The Neurobiology of Learning and Memory (PSYS 319)  
Spring 2016

Professor:  
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Office hours: By appointment

Meeting Time & Location:  
Dewey Hall 100  
Tuesdays, 1:15-4:15 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 meeting will give you the opportunity to present and discuss an article of your choosing.

Course Format  
The specific format of individual class meetings may vary somewhat. The general format will be that a pair of students will give a Powerpoint presentation describing and summarizing the readings. There will be time afterward for questions and then discussion. In some meetings, there will be small writing assignments, which may or may not be as part of small groups. The final hour or so of each class meeting, I will give a lecture that will serve as an organizing structure for the following week’s readings.

Course Goals  
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 have tried to choose recent important papers from different research groups for each topic so that you get a broad, balanced perspective rather than just a large dose of one researcher’s pet ideas and interpretation.

More broadly, I think that you will learn and/or refine your ability to read the primary literature, to present it, to ask questions about it, and (most importantly) to write about it. The writing that you do in this course is intended to sharpen your thinking and understanding of what you are reading. To me, thinking and writing are in a reciprocal relationship; if you are able to write about something, you are clear in your thinking about it, which leads to further thought (e.g., realizing that there are gaps in the literature), further writing, and so on.
Course Requirements

Reading responses. Beginning after Week 1, at the end of each of our meetings I will pass out thought questions for you to respond to (in writing), due for the next meeting. The goal of these is to stimulate and sharpen your thinking about the readings. My assessment of these reading responses will be based on the detail of your responses to the questions posed and your ability to integrate/synthesize material from our readings. Please write at least one-half page (single-spaced, 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 reading response 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 (and each student will do this twice). An important skill to develop in graduate school is the ability to synthesize multiple readings into a coherent “story”. By a “story”, I mean something with the following 4 elements: (1) a puzzle; (2) a narrative (what happened?); (3) a theme (what does the story mean?); and (4) showing (methods and results) and telling.

With that in mind, I would like you to start the discussion with a 20-30 minute Powerpoint presentation that does the following, in this order:

1. Introduction: Identify 2-3 “sub-themes”, within the overarching theme for that week’s readings, that cut across all of that week’s papers. About 1-2 slides total.
2. Methods and Results: For each paper, present the basic experimental design, a key neuroscience technique used, and the single most important figure. About 1-2 slides per paper.

NOTE: A few papers
3. Discussion: Tell us how each of the “sub-themes” you identified was addressed by the papers. Some papers might address more than one “sub-theme”. About 1-2 slides total.

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); however, you’ll likely need to put some hard work into developing your understanding.

Students who are not presenting should be following along and taking notes because one of your tasks will be to ask questions of the presenters. I will likely try out some different ways to doing this, so be ready!

Class presentation. For the final class, 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 before Spring Recess. 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. 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 newish technique (e.g., TetTag, DREADDs, 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**. You can use papers that we discussed as some of your references.

**Grading**

- Class participation (discussion leader) – **30% (15% for each)**
- Class participation (taking part in discussions) – **5%**
- Reading responses – **40%**
- Class presentation of student-chosen article in final class meeting – **5%**
- Final paper – **20%**

**Optional Background Reading**


**Course Outline**

Readings will be available on the Blackboard course site.

**Week 1 (Jan 19) – Introduction**

What is this course all about?
What can I do to make this course the best possible learning experience for you?
Sign-ups for presentations

**Week 2 (Jan 26) – What is the Neurobiology of Learning and Memory About?**


**Week 3 (Feb 2) – Episodic Memory: Medial Temporal Lobes**


**Week 4 (Feb 9) – Semantic Memory: Perirhinal Cortex**


**Week 5 (Feb 16) – Hippocampus-Dependent Memory: Systems Consolidation and Retrograde Amnesia**


Harand et al. (2012). The hippocampus remains activated over the long term for the retrieval of truly episodic memories. *PLoS ONE, 7*, e43495.


**Week 6 (Feb 23) – Retrieval and Reconsolidation**


Bridge & Voss (2014). Hippocampal binding of novel information with dominant memory traces can support both memory stability and change. *Journal of Neuroscience, 34*, 2203-2213.


Mar 1 – no class; Town Meeting Day

Mar 8 – no class; Spring Recess

**Week 7 (Mar 15) – Spatial Coding, Cognitive Maps, and Episodic-Like Memory in Rodents: Hippocampus**


Week 8 (Mar 22) – Cellular Mechanisms of Memory


Week 9 (Mar 29) – Fear Conditioning: Neural Plasticity Mechanisms

Yiu et al. (2014). Neurons are recruited to a memory trace based on relative neuronal excitability immediately before training. Neuron, 83, 722-735.

Week 10 (Apr 5) – Fear Extinction and Renewal Circuitry

Jin & Maren (2015). Fear renewal preferentially activates ventral hippocampal neurons projecting to both amygdala and prefrontal cortex in rats. Scientific Reports, 5, 8388.

Week 11 (Apr 12) – Trace Conditioning


Week 12 (Apr 19) – Actions and Habits


Corbit et al. (2013). The role of the amygdala-striatal pathway in the acquisition and performance of goal-directed instrumental actions. *Journal of Neuroscience, 33,* 17682-17690.


**Week 13 (Apr 26) – Learning and Memory in Mouse Models of Alzheimer’s Disease**


Early-onset AD (amyloid and tau triple transgenic mouse)
Davis, Eacott, Easton, & Gigg (2013). Episodic-like memory is sensitive to both Alzheimer’s-like pathological accumulation and normal ageing processes in mice. *Behavioural Brain Research, 254,* 73-82.

Early-onset AD (amyloid precursor protein inducible transgenic mouse)

Late-onset AD (apolipoprotein ε4 allele targeted replacement mouse)

**Week 14 (May 3) – Presentation and Discussion of Student-Chosen Topics**