Applying Cognitive Science to Enhance Medical Education

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Why do we ask questions?

- “Encourage curiosity”
- “Foster engagement”
- “Active observation”
- “Emphasize important points”
- “Target teaching”
- “Get students to commit to an answer”
- “Induce a little bit of stress”
- Practice retrieving and using knowledge
Study

Practice
Study  Practice
Retrieval changes memory.
Flash Cards

ANATOMY
FLASH CARDS

- Detailed anatomical labels on one side
- Tabbed cards so you can find the system you need
- Test yourself on the other
Learning Conditions

<table>
<thead>
<tr>
<th>Learning Conditions</th>
<th>Study</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study all, test all</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Study nonrecalled, test all</td>
<td>77</td>
<td>160</td>
</tr>
<tr>
<td>Study all, test nonrecalled</td>
<td>160</td>
<td>83</td>
</tr>
<tr>
<td>Study nonrecalled, test nonrecalled</td>
<td>78</td>
<td>78</td>
</tr>
</tbody>
</table>

Number of Trials

Karpicke & Roediger (*Science*, 2008)
Proportion Correct on Final Test

Learning Condition

Repeated Retrieval

One Retrieval

Karpicke & Roediger (*Science*, 2008)
The Testing Effect: Some Findings

• Retrieval practice produces better retention than other learning activities

• Repeated testing is better than a single test, especially when spaced over time

• Production tests tend to produce better retention than recognition tests
# The Testing Effect: Does It Generalize?

<table>
<thead>
<tr>
<th>Materials / Skills</th>
<th>Learners / Populations</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>All ages (children to older adults)</td>
<td>Laboratory</td>
</tr>
<tr>
<td>General knowledge facts</td>
<td>All levels of education</td>
<td>Classroom</td>
</tr>
<tr>
<td>Prose passages</td>
<td>All levels of cognitive ability and prior knowledge</td>
<td>Clinic</td>
</tr>
<tr>
<td>Lectures</td>
<td></td>
<td>(and many more...)</td>
</tr>
<tr>
<td>Pictures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese characters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complex functions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bird species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resuscitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navigational routes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Can Testing Promote Transfer of Learning?

“The influence of prior learning (retained until the present) upon the learning of, or response to, new material…”

- McGeoch (1942)
Transfer to a Different Knowledge Domain

Example:
Echolocation in bats vs. Sonar in submarines

Butler (*JEP:LMC*, 2010)
Methods for Practicing Retrieval

• Testing (e.g., exams, quizzes, etc.)
• Self-testing (e.g., flashcards)
• Asking questions
• Group discussions
• Writing exercises
• And many more…
Simulation

Mannequin Simulators

Standardized Patients
Participants: 41 1st year medical students
Clinical neurology topics: migraine, seizures, and myasthenia gravis
Review Written Test SP Test

Proportion Correct

Learning Condition

Larsen et al. (AHSE, in press)
One Caveat...
What is the capital of Australia?

A) Brisbane
B) Sydney
C) Canberra
D) Melbourne
E) Darwin
Implications for Medical Education

• Many students are unaware of the benefits of retrieval practice.

• Frequent practice with retrieving and using knowledge will improve long-term retention and understanding.

• Many dynamic ways to provide opportunities for retrieval practice.

• Retrieval practice should not be too difficult – successful retrieval is the critical mechanism.
Desirable Difficulties
People want learning to be quick and easy.
## Retrieval Strength

<table>
<thead>
<tr>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your ATM password?</td>
<td>What was your phone number growing up?</td>
</tr>
<tr>
<td>What did you eat for dinner last night?</td>
<td>How do you say “boat” in Swahili?</td>
</tr>
</tbody>
</table>
Desirable Difficulties

Conditions that slow learning or make it harder will produce better long-term retention and understanding.

Examples:

- Retrieval practice
- Spacing
- Interleaving
- Reducing or delaying feedback
- Many others...
Implications for Medical Education

• Performance during or immediately after learning is no guarantee of future performance.

• Introducing “desirable difficulties” during learning will produce better long-term retention.

• However, learners must be able to overcome the difficulties in order to benefit from them.

• Learners may not like conditions that make learning slower and more difficult.
Types of Cognitive Processing
A Useful Distinction...

<table>
<thead>
<tr>
<th>Item-Specific Processing</th>
<th>Explaining why each symptom of a particular disease occurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational Processing</td>
<td>Comparing and contrasting symptoms among different diseases</td>
</tr>
</tbody>
</table>
Transfer-Appropriate Processing
Transfer-Appropriate Processing

• Memory performance will be enhanced to the extent that the processes engaged during initial learning match the processes required for the criterial task.

Example:

<table>
<thead>
<tr>
<th>Learning</th>
<th>Retrieval</th>
<th>Match?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item-specific</td>
<td>Item-specific</td>
<td>Yes</td>
</tr>
<tr>
<td>Item-specific</td>
<td>Relational</td>
<td>No</td>
</tr>
<tr>
<td>Relational</td>
<td>Relational</td>
<td>Yes</td>
</tr>
<tr>
<td>Relational</td>
<td>Item-specific</td>
<td>No</td>
</tr>
</tbody>
</table>
Implications for Medical Education

• The way in which learners process information affects what is learned.

• When planning learning activities, it is critical to consider how knowledge will be used in the future.

• When assessing learning, it is important to consider both what was learned and how it was learned.
The Relativity of Memory
Learner Characteristics

Learning Tasks

Materials

Criterial Tasks
Conclusions

1. Retrieval practice produces superior long-term retention and understanding.

2. Introducing “desirable difficulties” during learning can be beneficial.

3. Educators should consider the relativity of memory when planning and assessing learning.
Collaborators

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Beth Marsh
Doug Larsen
Amy Lawson
Jeff Karpicke

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