Psychology G4430

# *Learning and the Brain*
# Spring 2017

T 2:10 – 4 P.M. Room 200C Schermerhorn Hall

**Prof. Daphna Shohamy**
**shohamy@psych.columbia.edu**

**Eileen Hartnett**
**eah2134@columbia.edu**

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How does past experience guide behavior? Are there different forms of learning and memory that guide behavior? If so, when do these different forms of learning take place? How do they guide choices and actions? What are the neural mechanisms that support learning, memory, and choices? These are the questions we will focus on in this seminar. We will review current theories in the cognitive neuroscience of human learning, with a particular eye towards understanding how learning and decision making – typically studied separately from each other – interact. We will review these fields with a focus on two heavily influential methods in the study of brain and behavior in humans: functional imaging and patient studies. We will debate the strengths and weaknesses of each approach and will discuss how methodological trends and limitations have shaped our view of cognitive function.

The seminar will survey recent literature on the cognitive neuroscience of learning, memory and decision making. Each weekly meeting will address a question in the field. We will begin each meeting by discussing the background and importance of that week's topic, followed by a student presentation of a recent empirical journal article that bears on this question. Finally, we will together consider how the data presented inform our understanding of that week's topic and how it relates to other questions discussed in the course.

The course will begin with an introductory lecture on how we study the brain bases of learning, surveying the broad questions that will be addressed in the seminar, and introducing the basic principles of studying brain bases of cognition in humans.

In the first half of the seminar, we will discuss what may be considered the "dogma" in the cognitive neuroscience of learning: that there are different "learning systems" dependent upon distinct brain regions. We will focus on the distinction between explicit and implicit learning. Explicit learning is thought to be

dependent on the medial temporal lobes and to support learning of facts and events. Implicit learning is thought to depend on other parts of the brain, particularly the basal ganglia, and to support the learning of skills, or habits. We will discuss some of the seminal papers that support this view, as well as some recent scientific findings that raise questions and pose challenges for this view.

In the second half of the seminar, we will discuss some important variables that impact learning and the brain mechanisms supporting it, with an emphasis on the role of motivation, reward, and curiosity.

## The reading list and weekly schedule

Readings will consist of empirical and review articles. All papers are available as downloadable pdfs by searching the PubMed archive at: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi. The following are a sample, subject to revision to represent recent publications.

## Course Schedule

**Week 1 (1/17): General Introduction**

**Week 2 (1/24): How do we study the link between brain and behavior?**
*Basic methods in brain research: Animal studies, human neuropsychology and functional imaging*.
We will discuss the historical development, the strengths and limitations of each of these methods, and the importance of converging evidence for informing our understanding about how the brain supports cognition and behavior.

> Principles of Cognitive Neuroscience, by Dale Purves et al. (Sinauer Press, 2008). Chapter 3: Exploring cognitive processes in neural terms; pp 34-61.
>
> Functional Magnetic Resonance Imaging, by Scott Huettel and Allen Song.
> Chapter 1: An introduction to fMRI; pp 1-26
> Chapter 15: Converging operations; pp 429-466.

**Week 3 (1/31): Do different kinds of learning depend on different areas of the brain? The "multiple memory systems" framework**

> Gabrieli, J. D. (1998). "Cognitive neuroscience of human memory." Annu Rev Psychol **49**: 87-115.
>
> Knowlton, B. J., J. A. Mangels, et al. (1996). "A neostriatal habit learning system in humans." Science **273**(5280): 1399-402.

**Week 4 (2/7): How do we learn habits? Reinforcement learning and the basal ganglia**

Yin, H. H. and B. J. Knowlton (2006). "The role of the basal ganglia in habit formation." Nat Rev Neurosci **7**(6): 464-76

Foerde, K., B. J. Knowlton, et al. (2006). "Modulation of competing memory systems by distraction." Proc Natl Acad Sci U S A **103**(31): 11778-83.

**Week 5 (2/14): How do we learn to predict reward? Dopamine and reward in reinforcement learning**

Schultz, W. (2000). Multiple reward signals in the brain. *Nat Rev Neurosci*, *1*(3), 199-207. doi:10.1038/35044563

Schultz, W., Dayan, P., & Montague, P.R. (1997). A neural substrate of prediction and reward. *Science*, Mar 14;275(5306):1593-9.

**Week 6 (2/21):**

O'Doherty, J. P. (2004). "Reward representations and reward-related learning in the human brain: insights from neuroimaging." Curr Opin Neurobiol 14(6): 769-76.

Foerde, K., & Shohamy, D. (2011). Feedback Timing Modulates Brain Systems for Learning in Humans. *Journal of Neuroscience*, 31, 13157-67

**Week 7 (2/28): Are there different kinds of motivation?**

Shohamy, D. (2011). Learning and motivation in the human striatum. Current Opinion in Neurobiology, 21(3):408-14.

Murayama, K., Matsumoto, M., Izuma, K., & Matsumoto, K. (2010). Neural basis of the undermining effect of monetary reward on intrinsic motivation. *Proceedings of the National Academy of Sciences*, *107*(49), 20911 -20916. doi:10.1073/pnas.1013305107

**Week 8 (3/7):** How do we remember specific episodes in our lives? Episodic memory and the hippocampus

Shohamy, D. & Adcock, R.A. (2010). Dopamine and adaptive memory. *Trends in Cognitive Science*, 14(10): 464-72.

Murty, V.P. & Adcock, R.A. (2014). Enriched encoding: reward motivation organizes cortical networks for hippocampal detection of unexpected events. *Cerebral Cortex*, 24(8):2160-8.

SPRING BREAK

**Week 9 (3/21): How does exploration drive memory?**

Davachi, L., (2006) Item, context and relational episodic encoding in humans. *Current Opinion in Neurobiology*, 16(6):693-700.

Voss, J. L., Gonsalves, B. D., Federmeier, K. D., Tranel, D., & Cohen, N. J. (2011). Hippocampal brain-network coordination during volitional exploratory behavior enhances learning. *Nature Neuroscience*, *14*(1), 115-120. doi:10.1038/nn.2693

**Week 10 (3/28): (How) does curiosity enhance learning (I)?**

Gottlieb, J., Oudeyer, P.Y. Lopes, M., and Baranes, A. (2013). Information seeking, curiosity and attention: computational and neural mechanisms. *Trends in Cognitive Science*. 17(11) (11):585-93.

Baranes, A., Oudeyer, PY, Gottlieb, J. 2015. Eye movements reveal epistemic curiosity in human observers. *Vision Research*, 117:81-90.

**Week 11 (4/4): (How) does curiosity enhance learning (II)?**

Kidd, C. & Hayden, B. 2015. The psychology and neuroscience of curiosity. *Neuron*, 4:88:449-60.

Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. Tyi, & Camerer, C. F. (2009). The Wick in the Candle of Learning. *Psychological Science*, *20*(8), 963 -973. doi:10.1111/j.1467-9280.2009.02402.x

**Week 12 (4/11): How does curiosity enhance memory?**

Miendlarzewska, EA, Bavelier, D, Schwartz, S. 2015. Influence of reward motivation on human declarative memory. *Neuroscience and Biobehavioral Reviews*, 61:156-76.

Gruber, MJ, Gelman, BD, Ranganath, C. 2014. States of curiosity modulate hippocampus-dependent learning via the dopaminergic circuit. Neuron, 22:85:486-96.

**Week 13 (4/18): How do motivation and reward change curiosity and learning?**

Murayama, K & Kuhbander, C. (2011). Money enhances memory consolidation but only for boring material. *Cognition*, 119(1):120124.

Hsee, CK, & Ruan, B. (2016). The Pandora effect: the power and peril of curiosity. *Psychological Science*, 27:659-66.

**Week 14 (4/25): Is motivation always better? (and general discussion)**

Mobbs, D., Hassabis, D., Seymour, B., Marchant, JL, Weiskopf, N, Dolan, RJ, Frith, CD. 2009. Choking on the money: reward-based performance decrements are associated with midbrain activity. *Psychological Science*, 20:955-62.

## Course requirements and grading

Requirements:

- Class participation: Prior to each class, students are expected to read the assigned papers. Students are encouraged to seek out additional research or theoretical papers that are relevant to the topic and to bring these up during the class discussion. All class participants are expected to actively contribute to the discussion.
- Class presentation: Each student will be responsible for presenting at least once during the semester. Presentations should be relatively brief (30-40 minutes), concise, and critical. The presentation should focus on providing a clear presentation of (a) Question – what is the main question the paper addresses, (b) Methods – how did the researchers address this question (c) Results and (d) Critique and Conclusions.
- Written assignments:
    - **Questions**: What would you like to learn about in this class? Before the second week students are required to email me a list of 5 questions that they are curious about on the topic of learning and the brain. Students are encouraged to think about these questions broadly in terms of general interest and *not* based on prior knowledge of the literature.
    - **Opinion/Critical Reviews**: During the semester, each student will select two topics they are particularly interested in for which to submit a briefly written critical review. The review will be no longer than two pages and will briefly describe your opinion on the paper: Did you like it, or not? Why not? What is your opinion on the theory, approach, findings, or conclusion?

- **Term Paper**: Term papers addressing a question discussed during the seminar can be written either as research proposals or as review papers. The final paper will be 10-15 pages long, 1.5 spacing, and will be submitted by the last class. Papers are due the last day of the term, Friday May 12th.

Grading:

- Class participation will count towards 25% of the final grade.
- Class presentations will count towards 25% of the final grade.
- Written assignments will count towards 50% of the final grade, as follows:
  - Question assignment – 5%
  - Critical reviews – 20% (10% each)
  - Term paper – 25%