, J. Neural Eng). This eliminates the need for a large set of manually-annotated data. Here, we implement a self-supervised neural decoder to predict reach intention during a center-out reaching task in non-human primates. In this approach, a convolutional neural network is trained to identify 8 reach directions by leveraging three simultaneous data streams: 1) electrocorticography recordings from the primary motor cortex, dorsal premotor cortex, and frontal eye fields, 2) hand movements in 3-D space, and 3) eye movements. The self-supervised model trained on multiple data streams had higher neural decoding accuracy compared to an unsupervised model trained on just one stream ($p < 0.05$) and approaches the accuracy of the supervised model. This indicates that the extra data streams are informative in improving the self-supervised decoder. Performance improved on sessions with more trials, indicating that the model performance may improve with a larger dataset. Future experiments could increase the

amount of training data, optimize the model hyperparameters, and increase the number of data streams to improve performance. The self-supervised, cross-modal decoder could be a promising step towards improving the practicality, effectiveness, and capabilities of BCIs.

Optimization of a Computational Model for Diagnosing Mild Cognitive Impairment

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Memory loss is a debilitating symptom of neurodegenerative diseases, but current clinical assessments lack the reliable, convenient, and repeatable qualities needed to capture the individualized and evolving nature of memory decline. Computational models of memory used in adaptive learning settings have been shown to accurately detect memory decline in patients with Mild Cognitive Impairment by estimating their "speed of forgetting". This measure of individual differences in long-term memory function has been shown to be reliable, stable over time, and can be decoded from resting-state functional connectivity. Prior lab research has shown that an individual's "speed of forgetting" was able to diagnose mild memory impairment with over 87% accuracy in a single 8-minute session, compared to the current standard of 93%. The main objective of the current study was to explore avenues for improvement by optimizing the model. Data collected from 20 undergraduates who completed two learning sessions with flags demonstrated that prior knowledge of the facts introduced during the session accounted for a significant source of error. Prior knowledge data was incorporated into the model using Maximum Likelihood Estimation to successfully recover the base-level activation of each fact. These model optimizations will be applied to clinical datasets and have implications for the early detection and management of various forms of dementia.

Estimating the Effects of Ischemic Stroke and Stimulation on the Connectivity Between Brain Regions Using Graph Learning

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[2]Department of Electrical and Computer Engineering, University of Washington, Seattle, WA
[3]Department of Bioengineering, University of Washington, Seattle, WA

Among the different types of strokes, ischemic strokes are the most common. Ischemic strokes occur when a blood clot blocks an artery that leads to the brain, causing disruptions in brain network activity that frequently leads to lifelong disability. While in recent years, therapies such as brain stimulation have shown promising results in treating post-stroke symptoms, our limited understanding of how stroke and rehabilitative stimulation affect brain networks is hindering progress. In this study we investigate the effects of ischemic stroke and subsequent stimulation on brain network connectivity using a non-human primate (NHP) model. In four NHPs, focal ischemic stroke lesions were induced via the photothrombotic technique, and a semi-transparent electrocorticographic (ECoG) array of 32 electrodes was used to record the neural activity before, during, and after lesion induction, as well as to stimulate the brain after lesioning. We estimated brain connectivity using the graph learning algorithm proposed by Kalofolias. The algorithm finds a sparse graph such that the neural activity between connected nodes is similar. We computed connectivity graphs before stroke, after stroke, and after stimulation for both ipsilesional and contralesional hemispheres. We also computed difference graphs that display the changes in connectivity due to stroke or stimulation. To plot the graphs, we used the Python library NetworkX. With the use of these graph learning techniques, we were able to see increased connectivity in the contralesional hemisphere following stroke and increased connectivity in the contralesional and ipsilesional hemispheres in those NHPs that received stimulation post-stroke.

ML Assistance Accelerates Self-Interference Cancellation in Full-Duplex Transceivers

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Full-duplex radio communication, in which clients can both send and receive simultaneously using the same carrier frequency, is known to have several benefits over alternative systems. In particular, it has reduced spectral requirements compared to frequency-division duplexing, and improved throughput versus time-division duplexing techniques. However, designing a system to effectively transmit and receive on the same frequency presents a variety of challenges, including that of self-interference, in which the system re-receives its own

transmissions in an undesired manner. In general, this occurs via two distinct vectors: direct coupling effects between the transmitting and receiving circuitry, and unexpected reflections from the surrounding environment. We have previously presented a mixed-domain analog/digital transmission system with the capacity to drastically reduce self-interference due to both direct coupling and environmental reflections. While effective, the environmental filter stage of this previous system required roughly 30 seconds to perform calibration, as it conducted a blind search of the filter parameter space. This made it unsuitable for most practical applications, as such cancellation systems generally adjust for environmental changes every few hundred microseconds. In this demonstration, we present a novel machine-learning calibration module which replaces the previous blind search algorithm. This new module takes the form of a convolutional neural network (CNN), an architecture which specializes in multi-level pattern recognition and abstraction. This particular CNN is trained on the results of a similar search algorithm and produces similar results, while running nearly six orders of magnitude faster (29.4 seconds versus roughly 32 μs per single iteration) than the blind search. While a few iterations might be required to approach an optimally calibrated state, the results are still sufficient to achieve near-real-time adaptation to varying environmental reflection conditions.

Investigating Molecular Strategies for Targeting Function-specific Neuronal Populations
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The innovative findings about using a specific viral vector may point to a new and transformative method for controlling neurons, offering significant potential for improving the treatment of spinal cord injuries. The research targets understanding neurons activated by rehabilitation and spinal stimulation therapies. Investigating the effectiveness of the AAV-RAM-d2TTA-TRE-ChR2 viral vector in converting spinal cord neurons in female Long Evans rats is the central focus. Carrying Yellow Fluorescent Protein (YFP) and Channelrhodopsin-2 (ChR2) genes, the viral vector enables tracking specific neurons. Four rats, divided into groups with varying doxycycline (dox) chow levels for gene control, received viral injections and specific therapeutic tasks, including Irvine Beattie Bresnahan, and Forelimb Reaching Tasks. After perfusion, their spinal cords were dissected, and frozen tissue sections were scrutinized under a microscope to determine the location and quantity of neurons labeled with green fluorescence at spinal segment C6. During the experiment, observations emerged from different rat groups. One rat, with dox chow removed 48 hours before and engaged in an hour of Irvine Beattie Bresnahan (IBB) task, showed several YFP-labeled neurons on the experimental side of the spinal cord, hinting at potential IBB-specific neuron labeling. Conversely, another rat, with dox chow removed and followed by 10-minute electrical stimulation (E-Stim), displayed numerous YFP-labeled neurons, suggesting non-task-specific neuron labeling. However, rats with dox chow removal and subsequent cage rest exhibited very few to no YFP-labeled neurons, indicating that general cage activity might not trigger activity-dependent transduction. Interestingly, a rat consistently on dox chow and performing an hour of IBB showed some neuronal labeling, possibly due to insufficient dox chow intake to halt transduction. Further experimentation is required to confirm this. Arrows were used to highlight YFP-labeled neuron presence. As this study unveils AAV-RAM-d2TTA-TRE-ChR2's potential, it prepares spinal cord injury treatment for revolutionary interventions through enhanced neuron control and activation strategies.

Take A Step: The Effects of Transcutaneous Spinal Cord Stimulation and Exoskeleton use on Step Length for Children with Cerebral Palsy
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How can the utilization of rehabilitation technologies affect step length for a child with cerebral palsy (CP)? CP is the prevailing cause of childhood-onset, lifelong physical disability, affecting approximately 1 in 500 children. Children diagnosed with cerebral palsy (CP) usually have reduced step lengths stemming from motor control abnormalities, muscle weakness, contractures, and spasticity. This can contribute to increased fatigue, reduced physical activity, and an overall decrease in quality of life compared to peers. We investigate whether a

single session using an ankle exoskeleton and spinal stimulation could lead to increases in step length for two children with CP. We use the SPARK by Biomotum as a resistive ankle exoskeleton (Exo) and the SpineX SCONE to deliver transcutaneous spinal cord stimulation (tSCS). We hypothesize that Exo, being resistive, will reduce step length in the short term, while tSCS will boost coordination of muscle activity to increase step length. Each participant attended four sessions where they walked for 20 minutes either with no devices, Exo only, tSCS only, or Exo + tSCS. Participants wore passive reflective markers to track the position of their feet while walking. Data were collected and analyzed in Qualisys Track Manager (QTM), and MATLAB to quantify the step length for each day. Early results suggest that this single use of Exo with biofeedback may lead to increased step length, while tSCS primarily reduces step length variability for two participants. Future work will involve more participants and repeated sessions to measure if more exposure to devices can contribute to a lasting change. The results of this ongoing work will help us to understand what mechanisms we might incorporate into physical therapy for children with CP to target changes in step length.

Spinal cord stimulation to improve walking in individuals with spinal cord injury in an exoskeleton

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Our study focuses on people who have experienced spinal cord injury. To evaluate the effects on gait performance, we paired transcutaneous spinal cord stimulation (tSCS) with exoskeleton assisted walking (EAW). Two people, at least one year after their spinal cord injury, participated in the study. Both participants underwent a training period and used an assistance mode appropriate for them. The positions of the electrodes were then marked on the participants' back. The intensity of spinal stimulation was adjusted in response to participant feedback and observed walking performance. Each outcome was repeated twice per session, once with stimulation off and once with stimulation on, and tested for significant changes [$p<0.05$]. Participant 1 needed less exoskeleton assistance during the swing phase of walking with stimulation [$p<0.05$]. Participant 2 was able to complete the two-minute walk test, and they walked faster and further with stimulation [$p<0.01$]. They also swung their legs faster and took longer steps with stimulation [$p<0.05$]. In summary, the addition of tSCS led to a significant decrease in the amount of assistance needed, faster gait speeds, longer step lengths, and shorter swing periods when compared to EAW alone. Spinal cord stimulation has shown promising results in improving walking using both implanted and transcutaneous stimulation. Our findings demonstrate that the addition of tSCS improved EAW gait performance and coordination as compared to EAW alone. The results from this study will guide the development of a follow-up study to investigate the long-term benefits of this combined approach. Our long-term goal is to restore movement and coordination, which could ultimately improve mobility and quality of life for individuals living with a spinal cord injury.

Transcutaneous Spinal Cord Stimulation to Restore Function in Cervical Spinal Cord Injury

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Spinal cord injury can often result in loss of motor, sensory and autonomic function. The current standard of care is patient-specific physical therapy (PT) interventions to allow existing neural pathways to provide some compensation. Transcutaneous electrical stimulation is a new technique where electrodes placed on the skin over the spinal cord send electrical pulses to nerves in or near the spinal cord. Transcutaneous stimulation can be combined with PT to improve arm or leg function. This study tests if transcutaneous stimulation with physical therapy is a more effective treatment than just physical therapy alone. Four participants in this study had an incomplete C2-C7 spinal cord injury and their injury occurred at least one year before the study, resulting in upper extremity dysfunction. Baseline measurements were conducted over four weeks. Intervention consisted of six weeks of PT alone and six weeks of stimulation combined with PT, in a randomized order separated by a washout period, followed by a twelve-week follow-up. Preliminary results indicated that improved upper extremity motor function and sensation were superior with PT combined with transcutaneous stimulation than just PT alone. These gains in function and sensation persisted throughout the follow-up period without further

stimulation. Transcutaneous spinal cord stimulation paired with PT could become the new standard of care for improving outcomes in people spinal cord injury for more than one year. Further research will test the efficacy and safety of transcutaneous spinal cord injury in a variety of individuals with co-morbidities.

Social and Environmental Enrichment Aiding Rehabilitation Post-SCI

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Spinal cord injuries (SCI) are physiologically devastating events that are often equally emotionally taxing. Severe car accidents and even illnesses can answer for this drastically impaired motor function. And, SCI, as expected, is no rarity; SCI directly impacts up to half a million individuals annually. Following these events, psychological stress, pre and post-SCI, can depress a patients' healing capabilities. A well-known stressor for social creatures alike is the presence of loneliness. This loneliness can be interpreted as psychological stress for the animal, which will then delay the healing process post-SCI. This delay has been found in Long-Evans rats but specifically in males. In an effort to improve recovery, a pilot experiment was conducted to expose male rats to more enrichment, both social and environmental. The expectation of this experiment is to induce neural plasticity via the enrichment. Of seven male rats, four were assigned to the experimental group based upon ages and weights. From there, they were grouped in pairs and acclimated to each other for roughly two weeks before contact was initiated, which lasted for around two weeks. After an initial assessment of motor recovery, it was found that there are no significant differences in motor control between the experimental group and the control group. This lacking difference could be due to the brief treatment period the experimental group received. Moving forward with this experiment, more time will be given to allow longer contact between the experimental pairs. Additionally, this enrichment will likely be done in conjunction to electrical stimulation, which is commonly utilized now and postulated to also induce neural plasticity. This combination can make a significant difference for the participants in this study as well as real world victims to SCI.