2024 Summer Undergraduate Research Symposium

August 14, 2024; Zillow Room (4th Floor), CSE2, University of Washington

Zoom: https://washington.zoom.us/j/99856070687

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

Short Talks (5 minutes + 2 minutes questions)

1.	9:03-9:10 am	Umme Habiba	(Ferguson Lab)
2.	9:10-9:17 am	Kelsey Carvajal	(Golden Lab)
3.	9:17-9:24 am	Ashton Newswanger	(Perlmutter Lab)
4.	9:24-9:31 am	Maryam Aslam	(Ramirez Lab)
5.	9:31-9:38 am	Katie Farrell	(Yazdan-Shahmorad Lab)
6.	9:38-9:45 am	Brianna Smith	(Bruchas Lab)
7.	9:45-9:52 am	Brady Borchelt	(Orsborn Lab)
8.	9:52-9:59 am	Mathew Sarti	(Orsborn Lab)
9.	9:59-10:06 am	Jason Klein	(Smith Lab)
10.	10:06-10:13 am	Taylor Graham	(Goering Lab)
11.	10:13-10:20 am	Charlie Walker	(Goering Lab)

10:20-10:30 am – BREAK

12.	10:30-10:37 am	Frankie Reyna	(Stocco Lab)
13.	10:37-10:44 am	Eva Swartz	(Stocco Lab)
14.	10:44-10:51 am	Yosun Gezahegn	(BassoLab)
15.	10:51-10:58 am	Noelle Mattingley	(Gire Lab)
16.	10:58-11:05 am	Daniel Wang	(Herron/GRID Lab)
17.	11:05-11:12 am	Viridian Klei	(de la Iglesia Lab)
18.	11:12-11:19 am	Tiffani Swalinkavich	(de la Iglesia Lab)
19.	11:19-11:26 am	Eric Feng	(Tuthill Lab)
20.	11:26-11:33 am	Brennan Summy	(Brunton Lab)
21.	11:33-11:40 am	Riley Bernas	(Steele Lab)
22.	11:40-11:47 am	Micaela E. Romero	(Wang Lab)

Program

11:47-1:00 pm – LUNCH BREAK

Posters

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

Umme Habiba | Kelsey Carvajal | Ashton Newswanger | Maryam Aslam | Katie Farrell | Brianna Smith
Brady Borchelt | Mathew Sarti | Jason Klein | Taylor Graham | Charlie Walker

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

Eva Swartz | Frankie Reyna | Yosun Gezahegn | Noelle Mattingley | Daniel Wang | Viridian Klei
Tiffani Swalinkavich | Eric Feng | Brennan Summy | Riley Bernas | Micaela E. Romero

ABSTRACTS

Investigating the Role of Intratelencephalic and Pyramidal Tract Neurons in the Prefrontal Cortex in Fentanyl Self Administration

Umme Habiba, Alex Whitebirch, Susan Ferguson
Department of Psychiatry, University of Washington, Seattle, WA
UW Center of Excellence in Neurobiology of Addiction, Pain, and Emotion

Fentanyl, a synthetic opioid, has been a major driver in the opioid crisis in recent years, highlighting the need for a better understanding of the neural mechanisms underlying its addictive properties. This study investigates the roles of intratelencephalic (IT) and pyramidal tract (PT) neurons within the prefrontal cortex (PFC) in fentanyl self-administration in a rodent model. The PFC, particularly the prelimbic cortex in rats, regulates functions such as decision-making, planning, and impulse control, which are important in addiction-related behaviors. Using a rodent model, we used intermittent access self administration to fentanyl to mimic human addiction patterns. The experiment involved phases of self-administration training, intermittent access, re-baseline, and extinction, during which we collected fentanyl infusion data and behavioral responses of the rats. Our findings in this cohort indicate a learning pattern where the animals quickly identify periods of drug availability and aimed to maximize drug intake during these periods, while minimizing attempts during periods of unavailability. This behavior suggests a strong influence of environmental cues on drug-seeking behavior. For our next cohort, we will aim to increase the sample size to better track sex differences and risk behaviors. GCaMP8, a genetically encoded calcium sensor, was delivered to target regions to monitor neuronal activity via a virus and in the future, we hope to adjust the injection site and fiber photometry equipment to enhance the quality of neuronal activity measurements.

Oral Fentanyl Self-Administration in Male and Female Mice

Kelsey Carvajal[1,2], Lukas MacMillen[3,4], Erica Sanchez[3,4], Jovana Navarrete[3,4,5], Kevin Coffey[3,4], Sam Golden[3,4]
[1]ENDURE Program, University of Washington, Seattle, WA
[2]Undergraduate Neuroscience Program, University of Washington, Seattle, WA
[3]Department of Biological Structure, University of Washington, Seattle, WA
[4]Center of Excellence in Neurobiology of Addiction, Pain, and Emotion (NAPE), University of Washington, Seattle, WA
[5]Graduate Neuroscience Program, University of Washington, Seattle, WA

The opioid epidemic in the United States results in over 80,000 deaths annually, with fentanyl accounting for more than 70,000 of these deaths. Addressing this crisis is challenging due to the limited understanding of the neural mechanisms underlying drug-seeking, drug-taking, and relapse behaviors in opioid addiction. To bridge this gap, a preclinical model was developed in which male and female CD-1 and C57 mice self-administered oral fentanyl and underwent behavioral economics. Recorded videos from these experiments were used to generate pose estimations for later behavioral analysis modeling. Findings show that mice can acquire the ability to self-administer fentanyl orally, exhibit active drug-seeking behaviors, and lever-press to sustain a 'desired' intoxication level. Additionally, pose estimation for black C57 mice was developed using the Social LEAP Estimates Animal Poses (SLEAP) program. The data collected can serve as valuable tools for further research into drug-seeking, drug-taking, and relapse behaviors associated with opioid addiction. Overall, these findings provide critical insights into the neural mechanisms of opioid addiction, contributing to the development of more effective strategies to combat the ongoing opioid epidemic.

Sex Differences in Anxiety and Locomotion After Cervical Spinal Cord Injury

Ashton S. Newswanger[1], Pratyush P. Kore[2], R. Logan Murphy[2], Chary M. Batista[2], Katherine D. Green[2], Robert Robinson[2], Steve I. Perlmutter[2,3]

[1]Neuroscience Department, Ursinus College, Collegeville, PA

[2]Physiology & Biophysics Department, University of Washington, Seattle, WA

[3] Washington National Primate Research Center, University of Washington, Seattle, WA

More than 15 million people are living with spinal cord injuries (SCI), but research has yet to discover a cure. The lab of Dr. Steve Perlmutter is developing an electrical spinal stimulation protocol to improve movement recovery after SCI. Initial studies in rats revealed that weeks of stimulation lead to significant improvement in motor function, but only in female rats. In this initial report of new studies, we explore if sex-dependent anxiety impacts locomotion after cervical spinal injuries through behavioral assays, such as open-field test (OFT) and light-dark box (LDB). The OFT and LDB are used to identify anxiety-like behavior through the rat's willingness to expose itself to an open area. Through computational analysis, we found that female rats exhibit greater anxiety-like behavior compared to males, unrelated to injury, and that locomotion significantly decreases two weeks post-injury (sub-acute phase of SCI) in males and females equally. In addition, injured rats exhibit a trend toward more anxiety-like behavior than uninjured rats, but without a sex-dependence. These findings lead us to investigate further post-injury impacts beyond the sub-acute period, as we have yet to identify a cause for female rat's sensitivity to therapy. The stimulation therapy begins to improve recovery in female, but not male, rats 4-6 weeks post-injury, making this time point of particular interest.

Characterizing swallow-breathing coordination in male MECP2 knockout mice compared to wild-type

Maryam S. Aslam[1], Ariah M. Richards[1], Alyssa Huff[1], Zack T. Glovak[1], Jan-Marino Ramirez[1,2]

[1]Norcliffe Foundation Center for Integrative Brain Research, Seattle Children's Research Institute, Seattle, WA, USA

[2]Department of Neurological Surgery, University of Washington School of Medicine, Seattle, WA, USA

Rett syndrome (RTT) is a neurodevelopmental disorder affecting 1 in 10,000 females each year, causing severe intellectual and physical disabilities[1]. It is mainly linked to mutations in the MECP2 gene on the X chromosome[2]. While an MECP2 mutation alone does not guarantee an RTT diagnosis[3], it significantly contributes to the disorder's symptoms, which include seizures, breathing problems, and gastrointestinal issues[4]. These symptoms worsen over time, reducing the quality of life for patients and increasing the burden on their caregivers[6]. Male MECP2 KO mice (n=10, age 5 weeks) were compared to WT mice using physiological monitoring in a plethysmography chamber to assess respiratory patterns during a 10-minute drinking session with a sucrose solution. The whole body plethysmography recorded the frequency and duration of breathing pauses. Mice were conditioned for 2 days prior to the study, and all sessions were video recorded. Behavioral and physiological data were collected and analyzed to compare respiratory patterns, identify apnea events, and visualize differences between KO and WT mice. KO mice exhibited RTT-like behaviors such as clasping, slow movement, tremors, and disheveled fur. Respiratory analysis revealed that KO mice had a lower breathing frequency and greater variability in breaths during drinking compared to WT mice. KO mice showed shorter drinking bouts, more frequent apnea episodes, and increased time between licks and bouts. Additionally, KO mice took longer to locate water sources. MECP2 KO mice demonstrate significant respiratory and swallowing dysfunctions compared to WT mice, reflecting the complex neural pathway deficiencies associated with RTT. These findings demonstrate the need for further studies using female RTT models and additional techniques such as fluorescence dye to detect aspiration and electrodes to study swallowing mechanics. This will deepen the understanding of RTT and aid in developing targeted interventions for respiratory and swallowing dysfunctions in affected individuals.

1.Hagberg et al. 2002 2. Petriti et al. 2023 3. Neul et al. 2010
4. Rett, 1966 5. Ramirez et al. 2020 6. Motil et al, 2011

Dynamical Similarity Analysis of primate cortical networks under targeted optogenetic stimulation

Kathryn Farrell[1], Felix Schwock[2], Azadeh Yazdan-Shahmorad[2,3]
[1]Princeton Neuroscience Institute, Princeton, NJ
[2]Department of Electrical and Computer Engineering, University of Washington, Seattle, WA
[3]Department of Bioengineering, University of Washington, Seattle, WA

Neural plasticity, or the capacity of neural circuitry to adapt its functionality and structure over time, is fundamental to the versatile computational power of biological neural networks. However, the effects of plasticity-driven reorganization on large-scale neural circuits are unclear. Previous work in categorizing the behavior of neural networks has focused primarily on the organization of high-dimensional neural signals into low-dimensional manifold spaces, and relies on the geometric properties of these latent spaces to characterize distinct computational processes. While this approach may effectively identify differences in the neural ensembles that compose network responses, emerging data from the fields of machine learning and dynamical neuroscience suggest that key distinctions between computational processes lie in the features of their temporal dynamics, and may be largely independent from their latent space geometry. Using the theoretical framework of Dynamical Similarity Analysis recently proposed by Ostrow et al., we examine linear approximations of the dynamical systems in primate cortical networks, as well as their topological distortion under targeted optogenetic stimulation. We demonstrate that the topological features of these dynamical systems are largely invariant to changes in network stimulation patterns, but remain consistently separable across different primate brains. Furthermore, we find that long-term stimulation conditioning is associated with an increasing distortion of these features over time. These findings clarify the behavioral dynamics of biological neural networks during stimulation-induced cortical reorganization, and provide insights into the topological landscape of neural plasticity adaptations.

Visualizing Mu-Opioid Activity in the Ventral Tegmental Area

Brianna Lynn Smith[1,2], Catalina A. Zamorano[2,3,4], Michael R. Bruchas[2,3,4,5]
[1]Department of Human Centered Design Engineering, University of Washington, Seattle, WA [2]Center for Neurobiology of Addiction, Pain, and Emotion, University of Washington, Seattle, WA [3]Department of Pharmacology, University of Washington, Seattle, WA
[4]Department of Anesthesiology and Pain Medicine, University of Washington, Seattle WA
[5]Department of Bioengineering, University of Washington, Seattle, WA

Opioid use disorder and opioid overdose affect people worldwide, with over 2.1 million people in the United States being impacted by opioid use alone. With the exponential increase in opioid use and its corresponding overdose death rates, it is important to further understand mu-opioid activity within the brain. Despite the severity of the opioid crisis, previous research has struggled to understand and detect endogenous opioid release and its involvement in reward. In this study, we used a novel mu-opioid biosensor to measure opioid release in the Ventral Tegmental Area (VTA). We found that the higher dose of fentanyl, an exogenous opioid, causes more activity at the sensor in the VTA brain compared to a lower dose. Additionally, the opioid antagonist naloxone decreased the fentanyl-induced increase within the VTA. Previous research trying to detect endogenous opioid release has largely been unsuccessful. These shortcomings are in part due to the inability to accurately measure opioid peptide release given the available techniques. One potential source of endogenous opioid release that has been identified by the lab is the Lateral Hypothalamus (LH). In order to better understand where enkephalin is located within the LH and what type of neurons it is expressed on, we conducted RNAscope. We found that enkephalin is expressed on both inhibitory and excitatory neurons in the LH, though there was slightly more enkephalin expression with inhibitory neurons. These results will help us understand how enkephalin could be impacting mu opioid receptor activity when released from the LH into the VTA. Our data furthers our understanding of the mechanisms of mu-opioid activity which will ultimately aid us in finding treatments for opioid use disorder.

Learning and Adaptation to 3D Visuomotor Rotations in a 2D Cursor Task

Brady Borchelt[1], Victoria Pierce[2], Leo Scholl[2], Pavithra Rajeswaran[3], Amy Orsborn[2-4]
[1]Undergraduate ENDURE Program, University of Washington, Seattle, WA
[2]Department of Electrical & Computer Engineering, University of Washington, Seattle, WA
[3]Department of Bioengineering, University of Washington, Seattle, WA
[4]Washington National Primate Research Center, Seattle, WA

Animals learn internal models that enable them to generate predictable movements. The factors determining whether an internal model is newly formed or rather adapted from a similar task are not fully understood. Previous non-human primate studies suggest that difficult rotations shifting task-relevant movement to a new plane may lead to the formation of new internal models, however, it is unknown if similar results occur in humans. To explore this, we used a novel visuomotor perturbation model to manipulate the relationship between hand and cursor movement in five human subjects. Participants were trained on a 2D point-to-point reaching task controlled by hand movements in 3D space, with initial cursor control matching up-down and left-right movement of the hand. We then introduced a 45-degree rotation of the mapping along both the x- and y-axes of the 2D task plane. Finally, we reverted the perturbed plane to its initial mapping to observe any effects of washout. We hypothesized that this 'out-of-plane' perturbation would lead to the formation of new internal models, showing no visible effects of washout. Our results indicated that the perturbed task plane was learned, as evidenced by an increasing success rate and decreasing variance in the task-irrelevant dimension. However, contrary to our hypothesis, the effects of perturbation were still present after reverting to baseline mapping. Analysis of the 3D hand movement suggests that subjects were using different strategies than expected to learn the perturbations. As this experiment is still in its early stages, we will continue testing more subjects with varying degrees and types of perturbations to investigate internal model formation and adaptation further.

Observing Motor Exploration in Primates during a 3D Center Out Task

Mathew Sarti[1], Pavithra Rajeswaran[2], Leo R. Scholl[3,4], Amy L. Orsborn[2,3,4]
[1]Molecular, Cell and Developmental Biology, University of California, Santa Cruz, CA
[2]Bioengineering, University of Washington Seattle, WA
[3]Electrical & Computer Engineering, University of Washington Seattle
[4]Washington National Primate Research Center, Seattle, WA

The brain learns and refines sensorimotor mappings with practice to optimally execute movements. These sensorimotor mappings often involve a reduction in dimensionality, which means that an animal must learn task relevant and irrelevant movements to perform tasks optimally. For instance, when a 3D input space is arbitrarily mapped to a 2D output space, users in order to learn which dimensions are task-relevant must explore in some strategic manner given that they don't have previous knowledge to guide movement. However, it remains unclear how this exploration occurs and changes, especially when task relevant dimensions are altered from previously learned arbitrary mappings. To study this, we analyzed delayed 2D center-out reaching task training data collected from two monkeys over 2 years. Initially, trials were intuitively mapped such that a 3D movement in the XY plane was projected to 2D cursor, while Z-axis movements were task irrelevant. We then introduced visuomotor perturbations, changing the relationship between arm movement and sensory feedback. We hypothesized that exploration of the task-irrelevant dimension, measured by variance in the Z-dimension, would decrease during learning and increase after exposure to perturbations where Z-dimension is task relevant. Our analysis shows that during learning of the center out task, variance in task irrelevant Z-dimension decreased steadily. However, after introducing perturbations, this variance increased, indicating enhanced exploration in the newly task-relevant dimension. These findings support our hypothesis and provide insight into how non-human primates adapt their sensorimotor strategies in response to changing task demands.

Radio Direction-Finding for Network-Aware Rover Path Planning

Jason Klein[1], Paolo Torrado[2], Joshua Smith[2,3]
[1]Bowers College of Computing and Information Science, Cornell University, Ithaca, NY
[2]Department of Electrical and Computer Engineering, University of Washington, Seattle, WA
[3]Allen School of Computer Science and Engineering, University of Washington, Seattle, WA

NASA is working on wireless communication infrastructure to support future science on the moon. Data transmission at all steps, from a source such as a rover to a destination such as a ground station on Earth, must be as efficient as possible. Prior work in this field of cognitive networking focuses on efficient inter-satellite routing and transmission protocols in the presence of obstructions, interference, and substantial time delays caused by the space environment. However, if a rover is responsible for collecting data, then efficient data transfer from the rover to either a base station or satellite is important as well. This work considers a rover traveling between two distant waypoints while communicating wirelessly with a base station. Our goal is to allow the rover to account for connection strength as it plans its path between waypoints. We do this without knowledge of the base station location by fusing odometry sensor readings with Channel State Information (CSI) computed as part of the wireless communication process. Specifically, beamforming algorithms convert raw CSI into Angle of Attack (AoA) information, which we then incorporate into a Model Predictive Control (MPC) local planner. We developed and open-sourced several Robot Operating System (ROS) packages that, together, extract AoA information from raw CSI and incorporate it into an MPC local planner. This combination of our ROS packages increases data transfer efficiency from rover to base station in both simulation and reality. Beyond efficient data transfer, our approach has a variety of applications, ranging from multi-rover cooperative exploration to lunar search-and-rescue of rovers that have lost satellite communication.

Stakeholder Views on Access and Ownership of Brain Data

Taylor Graham[1,2], Sara Goering[1], Eran Klein[1], Nicolai Wohns[1]
[1]UW Neuroethics Group, Department of Philosophy, University of Washington, Seattle, WA
[2]Fordham University, Bronx, NY

As private companies, such as Elon Musk's Neuralink, increasingly invest and conduct human-subject research in novel neurotechnologies, concern for brain data privacy and ownership arise. Who should have access to the sensitive brain data, who does it belong to, and how should it be shared and regulated? To address these questions, it is important to understand the perspectives of different stakeholders in order to ensure responsible innovation. To do so, I analyzed a qualitative interview with a participant from a BCI clinical trial, and conducted a literature review of perspectives from academic researchers and industry representatives regarding brain data privacy and ownership. The BCI participant expressed the opinion that they should have partial ownership of their brain data because (a) the brain data was derived from them, (b) it is like their medical information, and (c) they fear being exploited by industry for financial gain. Academic researchers believe they should have partial ownership of brain data because they give raw brain data meaning through their interpretation of it, but also believe study participants should have a right to the data because it is derived from them. Researchers also view current consumer neurotechnology regulations as inadequate. Industry representatives feel they have a partial ownership to brain data because they obtain consent from individuals to take ownership of it in certain ways, and owning the data is necessary for profit. A study between the industry perspective and the general public showed that industry representatives do not prioritize data privacy as strongly; they are optimistic that private companies can protect user privacy. These findings show that, though there seems to be no consensus regarding who owns neurotechnology-associated brain data, all stakeholders seem to acknowledge that ownership of brain data is shared, but also recognize that current brain data regulations need development.

Neurotechnology and Disability: Unpacking Ableist Assumptions in BCI Research

Charlie Walker[1], Andrew Brown[2], Eran Klein[2,3], Sara Goering[2]
[1]Department of Neuroscience, Georgia Institute of Technology, Atlanta, GA
[2]Department of Philosophy, University of Washington, Seattle, WA
[3]Department of Neurology, Oregon Health and Science University, Portland, OR

Disabled populations are the current targets and participants of implantable brain-computer interfaces (BCI). Despite this, there exists a conflict between disability communities' perspectives and BCI researchers' perspectives on how disability is framed and talked about. First, a review of disability studies literature was conducted to identify common assumptions regarding disability throughout society. This framework was then applied to BCI research literature to illustrate examples of these assumptions at work in the field. The assumptions identified were that disability must involve pain, suffering, and a lower quality of life; more risks and burden are acceptable if it means alleviating a disability; and disabled people desire normalization. These assumptions were observed in the language used in inclusion protocols for BCI studies, definitions of benefits in studies, and the ways in which intended use of devices were constructed. Such assumptions come together to paint a picture of disability as an inherently painful experience, making more risks acceptable in pursuit of an escape from disability, with the underlying belief that this is what all disabled individuals want. These assumptions are harmful and discount the value many find in disability and their disabled identity. Additionally, they ignore the social pressures on disabled people to normalize. Going forward, it is important to consider how disabled perspectives can be better integrated into the BCI research process to help avoid the further perpetuation of these assumptions. Furthermore, consideration should be given on how to ensure that disabled people do not feel undue social pressure to participate in BCI research and use BCI devices, and how to properly acknowledge the burden of BCI research participation. If assumptions about disability as a deficit are discarded, then the balance of benefits and burdens to BCI study participants must be reconsidered.

Investigation of MemoryLab's Underestimation of Patients Speed of Forgetting (SOF)

Frankie L Reyna[1], Andrea Stocco[2], Maarten van der Velde[3]
[1]Department of Psychology, University of Washington, Seattle, USA
[2]Institute for Learning and Brain Sciences, University of Washington, Seattle, USA

Recent Studies have advocated for the use of the ACT-R cognitive memory model as a way to diagnose cognitive impairments in patients using a key parameter, speed of forgetting (SOF). However, the tool used to diagnose patients, MemoryLab, has not been thoroughly tested on whether it diagnoses accurate SOF values. In this experiment, we run parameter recoveries on the MemoryLab algorithm with ACT-R model simulated patients to see how accurate estimated SOF values are. Additionally, we simulate various parameter combinations to test the reliability of MemoryLab diagnosing various types of patients. Data shows that the MemoryLab algorithm consistently underestimates the SOF of higher SOF models, and that variations in model parameters such as reaction time can have a significant effect on the accuracy of the algorithm. This gives insight into the possibility that previous studies underestimated patient SOF values, as well as gives insight into how the MemoryLab algorithm can be improved to account for variation in patients.

Investigating the Effect of Mass Presentation on Memory of Emotional Stimuli: A Pilot Study

Eva Swartz[1], Ariel Xinyue Li[2], Andrea Stocco[2]
[1]Neuroscience, Pitzer College, Claremont, CA
[2]Cognition and Cortical Dynamics Laboratory, University of Washington, Seattle, WA

Over 70% of people suffer a traumatic event at some point in their lives, and 20% develop Post-Traumatic Stress Disorder (PTSD). This number rises in certain professions - 1 in 3 first responders will develop PTSD, and over 28% of journalists. Some methods have been implemented in an attempt to reduce PTSD rates, such as allowing individuals time off after a potentially traumatic event. However, these methods fail to address the influence of spacing on memory encoding. In this study examining the effect of presentation on memory of emotional stimuli, two theories are implicated. The first is the Spacing Effect, which demonstrates that memories decay at a slower rate when they are recalled farther apart. The second is Multiple Trace Theory, stating that a memory's overall representation is made up of each time the event is recalled. This study examined the influence of spacing emotional images (low valence and high arousal) with neutral images (neutral valence and low arousal) on recall ability, number of memory intrusions, and distress of intrusions. We predicted that mass presented images would be recalled with lower accuracy, fewer intrusions, and lower average distress of intrusions. In this pilot study participants were shown several neutral, negative, and filler images in both spaced presentation (all versions of the same stimuli were shown one after another) and massed presentation (where negative images were presented with neutral and filler images between). The study demonstrated potential early evidence for mass presentation in reducing memory of emotional stimuli. No statistical significance was found, likely due to small sample size and participant bias. However, this pilot will inform future adjustments to the study which may have profound implications for preventing PTSD in vulnerable populations.

A High-Throughput Study of Two Macaque Species: The Relationship Between Cognitive Ability, Age, Health, and Age-Related Disease

Yosun Gezahegn, Kevan Kidder, Léana Doughty, Michele A. Basso
Department of Biological Structure, University of Washington, Seattle, WA

Neurodegenerative disorders such as Multiple-Sclerosis, Alzheimer's Disease, Parkinsons Disease, and Dementia, predominantly affect older adults, presenting significant global challenges due to an increasing aging population. Treating these disorders is problematic in that by the time many patients present clinically relevant symptoms it is often too late to significantly delay disease progression, making early detection of these disorders a key component to prevention and treatment. Data suggests a cascade of age- and disease-related physiological changes may occur decades before clinically relevant symptoms manifest. The current study aims to identify early-stage biomarkers related to age-related cognitive decline and neurodegenerative diseases using macaque monkeys. In order to achieve this goal, we designed and implemented a high-throughput cognitive testing device, allowing monkeys to interact freely with these devices from the comfort of their home cage. These cognitive testing devices are used both as a method of enrichment as well as to quantify macaque cognition across a range of cognitive domains. We concurrently collected blood and cerebrospinal fluid samples to analyze markers of inflammation and immune activation. At the end of the study the wealth of cognitive data that we collected will be correlated with our physiological data in order to identify those bodily changes which may serve as biomarkers for age-related cognitive decline and neurogenerative diseases.

Creating Automatic Posture Tools to Aid Sunflower Star Restoration and Analyze Behavior

Noelle I. Mattingley[1], Willem Weertman[2,3], Chloe Schwab[2], Vanessa Valdez[2], Jason Hodin[2], David Gire[3]
[1]Whitman College, Walla Walla, WA
[2]Friday Harbor Laboratories, University of Washington, Friday Harbor, WA
[3]Department of Psychology, University of Washington, Seattle, WA

Sunflower sea stars, *Pycnopodia helianthoides*, are large and relatively motile sea stars that are federally threatened and critically endangered. Sunflower stars are a keystone species that keep purple urchin populations in check, protecting kelp forests by preventing urchins from overgrazing. Breeding efforts at Friday Harbor Laboratories have been successful. We gathered a diverse data set, approximately 186,000 photos, from experiment archives and past projects. To select photos from image pools we used a sunflower star segmentation model to crop photos and a series of graph embedding and clustering steps to select sets of photos. We used CVAT, a web-based annotation tool, to annotate approximately 1200 photos, annotating madreporites, armpits, and disc centers. Using the annotated photos, we trained a YOLO-NAS (You Only Look Once-Neural Architecture Search) object detection model to identify sunflower star madreporites, armpits, and disc centers. The YOLO-NAS model has a positive relationship between average precision and recall and photos added. The model's average precision for madreporite annotations is higher than it is for other annotations. The overall recall for the model is low. The model's low recall may be due to the object detection models' perceptual window being designed for discrete objects, to test if this is the issue, we plan to do data transformations to train pose estimation models and semantic segmentation models. Ultimately, we plan to use sea star postural tools for automated behavioral tracking, quantitative morphometrics, and viewpoint estimation for photo re-identification.

Stream of Consciousness: Real-Time Intracranial Electroencephalography Data Streaming and Processing

Daniel Wang[1], Raphael Bechtold[2], Jeffrey Herron[2]
[1]Johns Hopkins University, Baltimore, MD
[2]University of Washington, Seattle, WA

Brain-computer interfaces (BCI) have the potential to transform the lives of people living with disabilities. A fundamental component of BCI is the robust, real-time streaming and processing of neural data. Invasive BCI have sensors that are surgically implanted into a patient's brain for access to high quality neural measurements. An example of such a sensor are stereo-electroencephalography (sEEG) electrodes, which are typically implanted in patients with epilepsy. These electrodes can be connected to a Natus Quantum, an FDA-cleared commercial neural signal amplifier, which runs for the entirety of the patient's stay in the hospital. We developed and implemented a software framework using Python and ZeroMQ that interfaces with the Natus Quantum for efficient and robust streaming of neural signals. This enables us to use an existing clinical device that's already in the clinical workflow for real-time neural data acquisition, visualization, and decoding for BCI applications.

Lunar Rhythmicity of Sleep Patterns in Urban Populations

Viridian Klei[1], Guadalupe Rodriguez Ferrante[2], Natalie Robison[3], Justin Kahn[2], Leandro Casiraghi[4], Ignacio Spiousas[4], Alicia Rice[2], Horacio de la Iglesia[2]

[1]Department of Bioengineering, University of Washington, Seattle, Washington

[2]Departmrnt of Biology, University of Washington, Seattle, Washington

[3]Departmrnt of Chemistry, University of Washington, Seattle, Washington

[4]Laboratorio Interdisciplinario del Tiempo (LITERA), Escuela de Educación, Universidad de San Andrés, Victoria, Argentina/CONICET

Historically, lunar cycles have been associated with changes in human behavior, but scientific evidence of this connection is often contradictory. In a past study, we established an association between moon phase and sleep timing/duration in rural Toba/Qom communities with restricted access to electric light. These participants sleep later and less during the days before the full moon, when moonlight is available during the first hours of the night. Surprisingly, similar results were found when studying, retrospectively and cross-sectionally, undergraduate students from Seattle, a highly urbanized environment where light pollution is brighter than moonlight. Here, we present a longitudinal study investigating whether the sleep patterns of young adults from Seattle cyclically change with the lunar month. We additionally compared our findings to the previously reported patterns seen in rural Toba/Qom communities. Participants from Toba/Qom communities (n=76), undergraduate students (n=34), and Seattle urban population (n=24) wore an actigraphy watch and completed sleep logs for 30-60 days (at least one complete lunar month). We observed that sleep presents an approximately 30-day period of rhythmicity at both the population and individual levels, in all groups. Using a linear model, our results from Seattle showed that sleep onset is delayed and sleep duration is shorter on the days before the new moon. Of the 58 participants from the Seattle area, 46 individuals (79%) showed statistically significant lunar rhythmicity for sleep onset and 41 (71%) for sleep offset and duration. The modeled phase for the Seattle participants is the almost direct opposite of the one found for the Toba/Qom communities. These phase differences may be caused by geographical location, time of collection, or access to artificial light. We are currently working to further understand the association between lunar cycles and sleep, at both the behavioral and physiological levels.

Fear Entrainment of Circadian Rhythms via Optogenetics

Tiffani N. Swalinkavich[1], Victor Y. Zhang[1], Sekun Park[2], Vivian Chen[1], Horacio O. de la Iglesia[1]

[1]Department of Biology, University of Washington, Seattle, WA

[2]Howard Hughes Medical Institute, University of Washington, Seattle, WA

Circadian rhythms synchronize, or “entrain”, to cyclic stimuli like the light-dark cycle, enabling the anticipation and coordination of physiological and behavioral functions. Our laboratory has shown that time-specific fear can also entrain circadian rhythms in mice. Using a naturalistic cage design, activity patterns of mice exposed to 24-hour recurring unpredictable footshocks were recorded and monitored, simulating cyclic dangers associated with seeking food and water outside a safe nest. When nocturnal mice experienced fearful stimuli during the nighttime in an area where they obtain all their food and water, they entrained to this cyclic stimulus and shifted circadian behaviors by 12 hours, becoming primarily day-active. Further studies demonstrated that an intact amygdala, an important fear-processing center, is necessary for fear entrainment. This study aimed to determine if local optogenetic activation of fear circuits can induce fear-entrained behaviors in mice. We targeted the expression of channel rhodopsin to Tac1 neurons in the parabrachial nucleus (PBN), an upstream region of the amygdala known to elicit escape behavior. Additionally, given the constraints of our fear conditioning chamber, we compared the efficacy of traditional fiber optic lasers versus new wireless LED probes in generating escape behavior and Fos induction in $Tac1^{PBN}$ neurons. Optogenetic stimulation using wireless LED probes did not induce flight responses or fear entrainment of behaviors, whereas fiber optic laser stimulation resulted in robust escape behavior and significant c-Fos expression within the PBN. Viral targeting of $Tac1^{PBN}$ neurons was consistent across all mice, regardless of placement or light intensity from either fiber optics or LED probes. These findings suggest that wireless LED probes lack sufficient power for effective optogenetic stimulation. Future studies will utilize laser-driven optogenetics to test whether stimulation of $Tac1^{PBN}$ neurons is sufficient to emulate cyclic fear entrainment.

Neural Control of Grip Strength in *Drosophila*

Eric Feng[1], Anthony Azevedo[2], John C. Tuthill[2]
[1]School of Computer Science, Carnegie Mellon University, Pittsburgh, PA
[2]Department of Physiology and Biophysics, University of Washington, Seattle, WA

Insects have evolved to grip and walk over many surfaces, in many cases even inverting to walk on ceilings. The claws at the end of each leg allows them to maintain this grip even while upside down. Previous work has characterized the anatomical specializations for grip: adhesive pads, and claws of varying sharpness, shape, and size. Much less is known about the neural control of these structures necessary for engaging and releasing the claw. Here, we investigate the neural control of substrate grip in *Drosophila Melanogaster* through a suite of genetic tools and novel maps of neural circuitry (connectomics) to understand the role of motor neurons (MNs) in substrate grip. We first measured the baseline grip strength of flies by placing them on a rotating platform, an insect centrifuge, and measuring the centripetal force at which they are ejected. We then used the split-GAL4 expression system to optogenetically inhibit a single MN innervating the Retractor Unguis (RU) muscle, the muscle responsible for claw retraction. Expressing the inhibitory opsin GtACR allowed us to silence that neuron's activity using green light. Our preliminary results found that when exposed to higher intensities of green light, GtACR-expressing flies endured lower centripetal forces, suggesting a lower grip strength. At the highest intensity, the flies endured, on average, 21.8% lower forces. Neural activity in MNs, is orchestrated by networks of presynaptic motor neurons (pre-MNs) that synapse onto them. This map of synaptic input to fly MNs, termed the connectome, indicates neural interactions that govern motor behaviors. Using this connectome, we compared leg MNs across segments of the fly ventral nerve cord (VNC) based on shared presynaptic input and identified pre-MNs with a putative role in controlling grip. These pre-MNs are targets for future studies to further investigate the neural basis of fly grip and broaden our understanding of insect motor control.

Neuroanatomy Inspired Models Pave the Way to Functional Realism in *Drosophila* Locomotion Simulations

Brennan Summy[1], Elliott Abe[2,3,4], Harsha Gurnani[2,3,4], Bing W. Brunton[2,3,4]
[1]Department of Physics, University of Washington
[2]Department of Biology, University of Washington
[3]Computational Neuroscience Center, University of Washington
[4]eScience Institute, University of Washington

While locomotion plays a major role in the lives of most animals, how the central nervous system synthesizes sensory feedback and internal signals to produce the complex series of coordinated muscle activations necessary for locomotion remains unknown. The fruit fly *Drosophila* is a convenient model for the study of this neural framework due to the availability of high resolution behavioral and anatomical data. In particular, recent advancements in motion capture paired with neural connectome data have allowed for the design of a biologically inspired computational model of fly walking behavior. The model structure includes several modules designed to collectively mimic the functional hierarchy of brain activity that controls walking in *Drosophila*. The heart of the model consists of a neural network and a controller module that work together to emulate functions of the fly Ventral Nerve Cord (VNC) which is involved in transforming high level input from the brain, such as intended walking direction, into the appropriate motor signals. After training the neural network with motion capture data, the model was shown to produce realistic walking movements even in the presence of stochastic perturbations. However, the physical dynamics equations underlying this model have so far excluded certain forces and have relied on approximation in order to support a linear controller module. These omissions limit both accuracy and breadth of predictions that the model can support about locomotion control in the fly. In this project we will extend both the controller module and the dynamics context in order to include all relevant forces in a nonlinear simulation. The resulting model will support abstract and specific predictions about multiple aspects of the fly's neural physiology in the context of locomotion, from broadly how movement can be conceptualized to how the fly brain balances proprioception and internal signaling in locomotor error correction.

Quantifying low-cost switch access play-kit usage in clinical settings: A first glance

Riley E. Bernas[1,2], Mia E. Hoffman[1,4], Heather A. Feldner[3,4], Katherine M. Steele[1,4]
[1]Department of Mechanical Engineering, University of Washington, Seattle, WA
[2]Mechanical Engineering, University of Connecticut, Storrs, CT
[3]Department of Rehabilitation Medicine, University of Washington, Seattle, WA
[4]Center for Research and Education on Accessible Technology and Experiences (CREATE), University of Washington, Seattle, WA

Play is a crucial part of development for all children. However, children receiving Early Intervention services to support their motor and cognitive development may find traditional play activities to be inaccessible. Adapted toys and switches offer alternative interaction methods, but are expensive, difficult to customize, and not widely available. Previous research has developed a low-cost, switch accessible, digital play kit with families and clinicians. This technology includes switches made from household materials, an input device containing a simple circuit board, and interactive digital media that can be accessed on a variety of devices. This study investigates how Early Intervention clinicians perceive the switch kit initially, and how a clinician's use of the technology with their clients can be quantified. Two clinicians were provided with the switch kit to use with clients over a period of four to six weeks. Clinicians participated in semi-structured interviews and completed surveys. Quantitative usage metrics, including interaction time and game play, were recorded using digital media in Scratch, a block coding language designed for kids. Initial perceptions show that clinicians were excited about the switch kit, and had several ideas about how they could use the technology with their clients. Usage data shows that clinicians have been using the kit regularly during the study thus far. Initial results suggest that the switch kit is a promising tool in Early Intervention settings because it provides accessible opportunities to play and learn without the barriers posed by commercial switches and adapted toys. Future investigation will include gathering interaction metrics from additional clinicians to gauge usage trends and evaluate the switch kit's efficacy. From there, it is our hope that the switch kit will become a tool that can be used by clinicians and families for a variety of needs from supporting therapy to play, improving access to switch technology for the broader community.

Bumblebees Exhibit Behavioral Changes Post-Isolation

Micaela E. Romero[1], Stephanie Yiru Zhu[2], Nastacia L. Goodwin[3], Sal Nemes [3], Z Yan Wang[2,3]
[1]Molecular Bioscience, Bellevue College, Bellevue, Washington
[2]Department of Biology, University of Washington, Seattle, Washington
[3]Department of Neuroscience, University of Washington, Seattle, Washington

The impacts of Covid-19 Pandemic Isolation were felt across the world and opened the door to discuss the most extreme form of isolation, solitary confinement. More than 15 days of solitary confinement is considered torture by the United Nations (UNOHCHR, 2024), but incarcerated individuals in Washington State may face 5, 10, 20, or more years in solitary confinement throughout their sentence prior to being released back to our communities. Existing isolation research models use mammals for observation or self-report assessments with humans due to ethical limitations. Bumblebees were used for the experimental design due to their eusocial behavior, hierarchical society, caste of workers, and complex cognitive abilities that have increased their use in Psychology & Neuroscience research. The treatment housed adult bumblebees similar to current solitary confinement conditions for humans in WA, including 24 hour light exposure, for 5 days of treatment, prior to behavioral trials and qPCR analysis. From the behavioral trials that have been analyzed, there are changes in open arena movement and interactions between the treatment groups and control. Ongoing research is being done to complete the data extraction and analysis as well as increase sample size. Long-term exposure to torture by incarcerated individuals may cause behavioral and biological damage that doesn't serve the interests in justice or community safety. For over a decade, Washington State has failed to pass legislation to limit the misuse of solitary confinement similar to legislation that exists in other states. Neuroscience was the basis for ending adolescent solitary confinement in the state; it can be the basis for extending those provisions to adults with further research to guide evidence-based solutions.

REFERENCES

United States: Prolonged solitary confinement amounts to psychological torture, says UN expert | OHCHR. United Nations Human Rights Office of the Commissioner. (2024, February 28). https://www.ohchr.org/en/press-releases/2020/02/united-states-prolonged-solitary-confinement-amounts-psychological-torture