NE/PSY 532: Neurobiology of Motivation, Decision Making, and Learning

Assigned readings and presentation signup

Week 1 (1/21): Course Introduction and Techniques

Background Reading: None

No assigned presentations or summaries due.

Week 2 (1/28): Motivation I

Background Reading:

Motivation concepts in behavioral neuroscience. Berridge, K. Physiol Behav, 2004

The Behavioral Neuroscience of Motivation: An Overview of Concepts, Measures, and Translational Applications. Simpson E et al. *Curr Top Behav Neurosci*, 2016.

- Which brain circuits and neurotransmitter systems are responsible for motivation?
- On what timescales does motivation fluctuate?
- How does the brain control innate motivational drives and homeostasis over slow timescales?

No assigned presentations or summaries due.

Week 3 (2/4): Motivation II

- Which brain regions are responsible for learned motivational drives?
- How do neural signals represent the learned motivational value of stimuli in the external world?

Background Reading: Same as prev lecture

Student Presentations:

Prolonged dopamine signalling in striatum signals proximity and value of distant rewards. Howe et al. *Nature,* 2013.

Presenter 1: Yamiley Laratte

Presenter 2: Allie Barlowe

Stochastic neuropeptide signals compete to calibrate the rate of satiation. Zhang et al. *Nature*, 2025.

Presenter 1: Emilia Entebi

Presenter 2:

Presenter 3:

Week 4 (2/11): Motivation III

- How are neuromodulatory signals signaling motivation to act translated into movement?
- How might activity in distinct basal ganglia circuits participate in motivation?

Reassessing Models of Basal Ganglia Function and Dysfunction. Nelson and Kreitzer. *Annu Rev. Neuroscience*, 2014.

Student Presentations:

1. Dopamine Is Required for the Neural Representation and Control of Movement Vigor Panigrahi et al. *Cell,* 2015.a

Presenter 1: Ari Centeno

Presenter 2: Allie Barlowe

Presenter 3: Heisha Medina

2. Dopamine dynamics are dispensable for movement but promote reward responses. Cai et al. *Nature*, 2024.

Presenter 1: Erica Matsui

Presenter 2: Yamiley Laratte

Week 5 (2/18): No class (Mon schedule)

Week 6 (2/25): Decision Making and Action Control I

- What are the distinct contributions that different brain regions make to decision making and action?
- How are goals and actions represented by neural activity in different brain regions?

Background Reading:

An Integrative Theory of Prefrontal Cortex Function. Miller and Cohen, *Ann. Rev. Neuro.,* 2001.

The Roles of the Cortical Motor Areas in Sequential Movements. Ohbayashi. *Front. Behav. Neurosci.,* 2021.

Functional architecture of basal ganglia circuits: neural substrates of parallel processing. Alexander et al. *TINS*, 1990.

Student Presentations:

1. Anatomically segregated basal ganglia pathways allow parallel behavioral modulation. Lee et al. *Nat. Neuro* 2020.

Presenter 1: Urvi Mishra

Presenter 2: Daisy Liljegren

Presenter 3:

2. Single neurons in prefrontal cortex encode abstract rules. Wallis et al. *Nature* 2001.

Presenter 1: Michael Pascale

Presenter 2: leslie hernandez

Week 7 (3/4): Decision Making and Action Control II

- How do circuits support action selection and working memory?
- How is sensory ambiguity and decision uncertainty resolved by neural circuits?
- How are neural representations of potential costs and benefits weighted to influence action?

Background Reading:

Decision Making as a Window on Cognition. Shadlen et al. *Neuron*, 2013.

Neural Representation of Costs and Rewards in Decision Making. Chen, *Brain Sciences,* 2021.

Student Presentations:

1. Ebitz et al. Exploration Disrupts Choice-Predictive Signals and Alters Dynamics in Prefrontal Cortex. *Neuron,* 2018.

Presenter 1: Michael Pascale

Presenter 2: Alua Tulbassova

Presenter 3: Clairette Kirezi

2. Localized Microstimulation of Primate Pregenual Cingulate Cortex Induces Negative Decision-Making. Amemori et al. *Nat Neuro*, 2012.

Presenter 1: Amena Nushrat

Presenter 2: Dayana Linares

Presenter 3: Aryn Lee

3. Antagonistic negative and positive neurons of the basolateral amygdala. Kim et al. *Nat Neuro*, 2016.

Presenter 1: Coro Vizcaio

Presenter 2: Allister Malik

Presenter 3: Cathy Qu

Week 8 (3/11): No lecture (Spring Break)

Week 9 (3/18): Learning I

- How are adaptive sensori-motor associations learned?
- How do signals reflecting positive outcomes influence later actions?

Background Reading:

Striatal plasticity and basal ganglia circuit function.

Student Presentations:

1. Selective corticostriatal plasticity during acquisition of an auditory discrimination task. Xiong et al. *Nature*, 2015.

Presenter 1: Viviana Castro

Presenter 2: Beckett Blocker

2. Dynamic refinement of behavioral structure mediates dopamine-dependent credit assignment.Tang et al. *BioRxiv*, 2023.

Presenter 1: Aryn Lee

Presenter 2: Edison Park

Presenter 3: Celine Schien

Week 10 (3/25): Learning II

- What are the neural signals that support learning from outcome feedback and how can they be explained through formal mathematical models?
- How are learning signals generated in neural circuits?

Background Reading:

Understanding dopamine and reinforcement learning: The dopamine reward prediction error hypothesis. Glimcher, P. *PNAS*, 2011.

Multiple Dopamine Functions at Different Time Courses. Schultz W., *Annu Rev. Neurosci*, 2007.

Student Presentations:

1. A distributional code for value in dopamine-based reinforcement learning. Dabney et al. *Nature,* 2020.

Presenter 1: leslie hernandez

Presenter 2: Sihyun Sung

2. Action prediction error: a value-free dopaminergic teaching signal that drives stable learning. Greenstreet et al. *BioRxiv*, 2024

Presenter 1: Yuqin Hu

Presenter 2: Kayla Xu

Presenter 3: Winnie Bai

Week 11 (4/1): Threat learning and avoidance

- What are the brain regions, neurotransmitter systems, and signals that support learning to avoid negative outcomes?
- What are the mechanisms underlying learning and escape from threats?
- Are there common algorithms and neural computations that support learning from positive, negative, or neutral feedback across systems?

Background Reading: N/A

Student Presentations:

1. A synaptic threshold mechanism for computing escape decisions. Evans et al. *Nature,* 2018.

Presenter 1: Ari Centeno

Presenter 2: Coro Vizcaino

2. Dopamine-mediated formation of a memory module in the nucleus accumbens for goal-directed navigation. Jung et al. Nat. Neuro, 2024.

Presenter 1: Emilia Entebi

Presenter 2:

Presenter 3:

Dynamical management of potential threats regulated by dopamine and direct- and indirect-pathway neurons in the tail of the striatum. Tsutsui-Kimura et al. *bioRxiv,* 2022.

No presentation for this paper, but we will discuss and you can choose this for a summary if you would like.

Week 12 (4/8): Parallel Systems for Learning and Behavioral Control

- How do different brain systems learn simultaneously to control different aspects of behavior?
- What behavioral features and neural systems are associated with flexible, goal-directed behaviors vs habitual behaviors?
- How do multiple systems cooperate or compete for behavioral control?

Background Reading:

Goals and Habits in the Brain. Dolan and Dayan. *Neuron*, 2013.

Student Presentations:

1. Differential Dynamics of Activity Changes in Dorsolateral and Dorsomedial Striatal Loops During Learning. Thorn et al. *Neuron*, 2010.

Presenter 1: Amena Nushrat

Presenter 2: Dayana Linares

Presenter 3: Daisy Liljegren

3. Uncertainty-based competition between prefrontal and dorsolateral striatal systems for behavioral control. Daw, Niv, Dayan, *Nat. Neuro* 2005.

Presenter 1: Urvi Mishra

Presenter 2: Erica Matsui

Week 13 (4/15): Studies of Human Motivation

Guest Lecturer: Dr. Mai-Anh Vu

Background Reading:

Learning and motivation in the human striatum. Shohamy D., *Curr Op in Neuro*, 2011.

Primer on fMRI

Student Presentations:

1. Distinct Regions of the Striatum Underlying Effort, Movement Initiation, and Effort Discounting. Suzuki et al, *Nat Human Behav*., 2021

Presenter 1: Alua Tulbassova

Presenter 2: Sihyun Sung

2. States of curiosity modulate hippocampus dependent learning via the dopaminergic circuit. Gruber et al. *Neuron*, 2014.

Presenter 1: Clairette Kirezi

Presenter 2: Heisha Medina

Week 14 (4/22): Disorders of Motivational Systems

- How can symptoms of disorders such as Parkinson's Disease and addiction arise from dysfunction of the normal neural circuit mechanism that control motivation and learning?
- How do current treatments act to (partially) correct neural circuit dysfunction?

Background Reading:

Circuits and Circuit Disorders of the Basal Ganglia. DeLong and Wichmann. *JAMA Neurology*, 2007.

The neuropsychological basis of addictive behavior. Everitt et al. *Brain Res Rev*., 2001.

Student Presentations:

1. Disruption of mitochondrial complex I induces progressive parkinsonism. Gonzalez-Rodriguez et al. *Nature*, 2021.

Presenter 1: Allister Malik

Presenter 2: Cathy Qu

2. Stochastic synaptic plasticity underlying compulsion in a model of addiction. Pascoli et al. *Nature* 2018.

Presenter 1: Beckett Blocker

Presenter 2: Viviana Castro

Week 15 (4/29): Future of Motivation Research and Therapeutics

- How might basic research in animal models be translated to help us better understand and develop new treatments for human disorders?
- What new tools are being developed (and are needed) to measure and manipulate brain activity and behavior at more precise spatial and temporal scales?

Background Reading:

From circuits to behavior: a bridge too far? Carandini, M. *Nat. Neuro*, 2012

Student Presentations:

1. Revealing the structure of pharmacobehavioral space through motion sequencing. Wiltschko et al. *Nat Neuro*, 2020.

Presenter 1: Yuqin Hu

Presenter 2: Kayla Xu

Presenter 3: Winnie Bai

2. Population-specific neuromodulation prolongs therapeutic benefits of deep brain stimulation. Spix et al. *Science,* 2021

Presenter 1: Edison Park

Presenter 2: Celine Chien