The Neurobiology of Learning and Memory (PSYC 380)
Spring 2007

Professor:
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Office hours: By appointment

Meeting Time & Location:
Dewey Hall 238
Tuesdays, 9:30 am-12:15 pm

Course Description
The focus of this course is on a systems level approach to the study of the neurobiology of learning and memory. We will largely (but not completely) avoid discussing the molecular and cellular basis of learning and memory and focus on how entire neural structures and circuits give rise to learned behavior. We will also emphasize “psychological” processes in learning and memory, such as encoding, consolidation, storage, and retrieval, and how they are instantiated at the neural circuit level. 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.

We will also largely focus on rodent (rats and mice) studies. Thus, we will take a somewhat, but not entirely, reductionist approach in this course. Specifically, we will focus on (relatively) simple forms of learning and memory in (relatively) simple organisms in the (relatively) simple environment of the laboratory and how specific brain structures underlie encoding, consolidation, storage, and retrieval of specific memories. I sometimes think of this as the (relatively) neglected “middle level” between the cognitive neuroscience approach to learning and memory (focusing on the entire brain) and the molecular neuroscience approach to learning and memory (focusing on the role of an individual molecule or gene in a specific brain area).

Course Objectives
In this course, we will study and discuss the basic principles of, and theory behind, the neurobiology of learning and memory. The course is designed in four parts, with the final part providing some integration, expansion, and closure. In part 1 (weeks 1-4), I hope to get you thinking about what learning and memory is at both a behavioral and a neural level. In part 2 (weeks 5-8), we will examine current thinking and data on the role of the key brain structures in four well-studied types of learning and memory: emotional, motor, “declarative”, and habit. The purpose of this section is to show you some of the techniques and approaches used to study the neural basis of learning and memory. In some cases, I’ve chosen recent studies that have significantly advanced the field. In other cases, I’ve chosen studies with more “modest” results
that I feel make an important point. Some of parts 1 and 2 of the course will be a review from
the Biobehavioral portion of Professional Seminar. In part 3 (weeks 9-12), we will examine the
neurobiology of learning and memory across early and late development, some of things that can
interfere with the brain’s ability to support learning and memory, and some potential ways to
ameliorate these problems.

In the penultimate class, we’ll try to integrate, as much as possible, the topics we’ve
discussed. We’ll also talk about how to integrate findings in non-human animals with the
neurobiology of human learning and memory.

In the final class, each student will give a 10 minute presentation (followed by 5 minute
question & answer) on a recent (2004-2007) article (empirical or review) of interest to them
related to the neurobiology of learning and memory. This should be in Powerpoint format and
should clearly define terminology and concepts that we have not discussed in class. Hopefully,
this will give you an opportunity to discuss something of interest to you that we’ve not covered.

Course Requirements

At the end of each week’s meeting, I will present a brief (~15-20 min) Powerpoint
presentation providing background material for the next meeting’s readings. I will also pass out
some thought questions for the next meeting. At the beginning of this next meeting, I will
quickly (~5-10 min) recap the presentation from the end of the week before. Then, we will
launch into discussion of the readings.

The discussion of each article will be led by a student. First, you should briefly
summarize the article. For empirical articles, this summary should include a bit of background
as to why the study was undertaken, what were the general methods used (just basics, such as
what particular methods were designed to accomplish), general results (focus on the big picture,
not every single ANOVA), and what the main result(s) mean). For review or theoretical
articles, this summary should define the topics under discussion and describe the arguments
and/or data supporting the topic. You should take no more than 10 minutes for this. The format
of sumary can involve any or all of the following: verbal description, Powerpoint presentation,
handouts, or video). Second, you should have prepared at least two questions about the article
that will get discussion going. These can be methodological or, ideally, conceptual. You are
welcome to expand on my “thought” questions, bring in outside sources, or use your own science
background. Students who do not lead discussion of a particular article should turn in their
written comments regarding either my thought question pertaining to the article, or your own
thoughts on the article at the end of class.

For the final class (May 1), I’d like to do something not unlike a “data blitz”. For this
class, I’d like each student 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, some recent data (from an empirical paper from 2004 to the
present), or a recent theory. You should be able to explain your topic in 10 minutes and with no
more than 3 Powerpoint slides. We’ll leave about 5 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.

Due in this final class will be a 5 page paper (1” margins, 12 pt font, 1.5 paragraph line
spacing) summarizing your article and integrating it with what you’ve learned in the course.
Grading

Article presentations – 30%
Class participation – 30%
Final class presentation – 15%
Final 5 page paper – 25%

Optional Background Text


Course Outline

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

Readings will be available by the Psych 1 office.

Part I: Using Biology to Explain Psychology and Psychology to Explain Biology

Jan 16 -- Introduction

Jan 23 – Historical and Conceptual Perspectives on the Neurobiology of Learning and Memory

Cahill, McGaugh, & Weinberger (2001). The neurobiology of learning and memory: Some reminders to remember. Trends in Neurosciences, 24, 578-581 (see also comment, pp. 77-78).
Hebb (1949). The Organization of Behavior. (pp. 60-66; 224-231)

Jan 30 – Behavioral Plasticity and Stability: Learning, Memory, and Remembering

Feb 6 – Neuronal Plasticity and Stability: Relations to Learning and Memory


Part II: Neural Substrates of Different Types of Learning and Memory

Feb 13 – Emotional Learning and Memory: The Amygdala


Feb 20 – Motor Learning and Memory: The Cerebellum

Feb 27 – Spatial/Contextual/Episodic/Discontiguous Stimulus Learning and Memory: The Hippocampal Formation (a big, confusing hunk of a structure!)


Mar 6 – no class; Town Meeting Day

Mar 13 – no class; Spring Recess

Mar 20 – Habit Learning and Memory: The Neo- (dorsal) striatum


Part III: Applying What We’ve Learned and Remembered

Mar 27 -- Early Development


**Apr 3 – Early Development and Exposure to Environmental Agents**


**Apr 10 – Aging**


**Apr 17 – Aging and Alzheimer’s Disease**


\textbf{Part IV: Bringing It All Back Home}

\textbf{Apr 24 – Integration Across Levels of Analysis and With Humans}


\textbf{May 1 – Presentation and Discussion of Student-Chosen Topics in the Neurobiology of Learning and Memory}