How do we study memory?

June 22, 2016
Announcements

• Don’t forget to check your Stanford email

• Food and laptops

• I will start taking attendance next week

• Syllabus and website
Exams

- **Midterm**: Wednesday, July 20th, in class
- **Final**: Friday, August 12, 12:15-3:15, location TBA

1. **Exams (25% midterm; 35% cumulative final)**. The midterm will be held in class on **Wednesday, July 20th**. The final will be held on **Friday, August 12 from 12:15-3:15 PM**. Although the final exam is cumulative, it will emphasize the second half of the course. If you have an unavoidable conflict with an exam, I must be notified of this two weeks prior to the exam date in order to arrange for an alternate exam.
2. **Responses to scientific journal articles (20%).** Throughout the course you will carefully read six journal articles and complete a reading response related to each one; these must be turned in by the start of class on the assigned date. *Each reading response will be graded on a scale of 0-5.* Late responses will lose one point per day that they are late, for a maximum of three lost points (e.g., a perfect response turned in at the end of the quarter would receive 3/5 possible points).

The readings will show you **how we investigate** memory in the lab using the **scientific process**. Responses and discussions will help you **think critically** about the scientific findings.
Responses to scientific journal articles

Readings: Instructions for accessing the readings are provided on the course website.


3. **Memory in action (10%).** In preparation for each class you will be asked to complete a short *demonstration* of a task, to *brainstorm* some real-world examples of the course material, and/or to *document* examples of the course material in your day-to-day life. The specific assignment for each upcoming class will be shared in class during the preceding class and also posted on the course website. These “memory in action” assignments must be turned in by 8 PM the night before the relevant class so that I have time to review them before class starts. *Each assignment will be graded on a scale of 0-5.* Any *memory in action* assignments that are turned in between 8 PM the night before class and the start of class will receive at most half credit. Because this material will be used in class on the day it is due, I *cannot accept* *memory in action* assignments that are turned in after the start of class.

*Demos, brainstorm, and journals will expose you to some of the experimental methods used in the lab, and have you critically think about how multiple memory systems influence our everyday lives!***
4. **Class participation and attendance (10%).** Attending class is very important because most of the material will be presented only in class. As such, your attendance in class is required. I will take attendance each class via a *participant prompt* that is completed in class or an *exit ticket* that includes your name and a question or comment that you have about the material that day. While in class, I ask that you engage as active learners by asking questions, participating in class activities and discussions, and directing your attention *only* toward the course material (e.g., not toward your phone, your friends, etc). You may miss two classes (not the midterm) without penalty.
Exam and assignment policies

Collaboration policy. You may discuss any assignments (other than exams) with your classmates, but you must write each of your assignments individually, in your own words.

Late and absence policies: Late and absence policies for each course requirement are described above. Serious health issues or other unexpected issues can be discussed with me but require an accompanying note from a doctor, a dean, or the Summer Session office. This policy is in place to ensure that you are getting the help that you need with any serious illness or issues that arise during the quarter.
**Honor code:** The Stanford Honor Code is in effect for all assignments. Please be sure that you are familiar with *all of* the policies explained in the honor code (http://honorcode.stanford.edu).

Briefly, following the Honor Code means that:

a. During exams you will answer all questions on your own without consulting any notes, books, outside sources, or your classmates; you also will not provide any help to any of your classmates during the exams.

b. Your written assignments will be written in your own words and you will properly cite any quotes or ideas from any other sources; you will not write any assignments for your classmates.

c. You will not modify any assignments after the submission deadline without informing me that you have done so.

If you are unsure about any of the honor code policies or whether you are at risk of violating the Honor Code, please come and see me before you turn in the work that you are unsure about.
Google Docs

- All assignments will be turned in using Google Docs
- Instructions are in syllabus
- You will need a gmail account (which is free)
- Note: all changes are tracked and timestamped — changing your submission after the deadline (without emailing me to tell me that you are accepting any associated late penalties) may be considered a violation of the honor code
To create and share your MIA Google Doc

1. Access Google Drive
2. Open Google Drive
3. Click on "NEW"
4. Select "Google Docs"
5. Share the document
6. Rename the document (LaRocque_MIA)
7. Send the document
8. Add text (My name is Karen, I am the instructor of the course, and I am coming from Stanford.)
9. Share with others (psych136s@gmail.com)
10. Send the link (Can edit)
11. Share the document
Homework

- **Memory in Action: Primacy & Recency Demonstration**
  - A link to the demo will be posted on the course website by Friday at noon
    - [http://stanford.edu/class/psych136s/memoryinaction/index.html#primacy-recency](http://stanford.edu/class/psych136s/memoryinaction/index.html#primacy-recency)
  - You will be prompted to answer questions throughout the demonstration — please type your answers in your MIA Google Doc by **8 PM on Sunday, June 26**

- **Looking Ahead: Reading Response to Owen et al., 2010**
  - Create your SJR Google Doc and share with psych136s@stanford.edu
  - Read the paper and answer the questions that will be posted on the course website
    - [http://stanford.edu/class/psych136s/reading/index.html#owen](http://stanford.edu/class/psych136s/reading/index.html#owen)
  - Due by **11:30 AM on Wednesday, June 29th**
• Memory for the past guides our behavior in the present

• Multiple forms of memory

• Medial temporal lobe amnesia: a **selective deficit** in long-term declarative memory
This time

• Neuroanatomy primer
• Neuroscience methods primer
• Real world to the lab: experimental design
• Lab to the real world: considerations
• How to read a scientific paper
This time

- Neuroanatomy primer
- Neuroscience methods primer
- Real world to the lab: experimental design
- Lab to the real world: considerations
- How to read a scientific paper
Neurons send & receive information

Transmission with a neuron is electrical — an electrical impulse from a neuron is called ‘firing’, a ‘spike’, or an ‘action potential’
Neurons communicate at synapses

A synapse is where the axon of one neuron communicates with the dendrite of another neuron.

The number and strength of connections between neurons — the synapses — change with experience.
The brain: gross anatomy

two hemispheres

right left
The brain: gross anatomy

four lobes within each hemisphere
The brain: basic orientation
The brain: basic orientation

- Top, superior, dorsal
- Front, anterior, rostral
- Bottom, inferior, ventral
- Back, posterior, caudal
The brain: basic orientation

lateral view

medial view

L-M  M-L
Slicing the brain

**Axial**
Slicing the brain

axial
coronal
Slicing the brain

axial

coronal

sagittal
Practice!

- The frontal lobe is **ANTERIOR OR POSTERIOR** to the parietal lobe
- The temporal lobe is **INFERIOR OR SUPERIOR** to the parietal lobe
- The occipital lobe is **ROSTRAL OR CAUDAL** to the parietal lobe
- A **SAGITTAL OR AXIAL** slice is at a single position in the medial-lateral direction
- A coronal slice is at a single position in the **ANTERIOR-POSTERIOR OR INFERIOR-SUPERIOR** direction
The brain: gray and white matter

**white matter:** axons

**gray matter:** cell bodies, dendrites, synapses
The brain: gray and white matter

**white matter**: axons

**gray matter**: cell bodies, dendrites, synapses
The brain: gray and white matter

**white matter**: axons

**gray matter**: cell bodies, dendrites, synapses

white matter

cortex / cortical (gray matter)
The brain: gray and white matter

white matter: axons

gray matter: cell bodies, dendrites, synapses

subcortical structures (gray matter)

cortex / cortical (gray matter)
The cortex: gyri and sulci

- **gyri** (ridge)
- **sulci** (valley)
The cortex: areas

- **Sensory areas** that process specific types of perceptual information
- **Motor and speech output areas**
The cortex: areas

- **Sensory areas** that process specific types of perceptual information

- **Motor and speech output areas**

- **Frontal and parietal control and attention networks** that can *change or coordinate* processing in sensory and output areas

courtesy of M Waskom
Medial temporal lobe memory system

medial temporal lobe cortex
(cortical)

and

hippocampus
(subcortical)

Banich & Compton, Davachi 2006, Clark & Squire, 2013
Medial temporal lobe memory system

medial temporal lobe cortex (cortical)

and

hippocampus (subcortical)

Banich & Compton, Davachi 2006, Clark & Squire, 2013
Medial temporal lobe memory system

medial temporal lobe cortex
(cortical)

and

hippocampus
(subcortical)

Banich & Compton, Davachi 2006, Clark & Squire, 2013
Medial temporal lobe memory system

medial temporal lobe cortex
(cortical)

and

hippocampus
(subcortical)

Banich & Compton, Davachi 2006,
Clark & Squire, 2013
Medial temporal lobe memory system

medial temporal lobe cortex (cortical)

and

hippocampus (subcortical)

Banich & Compton, Davachi 2006, Clark & Squire, 2013
This time

- Neuroanatomy primer
- Neuroscience methods primer
- Real world to the lab: experimental design
- Lab to the real world: considerations
- How to read a scientific paper
Disruption methods: *inactivate* or *disrupt (or stimulate)* a part of the brain while participants perform a task.

Recording methods: *record activity from* a part of the brain while participants perform a task.
Disruption methods

- **Disruption methods**: inactivate or disrupt a part of the brain while participants perform a task.

- Data are behavioral measures: how well (accurately or quickly) are participants able to perform our task compared to …
  - … healthy populations with no disruption
  - … populations with disruption of a different brain region

- Rationale: An area is necessary for a task if and only if disrupting that area disrupts performance on that task.

- Examples:
  - Permanent: human brain damage (lesion and disease) and animal lesions
  - Temporary: transcranial magnetic stimulation (TMS), intracranial stimulation
Recording methods

- **Recording methods**: record activity from a part of the brain while participants perform a task.

- **Rationale**: compare activity during two tasks, which differ in a single cognitive function —> any difference in brain activity between the two conditions is related to that cognitive function.

- **Examples**:
  - Functional magnetic resonance imaging (fMRI / BOLD): measure changes in blood flow.
  - Electroencephalography (EEG / ERP): measure large-scale changes in electrical activity.
  - Single unit recordings: measure action potentials from single neurons.
Single dissociation

• HM & EP can repeat back a list of four words (working memory) but can’t remember what they ate for breakfast (episodic memory)

• This is a single dissociation: damage to Brain Region A (medial temporal lobe) impairs Function X (episodic memory) but not Function Y (working memory)

• Is this evidence that working memory and episodic memory are separate systems that rely on different parts of the brain?
Single dissociation

Aliens have come to earth and are watching a baseball game. They are interested in determining which limbs are responsible for which actions ... but everything seems to be moving all the time.
Single dissociation

Fortunately, one of the players has a sprained ankle!

The aliens observe two single dissociations:

1. Damage to ankle (Area A) impairs running (Function X) but not throwing (Function Y)
2. Damage to ankle (Area A) impairs running (Function X) but not walking (Function Y)

They conclude:

1. Running (Function X) and throwing (Function Y) rely on different limbs
2. Running (Function X) and walking (Function Y) rely on different limbs

Are these conclusions accurate?

What could have gone wrong?

Sometimes single dissociations really do reflect separate systems, but sometimes they don’t. The problem is that we don’t know what situation we’re in.
Double dissociation

• Double dissociation:
  
  1. Damage to Brain Region A (medial temporal lobe, ankle) impairs Function X (episodic memory, running) but not Function Y (working memory, throwing, walking)
  
  2. Damage to Brain Region B impairs Function Y but not Function X

• What would we need to complete the double dissociation for running vs. throwing?

• For running vs. walking?

• For episodic vs. working memory?

• How hard would these be to find?

Double dissociations are strong evidence for separate systems
Multiple memory systems

What licenses us to partition memory in this way?
Multiple memory systems

Transient memory
- Sensory
- Working (short-term)

Long-term memory
- Declarative
  - Episodic
  - Semantic
- Non-declarative
  - Conditioning
  - Skill learning
  - Priming

What licenses us to partition memory in this way? Double dissociations.
This time

- Neuroanatomy primer
- Neuroscience methods primer
- Real world to the lab: experimental design
- Lab to the real world: considerations
- How to read a scientific paper
Operational definition

- Interesting questions are often complex — *how does technology affect my memory?* — *will taking notes on my laptop in class lead to better memory for the material?*

- We need to boil down our complex question into something that has an observable measure (operationalized)

Does taking notes on my laptop lead to better memory for the material?

- minutes spent looking at laptop
- minutes spent typing on laptop
- laptop vs. no laptop

leads to:

- score on a multiple choice test one day later
- score on an essay test one week later
- self-reported memory on a scale of 0-5
Correlational vs. experimental studies

- **Correlational**: *measure* both variables of interest and look for *relationships* between them

- **Examples of correlational studies**:
  - Measure **age** and **memory complaints** — find that **memory complaints** increase as **age** increases (positive relationship)
  - Measure **hours watching TV per week** and **working memory capacity** — find that **working memory capacity** decreases as **hours watching TV** increases (negative relationship)
  - Measure **number of plays on a slot machine per hour** in **drug addicts vs. non-addicts** — find that there are more **plays per hour** for addicts than non-addicts
Correlational vs. experimental studies

- **Causal relationship**: a change in Variable X *causes* a change in Variable Y
- Correlational studies **do not imply** a causal relationship
- If Variable X and Variable Y are correlated, it could be that:
  - X causes Y — *watching TV* hurts your *working memory*
  - Y causes X — *poor working memory* causes people to prefer to *watch TV* as a leisure activity
  - X causes Z which causes Y — *watching TV* leaves less time for *crossword puzzles* which leads to *worse working memory*
  - Z causes X and Y — *low motivation* causes people to prefer to *watch TV* and not try very hard on the *working memory task*

How could we test whether this relationship is causal?
Correlational vs. experimental studies

- **Experimental**: *manipulate* one variable of interest (*independent variable*) and look for *measure* a second variable (*dependent variable*)

- Examples of experimental studies:
  - Assign participants to take a memory test after a 1, 3, or 5 day delay after viewing words and measure how many words they recall — find that number of words recalled decreases as delay time increases
  - Assign participants to *practice or not practice* reading *script words* and then measure how many *script words* they can read per minute — find that participants who *practiced* read greater number of words than participants who *did not practice*

Experimental studies allow for causal claims
Why do correlational studies?

• Correlational: measure both variables of interest and look for relationships between them

• Examples of correlational studies:
  
  • Measure age and memory complaints — find that memory complaints increase as age increases (positive relationship)
  
  • Measure hours watching TV per week and working memory capacity — find that working memory capacity decreases as hours watching TV increases (negative relationship)
  
  • Measure number of plays on a slot machine per hour in drug addicts vs. non-addicts — find that there are more plays per hour for addicts than non-addicts
Why do correlational studies?

- Impossible to assign to a group
  - e.g., age, high vs. low brain activation

- Infeasible to assign to a group
  - e.g., hours of TV per week, memory athlete vs. non-memory athlete

- Unethical to assign to a group
  - e.g., addict vs. non-addict, effective vs. ineffective teacher

- Cost (time and money) is often lower

- Identify potential variables of interest to later manipulate
Reading a graph

y-axis: dependent variable

correlational study: variable we think is caused by the other

x-axis: independent variable

correlational study: variable we think is causing the other

experimental study: variable we manipulate

experimental study: variable we manipulate
Reading a graph

- Reading a graph
- best fitting line to relate the two variables
- working memory capacity (number of words remembered)
- hours watching TV per week (number of days between study and test)
- individual measurements
Reading a graph

Variability across measurements

Mean across measurements

# plays on a slot machine (% words read)

<table>
<thead>
<tr>
<th></th>
<th>addict (practice)</th>
<th>non-addict (no practice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>
Reading a graph

Drownings per day vs. Ice-cream cones eaten per day

What relationship do you see here?

Do you think one variable causes a change in the other? Why or why not?

How could you test whether it is a causal relationship?
Confounding variables

- **Confounding variable**: an *unintended* independent variable that occurs along with the *intended* independent variable and that could change the dependent variable.

- We want our manipulation to *isolate* a single independent variable without any confounding variables.

  Watching TV leaves less time for **crossword puzzles** which leads to worse working memory.
A lifetime of memories

Participants come to the lab with a lifetime of memories and prior knowledge that we don’t have access to and are outside of our control.

Previous memories affect new memories.

Common strategy: have participants learn (encode) and remember (retrieve) new (novel) information in the lab (e.g., random word lists, designs).
This time

• Neuroanatomy primer
• Neuroscience methods primer
• Real world to the lab: experimental design
• Lab to the real world: considerations
• How to read a scientific paper
Generalizing outside of the lab

• Who were the participants?

• How will other real-world variables *interact* with the variable that was isolated in the lab?

• How will the *simple* *stimuli* that I used in the lab generalize the the *complex events* in the real-world.

• Does the manipulation need to be supervised by a researcher?

• What could go wrong?
This time

- Neuroanatomy primer
- Neuroscience methods primer
- Real world to the lab: experimental design
- Lab to the real world: considerations
- How to read a scientific paper
Reading about science
Reading about science
The Pen Is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking

Pam A. Mueller* and Daniel M. Oppenheimer*
Princeton University and University of California, Los Angeles

Abstract

Taking notes on laptops rather than in longhand is increasingly common. Many researchers have suggested that laptop note taking is less effective than longhand note taking for learning. Prior studies have primarily focused on students’ capacity for multitasking and distraction when using laptops. The present research suggests that even when laptops are used solely to take notes, they may still be impairing learning because their use results in shallower processing. In three studies, we found that students who took notes on laptops performed worse on conceptual questions than students who took notes longhand. We show that whereas taking more notes can be beneficial, laptop note takers’ tendency to transcribe lectures verbatim rather than processing information and rephrasing it in their own words is detrimental to learning.

Keywords

Academic achievement, cognitive processes, memory, educational psychology

Revised 1/13; Revision accepted 1/16/14

Use of laptops in classrooms is controversial. Many believe that computers (and the internet) detract from class discussion and decrease in-class note taking (e.g., Yamamoto, 2007). Conversely, students often self-report a belief that laptops in class are beneficial (e.g., Barak, Lipson, & Lerman, 2006; Mitra & Steffenmeier, 2000; Skolnick & Puzo, 2008). Even when students admit that laptops are a distraction, they believe the benefits outweigh the costs (Kay & Lauricella, 2011). Empirical research tends to support the professors’ view, finding that students using laptops are not on task during lectures (Kay & Lauricella, 2011; Krsinich & Novak, 2010; Skolnick & Puzo, 2008; Sovrani, 2013), show decreased academic performance (Fried, 2008; Grace-Martin & Guy, 2011; Krsinich & Novak, 2010), and are actually less satisfied with their education than their peers who do not use laptops in class (Wurst, Smarkola, & Gaffney, 2008).

These correlational studies have focused on the capacity of laptops to distract and to invite multitasking. Experimental tests of immediate retention of class material have also found that Internet browsing impairs performance (Hembrooke & Gay, 2003). These findings are important but relatively unsurprising, given evidence on decrements in performance when switching (e.g., Iglic & Horvitz, 2007; Jailer & Evans, 2001). However, even when distractions are controlled for, laptop use might impair performance by affecting the manner and quality of in-class note taking. There is a substantial literature on the general effectiveness of note taking in educational settings, but it mostly predates laptop use in classrooms. Prior research has focused on two ways in which note taking can affect learning: encoding and external storage (see DiVesta & Gray, 1972; Kiewra, 1989). The encoding hypothesis suggests that the processing that occurs during the act of note taking improves learning and retention. The external-storage hypothesis notes the benefits of the ability to review material (even from notes taken by someone else). These two theories are not incompatible; students who both take and review
Handling unfamiliar terms

• Is it critical for your understanding of the article or interpretation of the results?
  
  **Yes**
  
  [Google search]
  
  Ask the instructors!
  
  **No**
  
  Don’t worry about it!
Handling unfamiliar terms

“Keep your eyes on the forest (what are the important points to be gleaned from this article?) and do not let some scraggly trees (what is multiple regression, anyway?) interfere with your overall comprehension of the main thrust of the article.

- Roediger & Gallo (2004)
Reading journal articles

• Abstract
• Introduction
• Method
• Results
• Discussion
Reading journal articles

- Abstract
- Introduction
- Method
- Results
- Discussion
Abstract

• What is the goal of the article?

• What are the important findings?

• What is the practical value/importance of the findings?

Keep these ideas in mind as you read the rest of the article!
Reading journal articles

- Abstract
- Introduction
- Method
- Results
- Discussion
Introduction

• What have previous studies discovered about this topic?

• What specific hypothesis is being tested?

• Why is this question interesting?

You should get a sense of the previous literature, and be eager to learn about the methods & results!
Brainstorm!

does taking notes on my laptop in class lead to better memory for the material?

sketch out one experimental (not correlational!) study (what are the benefits to using an experimental study?)

keep in mind:

how will you operationalize your variables?

what confounding variables are you worried about, and how can you avoid them?

how will you deal with the influence of pre-existing memories?
Reading journal articles

- Abstract
- Introduction
- Method
- Results
- Discussion
Method

• What are the **general procedures**? Imagine what it might be like to be a participant in this study!

• Is the method **appropriate**?

• What are the **independent** (what is *manipulated*) and **dependent** (what is *measured*) variables?

• What are your **predictions**?

You should understand how the experimenter conducted the study!
Reading journal articles

• Abstract
• Introduction
• Method
• Results
• Discussion
On factual-recall questions, participants performed equally well across conditions … However, on conceptual-application questions, laptop participants performed significantly worse than longhand participants (see Fig. 1).
Handling unfamiliar terms

Verbatim overlap between student notes and lecture transcripts was measured with an “n-gram program”

“3-gram” example (2 overlaps)

At its peak, the Indus Civilization may have had a population of over five million. The Indus cities are noted for their urban planning, baked brick houses, elaborate drainage systems, water supply systems, and clusters of large non-residential buildings.

Indus civilization had > five million people. Noted for city planning, baked brick houses, brick houses, water supply systems, huge non-residential buildings.
Results

• Was the data analyzed appropriately?
  
  • Which *conditions were compared* and why? Was anything *left out*?

• What is your *interpretation* of the results?

• What are some *applications* and *implications* of these results?

You should see what the experimenters discovered!
Results: Using graphs

“Participants who took longhand notes wrote significantly fewer words than those who typed.”

“Using 3-word chunks as the measure, we found that laptop notes contained an average of 14.6% verbatim overlap with the lecture, whereas longhand notes averaged only 8.8%.”
Results: “Imagining” graphs

“Participants who took more notes performed better.”

“However, those whose notes had less verbatim overlap with the lecture also performed better.”
Reading journal articles

- Abstract
- Introduction
- Method
- Results
- Discussion
Discussion

- What’s the **takeaway message**?
- Are the **conclusions** and **interpretations** warranted?

You’ll get an idea for how the results relate to the rest of the literature, and what *broader implications* the findings might have!
Conclusions

Taking notes with a laptop can impair performance on (conceptual) tests!

Although taking more notes is beneficial, notes are most helpful if synthesizing/summarizing content rather than writing a verbatim description!
Homework

- **Memory in Action: Primacy & Recency Demonstration**
  - A link to the demo will be posted on the course website by Friday at noon
    - [http://stanford.edu/class/psych136s/memoryinaction/index.html#primacy-recency](http://stanford.edu/class/psych136s/memoryinaction/index.html#primacy-recency)
  - You will be prompted to answer questions throughout the demonstration — please type your answers in your MIA Google Doc by **8 PM on Sunday, June 26**

- **Looking Ahead: Reading Response to Owen et al., 2010**
  - Create your SJR Google Doc and share with psych136s@stanford.edu
  - Read the paper and answer the questions that will be posted on the course website
    - [http://stanford.edu/class/psych136s/reading/index.html#owen](http://stanford.edu/class/psych136s/reading/index.html#owen)
  - Due by **11:30 AM on Wednesday, June 29th**
Questions?