



# McMaster Symposium on EDUCATION & COGNITION

Discovering evidence based practices in education  
July 26<sup>th</sup> & 27<sup>th</sup>, 2018 | McMaster University, MDCL

## July 26, 2018 | Workshops

Strategies for Effective Learning: The Learning Scientist workshop Led by Megan Sumeracki & Yana Weinstein

Ideas Congress (ICON): A transdisciplinary learning environment for experiential learning Led by Shoshana Jacobs

Writing Multiple Choice Questions to Create Effective Tests Led by Amy Pachai

Note taking: How research can better inform practice Led by Irina Ghilic

The Psychology of Focusing on What Really Matters: A Reset for Workplace Productivity Led by Joe Kim

Think Before You Speak: Using your Mental Strengths for Powerful Presentations Led by Laura Cole

## Public Lecture

Mike Atkinson  
Western University

## July 27, 2018 | Speakers

Bruce Wainman  
McMaster University  
*X Reality and the Concorde Fallacy in Education*

Megan Sumeracki  
Rhode Island College  
*Applying the Science of Learning from the Laboratory to the Classroom*

Veronica Yan  
University of Texas at Austin  
*A Toolkit for Building Better Learners*



# EdCogMcMaster.ca

## HOLD the Date: July 26-27, 2018

Visit our website to register and learn more:

<http://www.edcogmcmaster.ca>



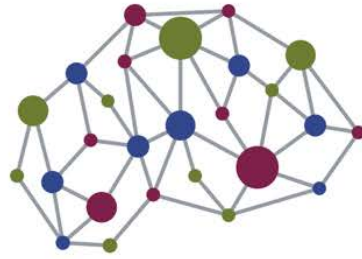
# Motivating durable learning: Focused attention and instructional design

Joseph A. Kim

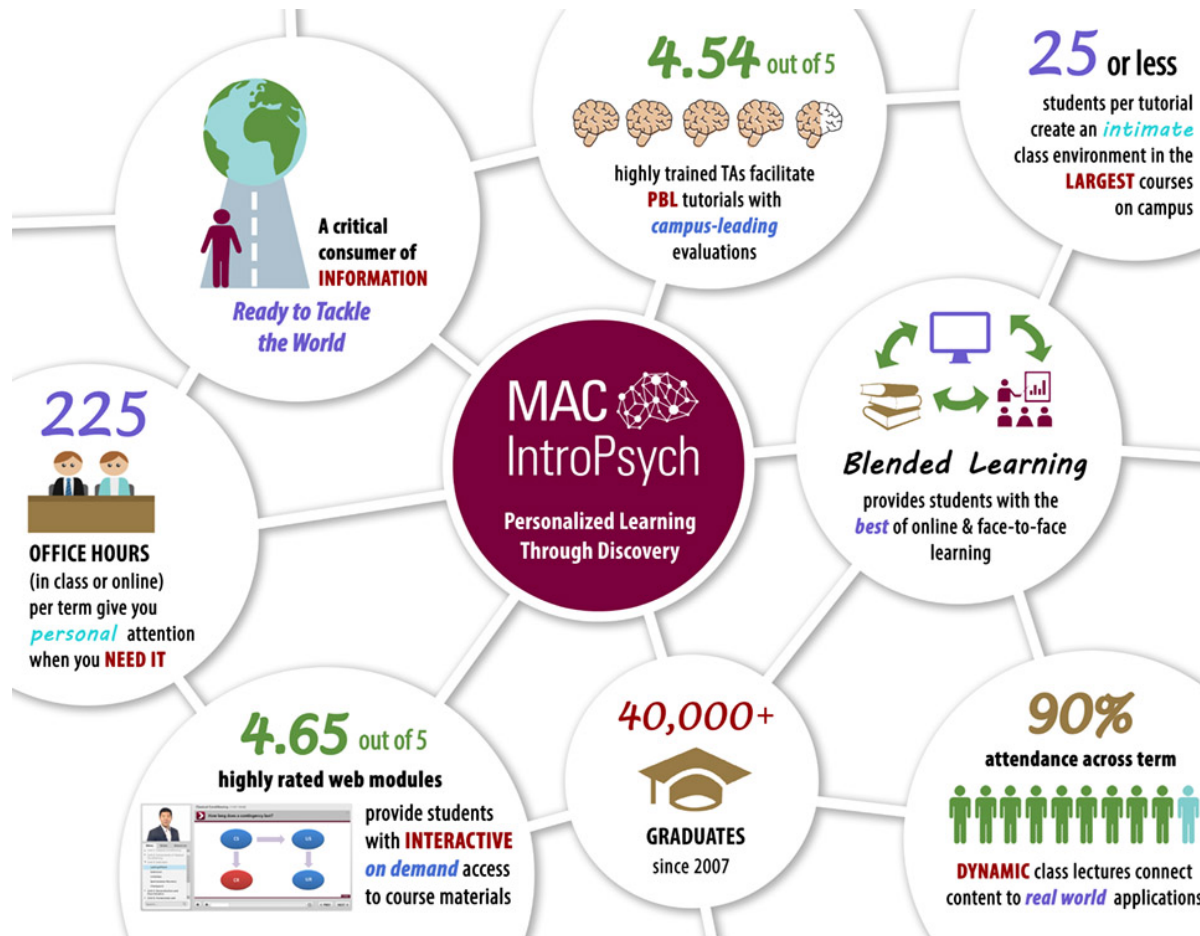
Psychology, Neuroscience & Behaviour  
McMaster University



# MAC



# IntroPsych.com





**Does the light in the fridge go out when you close the door?**



**Students are expected to consume volumes of information...**



**...retain  
knowledge to  
apply in novel  
situations.**



Mon 10:30



Thu 12:30



Mon 10:30

**“Lectures are an effective way to teach, but a poor way to learn.”**

- Stephen M. Kosslyn,  
Minerva University



Thu 12:30



Mon 10:30



Wed 10:30



Thu 12:30

**"Any teacher that can be replaced by a machine should be!"**

Arthur C. Clarke, "Electronic Tutors" (1980)



“...many teachers do not begin their careers with strong knowledge about strategies for learning...If teachers do not have well-developed knowledge about how to learn, it is unlikely that they will be able to lead their own students to develop knowledge about cognitive and metacognitive strategies for learning [and may] overlook the need for explicitly teaching students about cognitive and metacognitive strategies.”

Askell-Williams et al., 2012, p. 414





**Humans make poor metacognitive judgments on learning.**

# Intuitions about effective teaching influence educational practice.

People **do not** have different **learning styles**.

People **do not** use only **10% of their brains**.

People **do not** progress cognitively along a **fixed progression** of age-related stages.

People **are not** “**right-brained**” or “**left-brained**.”

Novices **do not** think in the **same ways as experts**.

# Which study skills help learners?

Technique
Elaborative interrogation
Self-explanation
Summarization
Highlighting
Keyword Mnemonic
Imagery use for text learning
Rereading notes or textbook
Practice Testing
Distributed Practice
Interleaved Practice

**I've read this chapter 10 times...  
I practically know it by heart.**



Many students are being left behind by an educational system that some people believe is in crisis. Improving educational outcomes will require effective interventions, but a central premise of this monograph is that one possible intervention is to help students to better regulate their learning through the use of learning techniques that could help them. In this monograph, we discuss 10 learning techniques in detail and evaluate their utility. We selected techniques that were expected to be useful and hence could be adopted by many students. Also, some techniques (e.g., highlighting and rereading) were selected because students report relying heavily on them, which makes it especially important to examine how well they work. The techniques we discuss are elaborative interrogation, self-explanation, summarization, highlighting (or keyword mnemonic), imagery use for text learning, rereading, practice testing, and interleaved practice. To offer recommendations about the use of these techniques, we evaluated whether their benefits generalize to different conditions: learning conditions, student characteristics, material characteristics, and whether a student studies alone or with others. The conditions include student age, ability, and level of prior knowledge. The material characteristics include the complexity of the problems to complicated and simple. The learning conditions include whether a student studies alone or with others. The student characteristics include whether a student is a high-achiever or a low-achiever. The material characteristics include whether the material is relevant to student interests.



## Durable learning



**Cognitive scientists  
have studied memory  
& attention in the lab  
for a long time.**

**Teachers have been  
teaching for a very,  
very long time.**

# Key factors for durable learning.



1. Learning begins with effortful & focused attention.



2. Instructional Design directly sets the stage for learning.



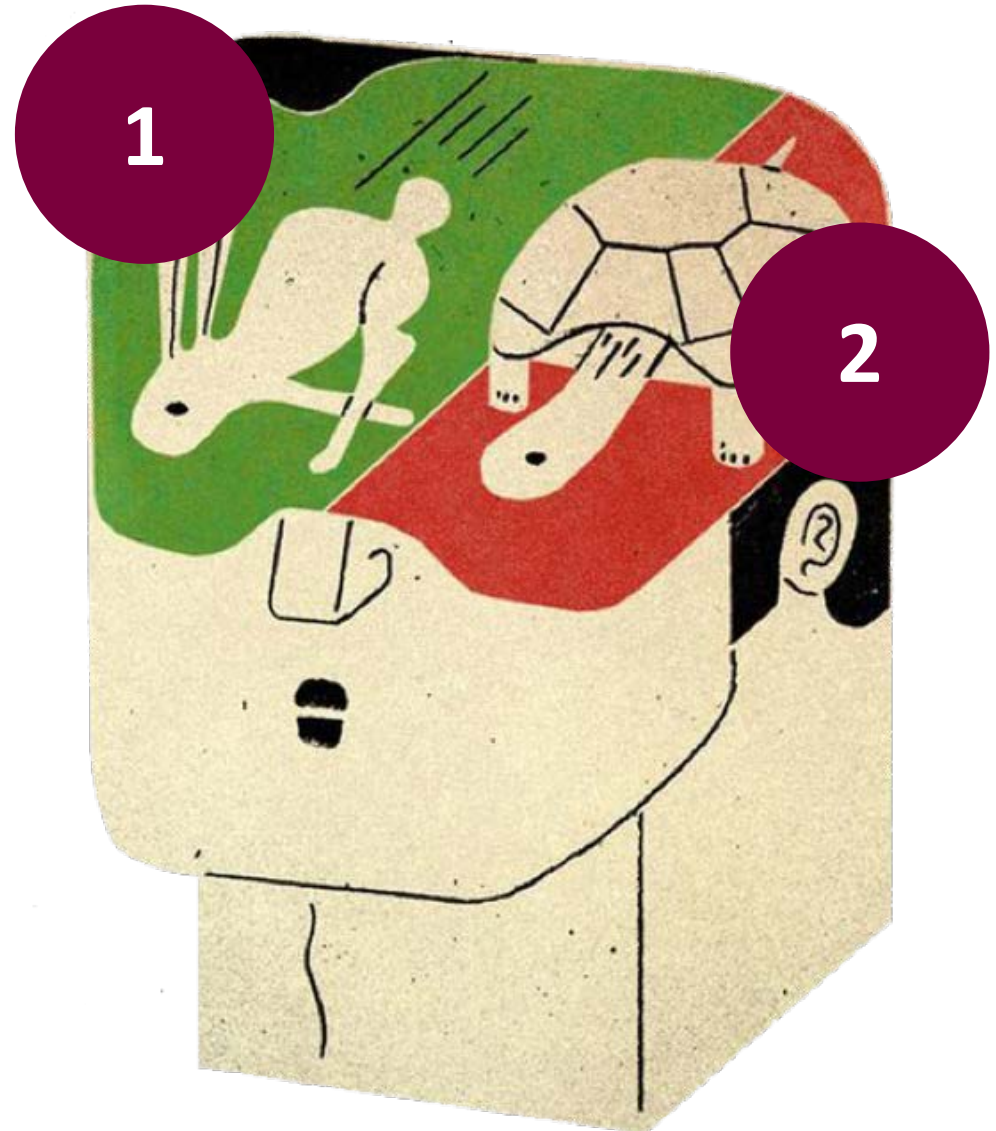
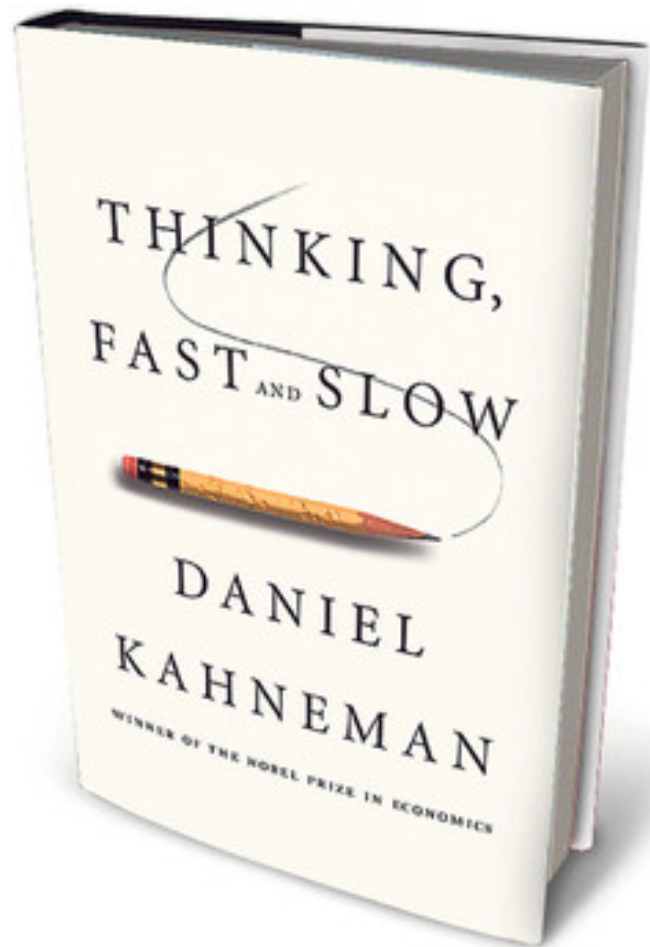
3. Effective study habits strengthen long-term retention.

**1**



**Learning begins with effortful  
& focused attention.**

# Thinking, fast and slow.





## **Effortful?** Are you thinking fast or slow?

A bat and a ball together cost \$1.10  
The bat cost \$1 more than the ball.

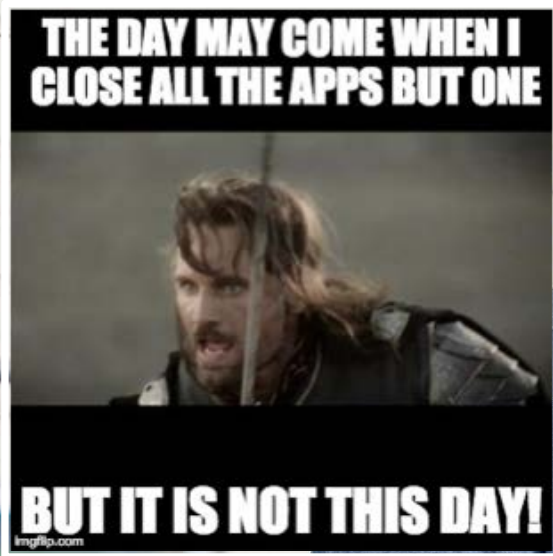
How much does each item cost?

## **Effortful?** Are you thinking fast or slow?

A BMW and a Tesla together cost \$160,000.  
The BMW cost \$100,000 more than the Tesla.

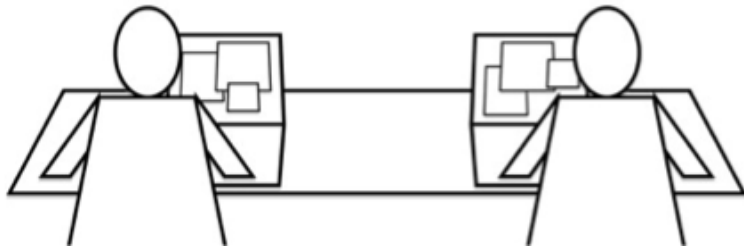
How much does each car cost?

# Focused? Learning while multi-tasking...

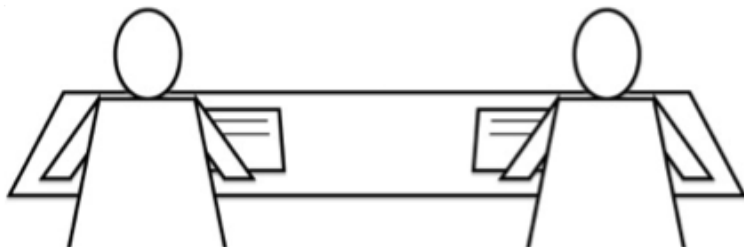


# Divided attention leads to reduced gains in learning for self and peers.

In view of a multitasking peer

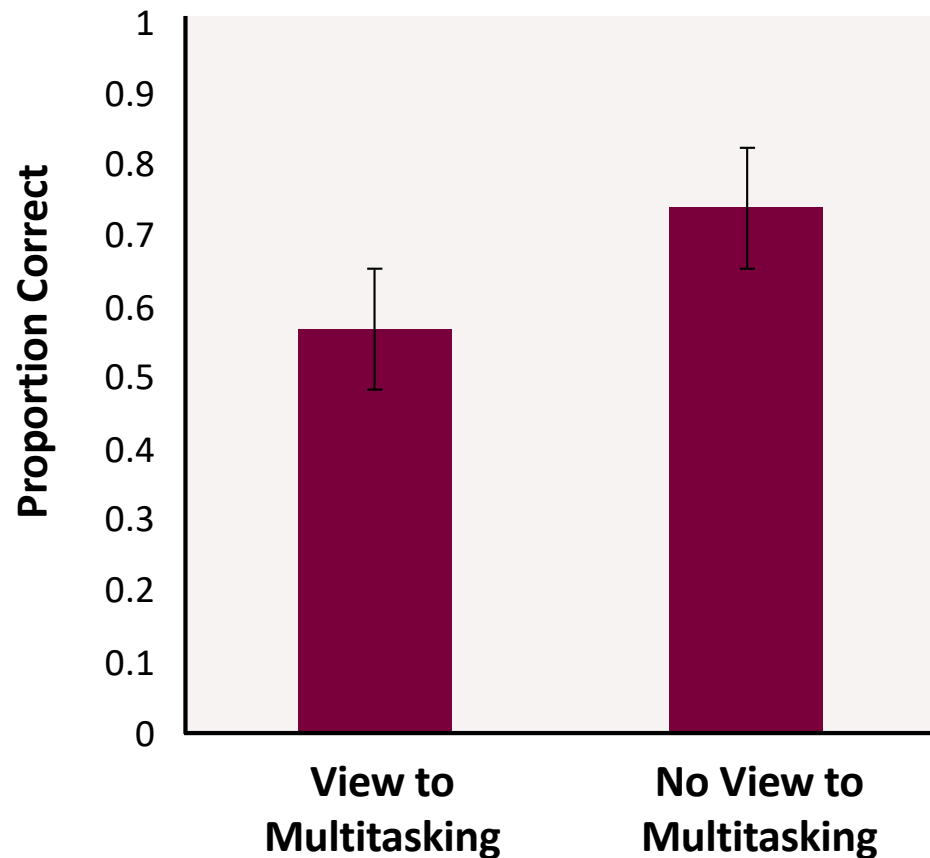


VS



Not in view of a multitasking peer

The Effect of Peer Distraction on Comprehension of Lecture Content



# How can interventions increase attention during learning?



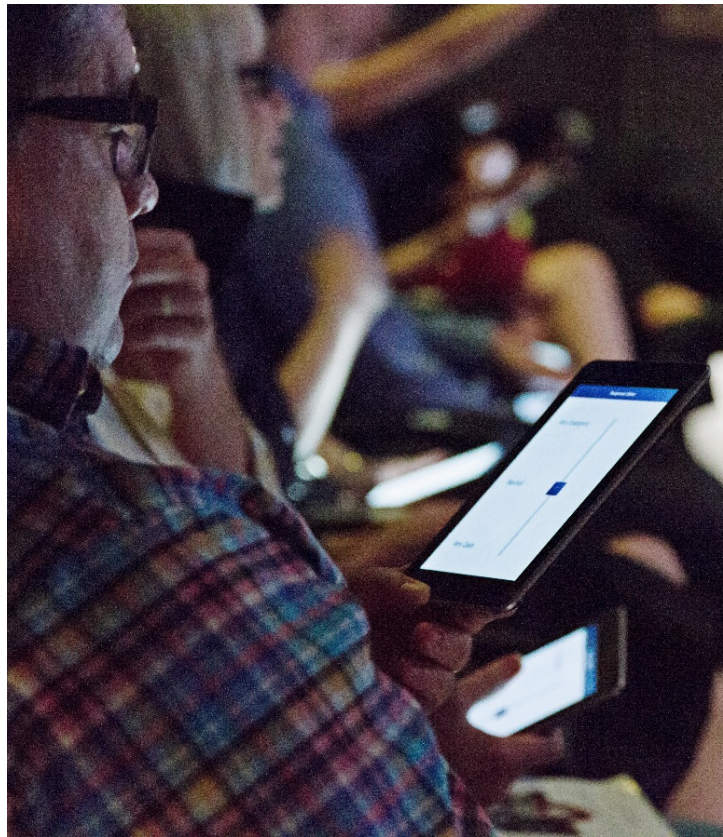
**Dr. Barb Fenesi**



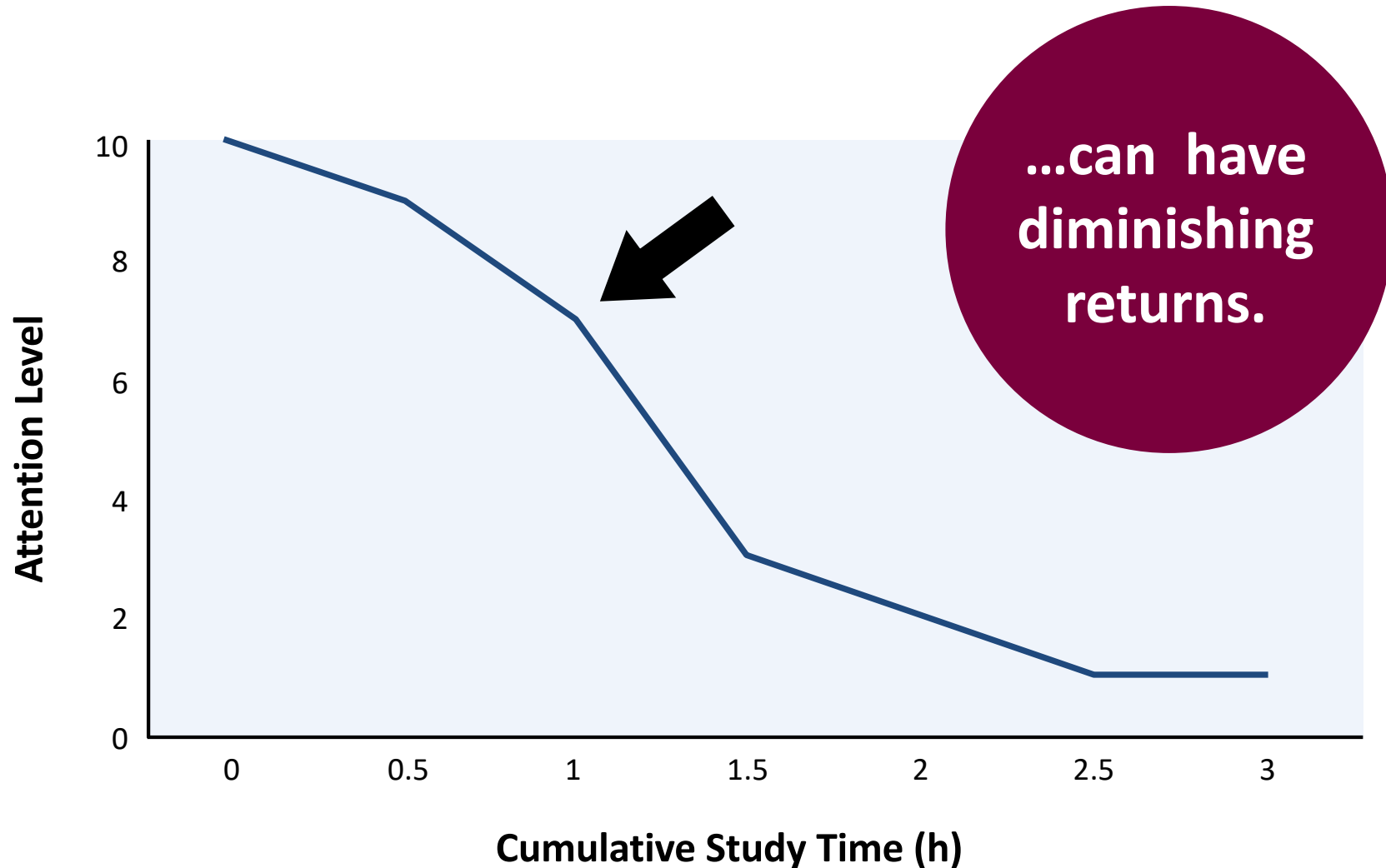
**Amy Pachai, PhD Candidate**



# On-task attention assessed using mind-wandering probes.



# Studying for sustained periods...

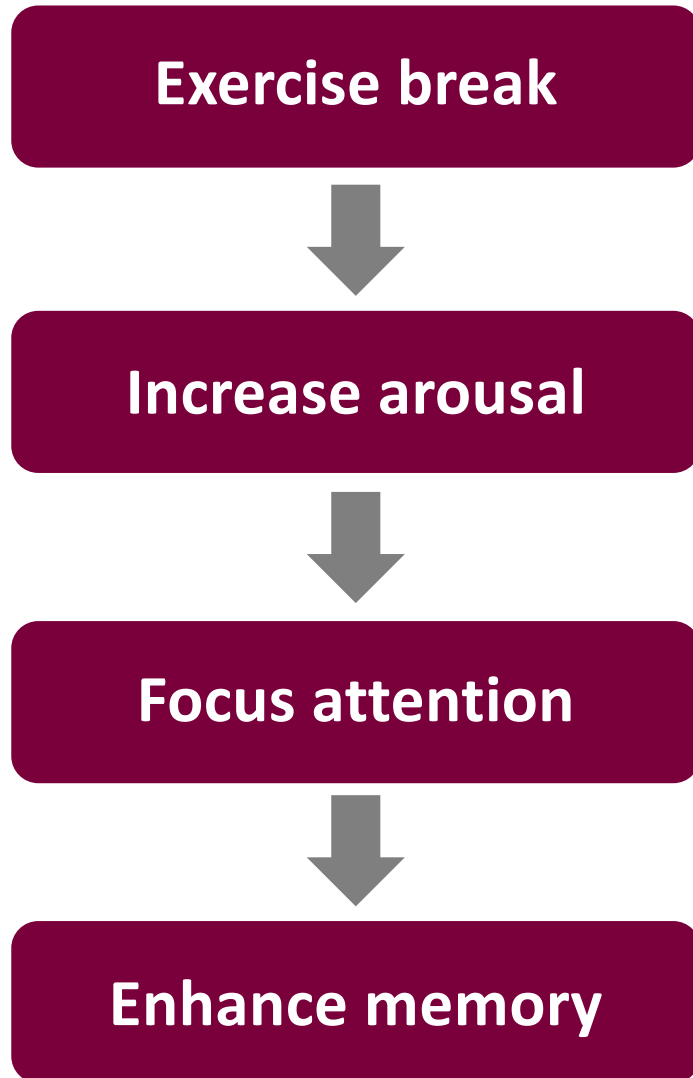


## 3h Night Class

1. We can have a couple breaks and go to the end....OR
2. We can push through and leave early.



# Do breaks increase on-task attention during extended study?



## Control

- No breaks

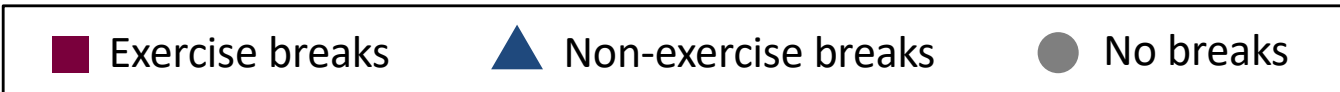
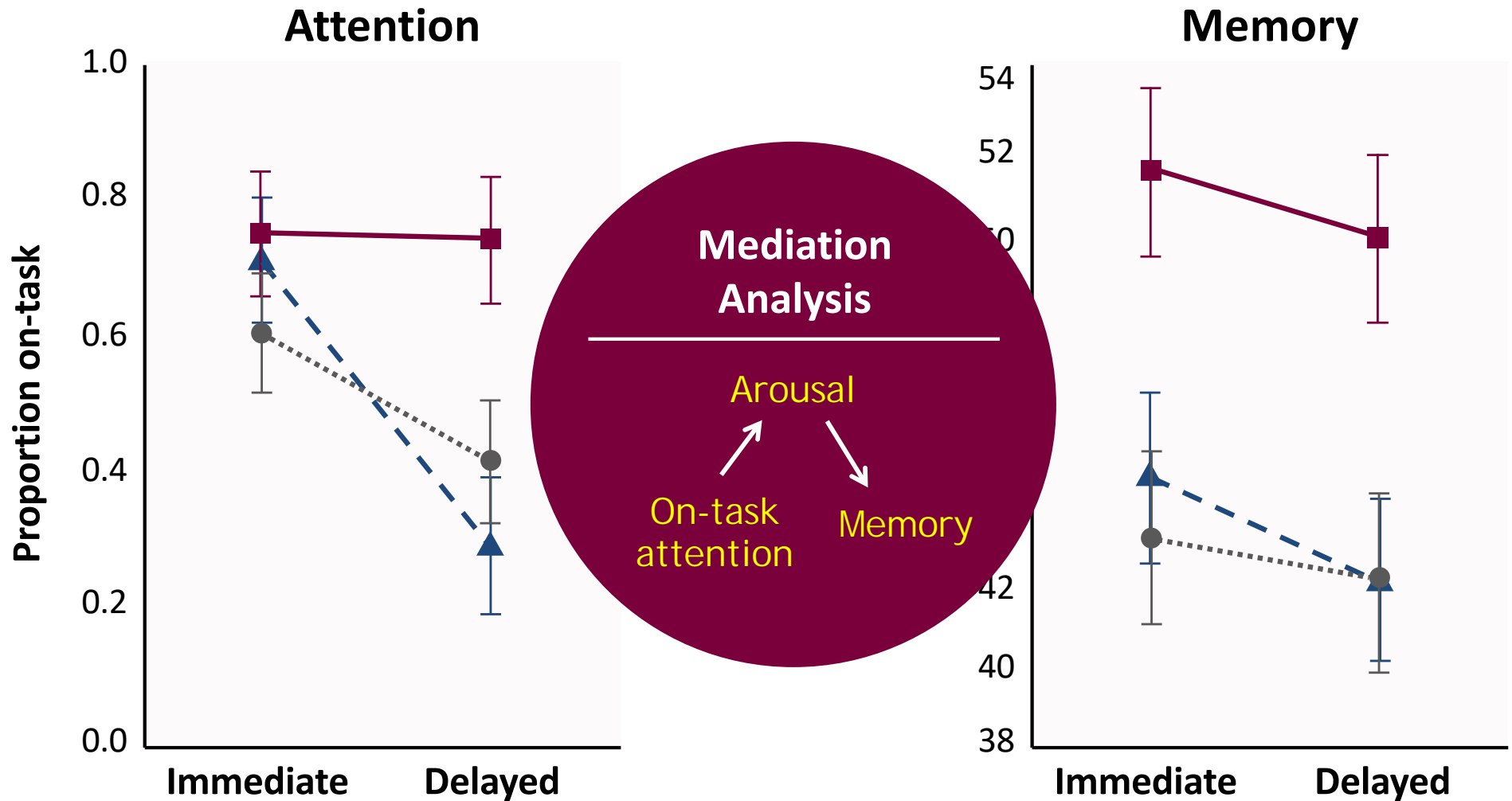
## Non-exercise

- 3 x 5min
- game

## Exercise

- 3 x 5min
- HIIT

# Exercise breaks increased on-task attention and improved memory.



# How does exercise reduce mind wandering for optimal learning?

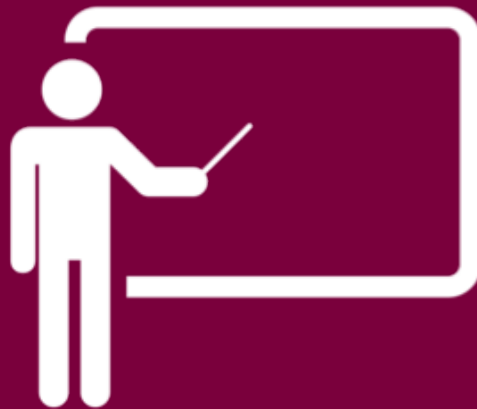
- Determine minimal effective doses of exercise interleaved with study.
- Understand interaction of arousal and key cognitive processes (working memory, processing speed, executive control).
- Field test of physical activity intervention in Rousseau Elementary school (Fall 2017).



# 1. Learning begins with **effortful** & **focused** attention.

- a. Maintaining effortful and focused attention increases in difficulty with time on task.
- b. Reduce attention lapses with activities to engage learner (quiz questions, active learning).
- c. When long learning sessions are required, integrate restorative breaks.

2



**Instructional Design directly  
sets the stage for learning.**

# Evidence-based approaches to multimedia design lead to durable learning.



Dr. Barb Fenesi

**Chemicals are ideal for biological systems**

- Genetic**
  - Often permanent
  - All or none in scope
  - Tedious, particularly multiple mutations
- Chemical**
  - Seconds timescale
  - Tunable specificity
  - Function/domain selectivity
  - Combinations easy

**Smooth light combination of waves are**  
 ...rated (pure) ... are viewed as a

**LAPLACE'S LAW:** ... pressure increases directly with ... disadvantage of large vessels - need lots of resources

$P \times r = \text{Wall Tension}$   
 $\text{Artery } (r = 1.3 \text{ cm}) \text{ needs } 170,000 \text{ dynes cm}^{-1} \text{ to maintain } 100 \text{ mm Hg}$   
 $\text{Capillary } (r = 4 \mu\text{m}) \text{ needs only } 16 \text{ dynes cm}^{-1} \text{ to be static}$   
 This equation must balance if the radius is to be static  
 ... normally this occurs automatically as the fibrous & elastic components of the vessel wall are stretched due to Hooke's Law  
 ... proportional to elongation "1" - e.g. rubber band

**Polycistron vs. Monocistron**  
 ... Tryptophan synthase in bacteria: polycistronic  
 ... Enzyme genes DNA molecules

**Rate law of action potential (AP)**

Strength of a stimulus is represented by rate of firing of AP.  
 The size of each AP is constant

**Components of Blood**

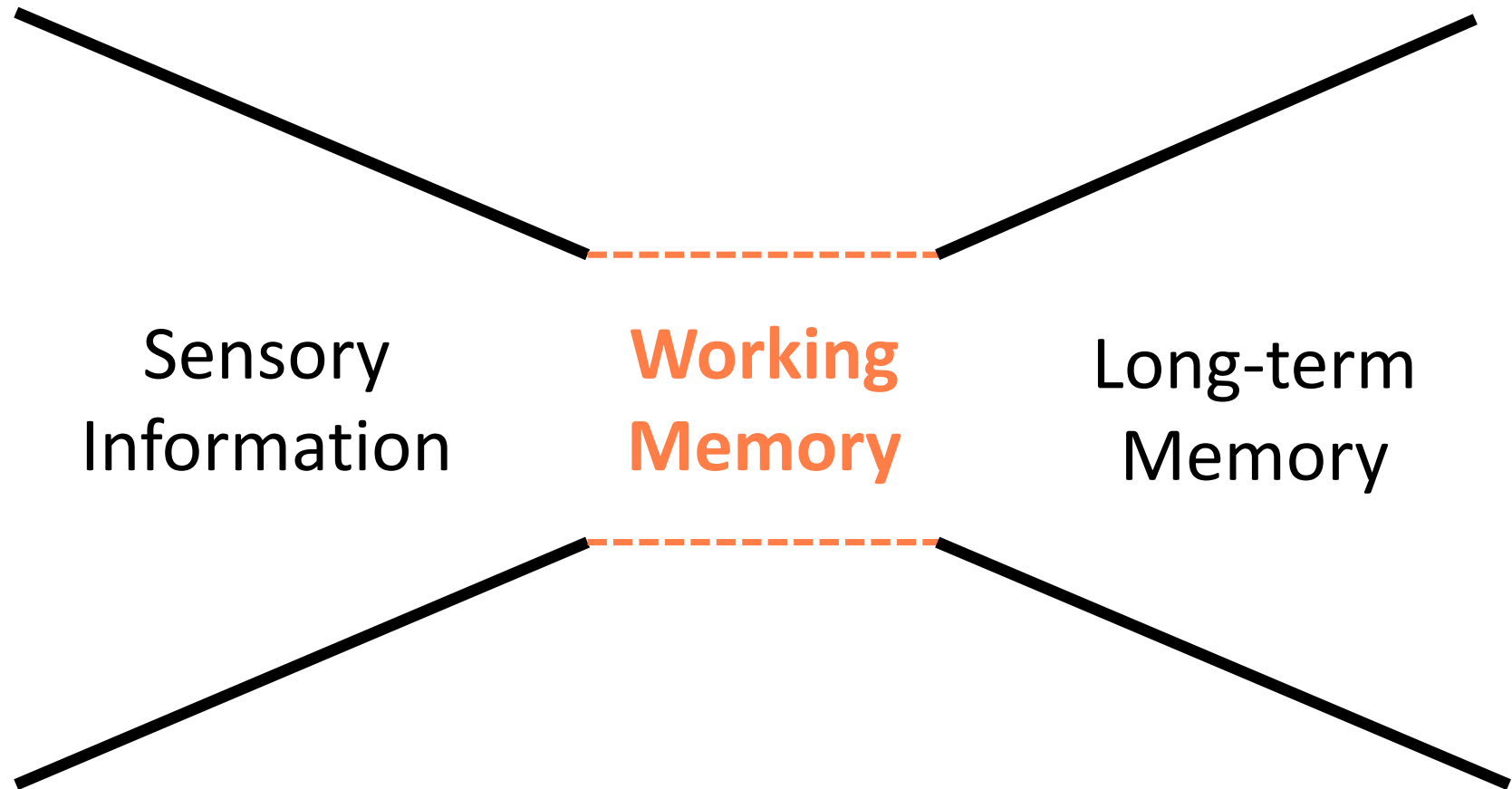
- Plasma (55% of whole blood)
- Buffy coat
- Leukocytes (WBC) and platelets (<1% of whole blood)
- Erythrocytes (RBC) (45% of whole blood)

**1. Can act as an intracellular protein buffer.**  
**2. Also - ability to accept hydrogen ions changes as the oxygenation state of Hb changes**  
 - At pH 7.4 oxyHb dissociates into  
 - At pH 7.4 deoxyHb re-associates  
 - Reduced Hb can act to buffer ... of acid ... significant car

**aP2 transgenic agouti mice**

Group	Weight	FAS activity	FAS mRNA	Lipolysis	Fat pad mass
No Ca <sup>2+</sup>	↑	↑	↓	↑↑↑	↓
CaCO <sub>3</sub> (1.2%)	↓	↓	↓	↑↑	↓
Med dairy Ca <sup>2+</sup> (1.2%)	↓	↓	↓	↑↑	↓
High dairy Ca <sup>2+</sup> (2.4%)	↓	↓	↓	↑↑	↓

The **attention span** of your audience is **limited** at a cognitive level.

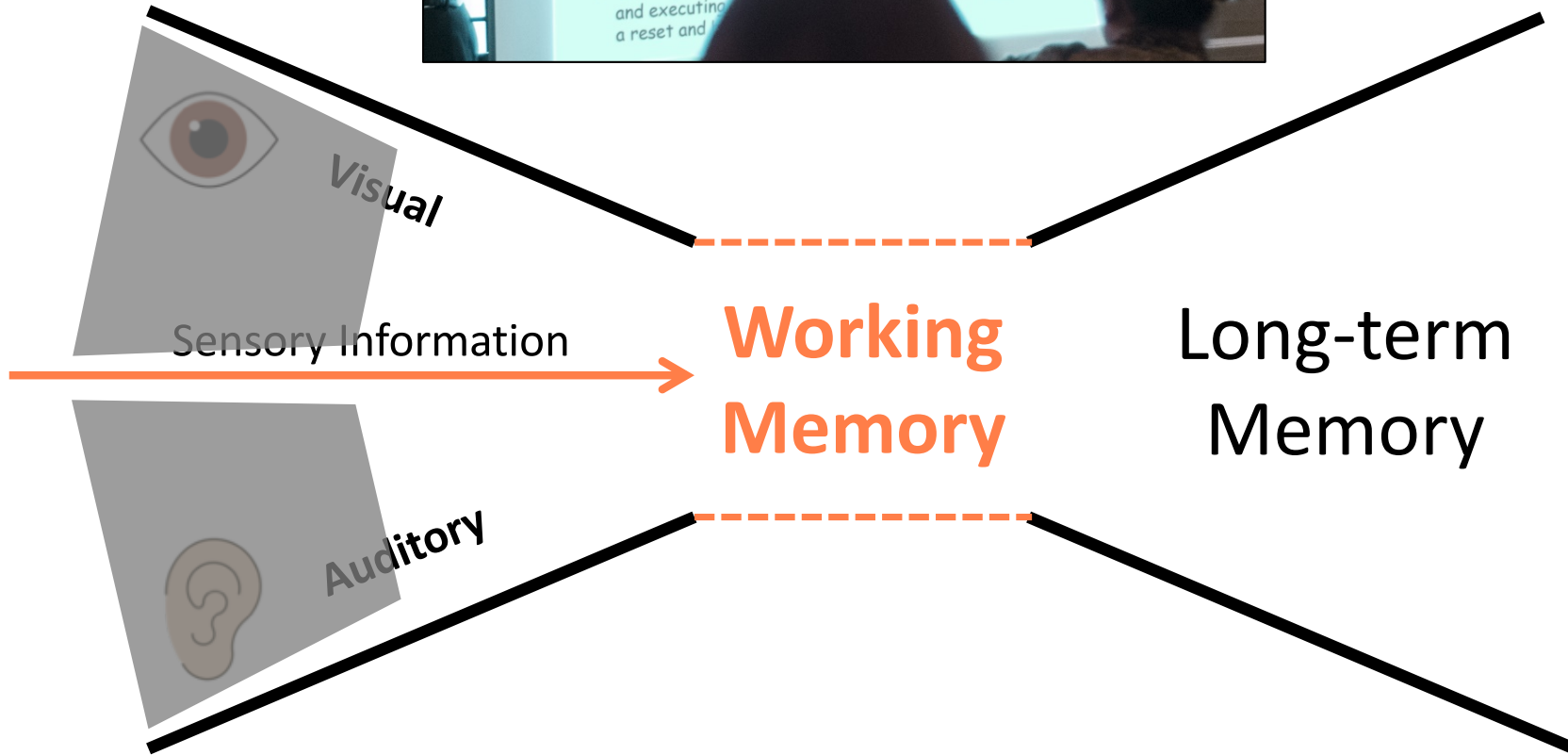
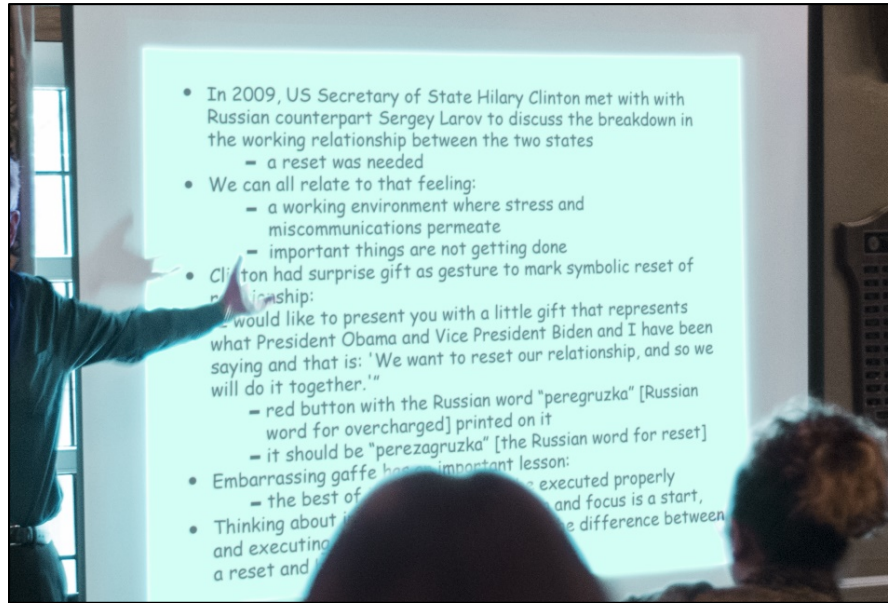


Are you making presentations to be  
remembered or forgotten?



ALZEMYERCHLORAZINE





Limited attention resources can lead learners to miss key information.

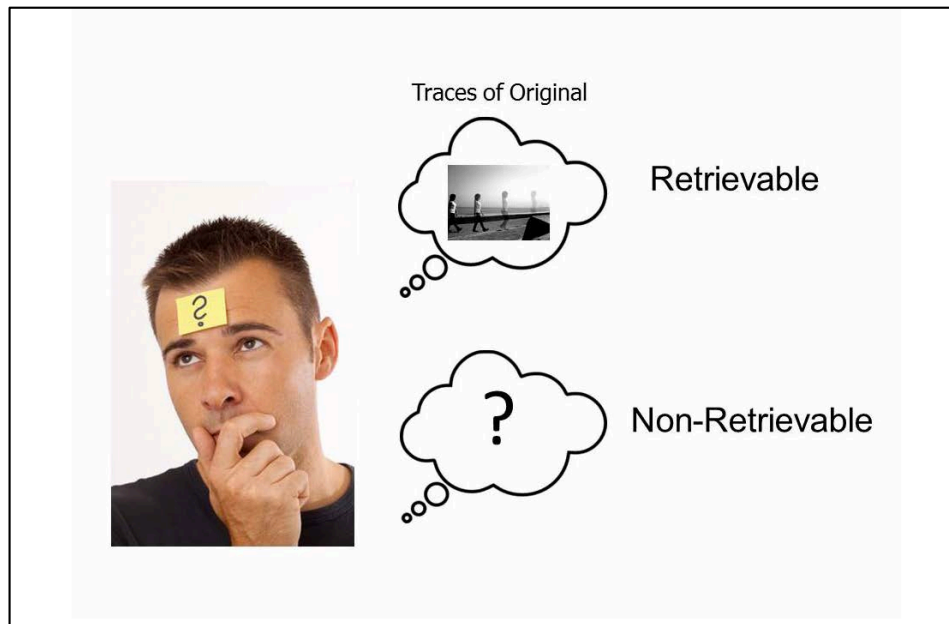


Learning to dispassionately transcribe what was dictated in the lecture hall.

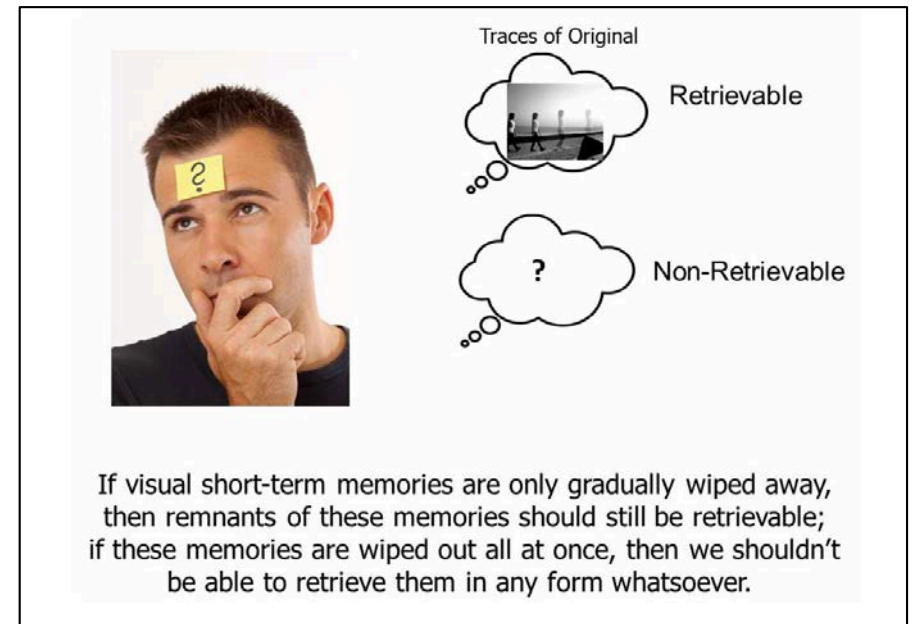


# Split-Attention reduces durable learning.

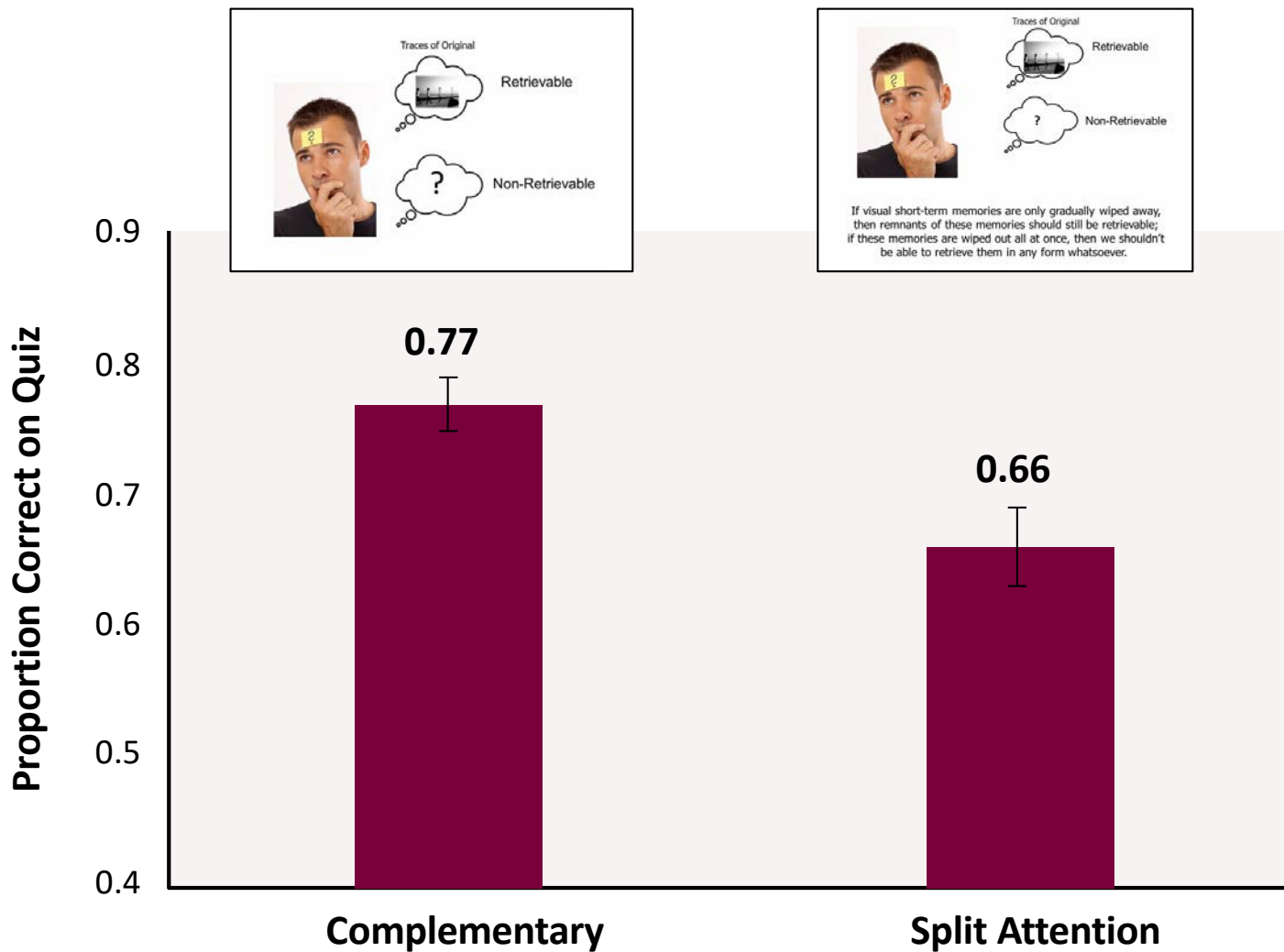
## Complementary



## Split-Attention

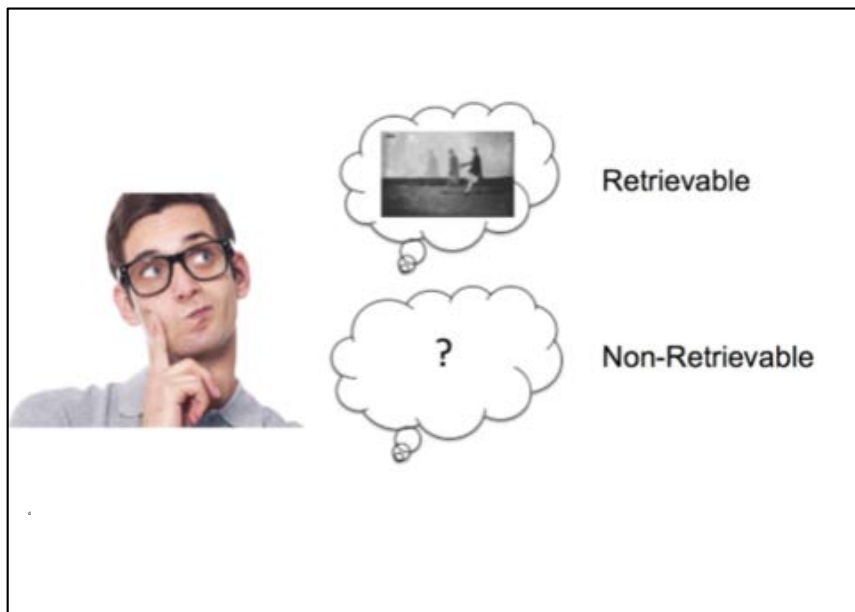


# Split-attention reduces learning.

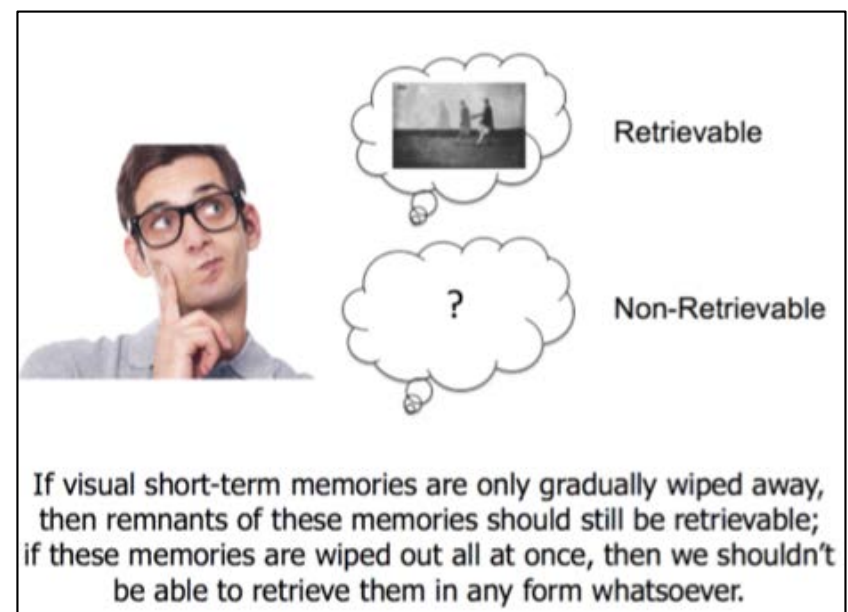


# How does presentation of visual information influence learning?

## Complementary



## Split-Attention



Fenesi et al. (2014, 2015)

Fenesi & Kim (2015)

Fenesi et al. (in press)

Sana & Fenesi (accepted)

# High Working Memory



Retrievable



Non-Retrievable

If visual short-term memories are only gradually wiped away, then remnants of these memories should still be retrievable; if these memories are wiped out all at once, then we shouldn't be able to retrieve them in any form whatsoever.

# Low Working Memory



Retrievable



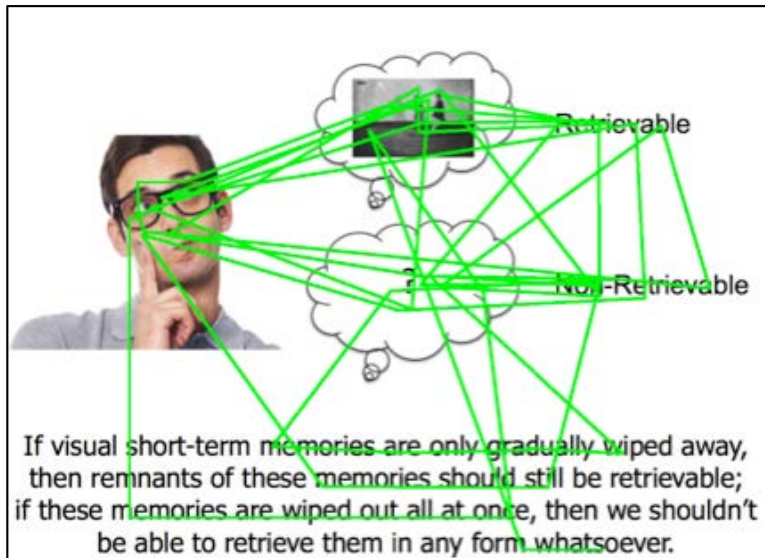
Non-Retrievable

If visual short-term memories are only gradually wiped away, then remnants of these memories should still be retrievable; if these memories are wiped out all at once, then we shouldn't be able to retrieve them in any form whatsoever.

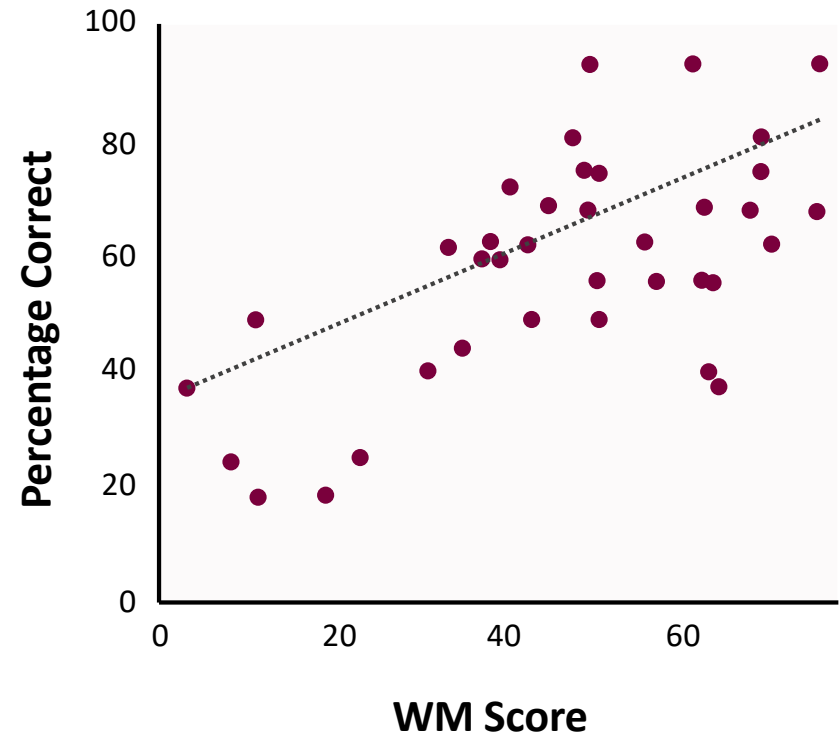
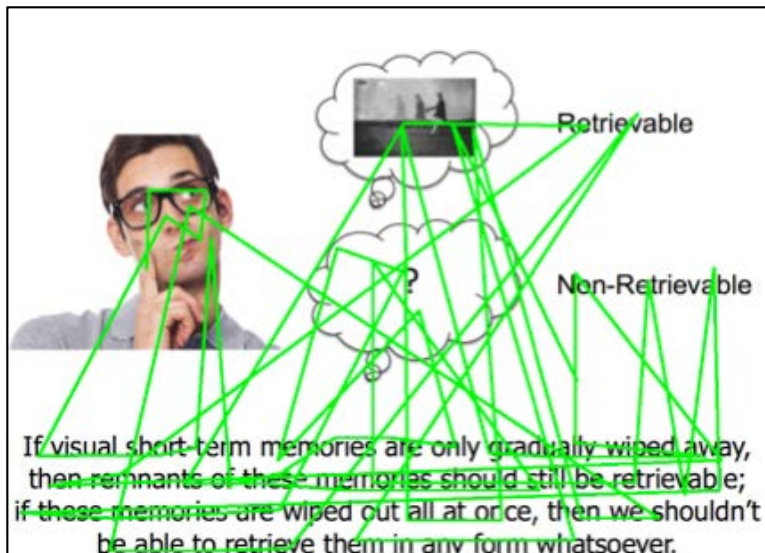


# Differences in attentional control predict learning outcomes.

High  
WM

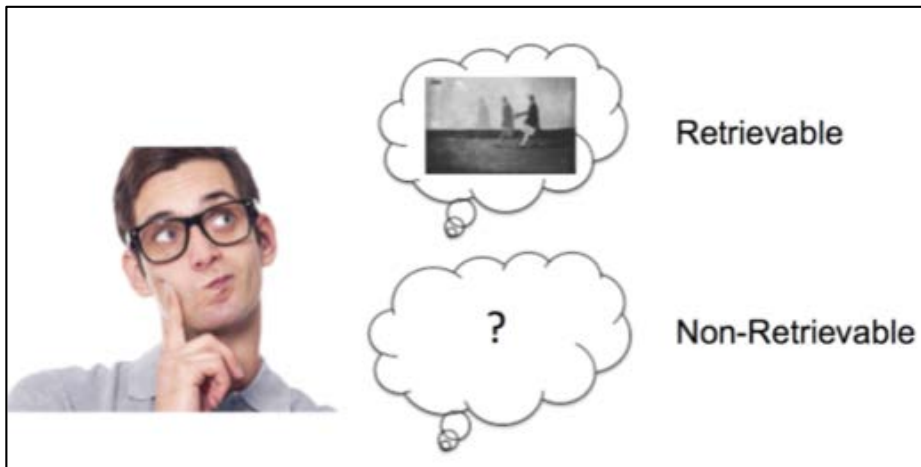


Low  
WM

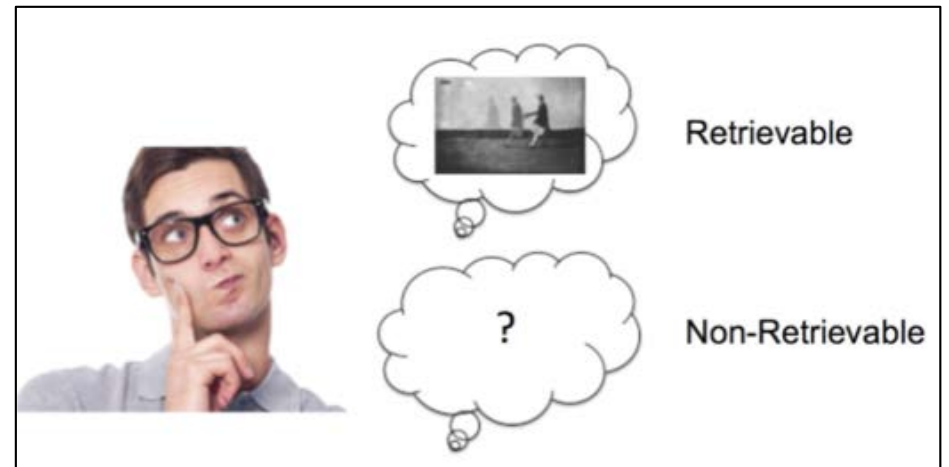


# Differences in attentional control predict learning outcomes.

**High WM**



**Low WM**

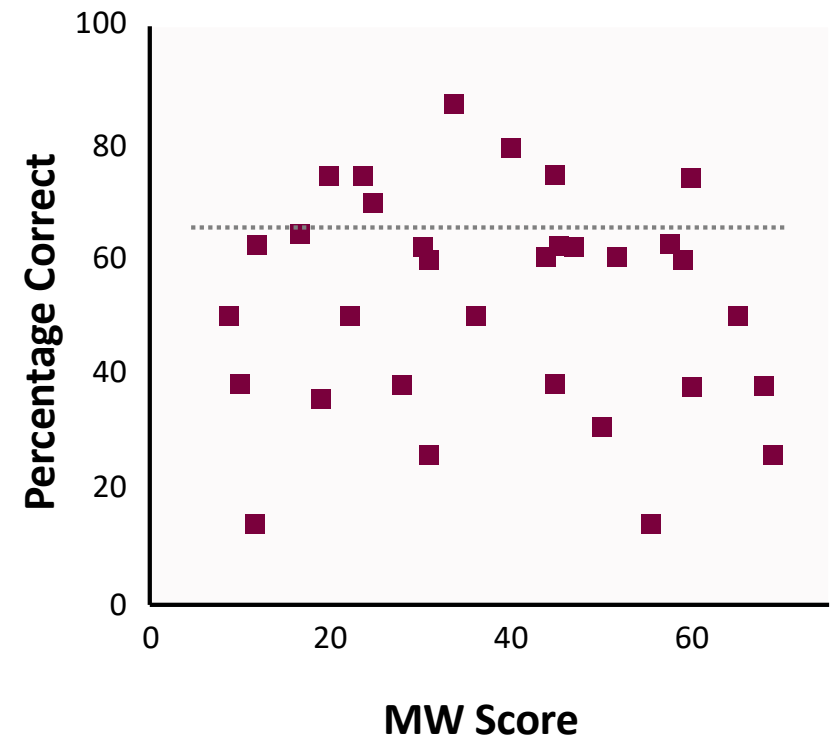
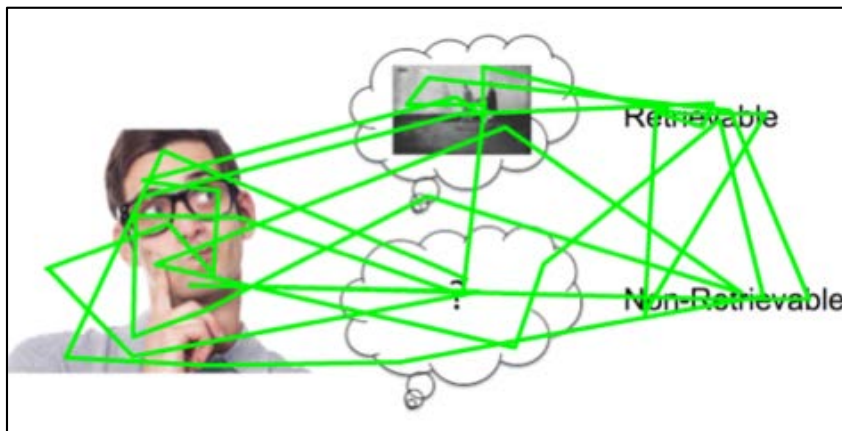


# Differences in attentional control impact learning outcomes.

High  
WM



Low  
WM



**Instructors can help focus learner attention.**



**Controlled  
attention**

Fenesi et al. (2015)  
Sana & Fenesi (accepted)

# Interventions for In-Class PowerPoint.



**Dr. Catherine Overson**

# Multimedia Principle

“People learn better from words and pictures than from words alone.”

Mayer, page 223

**ORIGINAL**

## Obesity (cont'd)

- Those individuals who are frequently stressed and **produce lots of CRH and some cortisol**, “On-off people”, tend to be **less hungry under stress**.
- Those individuals who are more likely to **produce high levels of cortisol (low CRH)** in chronic stress conditions, **tend to over eat**.
- Patterns of stress and how we respond lead to whether or not we are overweight.



**MODIFIED**

# Obesity (cont'd)

## Chronic Stress and Eating Behavior:

	Individuals who are frequently stressed and produce:	
Amount of CRH & Cortisol	High CRH & Some Cortisol (On-off people)	Low CRH & High Cortisol
Appetite	Are Less Hungry	Tend to Over Eat

Patterns of stress and how we respond are determinate factors in obesity

Example 2

**ORIGINAL**

# Positivist Approach



- Law & method of natural  
– Form & test hypotheses empirically
- Some hypotheses:
  - Law varies inversely w/ other social control
  - > stratification = more law
  - > “downward law” than “upward law”
  - > law as intimacy decreases [most law where people interact a lot w/ little intimacy]

**MODIFIED**



# Positivist Approach

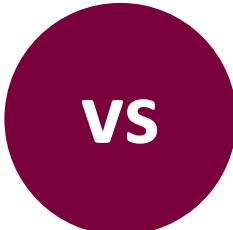
- Donald Black: perspective & method of natural *sciences*
  - Form & test hypotheses empirically
- Some hypotheses:
  1. Law varies inversely with other social control
  2. > stratification = more law
  3. > “downward law” than “upward law”
  4. > law as intimacy decreases
    - ✓ most law where people interact a lot with little intimacy

# Immediate Learning

Mean %  correct responses to

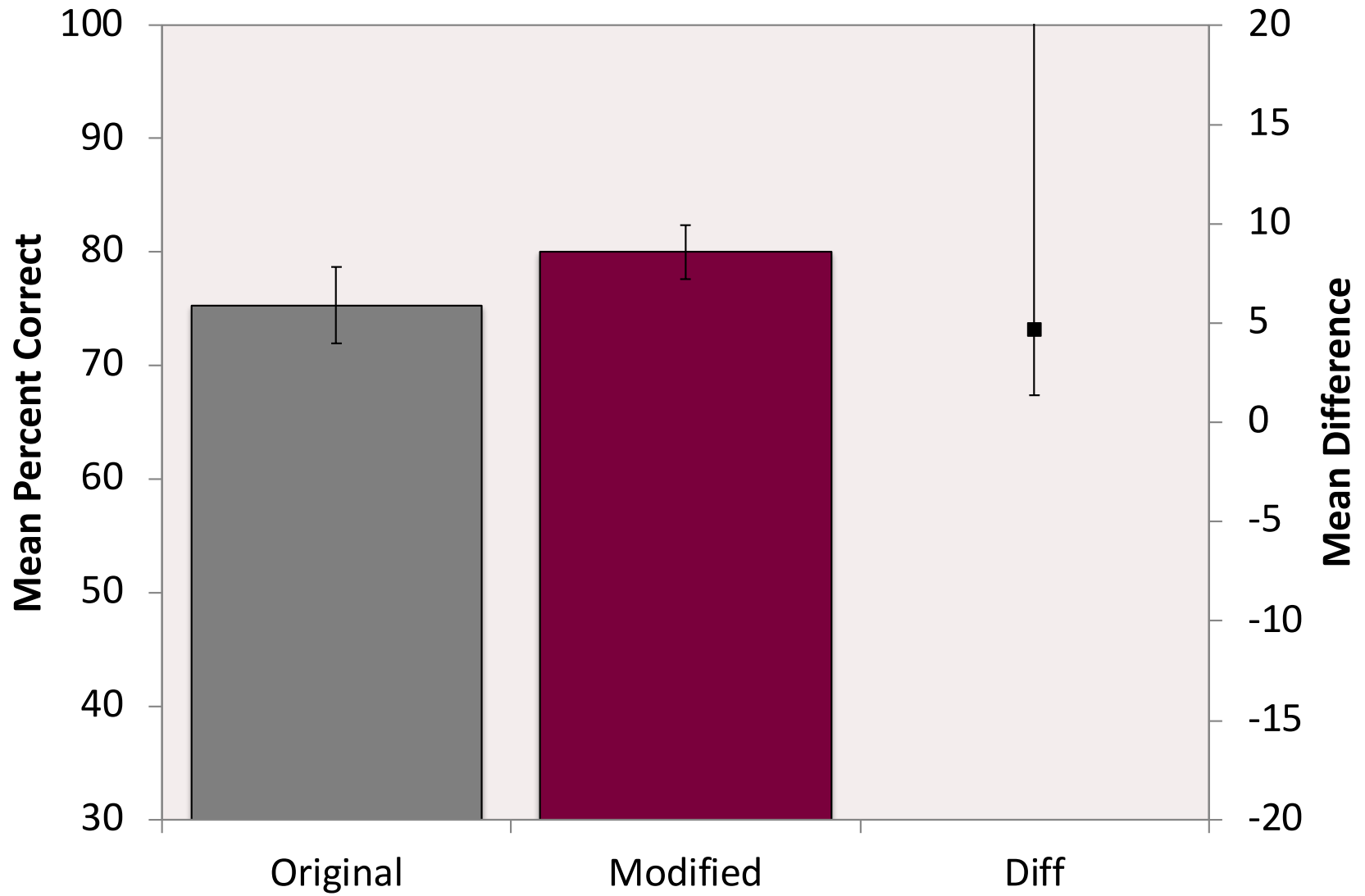
**Questions Asked @ End of Class**

during which

*Modified*  Original

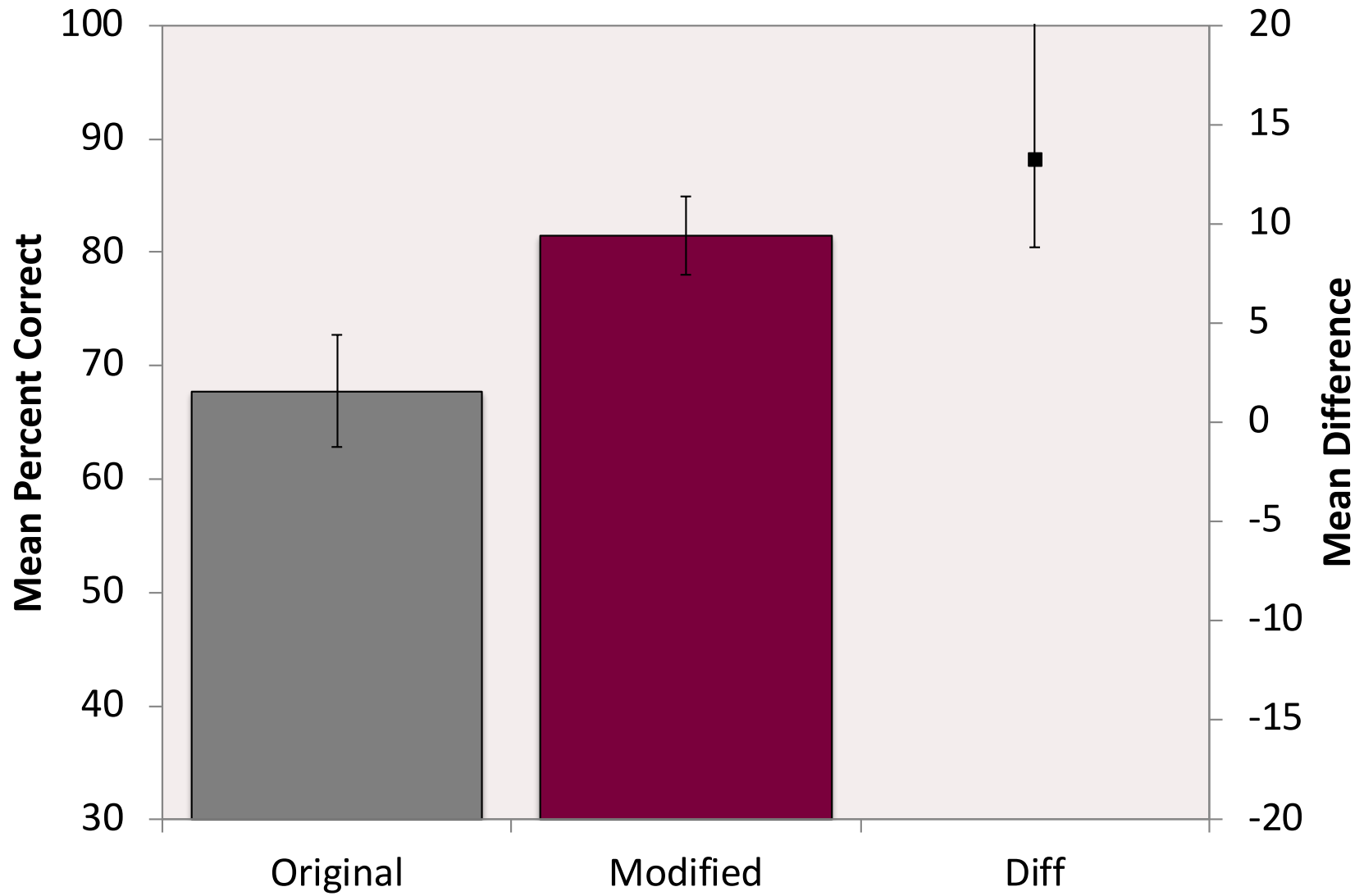
PowerPoint slides were presented

# Human Stress





# Justice Studies



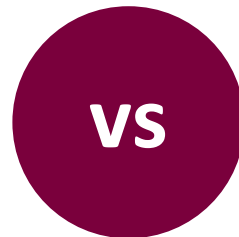
# Long-Term Retention

Mean %  correct responses to

## Midterm Exam Questions

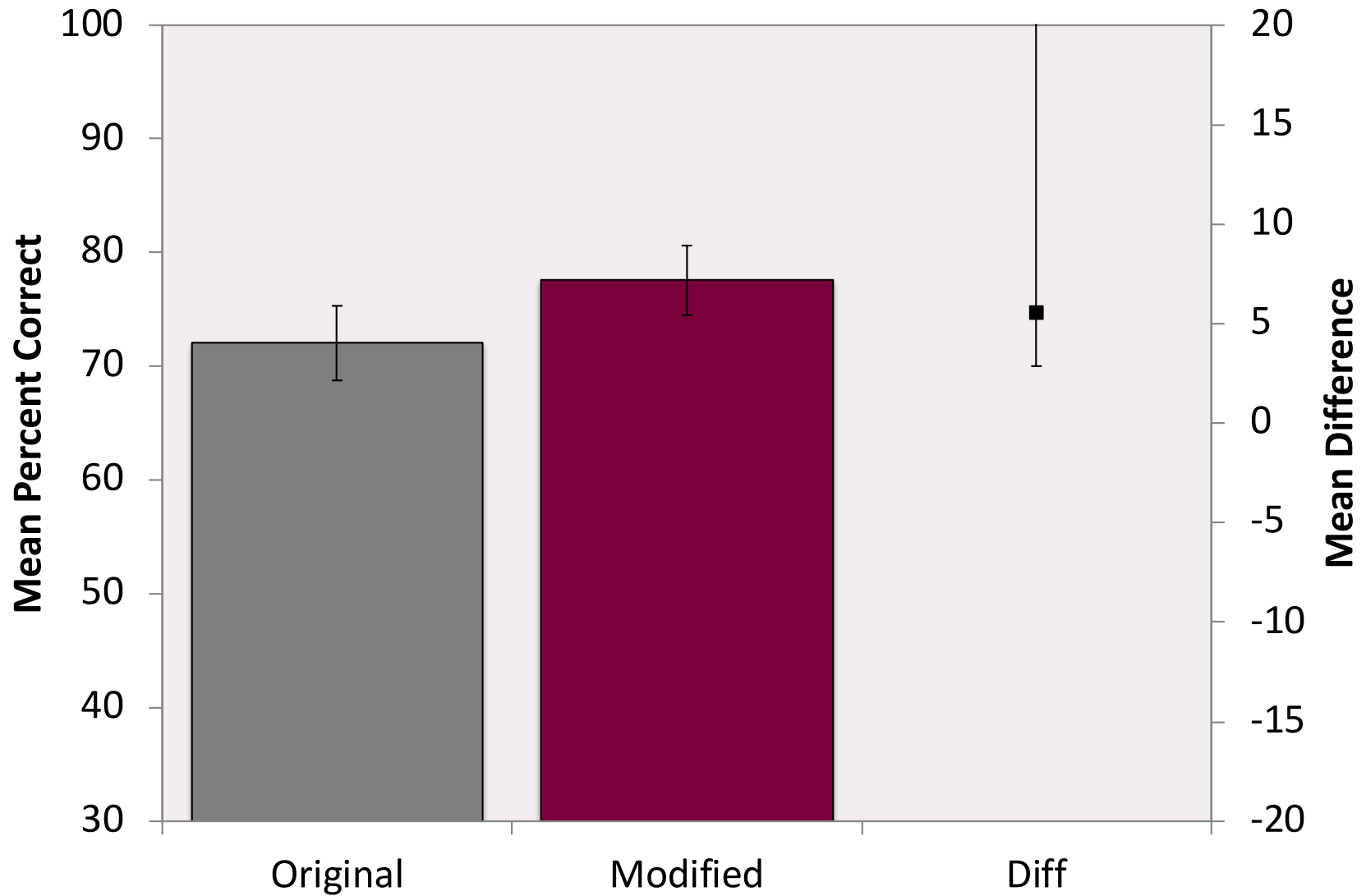
based on information in

*Modified  
PowerPoint  
slides*

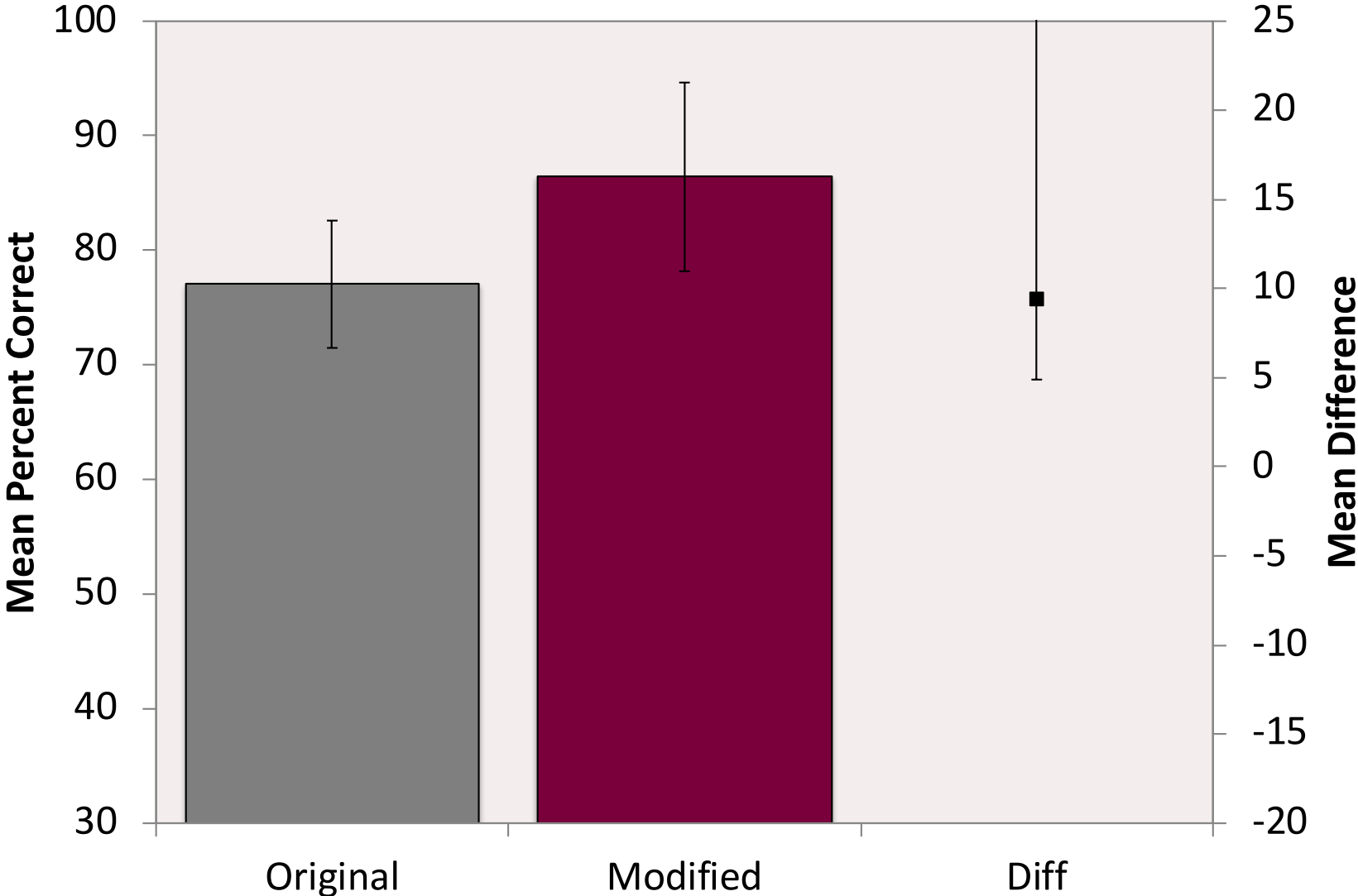


Original  
PowerPoint  
slides

# Epidemiology Study 1



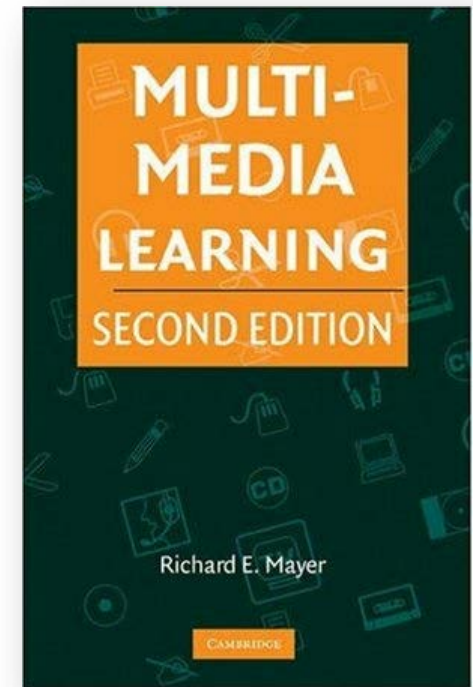
# Child Life





## 2. Instructional Design directly sets the stage for learning.

- a. Established multimedia design principles show medium to large effect sizes in the lab.
- b. Classroom intervention studies demonstrate robust gains in an authentic learning environment.



3



**Effective study habits can  
strengthen long-term retention.**

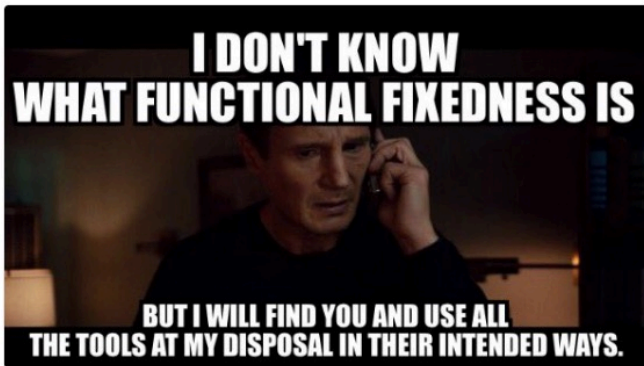
# Which study skills help learners?

Technique	Utility
Elaborative interrogation	Moderate
Self-explanation	Moderate
Summarization	Low
Highlighting	Low
Keyword Mnemonic	Low
Imagery use for text learning	Low
Rereading notes or textbook	Low
Practice Testing	High
Distributed Practice	High
Interleaved Practice	Moderate

# #MacIntroPsych #Mememes2Review



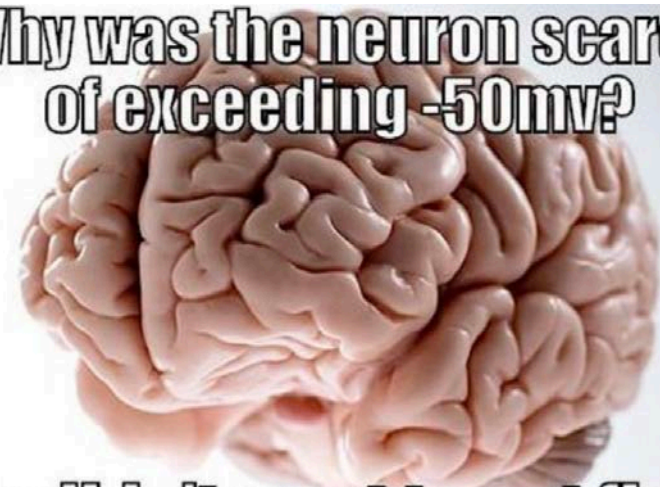
Thanks to the volunteers in class who bested me on the [#functionalfixedness](#) challenge - there's always next time. [#macintropsych](#) [#memetweet](#)



LIKES  
9



**Why was the neuron scared  
of exceeding -50mv?**



**He didn't want to get fired**

**AND WHAT DO WE SAY TO THAT  
SECOND-MARSHMALLOW?**



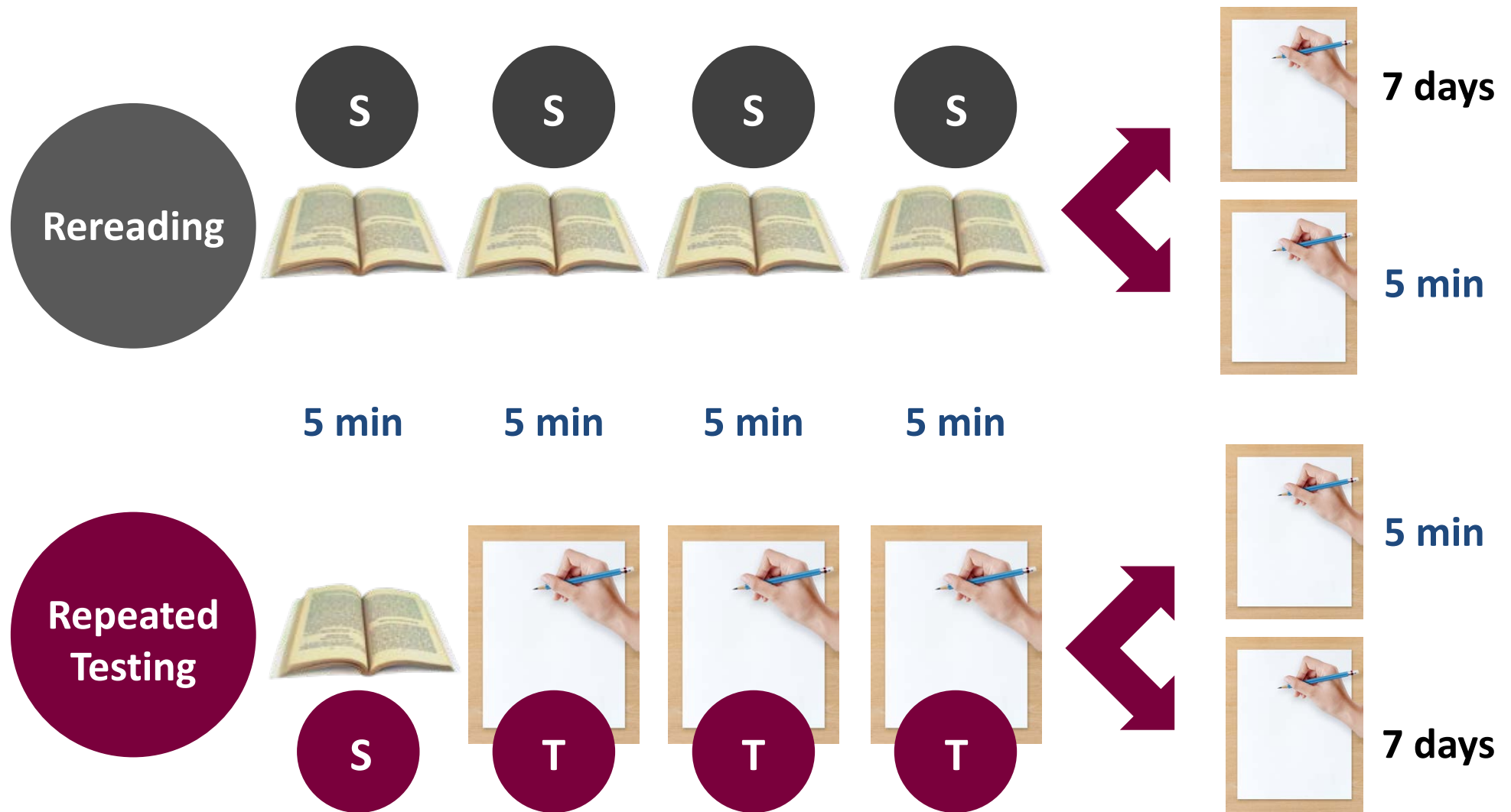
**NOT TODAY**



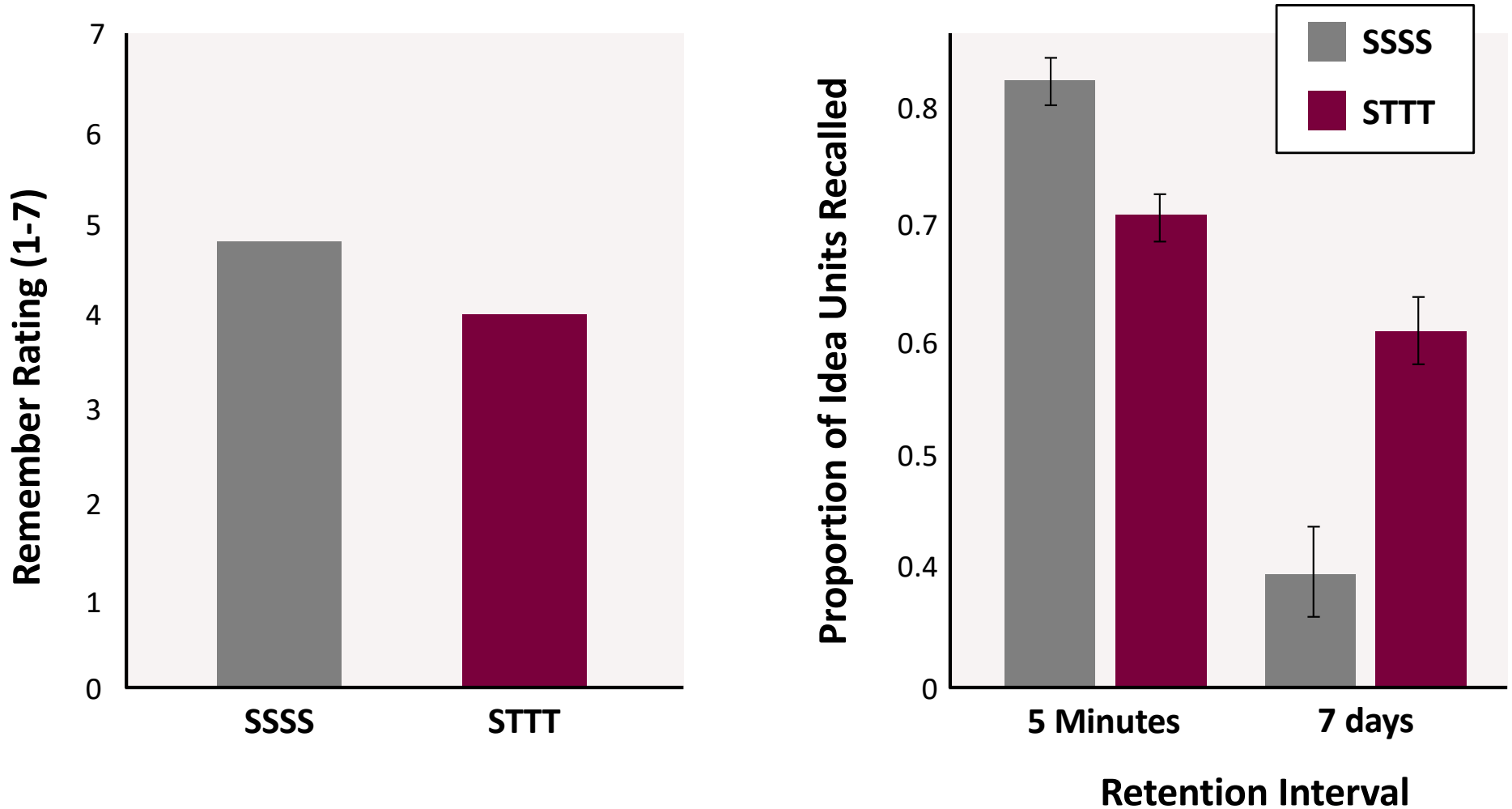
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Keyword Mnemonic	Low
Imagery use for text learning	Low
Rereading notes or textbook	Low
Practice Testing	High
Distributed Practice	High
Interleaved Practice	Moderate

# Retrieval Practice leads to durable learning.

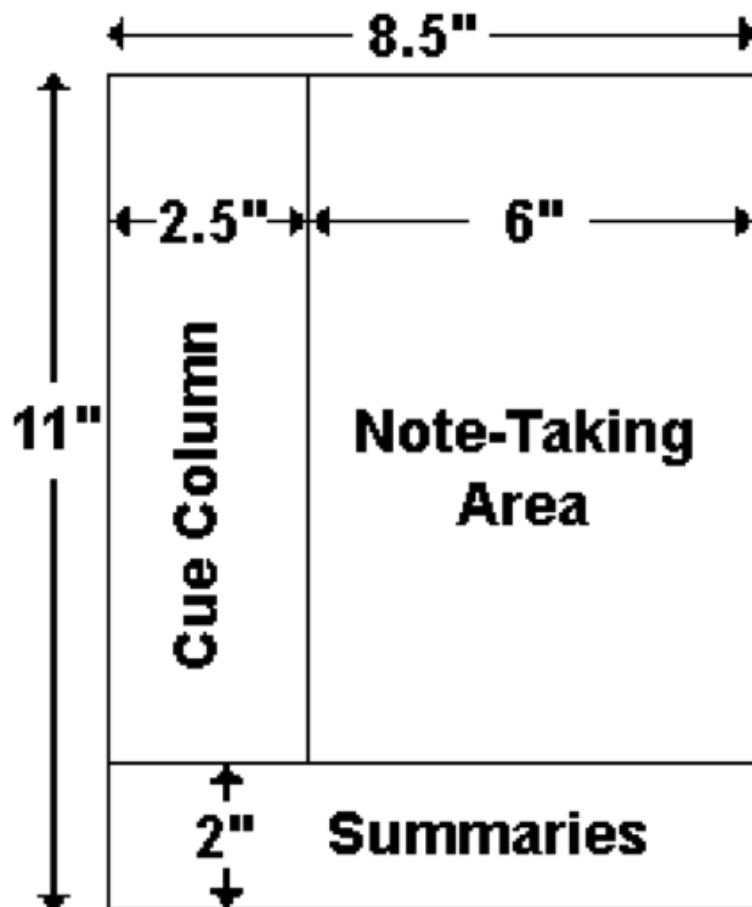


# Learners judge repeated studying to be better than practice testing...



...but practice testing leads to more durable learning.

# Apply: Learners can make retrieval practice a habit of note-taking.



October 3

Types of Leadership Theory  
Pg. 127

**Cue Column** →

Motivational Theories -  
- Explain how human relations affect motivation.

**Note-Taking Area** →

Maslow's Hierarchy of needs (motivational theory)

1. Physiological Needs - survival, food, shelter
2. Security Needs - stability and protection
3. Social Needs - friendship and companions
4. Esteem Needs - status and recognition
5. Self-Actualization - self-fulfillment

\* Developed By Abraham Maslow  
\* Must meet lower needs first.

Theory X - holds that people are naturally irresponsible.

Theory Y - holds that people are naturally self-motivated and responsible.

\* Developed by Douglas McGregor  
\* What type of leader you are is determined by which theory you believe in.

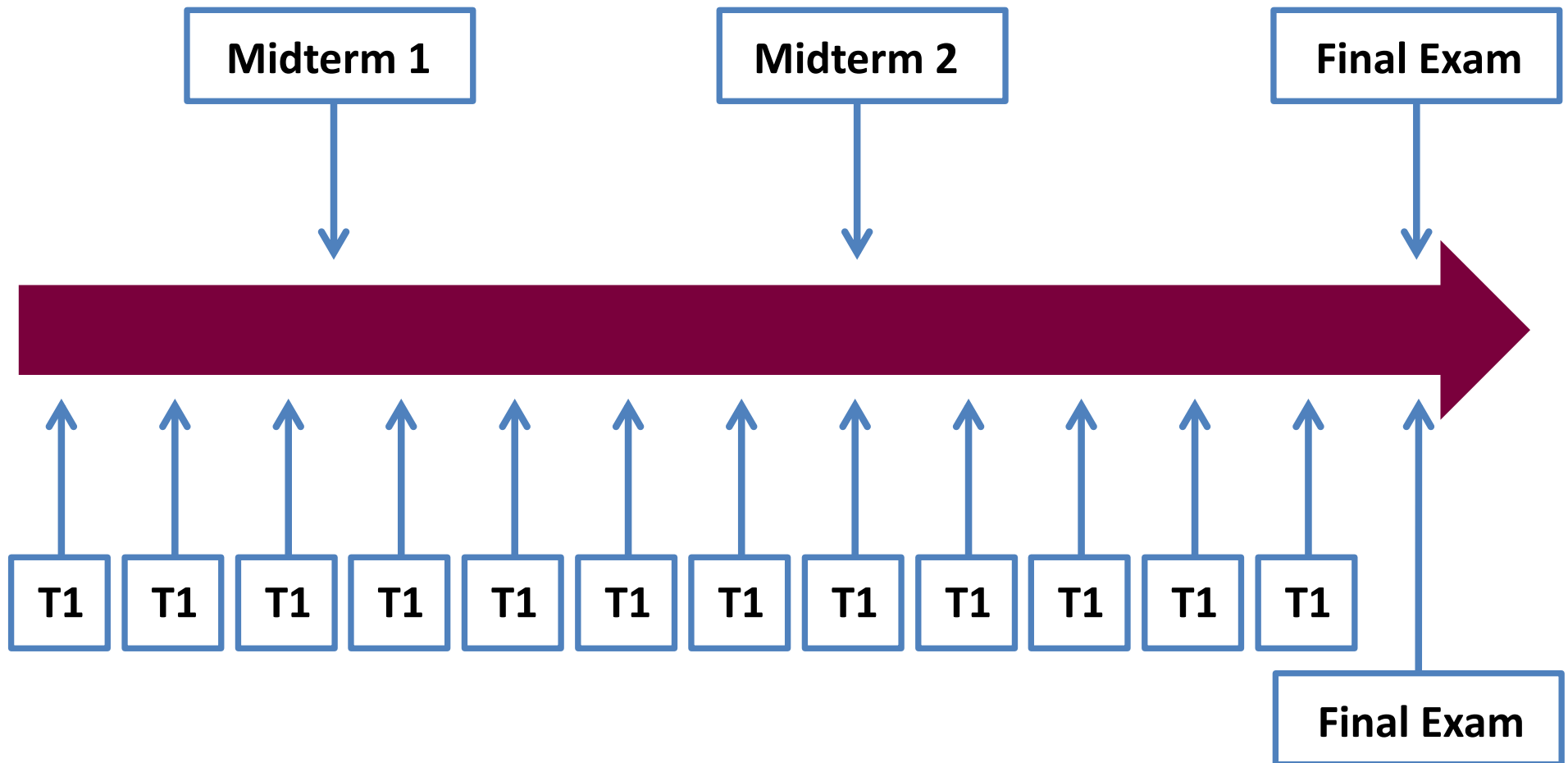
Pg. 122 →

Why do some believe in Theory X and others Theory Y?

Motivational theories explain how and why people are motivated. 2 motivational theories are Maslow's hierarchy of needs and Theory X and Y

**Summary Area** →

# Apply: Implement frequent testing with feedback to promote long-term learning.



You may have chosen to write the weekly quizzes in groups. Which of the following best describes your involvement in the group?

A. I wrote my quizzes on my own.

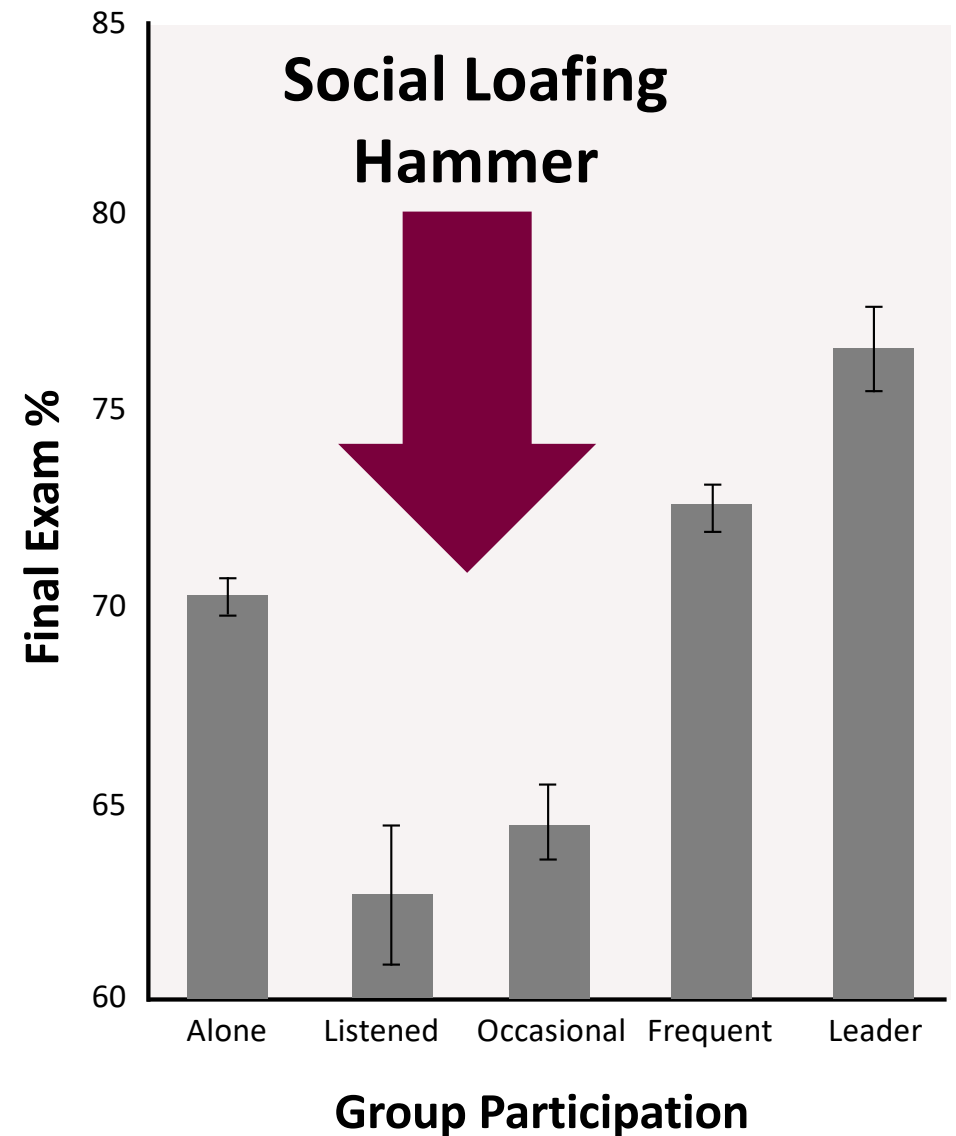
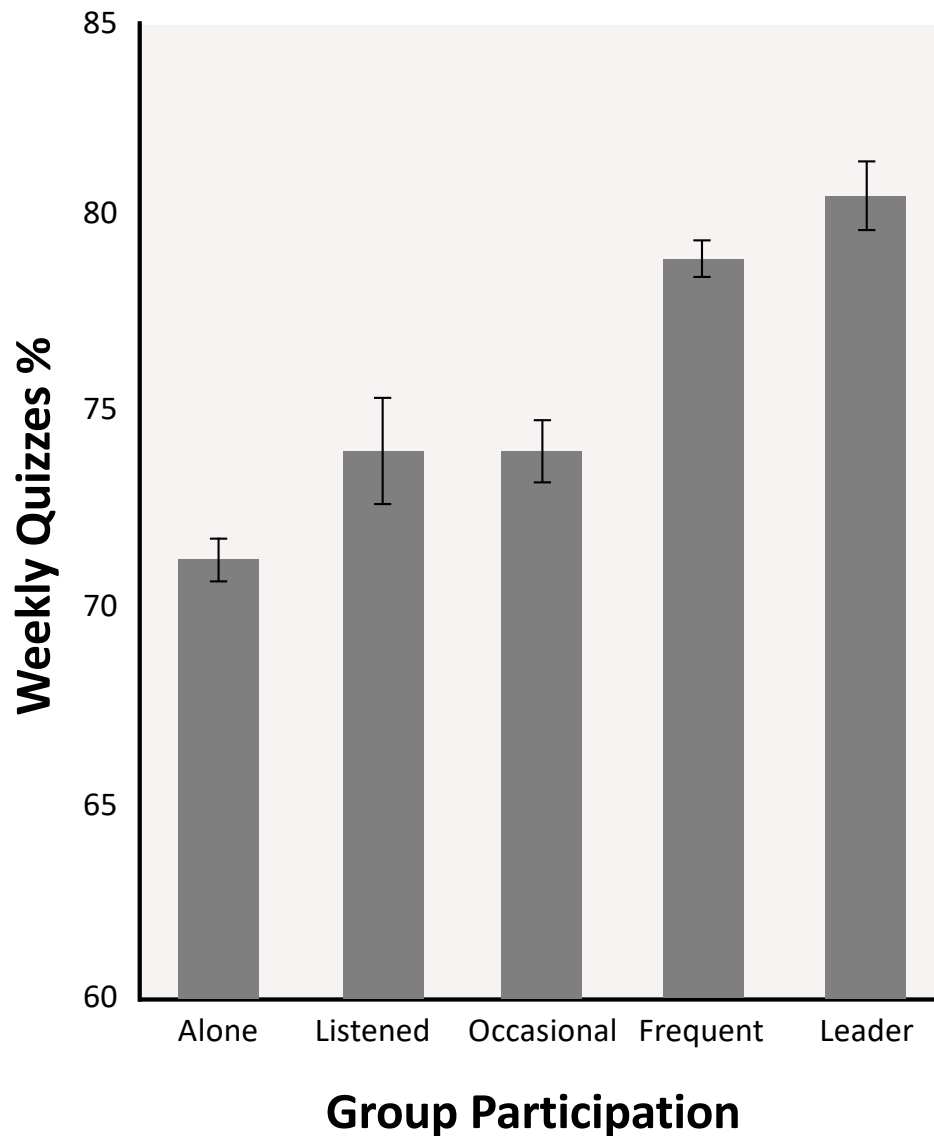
B. I actively listened and absorbed the discussion.

C. I actively listened to the discussion and occasionally provided input.

D. I frequently contributed to the discussion.

E. I led the discussion for most questions.

# Active vs. passive role in collaborative testing group impacts durable learning.



# Which study skills help learners?

Technique	Utility
Elaborative interrogation	Moderate
Self-explanation	Moderate
Summarization	Low
Highlighting	Low
Keyword Mnemonic	Low
Imagery use for text learning	Low
Rereading notes or textbook	Low
Practice Testing	High
Distributed Practice	High
Interleaved Practice	Moderate



# Distributed or massing practice sessions.

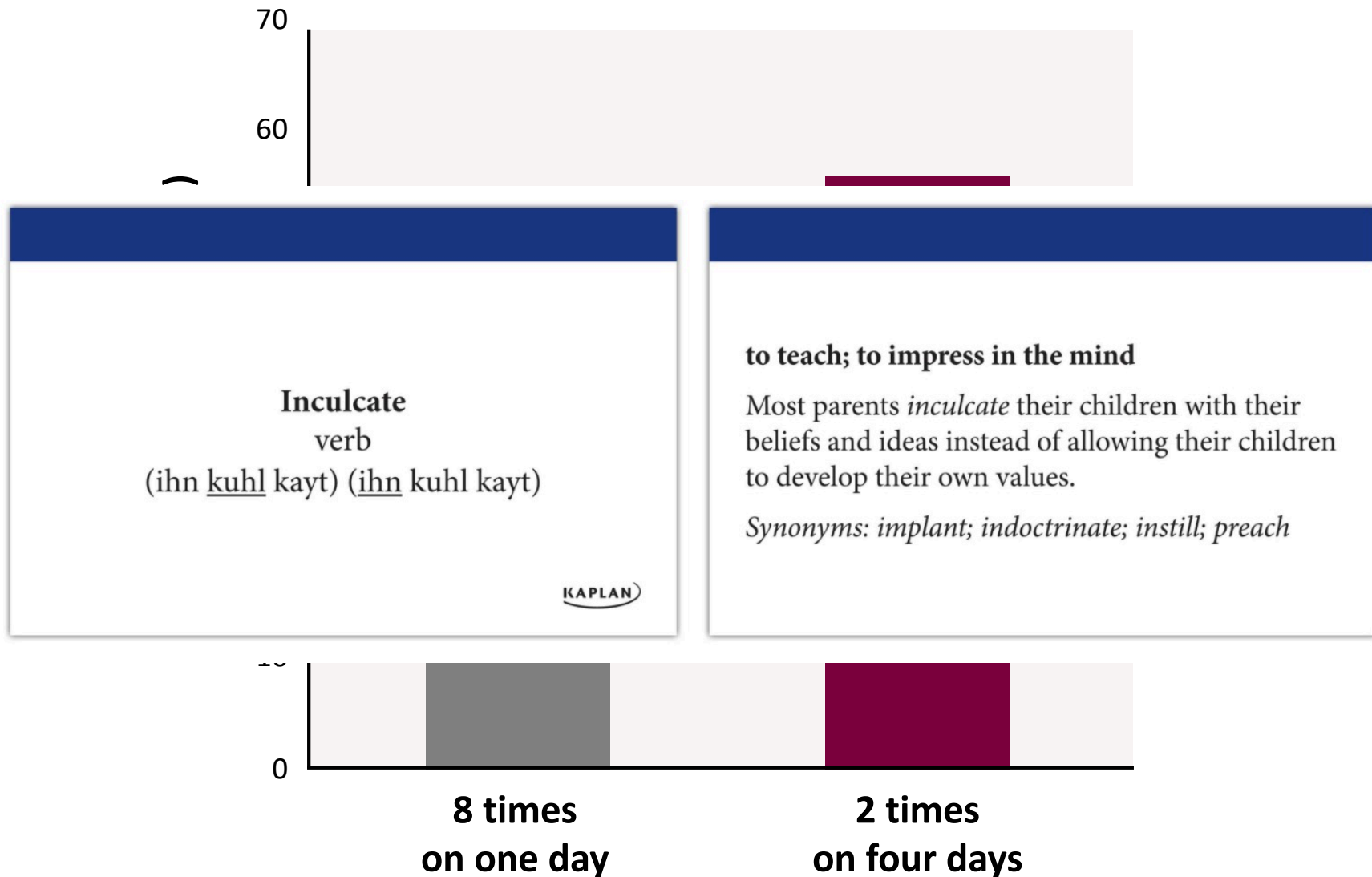


**Distributed Practice**

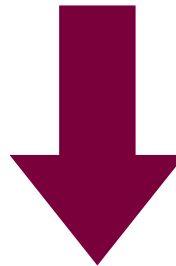
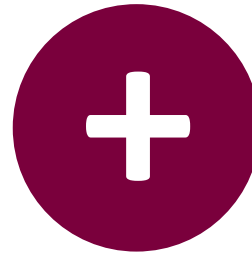
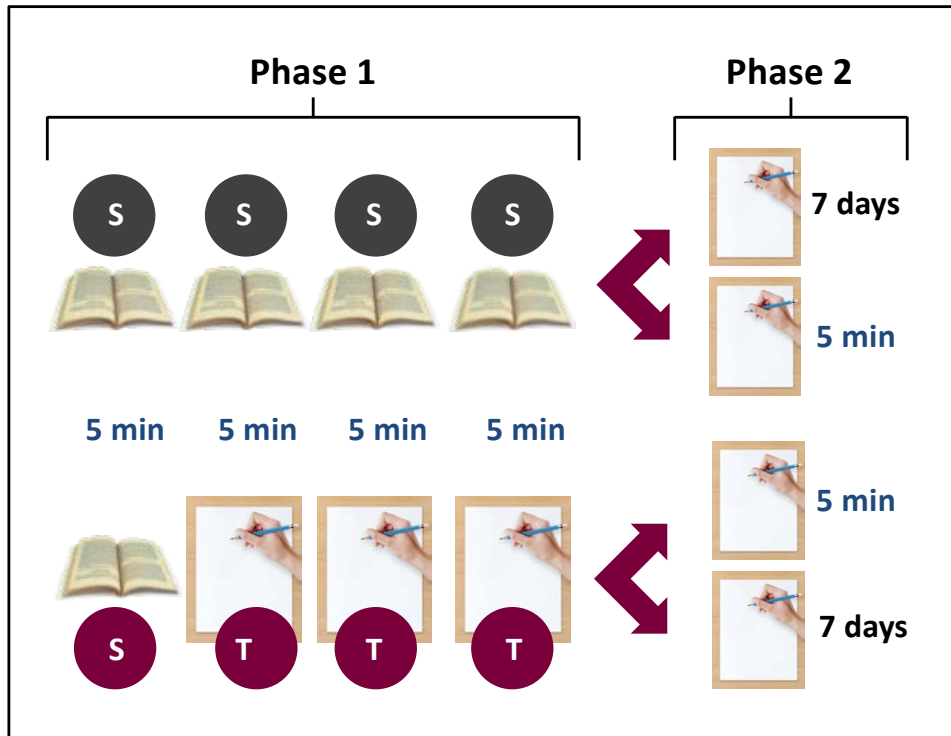


**Massing (Cramming)**

# Spacing study across days is better than cramming for the same study time.



# Successive Relearning



# Successive Relearning

Session

1

Learn content to specific criterion  
(practice retrieval plus restudy until correct)

Session

2

Relearn the same material

Session

3

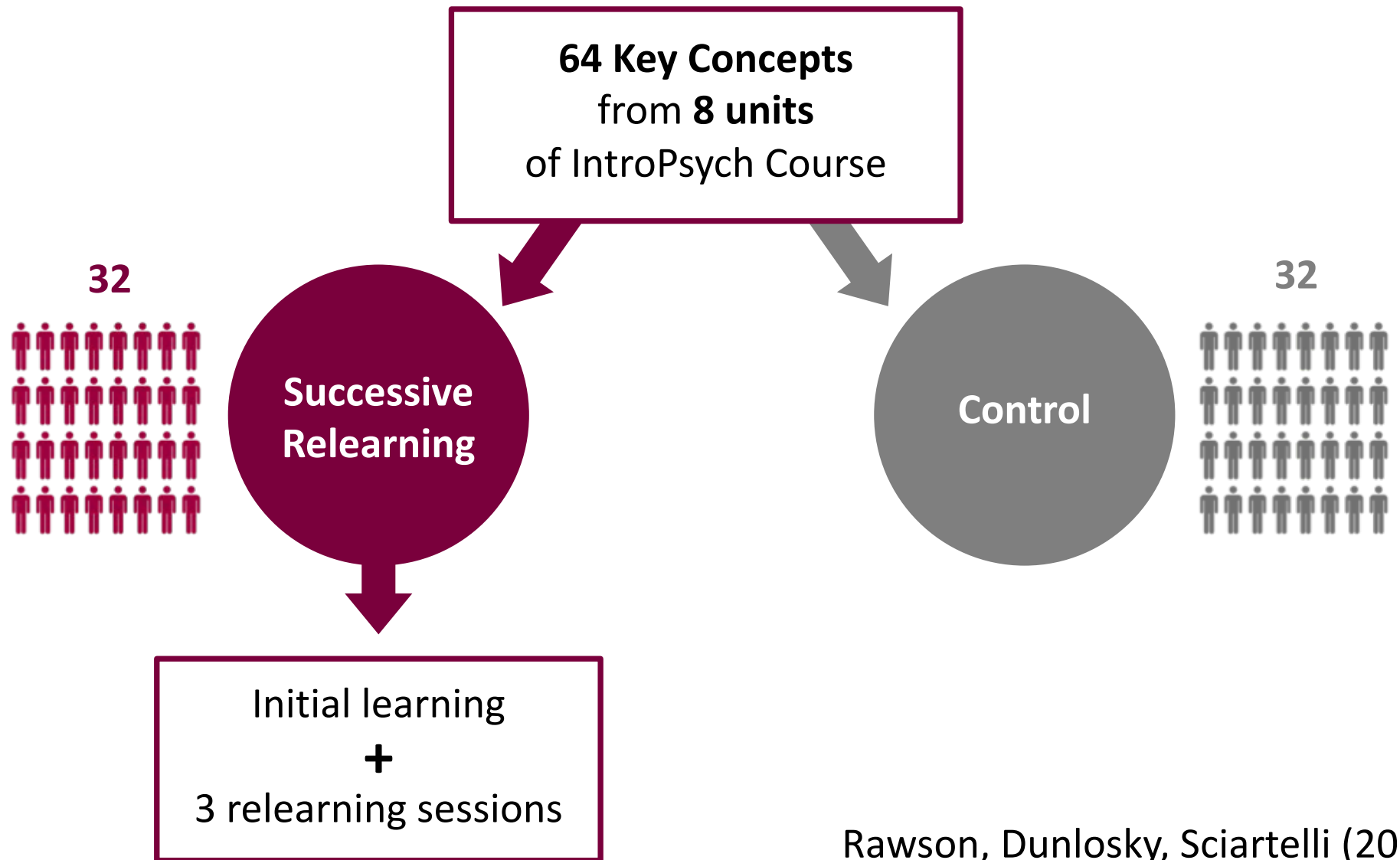
Relearn the same material

Session

4

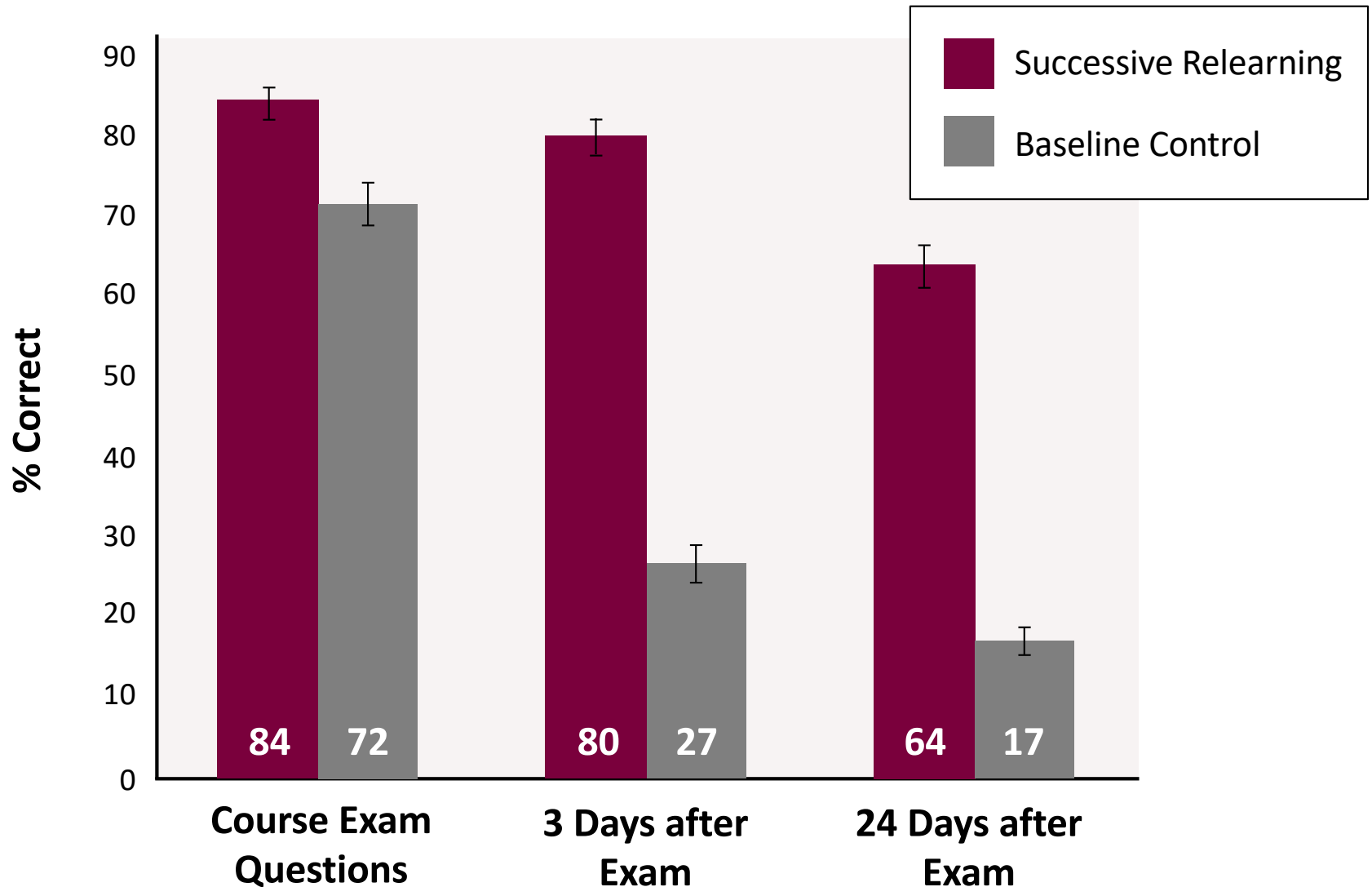
Relearn the same material

# Successive relearning in a class study.



Rawson, Dunlosky, Sciartelli (2013)

# Successive relearning leads to durable learning gains in the classroom.





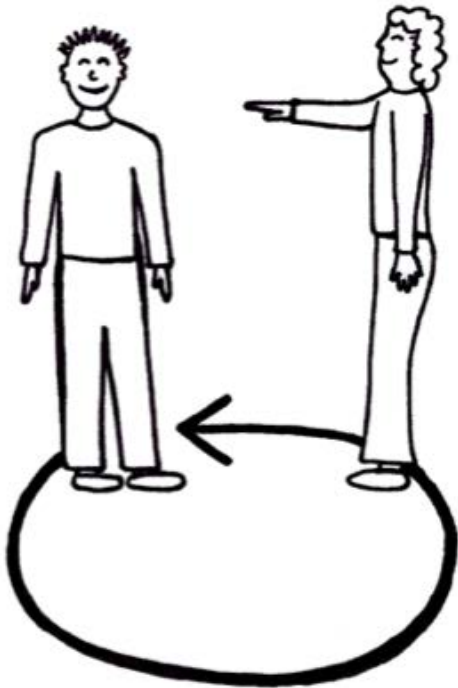
### **3. Effective study habits can strengthen long-term retention.**

- a. Poor metacognitive judgments lead students to select ineffective strategies for durable learning.
- b. Retrieval Practice + Spacing = successive relearning with large effect sizes in the lab and real learning gains in the classroom.

What habits lead to a healthy lifestyle?



# Activity: Put into practice active scheduling for the upcoming QuizTerm.



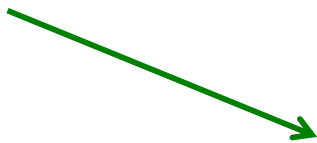
1. Estimate how much time you can devote to this task.
2. Schedule in 3-4 space study sessions into your calendar.
3. Set a start time for your QuizTerm.
4. Repeat above steps for your other major tasks due this week.
5. Spend 15 min every Sunday, and 5 min everyday, planning and reviewing your schedule.



# Training yourself to study is just a matter of applying instrumental conditioning.



$S^D$



R



$S^R$



AND

CHILL

# Key factors for durable learning.



1. Learning begins with effortful & focused attention.



2. Instructional Design directly sets the stage for learning.



3. Effective study habits strengthen long-term retention.



# McMaster Symposium on EDUCATION & COGNITION

Discovering evidence based practices in education  
July 26<sup>th</sup> & 27<sup>th</sup>, 2018 | McMaster University, MDCL

## July 26, 2018 | Workshops

Strategies for Effective Learning: The Learning Scientist workshop Led by Megan Sumeracki & Yana Weinstein

Ideas Congress (ICON): A transdisciplinary learning environment for experiential learning Led by Shoshana Jacobs

Writing Multiple Choice Questions to Create Effective Tests Led by Amy Pachai

Note taking: How research can better inform practice Led by Irina Ghilic

The Psychology of Focusing on What Really Matters: A Reset for Workplace Productivity Led by Joe Kim

Think Before You Speak: Using your Mental Strengths for Powerful Presentations Led by Laura Cole

## Public Lecture

Mike Atkinson  
Western University

## July 27, 2018 | Speakers

Bruce Wainman  
McMaster University  
*X Reality and the Concorde Fallacy in Education*

Megan Sumeracki  
Rhode Island College  
*Applying the Science of Learning from the Laboratory to the Classroom*

Veronica Yan  
University of Texas at Austin  
*A Toolkit for Building Better Learners*



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**"Any teacher that can be replaced by a machine should be!"**

Arthur C. Clarke, "Electronic Tutors" (1980)



**"Nothing can replace a good human teacher, but much of the drudgery of education -- the routine and the rote -- could be taken over by electronic devices."**

Thank you 



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