

PSYC 551 Spring 2024

Decision Neuroscience

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Office Hours: TBA
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Course Units: 4
Class Hours: Th 2-6pm
Class Room: SGM 601

Course Description

Choosing which action to take is as ubiquitous to everyday life as it is crucial to survival. Good decision-making is presumably subject to strong evolutionary selection; poor decision making is associated with many neurological and psychiatric disorders. This course explores how humans and animals make decisions, drawing broadly on many perspectives including particularly the nexus of psychological, neuroscientific, psychiatric, and computational considerations.

The course is organized around four modules covering key modern topics in decision neuroscience. The first module is "planning", exploring the neural basis of different forms of decision making. This module is computationally guided by reinforcement learning. The second module is "practice", covering how one can use computational models to analyze neural and behavioral data in practice. The third module is "inference", exploring the neural basis of inference problems that are critical for learning from consequences of decisions. This module is computationally informed by Bayesian theories. The last module, "psychopathology", is centered around the new topic of computational psychiatry, examining the neural and computational basis of dysfunctional decision making in pathological conditions.

Learning Objectives

After successfully completing the course, students are expected to have learned some of the most important topics in decision neuroscience, as well as how to formulate those problems computationally. Students are also expected to learn how they can effectively use computational models of decision making to analyze behavioral and neural data. The only requirement of the course is basic knowledge of probability.

- **Prerequisite(s):** Instructor permission

Course Notes

The course will comprise of a combination of lectures and paper discussions. Lectures cover fundamental concepts, while discussions, each led by a student, will center on significant experimental work. Lecture materials and their corresponding slides will be made available online after each lecture. There is no course textbook, but students will be expected to read 1-2 articles from the primary literature per week, which will be provided on the blackboard. The lectures may delve into materials not addressed in the readings, and students will be responsible for understanding the additional content covered solely in the lectures. Additionally, completing assigned readings on time is expected of all students.

Description and Assessment of Assignments

1. Reaction emails. Students are asked to write a brief note (one or two paragraphs) about their reactions to the week's reading assignments. These notes should be sent to the instructor prior to the class. All reaction emails should have the subject line "DN-course-reaction." If students send their reaction emails to a minimum of 80% of the sessions, they will receive full credit for this item.
2. Paper presentation. Each student will present an assigned paper and will moderate the discussion that follows. Students are expected to prepare slides for their presentation. The paper presentation carries a weight of 30% towards the final grade, and will be evaluated based on the quality of the slides, effective communication, and the student's competence in responding to questions.
3. Project presentation and final report. In lieu of a final exam, there will be a final project where students analyze a behavioral dataset. The goal is for students to gain firsthand experience leveraging computational decision-making models to effectively analyze behavioral data. This will include a project presentation, as well as a final report (4-6 pages.)

Grading Policy

- 10% Active participation
- 10% Reaction emails
- 30% Paper presentation
- 30% Project presentation
- 20% Final report

Grading Scale

Course final grades will be determined using the following scale:

Letter grade	Corresponding numerical point range
A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

Students are required to send their reaction emails at least one day before the corresponding discussion class.

Schedule and weekly learning goals

NOTE: The schedule is tentative and subject to change.

Thursday. 01/11. Introduction

Module 1: Planning

Thursday. 01/18. Sequential decision problems

Thursday. 01/25. Model-based vs model-free decisions

- Daw, N. D., Gershman, S. J., Seymour, B., Dayan, P., and Dolan, R. J. (2011). Model-based influences on humans' choices and striatal prediction errors. *Neuron*, 69(6):1204–1215
- Daw, N. D. (2018). Are we of two minds? *Nature Neuroscience*, 21(11):1497–1499

Thursday. 02/01. Prediction error theory of dopamine

- Schultz, W., Dayan, P., and Montague, P. R. (1997). A neural substrate of prediction and reward. *Science (New York, N.Y.)*, 275(5306):1593–1599
- Steinberg, E. E., Keiflin, R., Boivin, J. R., Witten, I. B., Deisseroth, K., and Janak, P. H. (2013). A causal link between prediction errors, dopamine neurons and learning. *Nature Neuroscience*, 16(7):966–973
- Niv, Y. and Schoenbaum, G. (2008). Dialogues on prediction errors. *Trends in Cognitive Sciences*, 12(7):265–272

Thursday. 02/08. Cognitive maps

- Behrens, T. E. J., Muller, T. H., Whittington, J. C. R., Mark, S., Baram, A. B., Stachenfeld, K. L., and Kurth-Nelson, Z. (2018). What Is a Cognitive Map? Organizing Knowledge for Flexible Behavior. *Neuron*, 100(2):490–509

Thursday. 02/15. Successor representation

- Russek, E. M., Momennejad, I., Botvinick, M. M., Gershman, S. J., and Daw, N. D. (2017). Predictive representations can link model-based reinforcement learning to model-free mechanisms. *PLoS computational biology*, 13(9):e1005768
- Stachenfeld, K. L., Botvinick, M. M., and Gershman, S. J. (2017). The hippocampus as a predictive map. *Nature Neuroscience*, 20(11):1643–1653

Module 2: Practice**Thursday. 02/22.** From model to data, and vice versa

- Daw, N. D. (2011). Trial-by-trial data analysis using computational models. In Delgado, M. R., Phelps, E. A., and Robbins, T. W., editors, *Decision Making, Affect, and Learning: Attention and Performance XXIII*, pages 3–38. Oxford University Press, New York
- Piray, P., Dezfouli, A., Heskes, T., Frank, M. J., and Daw, N. D. (2019). Hierarchical Bayesian inference for concurrent model fitting and comparison for group studies. *PLOS Computational Biology*, 15(6):e1007043

Module 3: Inference**Thursday. 02/29.** Bayesian inference**Thursday. 03/07.** Attention and learning

- Dayan, P., Kakade, S., and Montague, P. R. (2000). Learning and selective attention. *Nature Neuroscience*, 3 Suppl:1218–1223
- Behrens, T. E. J., Woolrich, M. W., Walton, M. E., and Rushworth, M. F. S. (2007). Learning the value of information in an uncertain world. *Nature Neuroscience*, 10(9):1214–1221

Thursday. 03/14. Spring recess**Thursday. 03/21.** Hidden cause inference

- Gershman, S. J., Blei, D. M., and Niv, Y. (2010). Context, learning, and extinction. *Psychological Review*, 117(1):197–209
- Shin, Y. S. and Niv, Y. (2021). Biased evaluations emerge from inferring hidden causes. *Nature Human Behaviour*, 5(9):1180–1189

Thursday. 03/28. Memory

- Rouhani, N., Norman, K. A., Niv, Y., and Bornstein, A. M. (2020). Reward prediction errors create event boundaries in memory. *Cognition*, 203:104269
- Franklin, N. T., Norman, K. A., Ranganath, C., Zacks, J. M., and Gershman, S. J. (2020). Structured Event Memory: A neuro-symbolic model of event cognition. *Psychological Review*, 127(3):327–361

Module 4: Psychopathology**Thursday. 04/04.** Computational psychiatry**Thursday. 04/11.** Addiction

- Redish, A. D. (2004). Addiction as a computational process gone awry. *Science (New York, N.Y.)*, 306(5703):1944–1947
- Everitt, B. J. and Robbins, T. W. (2016). Drug Addiction: Updating Actions to Habits to Compulsions Ten Years On. *Annual Review of Psychology*, 67:23–50

Thursday. 04/18. Anxiety

- Zorowitz, S., Katzman, P., and Daw, N. (2021). Anxiety is Associated With Reduced Value of Control in Sequential Decision Making. *Biological Psychiatry*, 89(9):S311–S312
- Browning, M., Behrens, T. E., Jocham, G., O'Reilly, J. X., and Bishop, S. J. (2015). Anxious individuals have difficulty learning the causal statistics of aversive environments. *Nature Neuroscience*, 18(4):590–596

Thursday. 04/25. Computational psychiatry in practice

- Gillan, C. M. and Daw, N. D. (2016). Taking Psychiatry Research Online. *Neuron*, 91(1):19–23
- Gillan, C. M. and Rutledge, R. B. (2021). Smartphones and the Neuroscience of Mental Health. *Annual Review of Neuroscience*, 44:129–151

Statement on Academic Conduct and Support Systems

Academic Integrity

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or recycle work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems

[Counseling and Mental Health](#) - (213) 740-9355 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#)- 988 for both calls and text messages 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline)

provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provosts Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.