Neuroscience Seminar Series schedule

All seminars are currently scheduled from 4-5 pm mountain time (this may have to change for some of our speakers on the East Coast presenting via Zoom meeting!). Local speakers may provide in-person seminars, while our out-of-state guests will join via Zoom Meeting.

Spring 2022

January 25, 2022 – Dr. Anu Sharma (tentatively in person)
Professor, Department of Speech, Language and Hearing Sciences, University of Colorado Boulder

Title: **Harnessing Neuroplasticity to Enhance Clinical Outcomes in Hearing loss**.

Abstract: One of the most remarkable aspects of the brain is neuroplasticity, or the brain's ability to adapt in response to change. A basic tenet of neuroplasticity is that the brain will re-organize following sensory deprivation. Hearing loss, which is one of the most common chronic health conditions, results in both structural and functional changes in the brain. Adults and children with hearing loss who receive intervention with hearing aids and cochlear implants provide a platform to examine the trajectories and characteristics of deprivation-induced and experience-dependent plasticity in the central auditory system. Cross-modal neuroplasticity is another form of cortical re-organization associated with hearing loss. For example, in deaf animals, auditory cortical areas are recruited and repurposed by visual and somatosensory modalities. In humans with hearing loss, cortical re-organization may result in decreased cognitive reserve and may be associated with dementia-related cognitive decline. Hearing loss has been recently described as a most important mid-life, modifiable risk factor for dementia. By harnessing neuroplasticity, we are developing brain-based biomarkers to detect early neurocognitive changes associated with hearing loss. The same biomarkers allow us to customize and monitor treatment for hearing loss which may result in improved neurocognitive outcomes.

February 8, 2022 – Dr. Roberto Cabeza (virtual via Zoom Meeting)

Professor, Department of Psychology and Neuroscience, and Department of Psychiatry and Behavioral Sciences, Duke University

Title: **Age-Related Compensation in Memory Networks and Representations.**

Abstract: Compensation refers the cognition-enhancing recruitment of brain resources. In functional neuroimaging studies, older adults often show greater activity than younger adults in the prefrontal cortex (PFC) and other brain regions. This effect is not limited to activity and can be also found in network connectivity. In one study, for example, we found that as working memory task demands increased, a PFC subnetwork become more integrated with the rest of the working memory network, particularly in high-performing older adults. A critical component of the episodic memory network, the medial temporal lobe (MTL) is impaired by aging. Our data suggest that this age-related MTL deficit is partly compensated by PFC function, which displays greater memory-related network integration and reconfiguration in older than younger adults. The causal mechanisms of compensation can be examined using Transcranial Magnetic Stimulation (TMS). In a TMS study, for instance, we found that disrupting the operation of left PFC in older adults led to an increase in functional connectivity of between this region and the contralateral right PFC, consistent with network-based compensation. Age-related compensation can be found not only in activity and connectivity but also in the quality of memory traces or representations. Visual representations tend to be less distinct in older than younger adults, a phenomenon known as age-related dedifferentiation. Our results showed that although older adults displayed dedifferentiation for sensory representations in early visual cortex regions, they showed hyperdifferentiation for categorical representations in the anterior temporal lobes. This finding is consistent with evidence that older adults may tap on semantic knowledge to compensate for deficits in other cognitive abilities. Taken together, our results illustrate how network and representational analyses can clarify the mechanisms of age-related compensation.

February 22, 2022 – Dr. John Thompson (in person)

Associate Professor, Departments of Neurosurgery and Neurology, University of Colorado Denver, School of Medicine

Title: **Spike, potential, and circuit: exploring neural function and pathology of the human brain in neurosurgical patients**

Abstract: Patients undergoing neurosurgical interventions provide a unique opportunity to explore normal and pathophysiological brain function in humans. Our lab works with patients with movement disorders and epilepsy treated with neuromodulatory interventions to examine sensory-motor processing, identify neurophysiological biomarkers of progression and therapeutic impact, as well as optimize therapy. In this seminar, I will discuss our work on improving intraoperative brain targeting and our exploration of the use of deep brain stimulation to improve sleep dysfunction in Parkinson's disease.

Marsh 8, 2022 – Dr. Lin Tian (virtual via Zoom Meeting)

Professor and Vice Chair, Biochemistry and Molecular Medicine, Affiliated with Center for Neuroscience, School of Medicine, University of California, Davis

Title: **Watching the brain in action: creating tools for functional analysis of neural circuitry.**

Abstract: To study the neural circuitry, the action of one cell under the context of others, one would precisely measure and perturb specific neuronal populations and molecules in behaving animals who are specifically engaged in performing the computation or function of interest. The dataset of millions of neurons firing together underlying a behavior are required to develop and refine theories (hypotheses) explaining animal behavior in terms of brain physiology. The focus of my lab is to develop novel genetically encoded indicators based on fluorescence proteins, especially focusing on direct and specific measurement of myriad input signals with needed spatial and temporal resolutions. In this talk, I will discuss our recent progress in developing and applying a new suite of genetically encoded indicators of neural activity. I will discuss the design, characterization and applications of these genetically encoded indicators for both in vivo imaging and drug discovery. In combination with calcium imaging and optogenetics, these sensors are well poised to permit direct functional analysis of how the spatiotemporal coding of neural input signaling mediates the plasticity and function of target circuits.

April 5, 2022 – Dr. Anthony Burgos-Roble (virtual via Zoom meeting)

Assistant Professor, Department of Neuroscience, Developmental & Regenerative Biology, University of Texas at San Antonio, TX

Title: **Surviving threats: Brain circuits controlling threat avoidance.**

Abstract: Safety and survival require efficient learning of potential threats in the environment. In this way, individuals can make appropriate behavioral responses to avoid any harm from the threats. In scientific terms, this brain function is known as threat avoidance learning. Since this function is affected in stress-related mental disorders such as anxiety and post-traumatic stress, to gain novel insight new studies are emerging to further explore the brain circuits and neural mechanisms underlying threat avoidance. In my lab, we have developed a couple of novel paradigms in mice to explore avoidance learning during distinct types of threat (e.g., artificial vs. naturalistic forms). We also implement various *in vivo* approaches to examine the functional role of specific brain regions and neural circuits. Finally, we implement models of chronic stress to examine alterations in the mechanisms of threat avoidance during disease-like states. These and other issues, such as differences between avoidance vs. safety learning, will be discussed in this seminar.

April 19, 2022 – Dr. Nikolaus Kriegeskorte

Professor, Department of Psychology, Department of Neuroscience, Columbia University

Title: **Controversial stimuli: Optimizing experiments to adjudicate among computational hypothesis.**

Abstract: Deep neural network models (DNNs) are central to cognitive computational neuroscience because they link cognition to its implementation in brains. DNNs promise to provide a language for expressing biologically plausible hypotheses about brain computation. A peril, however, is that high-parametric models are universal approximators, making it difficult to adjudicate among alternative models meant to express distinct computational hypotheses. On the one hand, modeling intelligent behavior requires high parametric capacity. On the other hand, it is unclear how we can glean theoretical insights from overly flexible high-parametric models. One approach toward a solution to this conundrum in the method of controversial stimuli. Synthetic controversial stimuli are stimuli (e.g. images, sounds, sentences) optimized to elicit distinct predictions from different models. Because synthetic controversial stimuli provide severe tests of out-of-distribution generalization, they reveal high-parametric models' distinct inductive biases.

Controversial stimuli can be used in experiments measuring behavior or brain activity. In either case, we must first define a controversiality objective that reflects the power afforded by different stimulus sets to adjudicate among our set of DNN models. Ideally, the objective should quantify the expected reduction in our uncertainty about which model is correct (i.e. the entropy reduction of the posterior). In practice, however, heuristic approximations to this objective may be preferable. If the models are differentiable, then gradient descent can be used to efficiently generate controversial stimuli; otherwise gradient-free optimization methods must be used.

We demonstrate the method in the context of a wide range of visual recognition models, including feedforward and recurrent, discriminative and generative, conventionally and adversarially trained models (Golan, Raju & Kriegeskorte, 2020). A stimulus was defined as controversial between two models if it was classified with high confidence as belonging to one category by one of the models and as belonging to a different category by the other model. Our results suggest that models with generative components best account for human visual recognition in the context of handwritten digits (MNIST) and small natural images (CIFAR-10). We will also share new results from applications of controversial stimuli in different domains and discuss the relationship of the method of controversial stimuli to adversarial examples, metamers, and maximally exciting stimuli, other types of synthetic stimuli that can reveal failure modes of models.

Controversial stimuli greatly improve our power to adjudicate among models. In addition, they provide out-of-distribution probes that reveal the inductive biases implicit to the architecture, objective function, and learning rule that defines each model. The method can drive theoretical insight because it enables us to distinguish computational hypotheses implemented in models that are sufficiently high-parametric to capture the knowledge needed for intelligent behavior.