The Neurobiology of Learning and Memory (PSYC 380)
Spring 2012

Professor:
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Office hours: By appointment

Meeting Time & Location:
Dewey Hall 238
Tuesdays, 1:00-3:45 pm

Course Description

The focus of this course is on a systems-level approach to the study of the neurobiology of learning and memory. While there will be some discussion of the molecular and cellular basis of learning and memory, the emphasis will be on how entire neural structures and circuits give rise to learned behavior. We will also integrate “psychological” processes in learning and memory, such as encoding, consolidation, storage, and retrieval into many of our discussions. I feel strongly that a solid grounding in the neurobiology of learning and memory must start at the behavioral and systems level; after all, learning and remembering are properties of the behavior of entire organisms interacting with their environments, not of individual neurons. Only with an understanding of the behavioral and systems level can one begin to approach the cellular and molecular level of learning and memory. In particular, what an organism can and can’t learn, and how learning and memory “look” at a behavioral level will, I feel, constrain interpretations of the cellular and molecular data.

My specific choice of topics in this course is guided by my sense of the ongoing, important areas of research that have a substantial body of data to support them. I have also tried to select readings that address an important area of debate within a particular topic. I always welcome student input in shaping the course and leave open the possibility of substituting readings based on student interest. In addition, our final meetings will give you the opportunity to present and discuss an article of your choosing.

Course Objectives

My intention is to give you a firm grounding in the concepts, theories, data, and techniques in the neurobiology of learning and memory so that you can apply what you’ve learned to your own research interests. You should also come away with an understanding of systems, behavioral, and cognitive neuroscience approaches in general.

While the readings for each week were chosen to paint a reasonably coherent picture of each topic, each of these topics represents an ongoing area of research in the field. Thus, there are no easy, “textbook” answers. I will give a 45-60 minute lecture in each class that will serve as an organizing structure but be prepared to put your own thought into how everything connects and where the contradictions are. Reading the original literature and learning how to integrate it are critical skills to learn in graduate school.
Course Requirements

**Thought papers.** At the end of some of our meetings, I will pass out thought questions, due for the next meeting. These are designed to get you thinking about the readings that we will discuss at the next meeting. *Your grade on these Thought papers will be based on the detail of your responses to the questions posed and your ability to integrate/synthesize material from our readings and/or your own research area.* Please write at least one single-spaced page (1” margins, 11 pt Arial font) on that week’s thought question(s), drawing on the week’s readings as much as possible. *You do not need to hand in a Thought paper for any week in which you are a discussion leader (see below).*

**Class participation.** The discussion of each week’s articles will be led by a **team of 2 students.** An important skill to develop in graduate school is the ability to synthesize multiple readings into a coherent “story”. In addition, discussions with your fellow students are at least as important as discussions with your professors in promoting understanding. A **note** here: You might have to look up some background information to prepare. I would prefer that you do this yourselves rather than rely on me, as graduate school is also about fostering independence. I’ve picked the topics and the readings for you, and I’m here to clarify (which I’ll also do in my lectures in class); you’ll need to put some hard work into developing your understanding.

The format for starting the discussion is open, but can include Powerpoint slides, handouts, film clips, clear verbal summary, etc. Creativity is encouraged. Important things to include: (1) What was the overarching theme of the week’s readings?; (2) How did each reading contribute to the theme, in terms of research question and answer?; (3) What were the general methods used in each reading (for an empirical article), the general model (for a theoretical article), or the general data reviewed (for a review article). You shouldn’t get too bogged down in details at this point, but be prepared to answer questions about the articles. Your opening should be no more than about 20 minutes in length. At this point, **students not leading the discussion should be ready with questions and comments.** These can include things like: (1) Clarification (e.g., “I don’t understand how they…”); (2) Connection (e.g., “This seems to be related to…”); (3) Issues that came up in response to the week’s Thought Question(s).

**Class presentation.** For the **final two classes,** each student will be allotted **5 minutes** to present **up to 3 Powerpoint slides** on something of interest to them related to the neurobiology of learning and memory that was not covered by the assigned readings. You can present something on a technique (behavioral or neuroscientific) with which you have at least some familiarity (make sure that you discuss how it is relevant to the study of the neurobiology of learning and memory), a recent (last 3 years) empirical paper, or a recent theory. We’ll leave **2 minutes** after each presentation for a question and answer session. This should be a somewhat informal but informative way for you to try to apply what you’ve learned in the course and expand upon it.

**Final paper.** A half-page paragraph outlining your topic is due by **our Mar 13 class meeting.** This will not be graded but I will read these and provide you feedback before our next meeting.

The **final paper is due at our final meeting (May 1).** The theme of this final paper is either (1) **integrating neurobiology of learning and memory approaches and/or questions with your own research interests,** or (2) **a literature review of an area of the neurobiology of learning and memory not covered in the course.** Possible examples of #1 would be: (1) incorporating substrates into experiments on learning and memory, (2) incorporating learning and memory into experiments on emotion, (3) incorporating a different level of analysis (e.g., cellular plasticity) into experiments on the
substrates of learning and memory, or (4) incorporating a new technique (e.g., lentivirus, optogenetics) into experiments on the substrates of learning and memory. You will also need to include justification for why a particular approach is included; try to integrate the approach so that it doesn’t feel “tacked on”. The final paper should be at least 7 full pages long (1” margins, 11 pt Arial font; 1.5 spacing) and should include at least 10 references.

Grading

Class participation (discussion leader) – 30%
Class participation (taking part in discussions) – 10%
Thought papers – 30%
Class presentation of student-chosen article – 10%
Final paper – 20%

Optional Background Reading


Course Outline

NOTE: The articles should be read in the order specified for the optimal learning experience.

Readings will be available on the Blackboard course site.

Week 1 (Jan 17) -- Introduction

Week 2 (Jan 24) – Conceptual Distinctions in Learning and Memory Research


Week 3 (Jan 31) – Episodic Memory: Medial Temporal Lobes

Feb 7 – no class; Neuroscience, Behavior, and Health Forum (Davis Center)

Week 4 (Feb 14) – Semantic Memory: A Different Brain Memory System from Episodic Memory?


Week 5 (Feb 21) – Episodic & Semantic Memory: Systems Consolidation and Retrograde Amnesia


Week 6 (Feb 28) – Spatial Learning and Memory: Hippocampus and Entorhinal Cortex


Mar 6 – no class; Spring Recess (and Town Meeting Day)

Week 7 (Mar 13) – Cellular Mechanisms of Hippocampus-Dependent Memory


Week 8 (Mar 20) – Fear Conditioning: Synaptic Plasticity


Week 9 (Mar 27) -- Fear Extinction: Hippocampus and Prefrontal Cortex in Addition to Amygdala

Burgos-Robles et al. (2009). Sustained conditioned responses in prelimbic prefrontal neurons are correlated with fear expression and extinction failure. Journal of Neuroscience, 29, 8474-8482.

Week 10 (Apr 3) – Retrieval and Reconsolidation of Fear (and Other) Memories


Week 11 (Apr 10) – Action and Habit Learning and Memory: Dorsal Striatum and Prefrontal Cortex

Balleine & O’Doherty (2010). Human and rodent homologies in action control: Corticostriatal

**Week 12 (Apr 17) – Trace Eyeblink Conditioning: Hippocampus and Prefrontal Cortex in Addition to Cerebellum**

Curlik & Shors (2011). Learning increases the survival of newborn neurons provided that learning is difficult to achieve and successful. Journal of Cognitive Neuroscience, 23, 2159-2170.

**Week 13 (Apr 24) -- Alzheimer’s Disease: Mouse Models and Human Imaging**

Billings et al. (2007). Learning decreases Aβ*56 and tau pathology and ameliorates behavioral decline in 3xTg-AD mice. Journal of Neuroscience, 27, 751-761.

**Week 14 (May 1) – Presentation and Discussion of Student-Chosen Topics**