MEMORY IMPROVEMENT

By Poornima Bedi
Subject: Psych 3061
AGENDA

- What is memory?
- Memory categorizations: Qualitative and Temporal
- Biochemical mechanisms for memory formation
- Finally, the question “How to improve memory?” will be addressed. Memory improvement techniques supported with scientific research will be discussed.
What is memory?

What is Learning?

- Learning is the process—the act of change (relatively permanent) in behavior, knowledge, or feelings of an individual that results from experience.
- Memory is the result of that change.

Experience ➔ Learning ➔ Memory
Memory Categorizations

- Memory can be categorized qualitatively and temporally.
  - Qualitative memories
    - Declarative: dependent on conscious recall. It has two subtypes:
      - **Semantic**: memories of facts like president of china, pope John Paul II was born in 1920, LTP is a candidate mechanism for memory formation, etc.
      - **Episodic**: memories of events like your mother’s birthday, your wedding, what you had for breakfast this morning, etc.
    - Procedural: not dependent on conscious recall
      - **Motor skills** like hitting a baseball, driving a car, swimming, etc.

(Purves et al., 2000)
Memory Categorizations contd.

- Temporal memories:
  - Immediate (sensory) memory (millisecond-1s)
  - Short-term memory (<1 minute)
  - Long-term memory (days, months, years)

Dubuc, B., 2005.
General Overview of how a memory forms

Stimulus

Sensory memory

Attention

Short-term memory

Consolidation

Long-term memory

Retrieval

Forgetting

Repetition

Dubuc, B., 2005.
Biochemical mechanisms for memory formation

- Long-Term Potentiation, (LTP)
- Long-Term Depression, (LTD)

These two mechanisms have been studied and researched extensively in vertebrates.

(Kalat, 2003; and Purves et al., 2000)
Long-Term Potentiation, LTP

- Discovered by Timothy Bliss and his colleagues in 1970s (Kalat, 2003; and Purves et al., 2000)
- Found throughout the brain
  - Hippocampus
  - Cortex
  - Nucleus accumbens
- LTP is a prolonged increase in response at a synapse. It occurs when one or more axons connected to post-synaptic dendrite stimulate it repeatedly—such as 100 synaptic excitations per second for 1 or 4 seconds. This actively repeated stimulization leaves some of the synapses potentiated for minutes, days, or weeks or more (Kalat, 2003)
LTP contd.

- LTP depends on changes at glutamate synapses.
- Several types of glutamate receptors are present in the brain
  - AMPA and NMDA ionotropic receptors are involved in LTP
- AMPA receptors are dependent only on glutamate in the synaptic cleft
- NMDA receptors are dependent on both glutamate and cellular depolarization

(Kalat, 2003; and Purves et al., 2000)
Suppose the axon that releases glutamate is active repeatedly. When glutamate massively stimulates AMPA receptors, Na+ ions move into the post-synaptic cell leading to depolarization of the post-synaptic cell. The resulting depolarization expels the Mg2+ ion (which normally blocks the NMDA-R) and glutamate binds to NMDA-Rs. Both Ca2+ and Na+ ions move into the post-synaptic cell. This triggers a complex intracellular cascade which produces changes in numbers of AMPA-Rs or their responsiveness. This establishes LTP.

(Kalat, 2003; and Purves et al., 2000)
Long-Term Depression, LTD

LTD is opposite of LTP. It is a prolonged decrease in response at a synapse. It occurs when two or more axons stimulate a post-synaptic cell repeatedly but at a low-frequency (Kalat, 2003).

Found in hippocampus and cerebellum.
Now

We’ll switch gears and talk about forgetting and then move onto some memory improvement techniques.
Forgetting

- Stress can cause forgetting. It affects the body by activating two systems: autonomic nervous system and HPA axis—the hypothalamus, pituitary gland, and adrenal cortex. (Kalat, 2003).
  - The activity of HPA axis leads to higher cortisol (a hormone) levels. Prolonged stress leads to higher cortisol levels and impair memory temporarily (Kalat, 2003).

- Lesions in the brain lead to forgetting due to damaged brain areas like hippocampus (the case of patient H.M.) (Purves, 2001; and Kalat, 2003)

- A review article by Wagner and Davachi, 2001 presents analysis of previous fMRI and electrophysiological recordings in humans.
  - They claim that forgetting could result from low recruitment of encoding processes that form effective memories and higher recruitment of alternative mechanisms that may impair effective learning.
Common Memory Improvement Techniques

- Mnemonics
  - Method of Loci (Kondo et al., 2004)
- Cognitive-Behavioral Model of Everyday Memory (McDougall, 2002)
- Enactment effect leads to improved memory
- Other mediums include intake of various herbs and intranasal insulin (Benedict et al., 2004)
Learning by association

- **Method of Loci**
  - Ancient strategy for improving memory (introduced by Greeks and Romans)
  - Spatial learning strategy—in which learners associate to-be-recalled material with familiar places (like their own rooms, design of their houses, etc). Then the learners recall the new material simply by taking an imaginary tour of their familiar places. (Brigham, 2000)

- The following fMRI study by Kondo et al., 2004 examines brain activation associated with the use of method of loci strategy within individuals.
Changes in brain activation associated with use of a memory strategy: a functional MRI study
By Kondo et al., 2004

- The authors used fMRI to examine brain activation within subjects associated with the use of the method of loci.
- Brain activations before and after instruction of the method of loci were compared during the encoding and recall phases of a task.
- The authors concluded that the use of the method of loci improved memory recall.
Changes in brain activation associated with use of a memory strategy: a functional MRI study
By Kondo et al., 2004

- Method: 14 healthy right-handed male volunteers were chosen
- Tasks were composed in the following manner:
  - 14 lists (with 10 stimuli in each) were compiled from 70 color photographs of living things + 70 color photographs of non-living objects.
  - 6 lists were used as encoding stimuli, another 6 lists were used as distracters during recognition tasks, and the remaining 2 lists were used for the instruction and training of the method of loci (MOL).
- The experimental design on the left was followed.
- The fMRI scanning led the authors to analyze changes in brain activations associated with the use of MOL.

Experimental design of the study
Results: The authors found that the mean correct responses for the recall tasks increased after the instruction and training of the MOL. Also, the mean correct responses for the recognition tasks increased minimally after the instruction of the MOL.
Changes in brain activation associated with use of a memory strategy: a functional MRI study
By Kondo et al., 2004

- fMRI scanning showed changes in brain activation pattern with the use of MOL
  - Differences in activations during the encoding tasks before and after instruction with the MOL:
    - common activity of the left fusiform gyrus (B) and lingual/cingulate gyrus (C) was observed.
    - Activity in different regions of the frontal lobe (A, D and E)

Figure 5 from Kondo et al., 2004
Changes in brain activation associated with use of a memory strategy: a functional MRI study
By Kondo et al., 2004

- Differences in activations during the recall tasks before and after instruction with the MOL:
  - Activity in left parahippocampal/retrosplenial/lingual/cingulate cortices (A)
  - Activity in left fusiform gyrus (B), left precuneus (C) and right lingual/cingulate gyri (D)

- **Conclusions:** The authors concluded that the use of the method of loci improved memory recall.

- Brain activations before and after instruction of the method of loci were different during the encoding and recall phases of a task.

Figure 6 from Kondo et al., 2004
Memory Improvement in Octogenarians
By McDougall, 2002

- This study was done with a group of residents (58 women, 20 men) in a retirement village in Northeast Ohio.
- Demographics: Average age of group: 82 years, with 16 years of education, and Mini-Mental State Examination score of 28. 13% were depressed.
- Through a previous study, McDougall (1994) had known that elder participants worried about memory decline with age and that they had less control over their memory.
- A memory enhancement program called Cognitive Behavioral Model of Everyday Memory (Table 1) was tested in this study. The model contains objectives designed to improve memory and was taught over the course of 8 weeks.
- Participants were pre-tested and post-tested on everyday tasks.
Table 1. Cognitive Behavioral Model of Everyday Memory

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the first class, the focus was on reducing anxiety using stress inoculation. After the three stages of memory were explained, encoding and retrieval were discussed. This unit introduced such internal memory-improvement techniques as association and visualization, elaboration, active observation, and rehearsal. Internal mnemonic devices, including the story method, chunking, first letter cues, creating a word, and categorization, were described, along with other methods to assist with recall, such as searching memory, alphabet search, and review.</td>
<td>The focus in unit 2 was on how memory changes as people age. Topics discussed included normal changes in memory with age and distinctions between normal cognitive aging, age-associated memory impairment, and Alzheimer’s disease. The session focused on memory changes most relevant to older adults. Individuals were asked to discuss their beliefs and stereotypes about the effects of aging on cognitive ability. The six factors that affect memory were discussed: (1) divided attention, (2) learning new information, (3) effort, (4) retrieval, (5) recall, and (6) accumulation of knowledge.</td>
<td>The focus of unit 3 was on factors affecting memory for people of all ages. This unit was designed to help people consider the influence of factors that they might not realize affected their memory and increase their knowledge about the general well-being of older adults. Topics discussed were attention and distraction, negative expectations, stress, anxiety, depression, loss and grief, inactivity, lack of social interaction, lack of mental stimulation, lack of organization in daily life, fatigue, physical illness, medications, vision and hearing problems, alcohol, and poor nutrition.</td>
<td>The focus of unit 4 was on how to use internal and external strategies as memory improvement techniques. This unit covered external memory strategies, such as written reminders, auditory reminders, and environmental change, e.g., use of place. General tips were given for remembering—be confident and believe in yourself, make conscious choices, focus your attention, cut out distractions, allow plenty of time, use all five senses, be organized, recognize negative influences, relax, laugh, and enjoy past memories.</td>
</tr>
</tbody>
</table>
Memory Improvement in Octogenarians
By McDougall, 2002

Method: A quasiexperimental design (which compares groups like experimental design but lacks random assignment of subjects in groups): the CBMEM program was tested in 3 groups. Group 1 subjects were taught the program for 8 weeks and were given a memory book named: Improving your memory: how to remember what you’re starting to forget (Fogler & Stearn, 1994), on the first day of class. Group 2 subjects received the memory book first for 4 weeks and then were given 4 weeks of classes of CBMEM. Group 3 was the wait-list control group and were given the memory book only.

The groups were pre-tested before the starting of the program and post-tested during the week after the program.

The author recorded the following variables and their measurement: each of the following variables were measured using a questionnaire
- Memory (The Rivermead Everyday Behavioral memory test, Cockburn & Smith, 1989)
- Memory efficacy (Memory Efficacy questionnaire, Lachman, 1990)
- Metamemory (Metamemory in Adulthood, MIA Questionnaire, Dixon, Hultsch & Hertzog, 1988)
- Strategy (subscale which includes internal and external strategies)
- Depression (Geriatric Depression Scale, Sheikh & Yesavage, 1986)
- Health (Health scale, Lawton, Moss, Fulcomer, & Kleban, 1982)
- Instrumental Activities of Daily living (IADLs) (IADL scale, Lawton, 1988)
Memory Improvement in Octogenarians
By McDougall, 2002

The use of strategies to improve memory was based on:
Internal strategies included: rehearsal, elaboration, effort
External strategies included: use of (to do) lists, notes, method of loci, depending on someone to remind you something, and calendars.

**Results:** The author concluded that following the Cognitive behavioral model of everyday memory (CBMEM) did lead to memory improvement and the subjects became pro in using memory strategies and techniques.

Table on the next slide shows the results of the experimental groups.
Largest improvement was in memory efficacy and through use of internal memory strategies.
Medium improvement was in instrumental activities (such as using the telephone, going shopping, cleaning the house, taking medications, handling money) and change (the perception of memory abilities as stable)
Smaller improvement in locus (the individual’s perceived personal control over remembering abilities) and memory performance.

Note: The author did consider the education level of participants (higher education level of participants did have positive effect on the results.)
Memory Improvement in Octogenarians, By McDougall, 2002

Results table.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Baseline M ± SD N</th>
<th>8 Weeks M ± SD N</th>
<th>Effect Size</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory Performance (SPS)</td>
<td>EXP 1</td>
<td>16.0 ± 4.9 (25)</td>
<td>16.8 ± 5.7 (25)</td>
<td>.25</td>
<td>.0141</td>
<td>0-24</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>16.3 ± 6.2 (15)</td>
<td>19.0 ± 5.3 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>17.8 ± 3.4 (20)</td>
<td>18.8 ± 3.9 (20)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory Performance (SS)</td>
<td>EXP 1</td>
<td>7.1 ± 2.2 (25)</td>
<td>7.1 ± 3.1 (25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>7.3 ± 3.0 (15)</td>
<td>7.7 ± 3.0 (15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>7.7 ± 2.0 (20)</td>
<td>8.7 ± 2.3 (20)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Memory-Efficacy</td>
<td>EXP 1</td>
<td>53.8 ± 15.8 (26)</td>
<td>57.7 ± 24.2 (26)</td>
<td></td>
<td>.64</td>
<td>.0007</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>48.8 ± 16.9 (18)</td>
<td>60.7 ± 14.6 (18)</td>
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<td></td>
<td>EXP 3</td>
<td>47.6 ± 25.2 (20)</td>
<td>69.8 ± 18.8 (20)</td>
<td></td>
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<tr>
<td>MIA-Anxiety</td>
<td>EXP 1</td>
<td>3.3 ± 0.5 (26)</td>
<td>3.3 ± 0.6 (28)</td>
<td>.06</td>
<td>NS</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>3.1 ± 0.6 (13)</td>
<td>3.0 ± 0.6 (13)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>3.6 ± 0.3 (15)</td>
<td>3.5 ± 0.4 (15)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>MIA-Change</td>
<td>EXP 1</td>
<td>2.3 ± 0.4 (23)</td>
<td>2.6 ± 0.6 (23)</td>
<td>.50</td>
<td>.0013</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>2.4 ± 0.4 (17)</td>
<td>2.6 ± 0.4 (17)</td>
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<tr>
<td></td>
<td>EXP 3</td>
<td>2.5 ± 0.7 (16)</td>
<td>2.7 ± 0.6 (16)</td>
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<tr>
<td>MIA-Locus</td>
<td>EXP 1</td>
<td>3.3 ± 0.4 (27)</td>
<td>3.5 ± 0.4 (27)</td>
<td>.24</td>
<td>.0174</td>
<td>1-5</td>
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<tr>
<td></td>
<td>EXP 2</td>
<td>3.4 ± 0.3 (17)</td>
<td>3.6 ± 0.5 (17)</td>
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</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>3.4 ± 0.5 (19)</td>
<td>3.5 ± 0.4 (19)</td>
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</tr>
<tr>
<td>MIA-External Strategies</td>
<td>EXP 1</td>
<td>3.9 ± 0.3 (26)</td>
<td>3.9 ± 0.4 (26)</td>
<td>.10</td>
<td>NS</td>
<td>1-5</td>
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<tr>
<td></td>
<td>EXP 2</td>
<td>3.9 ± 0.6 (17)</td>
<td>4.1 ± 0.5 (17)</td>
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<tr>
<td></td>
<td>EXP 3</td>
<td>4.2 ± 0.5 (19)</td>
<td>4.3 ± 0.4 (19)</td>
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</tr>
<tr>
<td>MIA-Internal Strategies</td>
<td>EXP 1</td>
<td>3.5 ± 0.5 (26)</td>
<td>3.7 ± 0.4 (26)</td>
<td>.66</td>
<td>.0032</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>3.5 ± 0.2 (17)</td>
<td>3.7 ± 0.4 (17)</td>
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</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>3.5 ± 0.5 (19)</td>
<td>3.6 ± 0.5 (19)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IADLs</td>
<td>EXP 1</td>
<td>27.4 ± 4.4 (21)</td>
<td>26.1 ± 4.3 (21)</td>
<td>.46</td>
<td>.0187</td>
<td>8-31</td>
</tr>
<tr>
<td></td>
<td>EXP 2</td>
<td>28.0 ± 3.7 (12)</td>
<td>26.4 ± 4.4 (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EXP 3</td>
<td>28.7 ± 2.0 (18)</td>
<td>31.0 ± 1.2 (18)</td>
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</tbody>
</table>

Note: Memory performance (SPS, standard profile score) was collected from normal community dwelling adults that were middle aged and older.
Enactment effect leads to improved memory

Cognitive psychologists like Engelkamp, 1998 have examined the enactment effect, which is that previously performed actions lead to better recall than heard-only actions.

- Many studies have examined this effect and claim that memory of the action is improved due the motor aspect of performing the action. Specifically, Engelkamp, 1997 claimed that,

> “A stable memory trace for action-phrases seems to rely on the actions having actually been carried out; merely concentrating on the movement as while observing or mentally simulating enactment although effective, does not produce the same high-quality encoding as real enacting.”

- Some studies claim that enactment effect produces better recall of actions since it might rely on procedural learning. For instance, in Alzheimer’s disease, the declarative memory functions are more deeply disrupted but the enactment effect is still intact (Karlsson et al., 1989)
Other mediums for improving Memory…

Many herbs are known to enhance memory. However, in the scientific research community, the administration of following herbs have claimed to improve memory:

- Guarana (*Paullinia Cupana*), tested in humans (Kennedy et al., 2004)
- *Ptychopetalum olacoides*, tested in mice (Silva et al., 2004)
- Ginkgo biloba (Kalat, 2003)

Another interesting example of improving memory is the administration of intranasal insulin in humans (Benedict et al., 2004)

Benedict et al., 2004 administered intranasal insulin in humans and hypothesized that there would be improvement in their declarative memory functions and mood.

Their hypothesis was based on previous research findings such that there are insulin receptors in the limbic system and hippocampus and that systemic administration of insulin leads to memory improvement.

The results did show improved declarative memory functions and mood.
Concept Map

**Qualitative categories:**
- **Declarative** (dependent on conscious)
- **Semantic & Episodic**
- **Procedural** (Motor skills)

**Biochemical Mechanisms:**
- **LTP** (in hippocampus, Cortex, nuclear Accumbens) and **LTD** (cerebellum, hippocampus)

**Temporal categories:**
- Immediate (sensory) memory (milli secs-sec)
- Short-term memory (sec-min)
- Long-term memory (min-days-years)

**Memory**

**Formation**

**Kinds**

**Issues**
- Forgetting
- Amnesia (Retrograde, anterograde)
- Interference
- Lesions of various parts of the brain lead to memory impairment (ex: hippocampus, cerebellum)

**Improvement Strategies**
- **Mnemonics**
- **Method of Loci**
- **Enactment effect**
- **Cognitive behavioral model of everyday memory (CBMEM)**
- **Sleep**
- Other ways: intake of herbs and intranasal insulin, getting adequate sleep, stay healthy and exercise, keep a positive attitude and relax.
Summary

- Experience → Learning → Memory
- Memory categorizations: Temporal and Qualitative
  - Temporal: Immediate (sensory) memory, STM, LTM
  - Qualitative: Declarative (includes semantic and episodic memories) and Procedural (motor skills memories)
- General overview of how a memory forms
  - Diagram on slide # 6
- Biochemical mechanisms of memory formation
  - LTP and LTD (depend on glutamate synapses)
- Memory Improvement techniques: Mnemonics, method of loci, enactment effect, cognitive behavior model of everyday memory (CBMEM), and other minor ways.
References:


References:


