“DESIRABLE DIFFICULTIES”

STUDYING

LEARNING

REMEMBERING

J Baucom, Landmark College, Summer Institute 2017
Zeus, Mnemosyne, and the Nine Muses
(Anton Mengs, 1761)
Six Highly Effective Study Practices

- Space Your Studying
- Vary the Conditions of Study
- Test Yourself
- Write Questions
- Draw Visuals
- Summarize What You Learn
Agenda:

- Important features of memory
- Why difficulties in learning are good
- 3 study strategies that build on how memory works
- Selected research studies
- What insights into studying tell us about teaching
- Educational implications, questions
QUIZ

1. What was the name of your 6th grade math teacher?

2. Who was the 25th President of the United States?

3. What is the name of the person you introduced yourself to at the beginning of this session?
Hermann Ebbinghaus (1885)

- First to apply experimental procedures, mathematical models, and statistics to the study of learning and memory

- Conducted a series of rigorously controlled experiments between 1879-1884 with a single subject
Ebbinghaus: 4 Major Contributions

- Forgetting Curve
  - What is lost

- Relearning Effect
  - What is saved

- Spacing Effect
  - How it’s distributed

- Overlearning
  - Surplus practice
Ebbinghaus's Forgetting/Retention Curve

Percentage of information relearned versus interval between original learning and memory test.
A New Theory of Disuse
Robert and Elizabeth Bjork (1992)
Two Distinct Memory Strengths

Storage: How well learned
   Strong | Weak

Retrieval: How accessible
   Strong | Weak
<table>
<thead>
<tr>
<th>High SS/Low RS</th>
<th>Low SS/ High RS</th>
</tr>
</thead>
<tbody>
<tr>
<td>childhood street address</td>
<td>current hotel room number</td>
</tr>
<tr>
<td>Distributive law in mathematics</td>
<td>Ebbinghaus: what percentage of memory loss occurs in first 20 minutes after learning?</td>
</tr>
<tr>
<td>Low SS/Low RS</td>
<td>High SS/High RS</td>
</tr>
<tr>
<td>old hotel room number</td>
<td>current street address</td>
</tr>
<tr>
<td>25th US president</td>
<td>how to calculate a percentage</td>
</tr>
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</table>
Key Design Features of Storage

- Unlimited
- Doesn’t Diminish
- Expands with Use
- Latent
Value of Storage Strength

- Enhances gain of RS
- Slows the loss of RS
- Enables us to recognize or relearn info
What Strengthens Storage?

- Repeated Practice
- Meaningfulness
- Connection to Existing Knowledge
Key Design Features of Retrieval

- Limited, Frail
- Strengthens with Difficulty
- Determines Current Performance
- Changes Memory
Determinants of Retrieval

- Relative Strength
- Absolute Strength
- Context Cues

RS
Who was the 25th President of the United States?

Which President was assassinated, resulting in Theodore Roosevelt becoming President?

William McKinley
Adaptive Value of Disuse Theory
Takeaways/Educational Implications

Forgetting is good

Beware "illusion of mastery"

Good teaching = SS +++

How do we boost RS?

High RS Low SS
What Is A Desirable Difficulty?

- “training conditions that are difficult and appear to impede performance during training but that yield greater long-term benefits than their easier training counterparts” (Bjork, 2016)

- “…conditions that produce the fewest errors during learning (like massed practice…) can lead to very poor long-term retention” (Karpicke and Roediger 2008)

- **Study harder?**
The Cognitive Reflection Test (Frederick 2005)

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.

How much does the ball cost?

Answer:
Alter et al (2007) administered CRT to Princeton students
Avg Score: 1.9/3

With altered font? Avg score: 2.45 out of 3
Strategy/Desirable Difficulty 1: Space Your Studying (Distributed Practice)

- Spread out practice of material over time rather than in one large time block
- Opposite of cramming
## Spaced Study or Distributed Practice

<table>
<thead>
<tr>
<th></th>
<th>Mon</th>
<th>Tues</th>
<th>Wed</th>
<th>Thurs</th>
<th>Total Study Time</th>
<th>Fri-Test Day</th>
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</thead>
<tbody>
<tr>
<td>John</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
<td></td>
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<tr>
<td>Susan</td>
<td></td>
<td></td>
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<td></td>
<td>4 hours</td>
<td></td>
</tr>
<tr>
<td>Fernando</td>
<td></td>
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<td>4 hours</td>
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</tr>
<tr>
<td>Susan</td>
<td></td>
<td></td>
<td>2 hours</td>
<td>2 hours</td>
<td>4 hours</td>
<td></td>
</tr>
<tr>
<td>Fernando</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>4 hours</td>
<td></td>
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</thead>
<tbody>
<tr>
<td>John</td>
<td></td>
<td></td>
<td></td>
<td>4 hours</td>
<td>4 hours</td>
<td>C-</td>
</tr>
<tr>
<td>Susan</td>
<td></td>
<td></td>
<td>2 hours</td>
<td>2 hours</td>
<td>4 hours</td>
<td>B-</td>
</tr>
<tr>
<td>Fernando</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>4 hours</td>
<td>A</td>
</tr>
</tbody>
</table>
Cepeda et al. 2006

- 839 assessments of spaced study
- 317 different experiments
- 14,000 participants
- Average benefit of 15% on test performance for spaced study over massed study
Spacing between study sessions should be 10-20% of the **desired** retention interval (the delay between final study session and criterion task) Dunlosky et al., 2013

To remember info 30 days later, aim for 3-6 days between study sessions

- University of Toronto Department of Surgery
- Taught complex surgical skill using different schedules of instruction:
  - Massed Training: 4 sessions in one day
  - Distributed Training: 1 session per week, over 4 weeks
Immediately After Training

• Both groups equal performance

One Month Later

• DT group better on retention and transfer
Why Does Spacing Work?

- Relearning Effect
- Forgetting Occurs
- Desirable Difficulty
Ebbinghaus on Spacing Effect

- ...the method naturally employed in practice agrees. The schoolboy doesn’t force himself to learn his vocabularies and rules altogether at night, but knows that he must impress them again in the morning. A teacher distributes his class lesson not indifferently over the period at his disposal but reserves in advance a part of it for one or more reviews” (p. 89)
Implications Beyond School and College
Educational Implications/Reflection

- Writing Exercise: What are the implications for spacing in the design and implementation of our educational models?

- Writing Exercise: Knowing what you know about spacing effects, how might you apply this powerful strategy in your work?
Strategy/Desirable Difficulty 2:

- Vary the Conditions of Your Learning
- Physical Context

- Cognitive Context (questions, visuals, summaries)

- Informational Context: Interleaving
Why Create Variation?

- Builds a richer network of connections and associations, “memory landmarks”
- Reduces context dependency, encoding specificity (Tulving, 1973)
**Task:** Study a list of 40 words

<table>
<thead>
<tr>
<th></th>
<th>Study Session 1</th>
<th>Study Session 2</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td>Context A</td>
<td>Context A</td>
<td>Context C (15.9 words, 39%)</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td>Context A</td>
<td>Context B (completely different)</td>
<td>Context C (24.4 words, 61%)</td>
</tr>
</tbody>
</table>
Adding Variation: Interleaving

- Alternate skills or concepts within a given time period, rather than studying each one in a large block

- A-A-A, B-B-B, C-C-C

- A-B-C, A-B-C, A-B-C **or** A-B-C, B-A-C, C-B-A

- Applies to motor skills, semantic knowledge, procedural knowledge, arts, music, athletics
Kang and Pashler (2012), college students studied 40 paintings by three artists (Blencoe, Lindenberg, O’Shea) and their styles in interleaved, massed block, or spaced block conditions.

- Interleaved group best able to recognize painters’ styles on a transfer test.
Interleaving Math Instruction (Rohrer et al, 2015)

- Over a 3 month period, 126 7th graders were taught how to graph linear equations and how to find the slope of a line

- Some classes = homework with interleaved graph, blocked slope problems

- Other classes = homework with interleaved graph and blocked slope problems
Results of Rohrer Experiment 2015

- **I day delay**
  - Interleaved: 80
  - Blocked: 60

- **30 day delay**
  - Interleaved: 70
  - Blocked: 40

Legend:
- Red: Interleaved
- Yellow: Blocked
Why Does Interleaving Work?
Educational Implications/Reflection

- How well do we “mix up” and create varying conditions in our teaching? Are we too cautious about mixing it up?

- Do we interleave instruction or teach in blocked units?

- Interleaving is how the “real world” works!

- Writing Exercise: Knowing that varying the conditions of learning can impact retention, how might you apply this desirable difficulty in your work?
Strategy/Desirable Difficulty 3: Test Yourself

- Test-enhanced learning
- “Testing effect”
- One of the best study practices (Dunlosky et al. 2013)
Studying vs Testing

Roediger & Karpicke 2006

Proportion of Ideas Recalled

Retention Interval

SSSS  SSST  STTT
Why does testing improve learning?

- Demands Retrieval
- Modifies Memory
- Increases SS and RS
How Can Students Test Themselves?

- Summaries
- Visuals
- SMART Cards
- Quizlet.com
- Reciprocal Teaching
- Practice Tests
Educational Implications/Reflection

- Is the testing effect utilized as a teaching tool often enough?

- Perception: 1) purpose, value of testing 2) low-stakes vs high stakes testing

- Writing Exercise: Knowing what you know about the testing effect, how might you apply this powerful strategy in your work?
### Putting It All Together: A Study Plan 😊

<table>
<thead>
<tr>
<th>Mon Mar 11</th>
<th>Mon Mar 18</th>
<th>Mon Mar 25</th>
<th>Mon Apr 1</th>
<th>Sun Apr 7</th>
<th>Mon Apr 8 Test Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karen</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

**Where?**
- Context A EAB108
- Context B Library
- Context A EAB108
- Context C Dining Hall
- Context A EAB108
- Context A EAB108

**How?**
- **Study**
- **Interleave**
- **Self Test**
- **Interleave**
- **Self Test**
- **Interleave**
- **Self Test**
- **Interleave**
- **Study**, night before test, then sleep
- **Real Test**
Spaced Study

- Writing Exercise: What are the implications for spacing in the design and implementation of our educational models?

- Writing Exercise: Knowing what you know about spacing effects, how might you apply this powerful strategy in your work?
Interleaving

- Writing Exercise: Knowing that varying the conditions of learning can impact retention, how might you apply this desirable difficulty in your work?
Testing Effect

- Writing Exercise: Knowing what you know about the testing effect, how might you apply this powerful strategy in your work?
Sources Cited


