Non-mnemonic functions of memory systems

GU4435 / Course Syllabus / Spring 2024
4 Points

When / Where
Fridays, 2:10-4pm, Schermerhorn 405

Instructor
Dr. Mariam Aly [ma3631@columbia.edu]
Office hours: Mondays and Fridays 4-5pm or by appointment, Schermerhorn 355D
no office hours on academic or university holidays

Prerequisites
Undergraduate students: UN1010 (Mind, Brain, & Behavior), UN2430 (Cognitive Neuroscience), or equivalent introductory course in neuroscience or cognitive psychology, **and** instructor's permission
Graduate students: Open to Ph.D. students in the Psychology department and graduate students in other related departments, with instructor's permission.

Bulletin description
The past decade has produced an extraordinary amount of evidence that challenges the classic view of a "medial temporal lobe memory system", namely, the idea that the medial temporal lobe plays a necessary role in long-term episodic memory but not other cognitive functions. This course will introduce these challenges to the traditional perspective by exploring functions of the so-called memory system in domains outside of episodic memory.

Detailed description of the course
The goal of the seminar is to arrive at a deeper understanding of how the computations and representations of "memory systems" (like the hippocampus) can enable them to play a broad role in cognition, including in visual perception, short-term memory, imagination, language processing, decision making, and implicit learning.

Each week will be devoted to a different topic. Each student will lead class discussion for one week, by preparing a slide presentation focused on the required readings *in addition to other papers they find on the topic*. The required readings provide only a starting point. A key component of this course is the ability to do research — given a particular topic, find what has been published on it, and be prepared to summarize *and evaluate* the findings to the class. Find contradictory studies if you'd like — it'll make the debate more interesting! You should try to engage the class as much as possible — seminars are meant to be discussions. At the end of each class, we can talk about whether we have sufficient evidence to challenge the dominant memory systems perspective, or what more needs to be done.

Course goals and learning objectives
This course will give you training in reading primary research articles and review papers, the majority of what scientists read. Primary research articles and review papers are a much different reading experience than textbooks, and reading, dissecting, and critically thinking about them is a key skill for the developing scientist. This course will also enable you to engage in constructive scientific conversations and debates, which will broaden and deepen your understanding of cognitive neuroscience research, and teach you about which questions you should be asking as you read and hear about new results, and how to interpret them in the context of other studies. Furthermore, this course

will enable you to learn how to effectively communicate, with both oral presentations and written work. You will learn how to review the literature and find relevant peer-reviewed papers, thus allowing you to keep up to date in any field of science. You will also gain a deep understanding of the links between different areas of episodic memory research, and gain an appreciation of the development of this research over several decades, challenges to this research, and the latest advancements.

Role in the Psychology curriculum

GU4435 is a seminar open to graduate students and advanced undergraduate students. It fulfills the following degree requirements:

- For graduate students, it can partially fulfill the seminar requirement for the M.A. or the elective requirement for the M.Phil.
- For undergraduates pursuing a Psychology major or concentration in the College or GS or the Psychology Postbac certificate, it meets the Group II (Psychobiology and Neuroscience) distribution requirement.
- For Psychology majors and Psychology Postbac students, it fulfills the seminar requirement.
- For undergraduates pursuing the Neuroscience & Behavior major, it fulfills the advanced seminar requirement in the Psychology portion of the major.
- Graduate students in Psychology and junior and senior Neuroscience & Behavior and Psychology majors will have priority for registration. However, for non-majors in the College and in G.S., GU44xx could count as one term of the natural science requirement, provided the student has taken the prerequisite courses and has instructor permission.

Course schedule

January 19: Introduction
January 26: Attention
February 2: Perception
February 9: Working memory
February 16: Implicit memory
February 23: Statistical learning
March 1: Prediction
March 8: Imagination
No class March 15 – Spring Break
March 22: Decision making
March 29: Semantic Memory and/or Language (presenter's choice)
April 5: Problem solving
April 12: Creativity
April 19: Social spaces
No class April 26: Work on your Final Paper!

Grading

Seminars are meant to be engaging discussions. To participate in these discussions, you must carefully read the relevant papers *before* class, and contribute to the conversation. Grading will be based on whether you have shown that you have read the papers, thought deeply about them, can write about them, and your contribution to class discussions. Grading will be as follows:

30%: attendance and participation
35%: class presentation, including mandatory meeting with the instructor
35%: final paper (research proposal; due by 11:59pm on **April 26**), including 1-paragraph overview (due by 11:59pm on **March 29**)

Attendance and Participation

Every student has something valuable to share, and I would love to hear your voice. Everyone is encouraged and expected to attend and participate in *every* class. Attendance will be taken prior to each class, and each student should contribute at least once (but preferably more!) to each class discussion. If participating in class is difficult for you, please see me and we can discuss other ways that you can contribute. Absences may be excused if they are accompanied by a note from your advising dean. **Attendance and participation are worth 30% of your grade.**

If you are sick, especially with something infectious, please stay home! There will not be an attendance penalty. Just let me know in advance via email. If you are feeling well enough to attend via Zoom, I can Zoom you in. Please also see *Accommodations for health or family emergencies*, below, for more information.

If you have to miss class for another reason that you believe should be excused, you must email me in advance of class to explain your situation.

Class Presentation

Each student is also expected to present for one class period: choose at least three papers (at least 1 from the required reading *and 2 or more from research you do on your own*) and make a slide presentation to lead the class through the papers. **You cannot present all empirical papers or all review papers, and you must present at least 2 empirical papers**. A good approach might be 1-2 review papers and at least 2 empirical papers. If it is an empirical paper, describe the main question, the method, the results, the conclusions, and then bring up points for discussion. Don't get bogged down by details in the methods, especially for neuroimaging studies: convey the critical parts of the method that we need to understand the paper. If it is a review paper, describe the big question it attempts to answer, the different theories it brings up, the evidence for each, the conclusions reached, and then bring up points for discussion. Often, papers are much too comprehensive to go over in detail in a short presentation; you therefore must decide what the main points are, and communicate those. If some sections in a paper are tangential to the main topic, feel free to skip them in your presentation. And remember: presentations are meant to be engaging, and you should try to involve your classmates as much as possible (e.g., by posing questions or asking for opinions regularly). Do your best to understand the background, main findings / arguments, and conclusions of each paper — but it's okay if you don't understand everything. You can also bring up challenging aspects of the paper(s) in class, and we can discuss them together. But try your best to figure things out on your own first.

This presentation is **not** meant to be just a series of article summaries. It must include discussion of the articles you selected, but this discussion should be in the service of putting together a coherent presentation around the topic for that week. Do not just jump from paper to paper. Make sure that there is a *narrative* in your presentation. Think about how to transition from paper to paper to help lead the class through the 'story' you want to tell. That means you must make sure to set up the big question for each paper, why that research is important, what the results mean and their bigger implications.

Each student is required to meet with me before their presentation so that they can receive feedback and have time to incorporate edits before their class presentation. Doing so can substantially improve your grade, and not doing so will result in an automatic 5-point deduction from your presentation. This meeting will also give me a chance to look at the additional papers you chose for your presentation, and make sure they are ok (i.e., peer-reviewed in reputable journals, on a suitable topic).

Each student is also required to e-mail me the additional papers they will present, so I can post them on Courseworks for the class to read before the presentation.

Your class presentation is worth 35% of your grade, and is graded out of 50 points. Describing the questions of each paper is worth 5 points, describing the method (empirical paper) and/or theories discussed (review paper) is worth 10 points, describing the results (empirical paper) and/or evidence for each theory (review paper) is worth 10 points, describing the conclusions reached is worth 5 points, and bringing up points for discussion is worth 10 points. Clarity of presentation (speaking and slides) is worth an additional 10 points.

Final Paper

At the end of the course, each student must submit a research proposal on any of the topics discussed in class. The goal of the research proposal is for you to think about how you would conduct an experiment to test any of the questions we addressed in class (about the role of the hippocampus/MTL in cognitive functions beyond episodic memory). If you had access to fMRI, patients, or animal models, what experiment would you run, why, what do you expect to find, and how does it address open questions in the field? ***You cannot just re-do an experiment someone else published with minor modifications; the experiment you design should contain substantive differences from experiments you read about.*** The research proposal should be prefaced with a short abstract (~300 words) summarizing the background, your proposed experiment, your anticipated results, and the conclusion. **Not including an abstract will result in a 5-point deduction**. The research proposal will consist of the background to the problem (i.e., a literature review and introduction of the topic; this is worth 10 points), methods for your proposed experiment (don't worry about complex details of fMRI data collection or analysis; this is worth 10 points), anticipated results (this section is worth 10 points; **a figure showing anticipated results must be included and it must have a caption; not having a figure will result in a 5-point deduction**), and a discussion section that summarizes your results and their contribution to the literature, raises limitations and future directions, and includes a brief conclusion (this is worth 10 points). Remember to write about why your experiment is important (why run it at all?) and what it would mean for the field if you found (or didn't find) your anticipated results; these should be key parts of the introduction and discussion. Your research proposal must be **12-15 pages double-spaced** (8.5" by 11" paper, 1" margins, 11- or 12-point font), including figures but excluding the abstract and references. You should aim to read and cite at least 12 papers, no more than half of which can be articles from the course reading list. Clarity of writing and number / suitability of references is worth an additional 10 points. **Your research proposal is worth 35% of your grade**, graded out of 50 points as mentioned above. It is due on **Friday, April 26** (**by 11:59pm).**

To make sure you are on track, you are required to submit one paragraph (~300 words) on Courseworks, describing what you intend to write about, and include some new references relevant for your paper that are not in the class readings. Note that you should be designing an experiment that is somewhat novel, so in your proposal make sure to give me some highlights of what your experimental manipulations will be and what you will measure. This proposal must be handed in no later than Friday, March 29 (by 11:59pm). Not handing this in will result in an automatic 5-point deduction from your final paper.

Additional course notes

Academic integrity

As a member of the academic community, one of your responsibilities is to uphold principles of honesty and integrity. This means that you can only present your own work on assignments and presentations

— plagiarism is strictly prohibited. You cannot present work as your own when it was done by someone else (where "someone else" includes any source other than you, whether it is a classmate, a friend, the internet, books, or artificial intelligence). Doing so compromises your academic integrity and potentially your academic standing.

You are **never** permitted to copy and paste text that you find on the internet or take from someone else, and minor paraphrasing (e.g., copying and pasting text from another source with only a relatively minor change in words) is also not permitted. Always put things in your own words and cite your source(s). All your work, including your oral presentation, must be in your own words. You cannot copy and paste text from articles or book chapters into your presentation or your written assignments. You cannot read from assigned papers for your presentation. Everything you present or write must be in your own words.

If you would like to share a quote from a source (e.g., an article), you may put it in quotations and cite it. But quotations should be used sparingly (one or two sentences at most) and only when it is critical that the reader sees the original words of a different author; quotations cannot be used instead of writing text in your own words.

If you feel like you are falling behind, don't understand the material, or are not confident about your writing or presentation, talk to me as soon as possible instead of taking measures that go against principles of academic integrity. You can read more about this in Columbia's Guide to Academic Integrity (http://www.college.columbia.edu/academics/academicintegrity).

Students with disabilities
If you are a student with special needs and require any type of accommodation, make an appointment with me before the first class to discuss your needs. You should also contact the office of Disability Services (https://health.columbia.edu/disability-services) before the first class to register for specific accommodations.

Accommodations for health or family emergencies
To do well in class, you are highly encouraged to do all the readings and assignments, attend all classes, and participate. That said, I recognize that all of us have lives outside of school and constantly face personal challenges. For this reason, I will aim to be as helpful and accommodating as possible to your unique situations. If you require accommodations because of health or family emergencies, please email me as soon as you know you need accommodations and explain to me what your needs are so that you can do well.

If you are ill, particularly with anything infectious, you should stay home! I can Zoom you in if you are well enough to participate. If not, just let me know that you are ill and there will not be an attendance penalty.

Letter Grade Assignment (in between whole numbers? 0.5+ will be rounded up)

97-100: A+	87-89: B+	77-79: C+	<69: D
94-96: A	84-86: B	74-76: C	<60: F
90-93: A-	80-83: B-	70-73: C-	

Schedule and required readings

January 19: Introduction

Schiller D, Eichenbaum H, Buffalo EA, Davachi L, Foster DJ, Leutgeb S, Ranganath C. (2015). Memory and space: Towards an understanding of the cognitive map. Journal of Neuroscience, 35, 13904-13911.

Turk-Browne NB. (2019). The hippocampus as a visual area organized by space and time: A spatiotemporal similarity hypothesis. Vision Research, 165, 123-130.

January 26: Attention

Aly M, Turk-Browne NB. (2017). How hippocampal memory shapes, and is shaped by, attention. In *The Hippocampus from Cells to Systems: Structure, Connectivity, and Functional Contributions to Memory and Flexible Cognition.* (Eds. Deborah E. Hannula and Melissa C. Duff). Springer. p369-403.

Mack ML, Love BC, Preston AR. (2016). Dynamic updating of hippocampal object representations reflects new conceptual knowledge. PNAS, 113, 13203-13208.

February 2: Perception

Bonnen T, Yamins DLK, Wagner AD. (2021). When the ventral visual stream is not enough: A deep learning account of medial temporal lobe involvement in perception. Neuron, 109, 1-12.

Lee ACH, Yeung LK, Barense MD. (2012). The hippocampus and visual perception. Frontiers in Human Neuroscience, 6, article 91, 1-17.

Wu Z, Buckley MJ. (2023). Prefrontal and medial temporal lobe cortical contributions to visual short-term memory. Journal of Cognitive Neuroscience, 35, 27–43
** Useful for both Perception and Working Memory **

February 9: Working memory

Borders AA, Ranganath C, Yonelinas AP. (2022). The hippocampus supports high-precision binding in visual working memory. Hippocampus, 32, 217–230

Olson IR, Page K, Moore KS, Chatterjee A, Verfaellie M. (2006). Working memory for conjunctions relies on the medial temporal lobe. Journal of Neuroscience, 26, 4596-601.

Wu Z, Buckley MJ. (2023). Prefrontal and medial temporal lobe cortical contributions to visual short-term memory. Journal of Cognitive Neuroscience, 35, 27–43
** Useful for both Perception and Working Memory **

February 16: Implicit memory

Hannula DE, Greene AJ. (2012). The hippocampus re-evaluated in unconscious learning and memory: At a tipping point? Frontiers in Human Neuroscience, Volume 6, Article 80, 1-20.

Henke K. (2010). A model for memory systems based on processing modes rather than consciousness. Nature Reviews Neuroscience, 11, 523-532.

February 23: Statistical learning

Covington NV, Brown-Schmidt S, Duff MC. (2018). The necessity of the hippocampus for statistical learning. Journal of Cognitive Neuroscience, 30, 680-697.

Schapiro AC, Kustner LV, Turk-Browne NB. (2012). Shaping of object representations in the human medial temporal lobe based on temporal regularities, Current Biology, 22, 1622-1627.

March 1: Prediction

Buckner RL. (2010). The role of the hippocampus in prediction and imagination. Annual Review of Psychology, 61, 27-48. ** Useful for both Prediction and Imagination **

Kok P, Turk-Browne NB. (2018). Associative prediction of visual shape in the hippocampus. Journal of Neuroscience, 38, 6888-99.

Pfeiffer BE, Foster DJ. (2013). Hippocampal place-cell sequences depict future paths to remembered goals. Nature, 497, 74-81.

March 8: Imagination

Buckner RL. (2010). The role of the hippocampus in prediction and imagination. Annual Review of Psychology, 61, 27-48. ** Useful for both Prediction and Imagination **

Hassabis D, Kumaran D, Vann SD, Maguire EA. (2007). Patients with hippocampal amnesia cannot imagine new experiences. Proceedings of the National Academy of Sciences, 104, 1726-1731.

Schacter DL, Addis DR, Szpunar KK. (2017). Escaping the past: Contributions of the hippocampus to future thinking and imagination. In *The Hippocampus from Cells to Systems: Structure, Connectivity, and Functional Contributions to Memory and Flexible Cognition.* (Eds. Deborah E. Hannula and Melissa C. Duff). Springer. p439-465.

March 22: Decision making

Biderman N, Bakkour A, Shohamy D. (2020). What are memories for? The hippocampus bridges past experience with future decisions. Trends in Cognitive Sciences, 24, 542-556.

Yu JY, Frank LM. (2015). Hippocampal-cortical interaction in decision making. Neurobiology of Learning & Memory, 117, 34-41.

March 29: Semantic Memory and/or Language (presenter's choice!)

Semantic memory

Duff MC, Covington NV, Hilverman C, Cohen NJ. (2020). Semantic memory and the hippocampus: Revisiting, reaffirming, and extending the reach of their critical relationship. Frontiers in Human Neuroscience. doi: 10.3389/fnhum.2019.00471

Grilli MD, Sabharwal-Siddiqi S, Thayer SC, Rapcsak SZ, Ekstrom A. (2023). Evidence of impaired remote experience-near semantic memory in medial temporal lobe amnesia. Journal of Cognitive Neuroscience, 1–12. https://doi.org/10.1162/jocn_a_02057

Language

Duff MC, Brown-Schmidt S. (2012). The hippocampus and the flexible use and processing of language. Frontiers in Human Neuroscience, Volume 6, Article 69, 1-11.

Piai V, Anderson KL, Lin JJ, Dewar C, Parvizi J, Dronkers NF, Knight RT. (2016). Direct brain recordings reveal hippocampal rhythm underpinnings of language processing. Proceedings of the National Academy of Sciences, 113, 11366-11371.

April 5: Problem solving

Sheldon S, McAndrews MP, Moscovitch, M. (2011). Episodic memory processes mediated by the medial temporal lobes contribute to open-ended problem solving. Neuropsychologia, 49, 2439-2447.

Sheldon S, Vandermorris S, Al-Haj M, Cohen S, Winocur G, Moscovitch M. (2015). Ill-defined problem solving in amnestic mild cognitive impairment: Linking episodic memory to effective solution generation. Neuropsychologia, 68, 168-175.

April 12: Creativity

Rubin RD, Watson PD, Duff MC, Cohen NJ. (2014). The role of the hippocampus in flexible cognition and social behavior. Frontiers in Human Neuroscience, 8, 742, 1-15.

Warren DE, Kurczek J, Duff MC. (2016). What relates newspaper, definite, and clothing? An article describing deficits in convergent problem solving and creativity following hippocampal damage. Hippocampus, 26, 835-840.

April 19: Social Spaces

Omer DB, Maimon SR, Las L, Ulanovsky N. (2018). Social place-cells in the bat hippocampus. Science, 359, 218-224.

Schafer M, Schiller D. (2018). Navigating social space. Neuron, 100, 476-489.