Active Learning 101

Why and How to Get Started

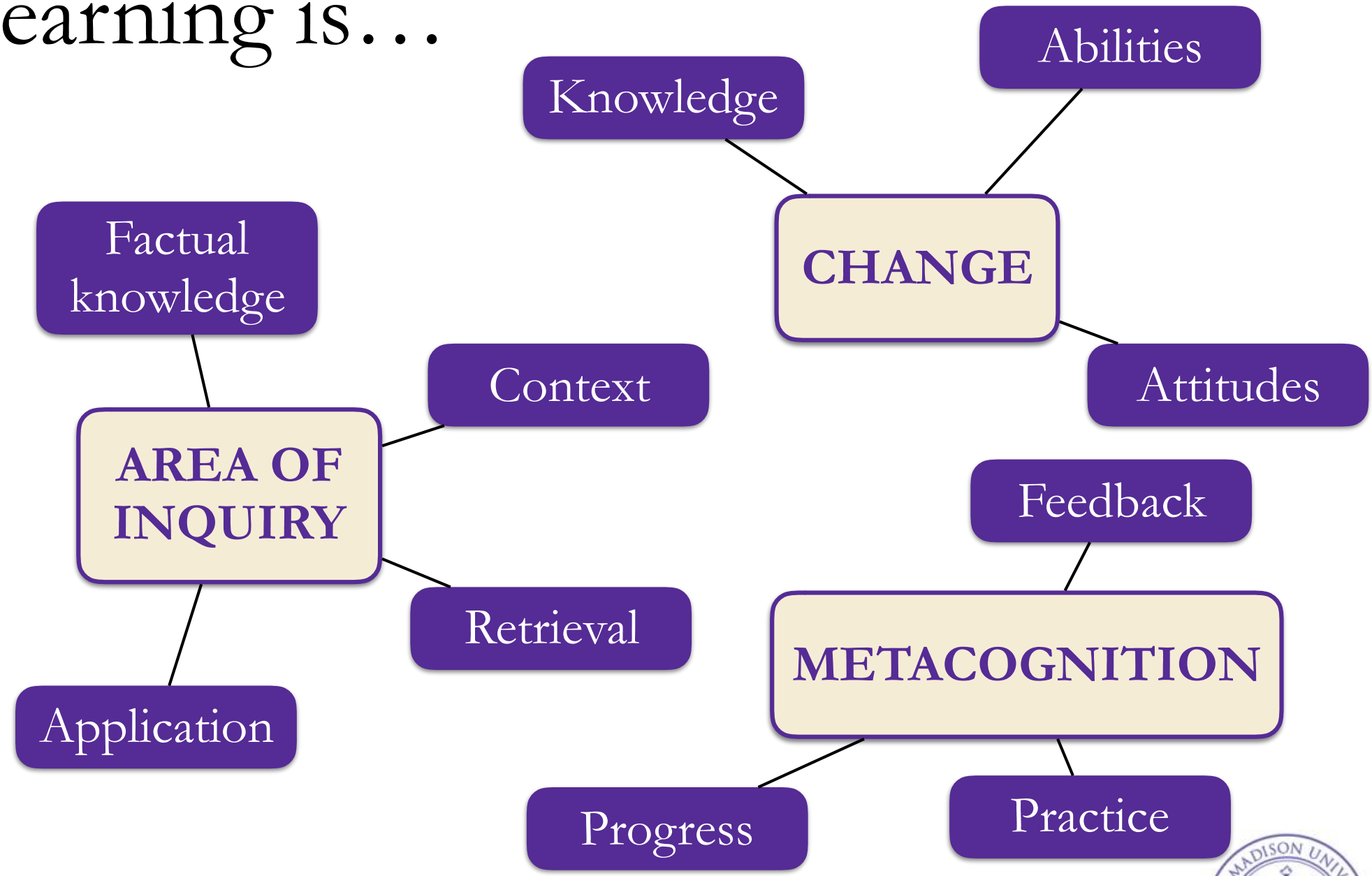
Michael S. Kirkpatrick

CFI New Faculty Orientation

August 21, 2017

“Learning is…”

Learning is…


Knowledge
Abilities
CHANGE
Attitudes
Factual knowledge
Context
AREA OF INQUIRY
Retrieval
Application
Feedback
METACOGNITION
Progress
Practice

A short quiz

True or False:

- ✗ Good learning makes us feel confident and clear.
- ✓ Learning can occur without intentional effort.
- ✗ You have to be interested and motivated to learn.
- ✗ Intelligent people learn more easily.
- ✓ Adapting instruction based on learning styles has no effect on learning.
- ✗ Rereading textbooks efficiently reinforces concepts and leads to greater mastery.

M. Pasupathi, *How We Learn*. The Great Courses. Chantilly, VA, USA: The Teaching Company, 2012.
P. Brown, H. Roediger, and M. McDaniel, *Make It Stick : The Science of Successful Learning*. Cambridge, MA, USA: Harvard University Press, 2014.

ALL

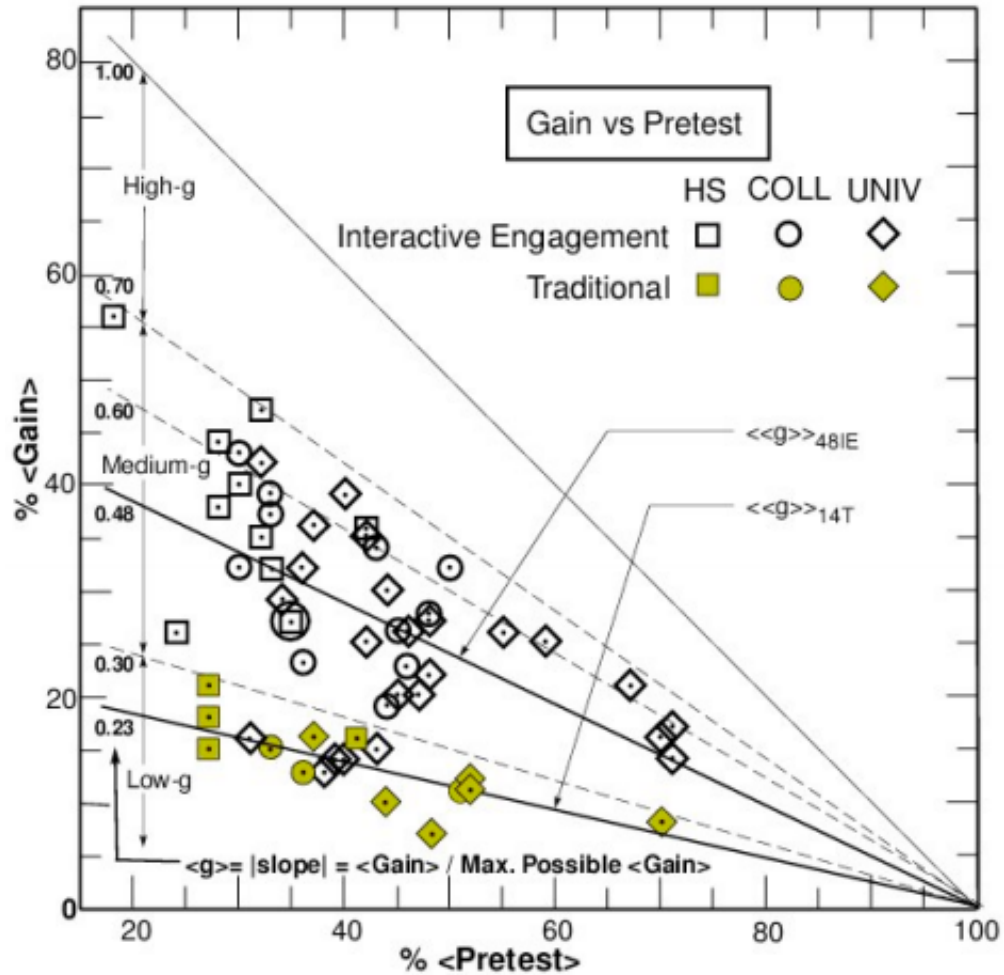
"Adopting instructional practices that **engage students in the learning process** is the defining feature of active learning."

-Michael Prince

Why active learning?

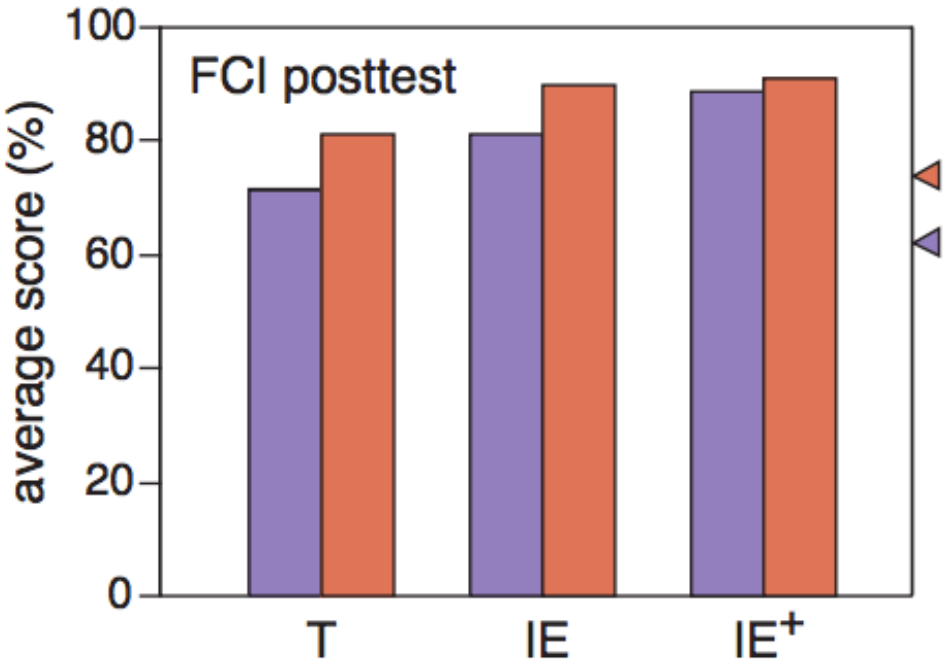
Pre- vs. post- in physics

- Mechanics Diagnostic
- Force Concept Inventory
- 62 courses (14 trad.) at multiple institutions
- 6542 students (2084)
- **Worst** active learning comparable to **best** traditional lecture



R.R. Hake, "Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," Am. J. Phys. 66, 64- 74 (1998). http://www.physics.indiana.edu/~sdi/ajpv3i.pdf

Why active learning?



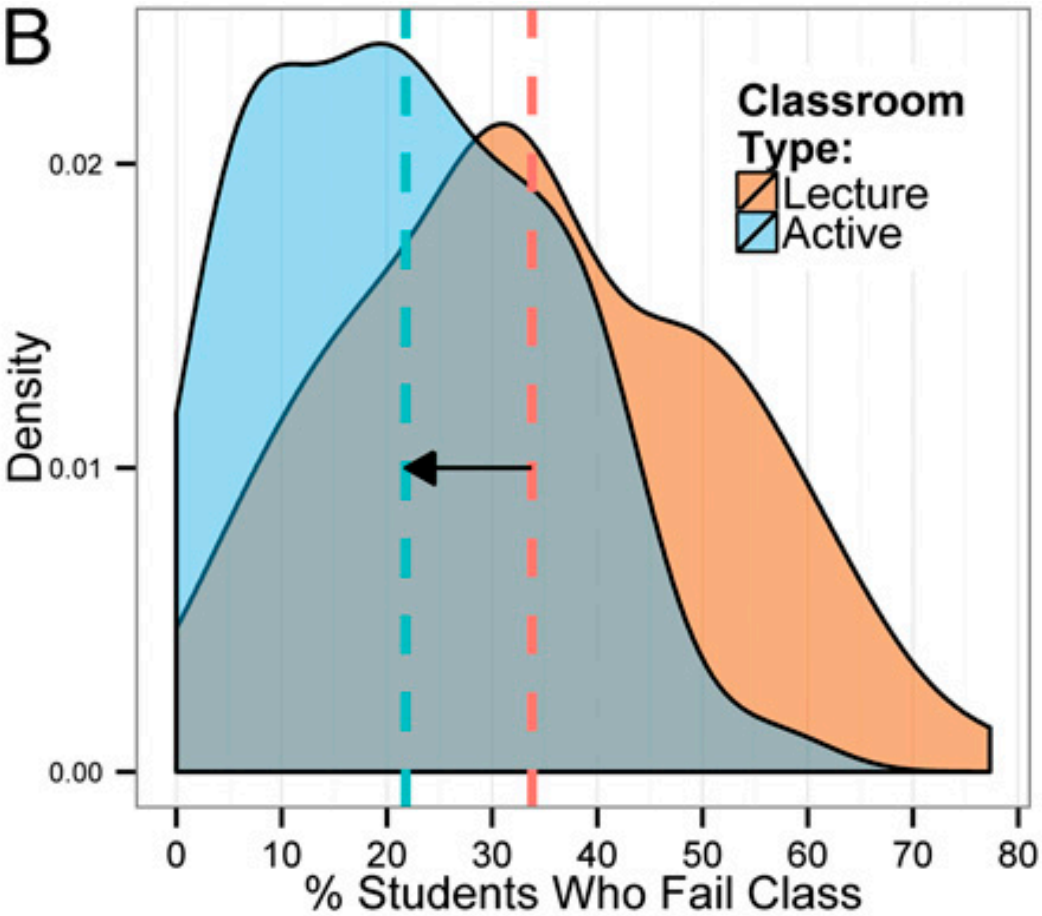
T: traditional lectures
IE: interactive lectures
IE+: interactive assignments, lectures, tutorials

Closing the gender gap

- Pre-test scores were 10% points higher for men
- Gap persisted with lecture
- Post-test results for cooperative classes were almost equal
- Requires more than just interactive lecture

E. Mazur, "The scientific approach to teaching: Research as a basis for course design," keynote/plenary talk at the International Computing Education Research Conference (ICER), 2011.
http://mazur.harvard.edu/search-talks.php?function=display&rowid=1712

Why active learning?



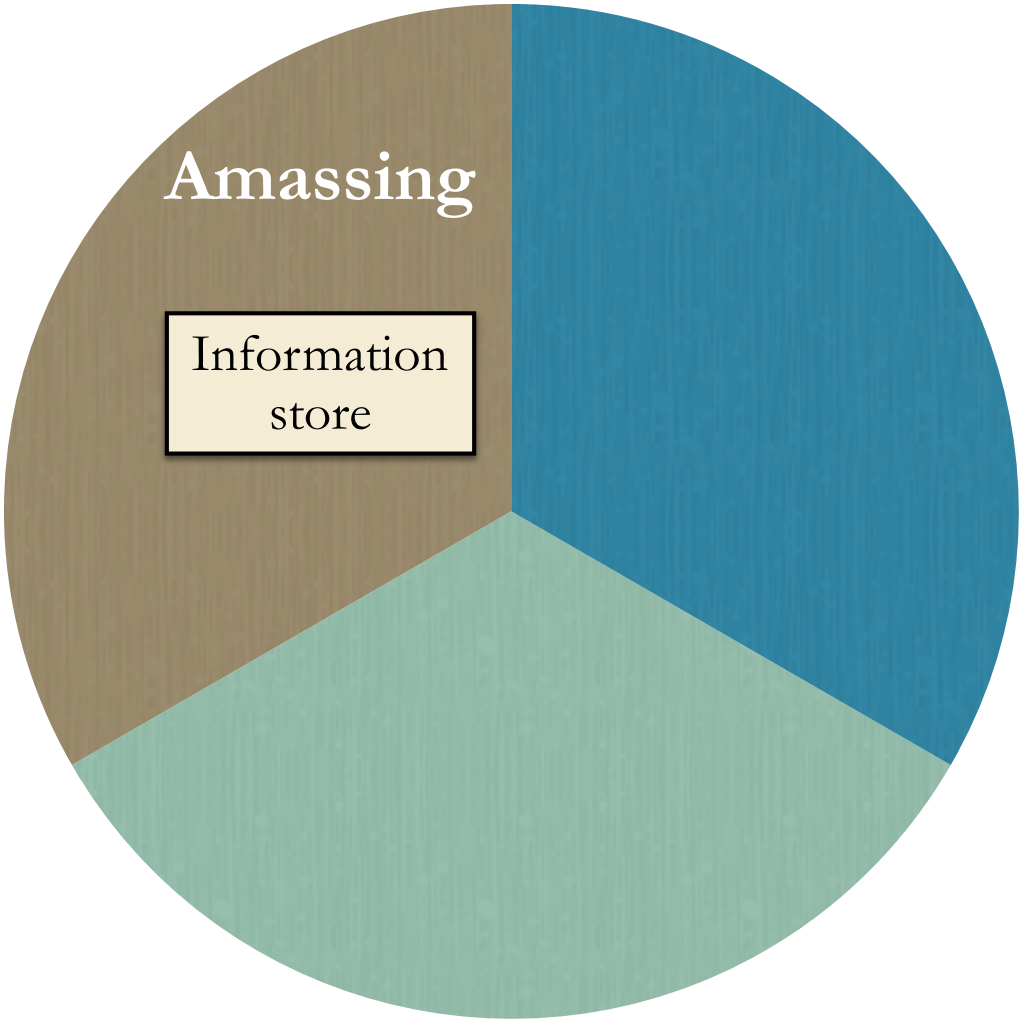
Metaanalysis of 225 studies

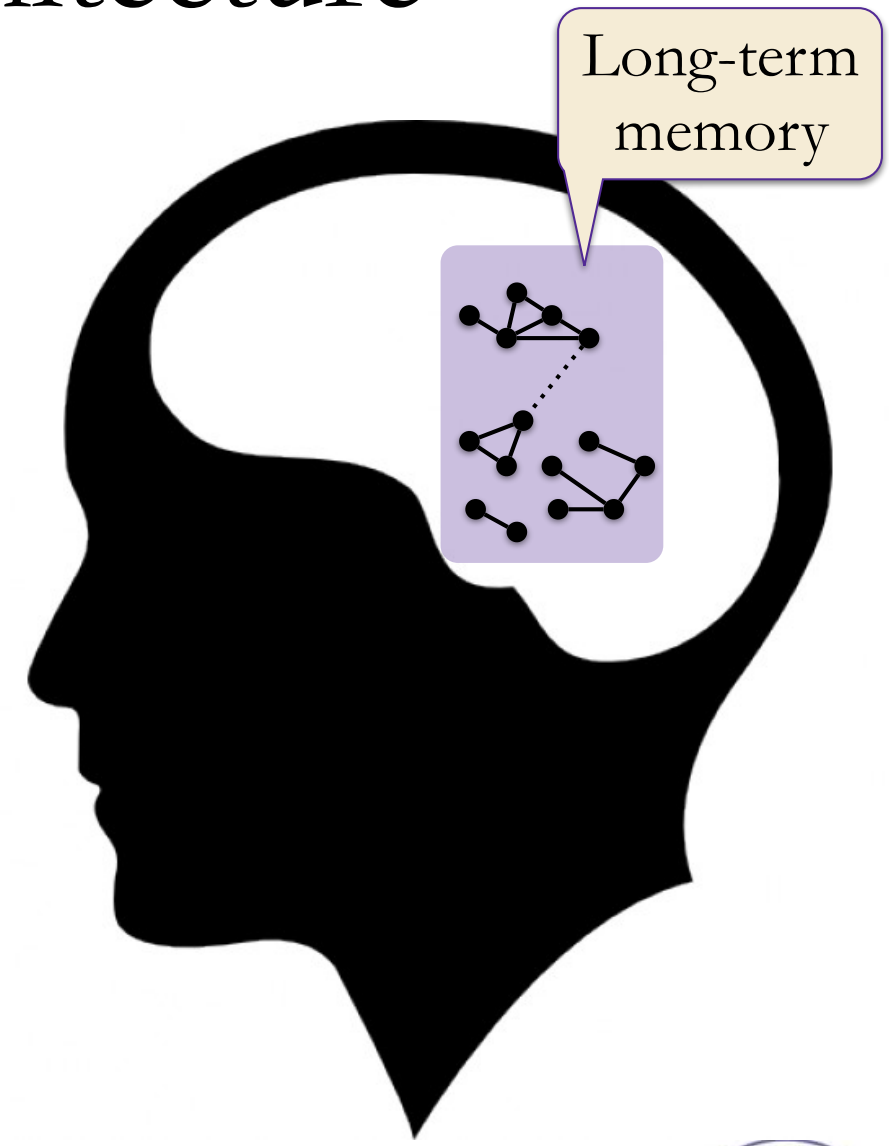
- 158 studies (exams/CIs)
  - 0.47 SDs increase
  - 6% grade increase
- 67 studies (failure rate)
  - 33.8% ⇒ 21.8%

S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," Proceedings of the National Academy of Sciences 111(23), 8410- 8415, 2014.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4060654/pdf/pnas.201319030.pdf

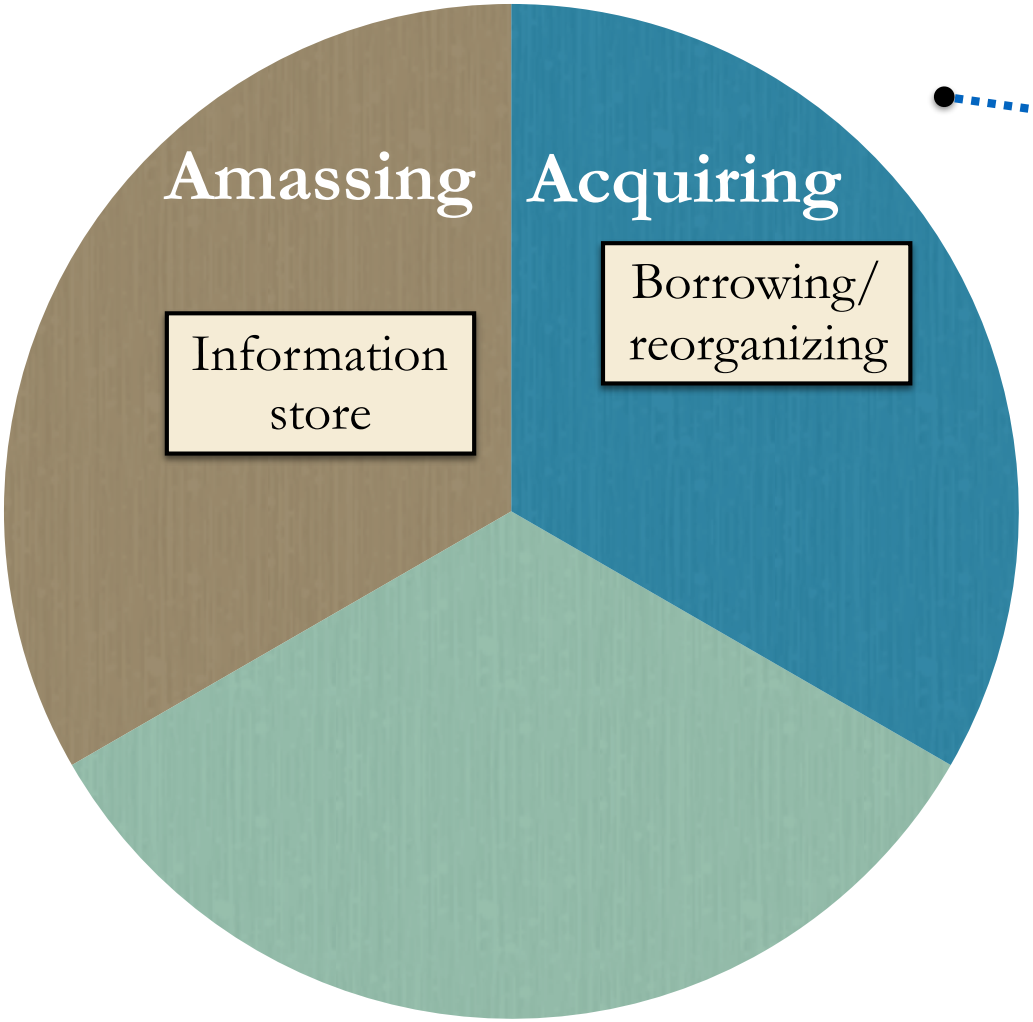
Why active learning?

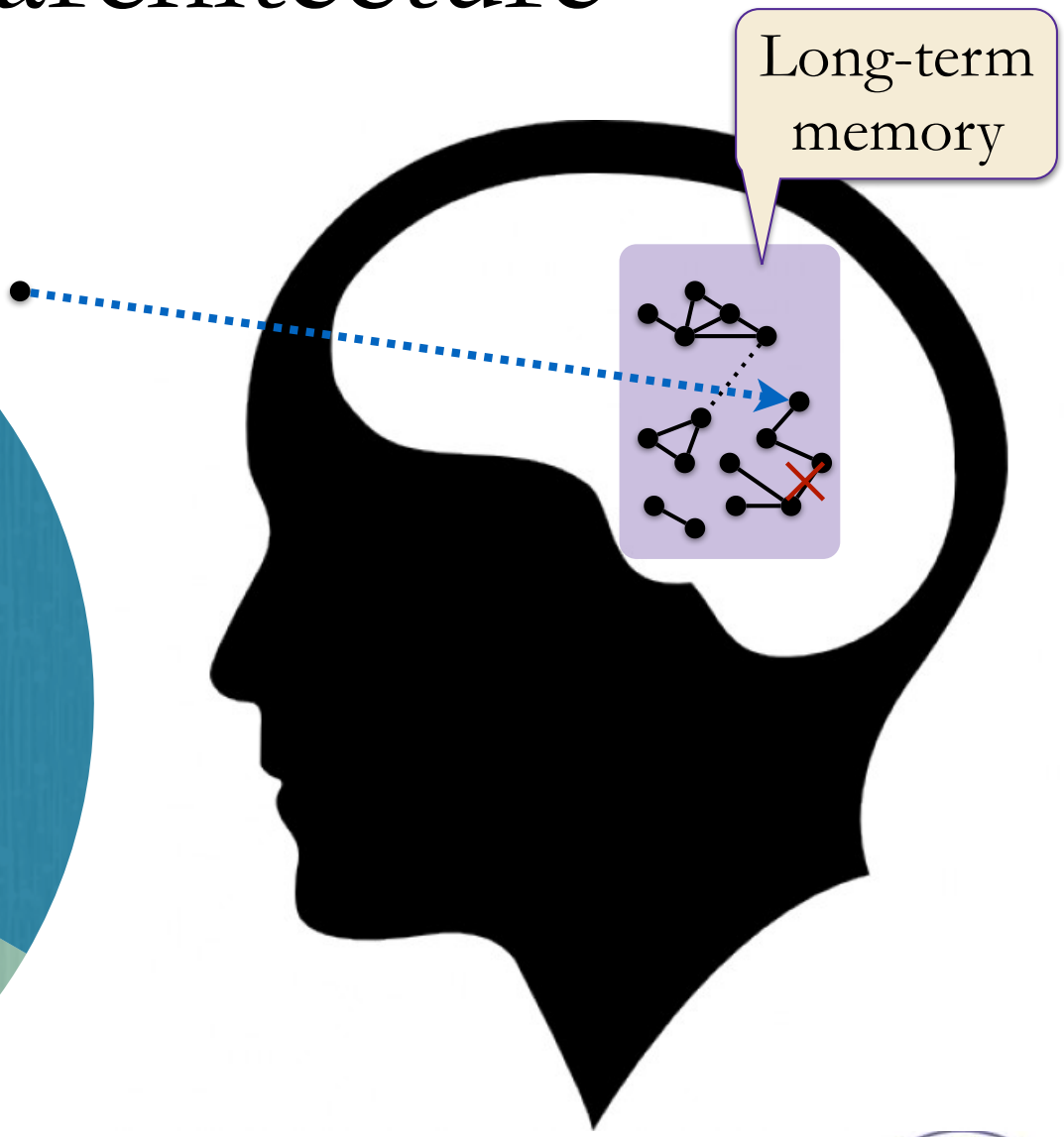
Human cognitive architecture



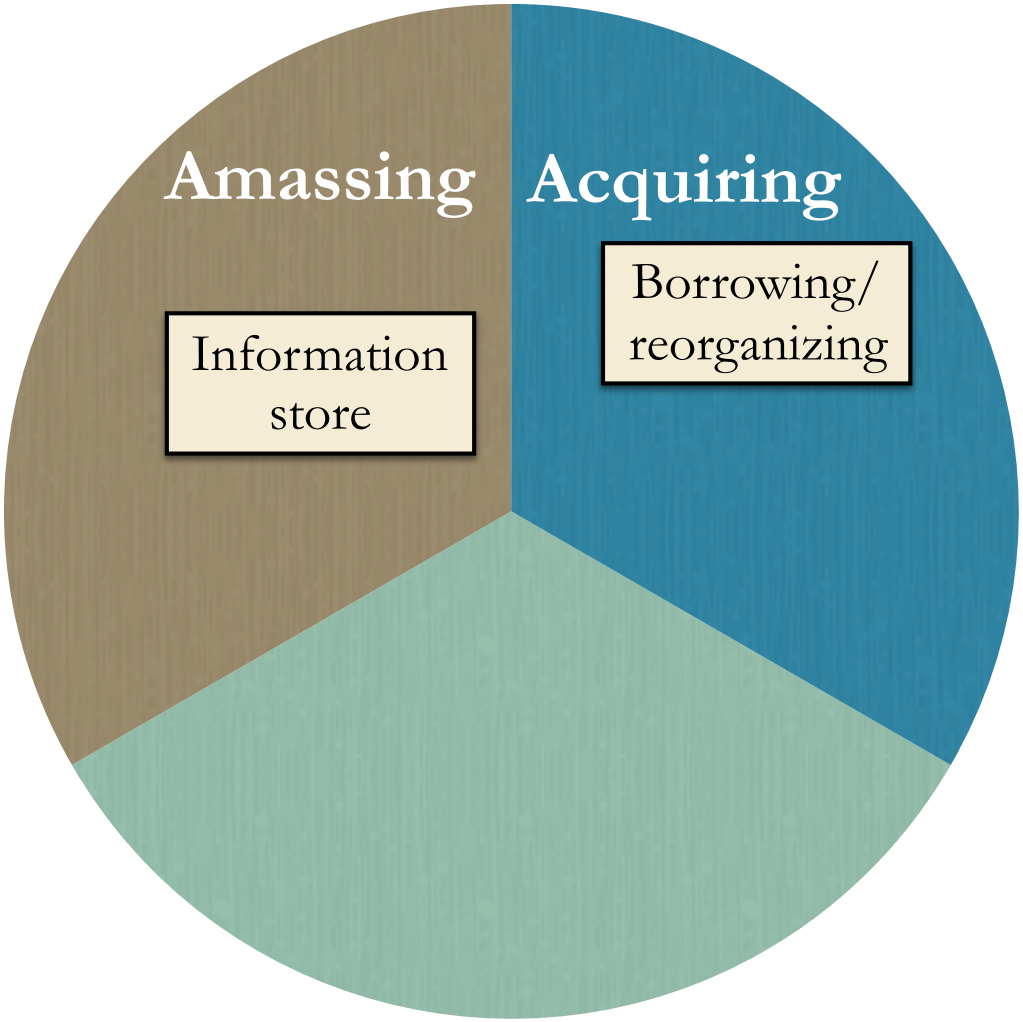


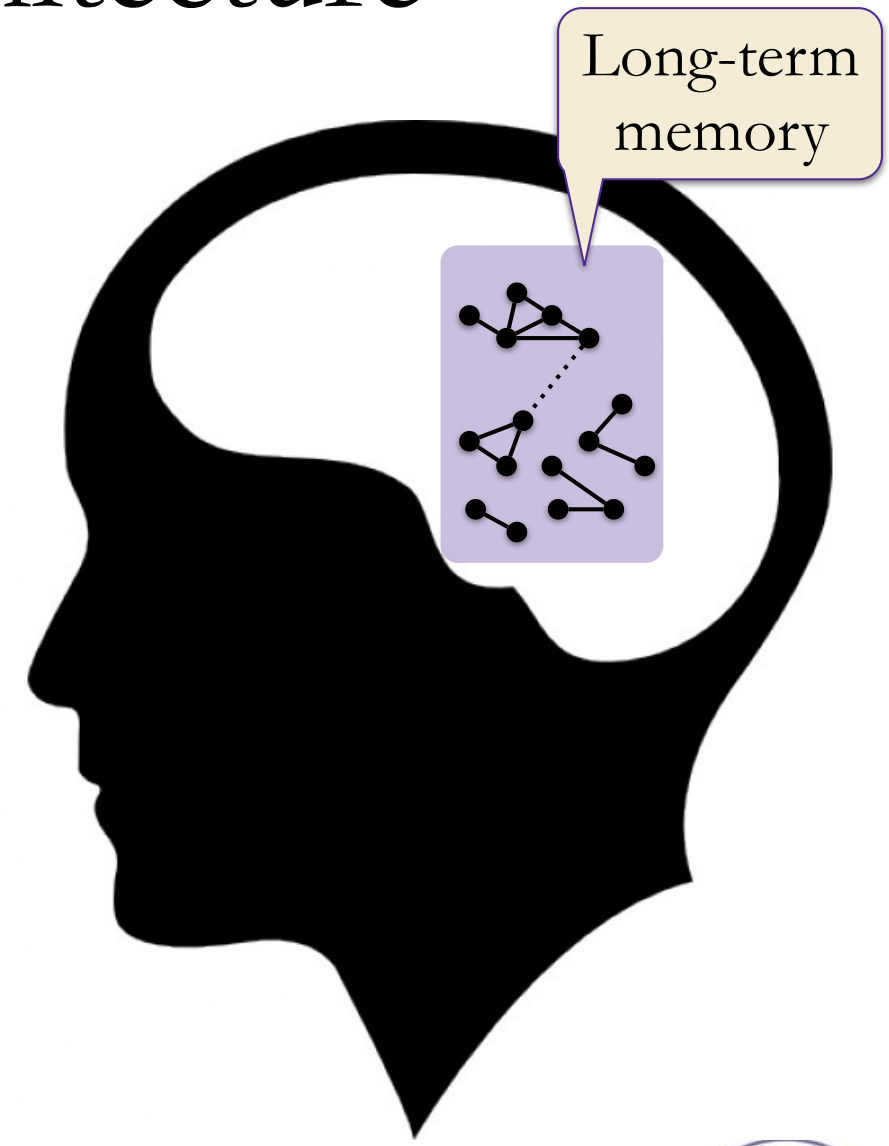
Human cognitive architecture



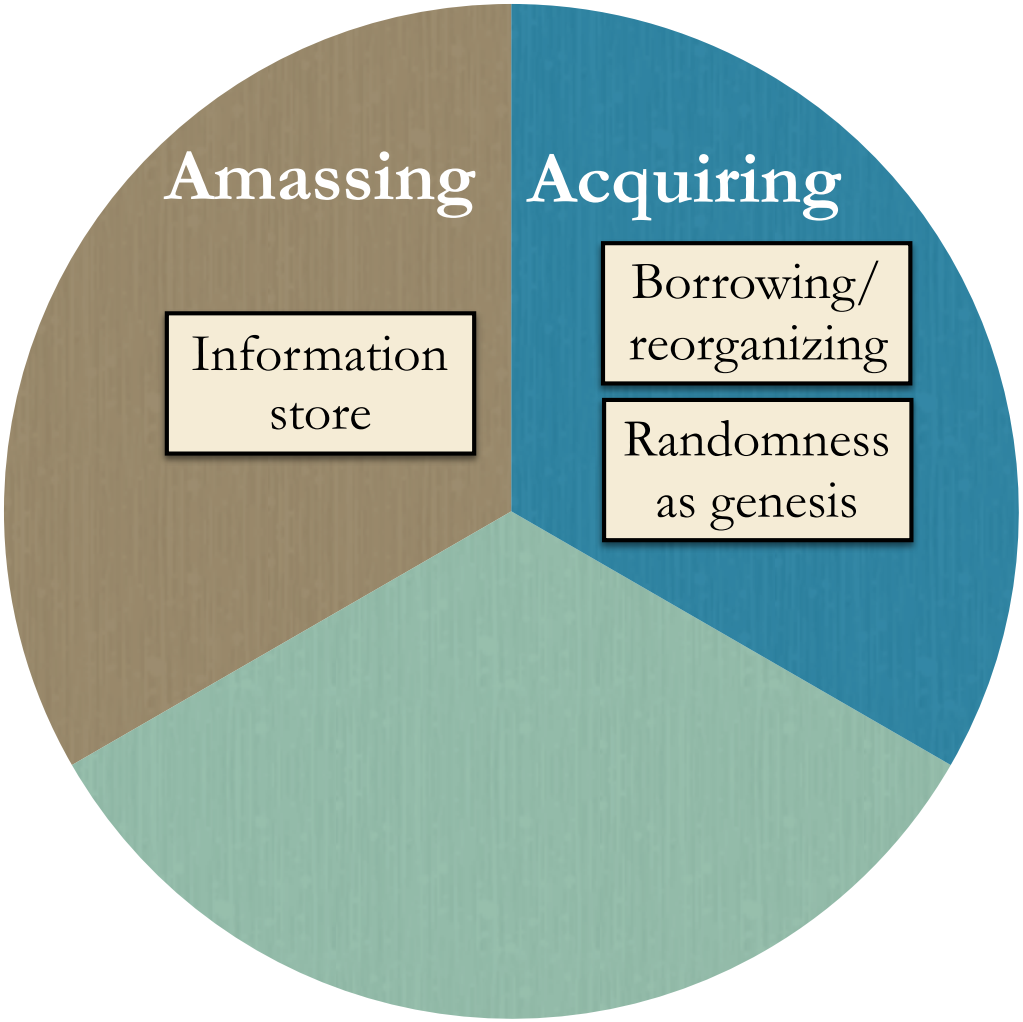


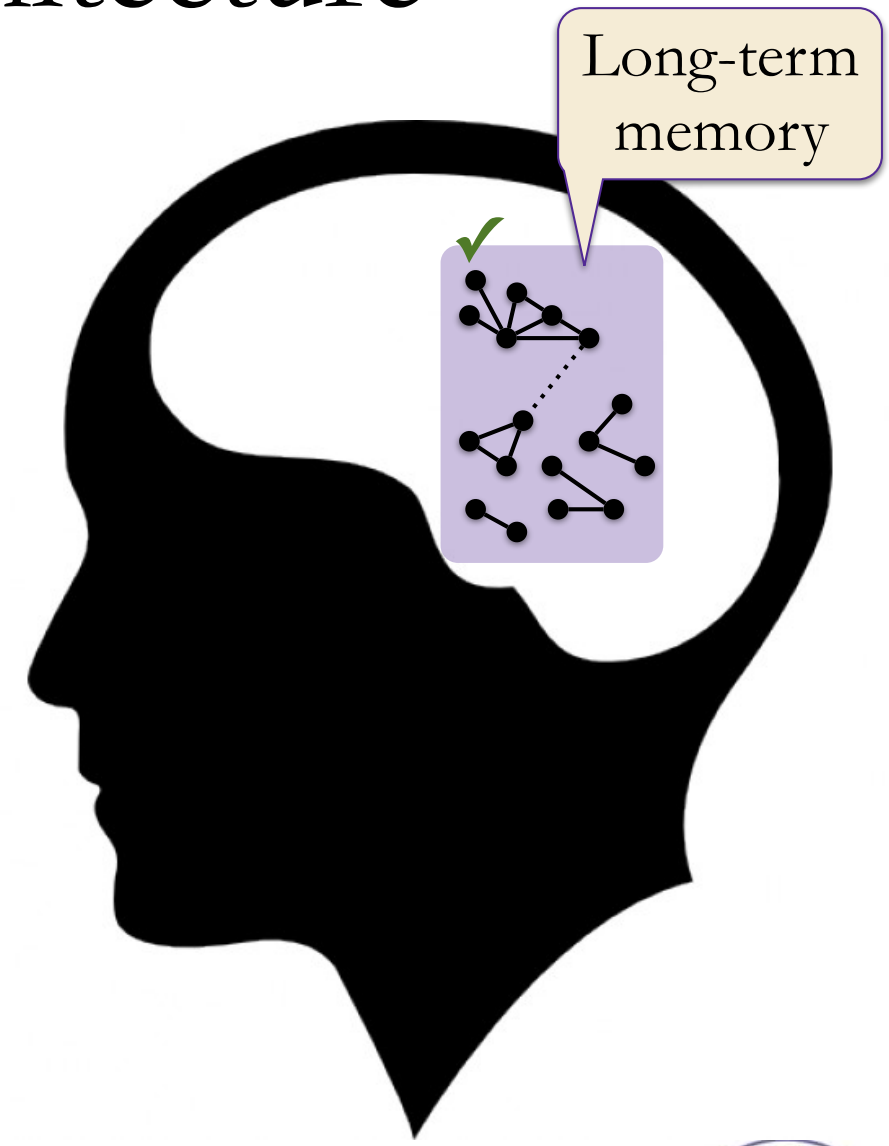
Human cognitive architecture



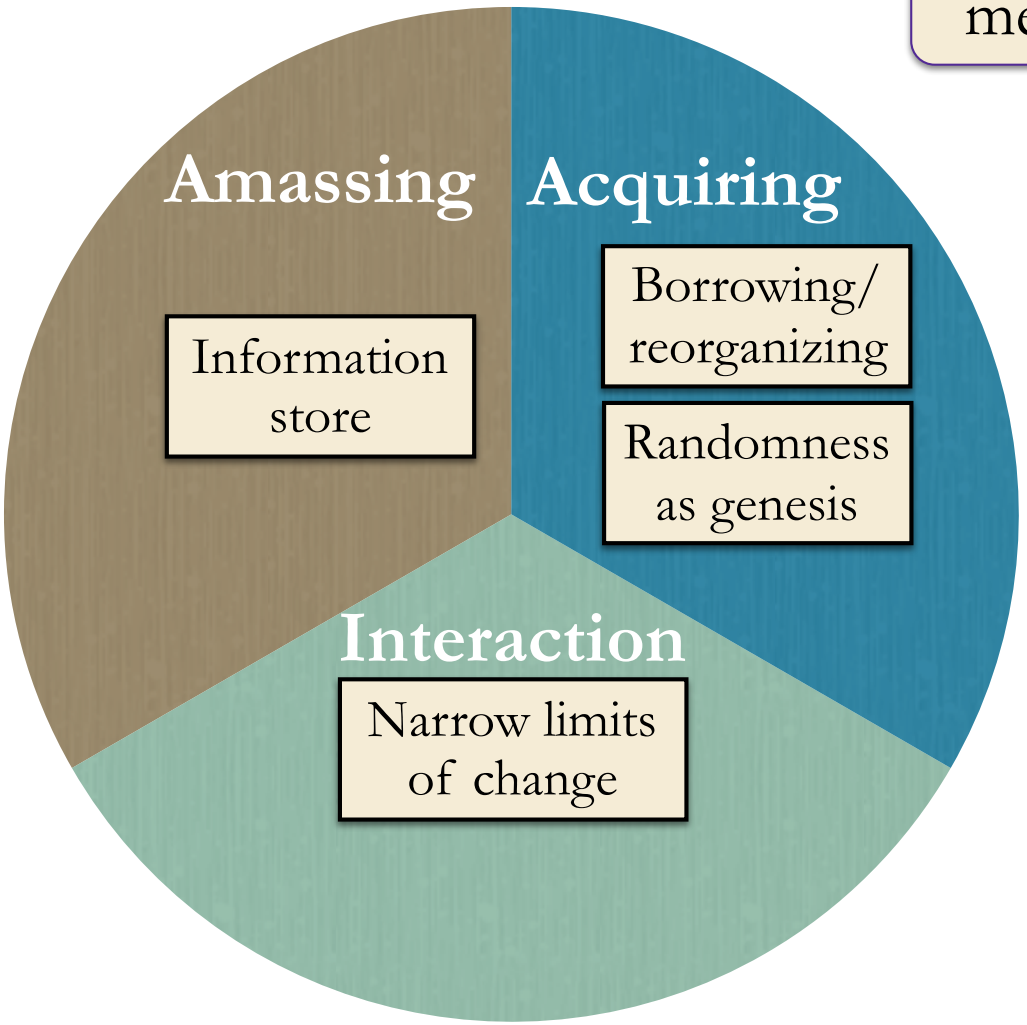


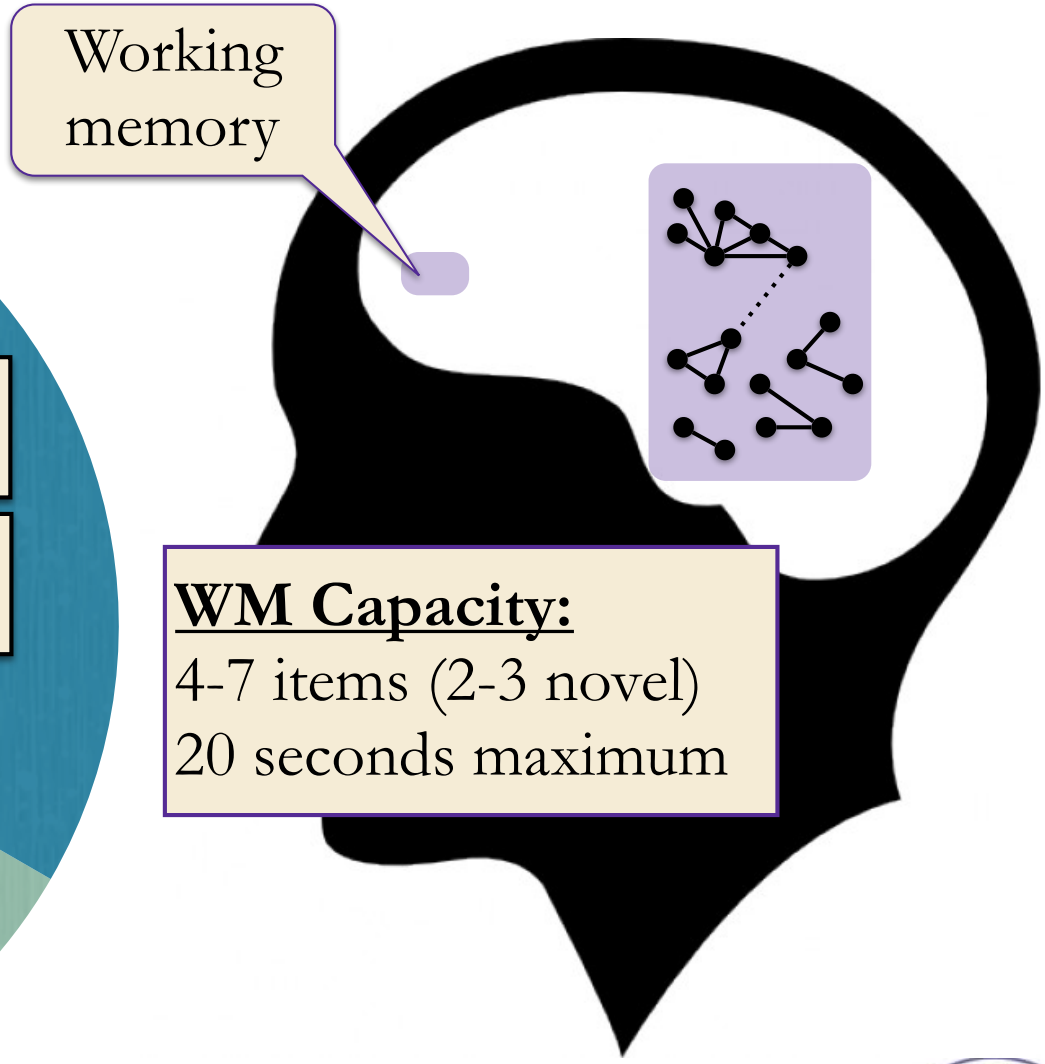
Human cognitive architecture





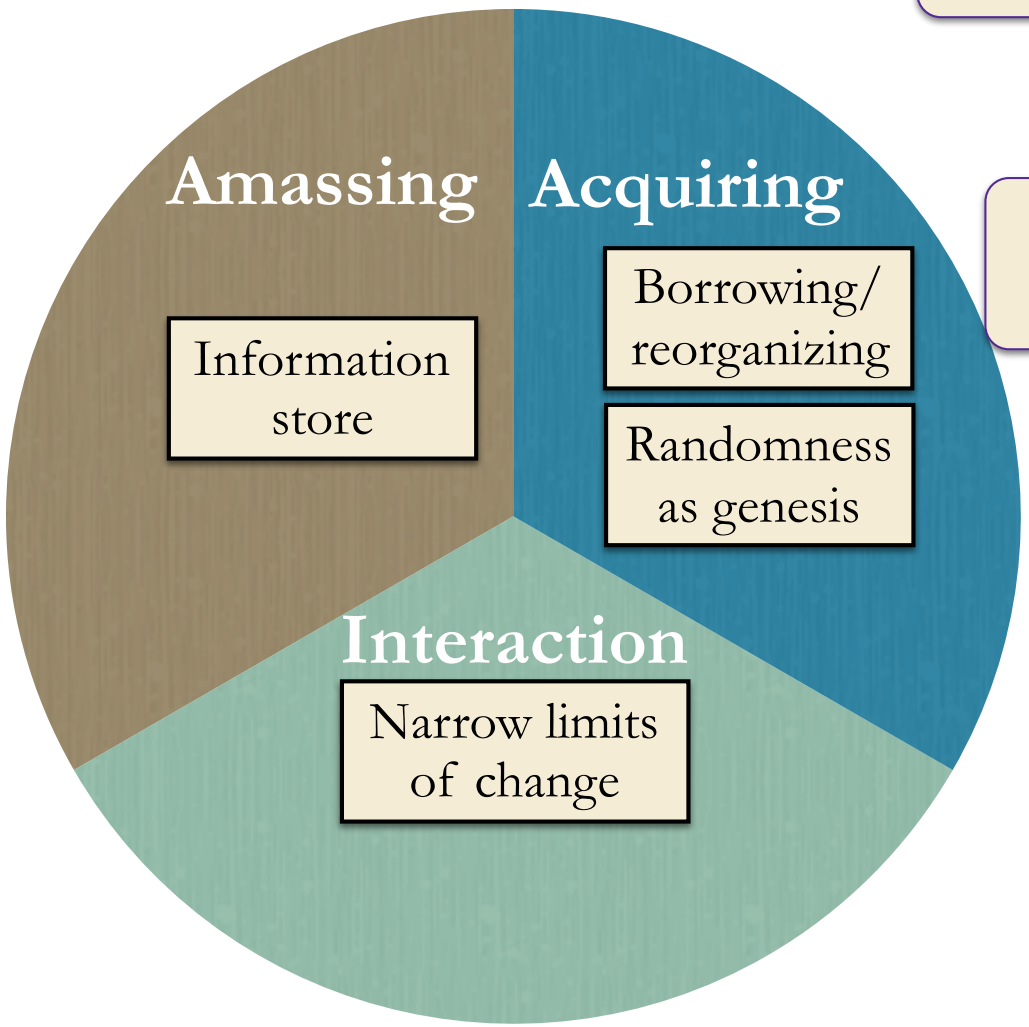
Human cognitive architecture

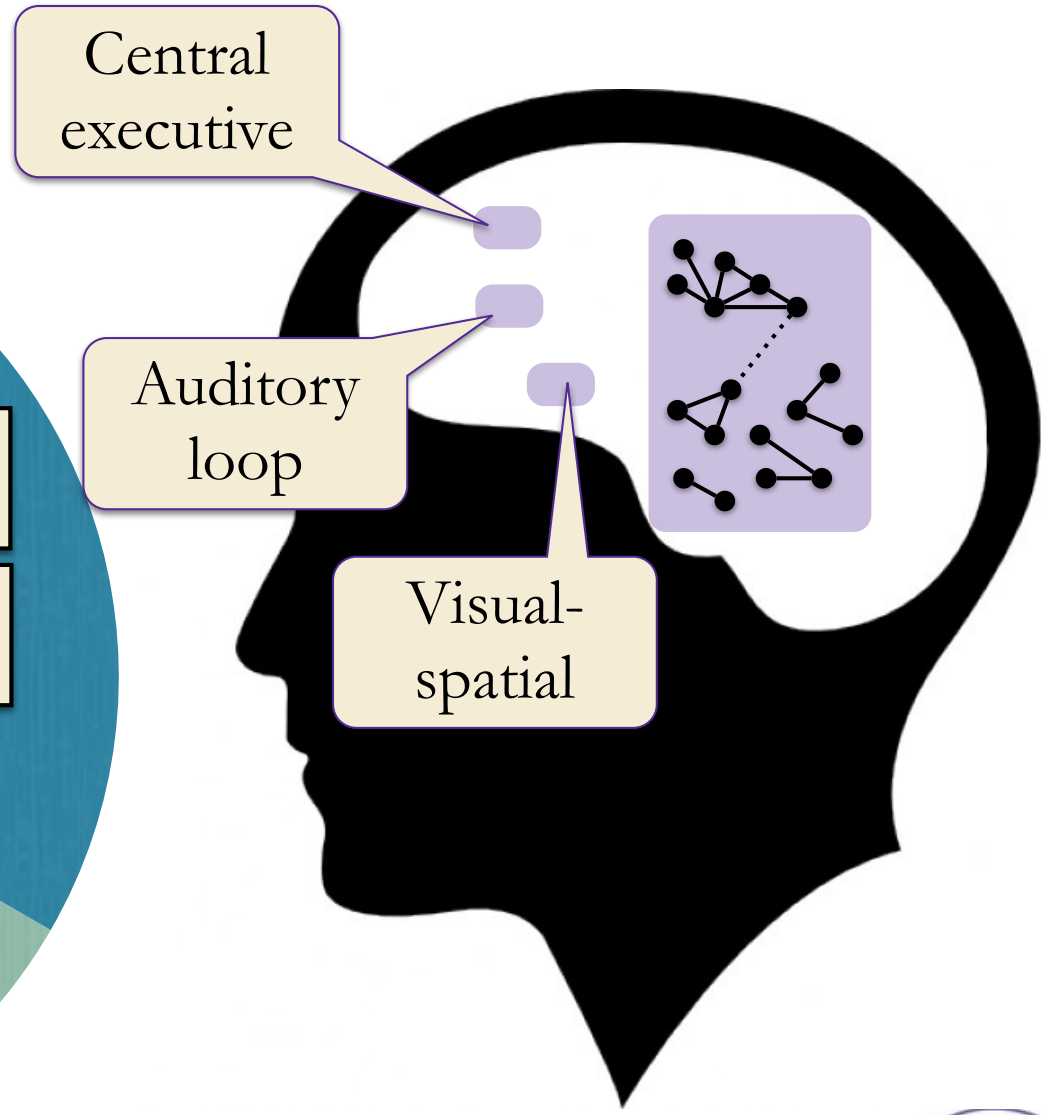




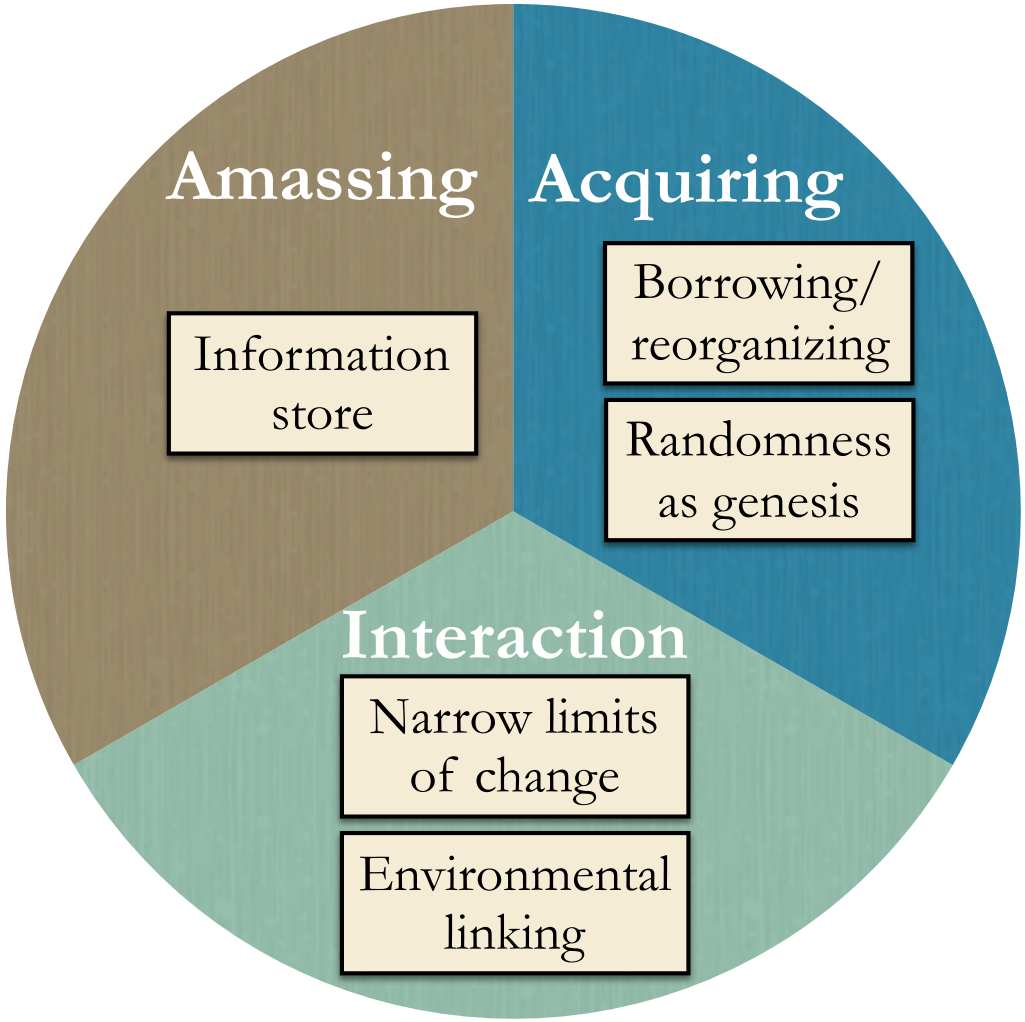
WM Capacity:
4-7 items (2-3 novel)
20 seconds maximum

Human cognitive architecture

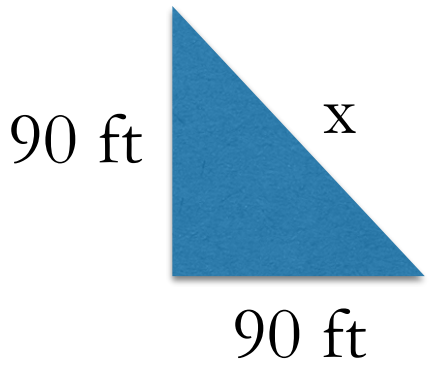


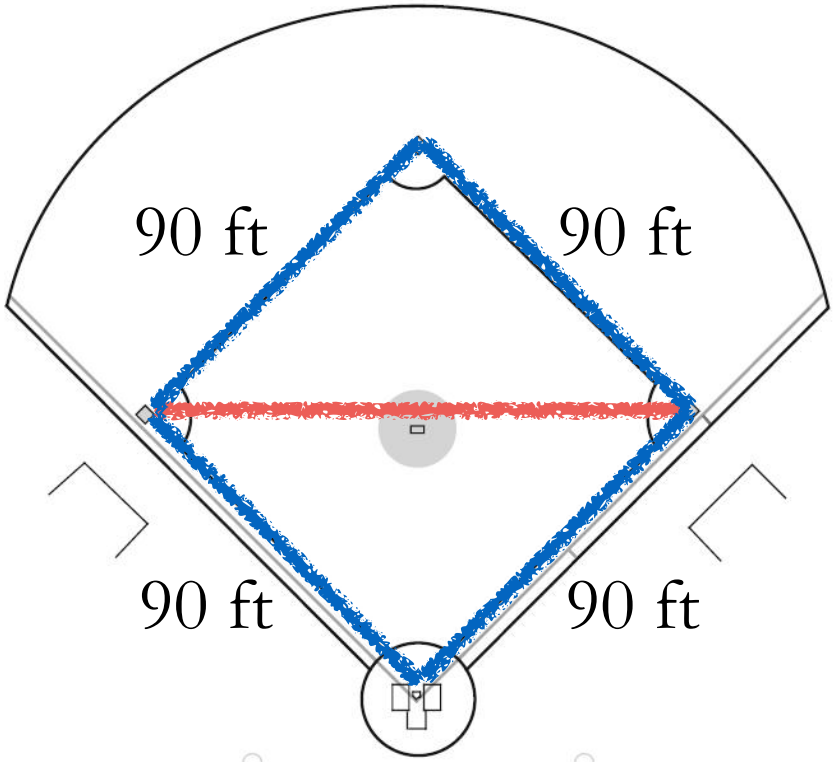


Human cognitive architecture



Far transfer





Apply the Pythagorean theorem to the above triangle to find the value of x.

In a baseball diamond, the distance between each base is 90 ft. Which of the following is true about the shortest distance between 1st and 3rd bases (the red line shown above)?

1. It is less than 90 ft.
2. It is between 90 and 120 ft.
3. It is greater than 120 ft.

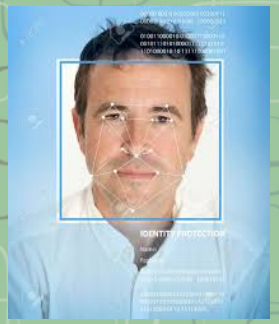
Human cognitive architecture

Which of these principles of human cognition best explains why active learning is more effective than traditional lecture?

A. Information store
B. Borrowing and reorganizing
C. Randomness as genesis
D. Environmental linking

Types of knowledge

Biologically Primary



Biologically Secondary

Additive Rules

$$\frac{}{\Delta, 0 \vdash \Gamma}\ 0L \qquad \frac{}{\Delta \vdash \top, \Gamma}\ \top R$$

$$\frac{\Delta, B_i \vdash \Gamma}{\Delta, B_1 \,\&\, B_2 \vdash \Gamma}\ \&L\ (i = 1, 2) \qquad \frac{\Delta \vdash B, \Gamma \quad \Delta \vdash C, \Gamma}{\Delta \vdash B \,\&\, C, \Gamma}\ \&R$$

$$\frac{\Delta, B \vdash \Gamma \quad \Delta, C \vdash \Gamma}{\Delta, B \oplus C \vdash \Gamma}\ \oplus L \qquad \frac{\Delta \vdash B_i, \Gamma}{\Delta \vdash B_1 \oplus B_2, \Gamma}\ \oplus R\ (i = 1, 2)$$

Quantifier Rules

$$\frac{\Delta, B[t/x] \vdash \Gamma}{\Delta, \forall x.B \vdash \Gamma}\ \forall L \qquad \frac{\Delta \vdash B[y/x], \Gamma}{\Delta \vdash \forall x.B, \Gamma}\ \forall R$$

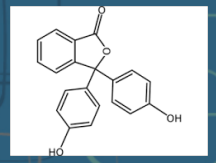
$$\frac{\Delta \vdash B[t/x], \Gamma}{\Delta \vdash \exists x.B\Gamma}\ \exists R \qquad \frac{\Delta, B[y/x] \vdash \Gamma}{\Delta, \exists x.B \vdash \Gamma}\ \exists L$$

Exponential Rules

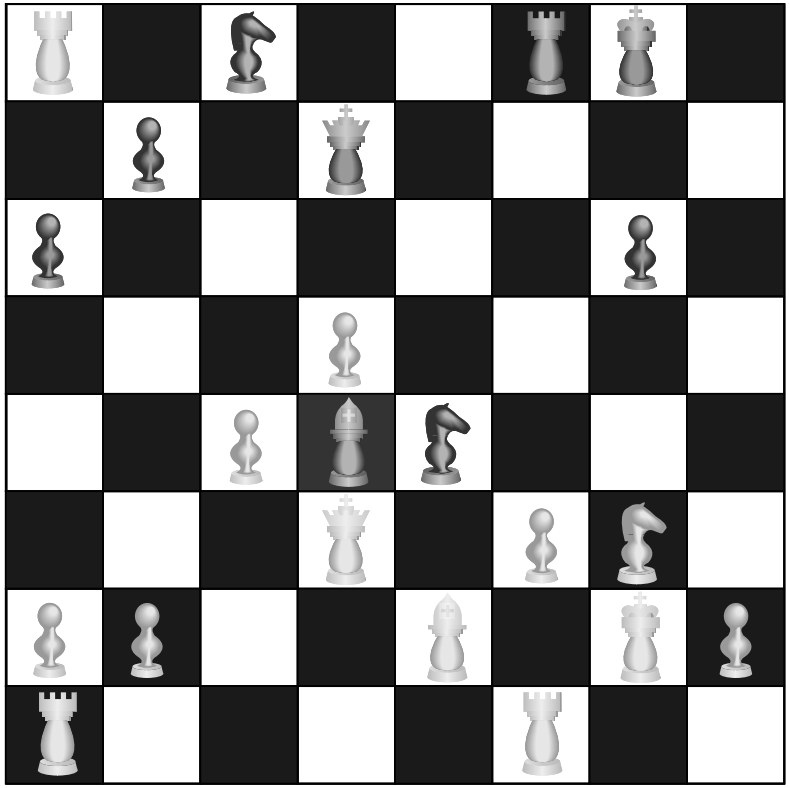
$$\frac{!\Delta, B \vdash ?\Gamma}{!\Delta, ?B \vdash ?\Gamma}\ ?L \qquad \frac{!\Delta \vdash B, ?\Gamma}{!\Delta \vdash !B, ?\Gamma}\ !R$$

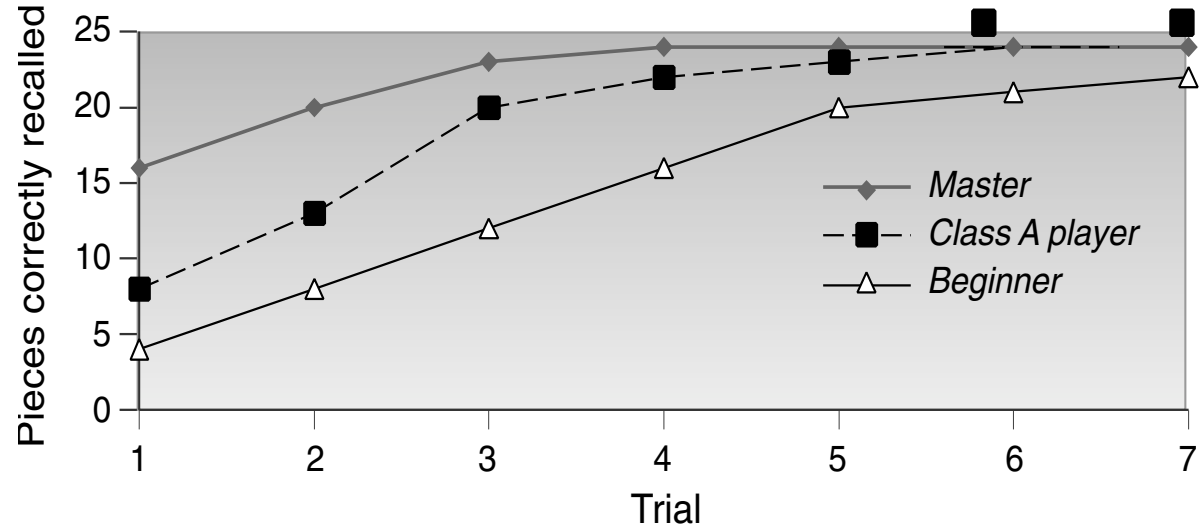
$$\frac{\Delta \vdash \Gamma}{\Delta, !B \vdash \Gamma}\ !W \qquad \frac{\Delta, !B, !B \vdash \Gamma}{\Delta, !B \vdash \Gamma}\ !C \qquad \frac{\Delta, B \vdash \Gamma}{\Delta, !B \vdash \Gamma}\ !D$$

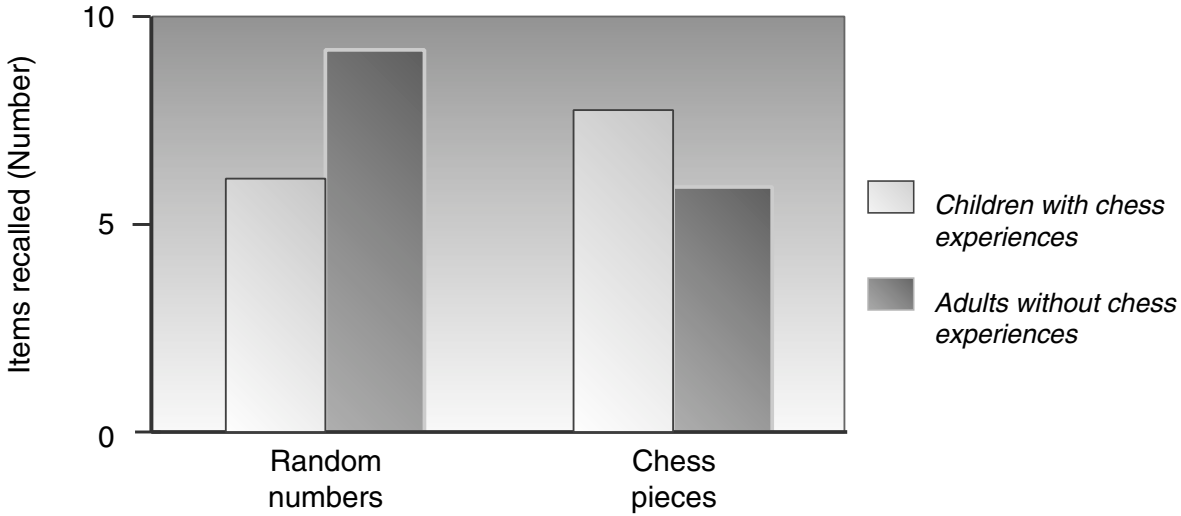
$$\frac{\Delta \vdash \Gamma}{\Delta \vdash ?B, \Gamma}\ ?W \qquad \frac{\Delta \vdash ?B, ?B, \Gamma}{\Delta \vdash ?B, \Gamma}\ ?C \qquad \frac{\Delta \vdash B, \Gamma}{\Delta \vdash ?B, \Gamma}\ ?D$$



Retrieval fluency







J.D. Bransford *et al.*, *How People Learn: Brain, Mind, Experience, and School*. National Academy Press. 2000. https://www.nap.edu/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition

Principles of effective learning

What works: (TIPPED)

- Testing as calibration
- Interleaved/spaced practice
- Pre-learning foundation
- Pre-instruction problem solving attempts
- Elaborative encoding
- Deliberative effort

What doesn't: (PRIMaL)

- Passive observation
- Rereading texts
- Intuitive judgments
- Massed practice
- Learning style adaptations

P. Brown, H. Roediger, and M. McDaniel, *Make It Stick : The Science of Successful Learning*. Cambridge, MA, USA: Harvard University Press, 2014.

Assessment jigsaw

<u>Read your description and answer the following:</u>

- How does it work?
- When is it good to use?
- What is the effort and impact?
- How does it align with TIPPED principles?

Closing Reflection