Learning

• Learning = long-lasting change in behavior due to environment
• Contrast learning with
  – Reflex: built-in pairing of specific event with an involuntary response
    • Moro reflex: loss of support -> spread out arms + cry
    • Rooting reflex: move mouth toward stroked cheek
    • Pupil constricting with light
  – Fixed Action Pattern: built-in, reliably evoked, whole-animal complex responses to a situation
    • Opossum playing dead
    • Cowbirds replacing eggs from another bird’s nest with their own egg
    • Goose rolling eggs back to nest
    • Extra credit: human fixed action pattern?
Why is learning needed?

• Every animal faces different environments, so behaviors can’t be hardwired in.

• Every human also faces different cultures, artifacts, and technologies, which are changing faster than evolution can keep up.

• Solution: animals engage in learning that allows them to adapt to an environment within their own lifetime.

• Example: Prism glasses – constantly learn to adapt our eye-hand coordination.
Recommendations from Cognitive Psychology for Improving Learning

- Self-explanation
- Retrieval practice (the Testing Effect)
- Distributed and interleaved practice
- Variability
- Idealization and caricaturization
- Desirable difficulties
- Peer instruction
- Comparison
- Growth mind set
**Self-explanation**

- Ask deep explanatory questions. Use instructional prompts that encourage students to pose and answer “deep-level” questions on course material

- **Learning physics (Van Lehn et al., 2007)**
  - Half of students construct explanations (with human or computer tutor)
  - Half only read explanations
  - Example: “When a car without headrests on the seat is struck from behind, the passengers often experience neck injuries. Why do passengers experience neck injuries in this situation?”
  - Students showed better understanding of physics when they constructed their own explanations

- **Self-explanation encourages students to integrate information and create their own mental models of a situation**

- **Illusion of explanatory depth**: people THINK they know how a phenomenon works until they are forced to provide the explanation
Illusion of Explanatory Depth

How well do you understand how a helicopter flies?

Give situations to explain like: how does helicopter change from hovering to forward flight?

Rating of final knowledge after reading expert explanation

Rating of initial knowledge after reading expert explanation

Asking people to generate explanations makes them confront what they do not know
Retrieval Practice
(Roediger & Karpicke, 2006)

• Use quizzing with active retrieval of information to exploit the ability of retrieval to facilitate consolidation of long-lasting memory traces

• Practicing the retrieval of items is better than simply restudying the items for long-lasting memories
  – For immediate test, restudying is good
  – For later tests, testing is better
  – Students think that restudying is better than testing
  – Active versus passive use of flashcards

• Retrieving memories causes the memories to be elaborated, and increases the number of retrieval cues

• Possible connection to reconsolidation
Retrieval as an active process

- Reconsolidation of memories during their retrieval
- Repeatedly pair bell ring with shock for rat -> freeze response to bell
- Then, as bell is played, inject anisomycin – a drug that prevents new neural connections
- Freeze response to bell is unlearned, but only if memory is being retrieved
- Memories are reconsolidated/rebuilt when they are retrieved
- Application for treating Post-traumatic Stress Disorder
- Retrieval is not just a process of pulling out an item from a stack, but rather memories are particularly malleable when they are retrieved
Distributed Practice
(Cepeda et al., 2008)

- Memory for trivia questions
- It is generally better to **space** out repetitions of the same information rather than **mass** them together
- The ideal spacing of items is longer if the memory should be retained for a longer period of time
- Benefits of spacing are bigger than the disadvantages of spacing too much, so err on the side of spacing
- Try distributing practice for exams
Interleaved Practice

- Alternate between reading already worked solutions and trying to solve problems on your own
- Alternate different types of problems (ABCABCABCABC) rather than blocking one type all at once (AAABBBBCCC)
  - Math formulae: faces, edges, corners, and angles (Taylor & Rohrer, 2010)
  - Sports performance: curveballs, fastballs, and change-ups (Hall, Dominguez, & Cavazos, 1994)
  - Music performance: learn three different melodies intermingled
  - Learners feel that they are learning more effectively when training is blocked, but opposite is true!
Variability

- Introduce variability into training to achieve more robust learning, and particularly transfer to new situations
- Children who get usual (2 + 3 = ?) PLUS unusual (? = 2 + 3, 2 + ? = 5, 2 ? 2 = 4) forms get better conceptual understandings of addition than those who only receive usual forms
- Variability in targets or standing locations in dart throwing, basketball shooting, volleyball serving, tennis serving, etc. all show better performance to new situations than constant practice
- Vary settings in which learning takes place
- People often feel that they are learning more with constant practice (because learning is often FASTER), even though their future performance is better with variable practice
Idealization

- Concrete, hands-on materials are often useful for teaching but
- Children often get distracted by the physical forms and have a hard time seeing what is critically important
- Benefits for idealization: representations that simplify a concrete representation to its critical essence
- Idealization is particularly useful for transfer of learning to new situations that are superficially dissimilar
- Benefits of concreteness fading: starting with concrete, visually rich and distinctive materials, but becoming more idealized and symbolic over time
Idealized Concrete
Son, Smith, & Goldstone (2008)

Concrete Idealized
Kaminsky, Sloutsky, & Heckler (2008)

Concrete Idealized
McNeil, Uttal, Jarvin, & Sternberg (2009)

Concrete Idealized
Uttal, Liu, & DeLoache (2006)
Distance of food patch to closest ant

Concrete

Idealized

Transfer

Concreteness Fading
Dragon Box for Algebra Learning
Caricatures

• A caricature exaggerates distinctive features of an object
• Caricatures are typically identified faster than real objects
• Rats learn to discriminate light from dark gray better if first trained on white versus black than if simply given more training on same task
• Better learning /r/ vs /l/ discrimination if first give extreme examples compared to typical ones (McClelland et al., 2002)
• Good sequence: start with caricatures and move inwards
Advantages of caricatures
Advantages of Caricaturization
(Dror, Stevenage, & Ashworth, 2008)

Enhanced = caricatured
Desirable difficulties

- No pain, no gain: introducing certain difficulties into the learning process can improve long-term retention of the learned material.
- Previously described advantages of retrieval practice, distributed repetitions, interleaving, self-explanation, and variability fit this notion of making learners work harder to improve memory.
- General pattern: people think they are learning less when learning is hard (because their performance during learning is poor), but they are actually learning a lot.

- Using fonts that are slightly harder to read makes novel facts more memorable (Diemand-Yauman, 2010).
- Making learners generate word in pair salt: p_pp_r makes pair more memorable than just reading salt: pepper.