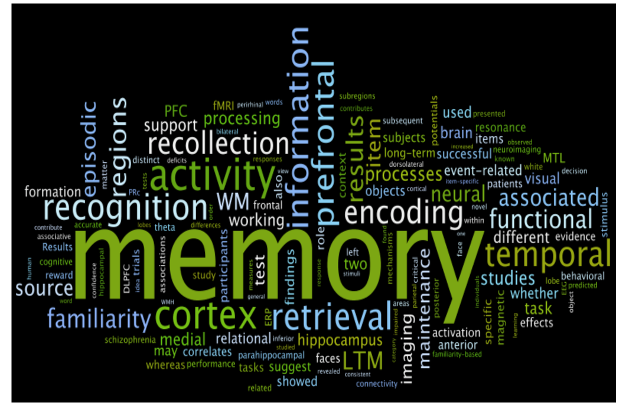
prev lecture: associative learning, stimuli, instrumental conditioning

Learning & Memory (Ch.17) II

- Taxonomies of Memory
  - Temporal stages of memory storage
- The hippocampus and memory
  - The case of HM
- Taxonomies of memory revisited
  - Types of information stored in memory
- Studies of hippocampus and memory in animals
  - Spatial/relational memory

patterns of activity have to be translated into neurons for memory systems to encode; requires attention

Memory



➢ Three key components

- **Encoding**: Getting sensory info into your brain by translating it into a neural code it can understand.
  - Typically requires attention
- **Storing**: Retaining information over time. Note that biological memories tend to be more "fuzzy" and fragile

Tend to use computer analogy, but this is inaccurate, our memory is far more imperfect

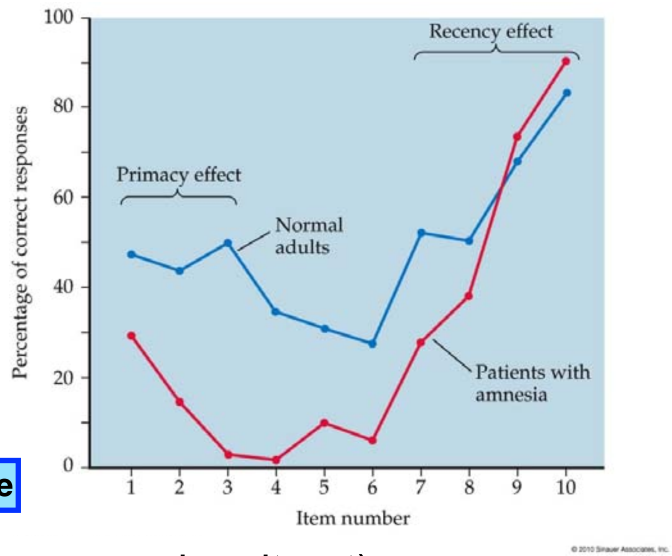
"best guess" at what actually happened, inc. shortcuts + filling in

- **Retrieval**: The active processes of locating and using stored information
  - Typically entails reactivated neural networks in a manner similar to how they were active when memories were encoded

free recall much harder than cued

  - Some forms of retrieval (e.g. free recall) are more taxing than others (cued recall, recognition)
- **Main points to understand about the neural basis of memory:**
  - ➢ 1) There are multiple forms of memory
  - ➢ 2) Different types of memory are regulated by distinct brain regions
  - ➢ 3) One type of memory is regulated by interactions between multiple brain regions

<u>Defining Memory by How Long it Lasts</u> (I)



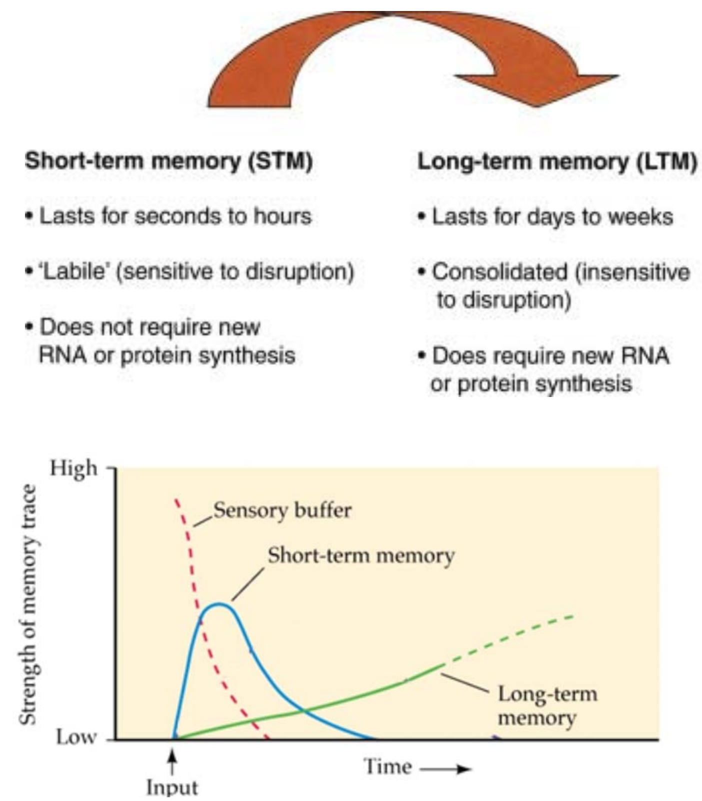
- **<u>Short-term memory</u>:** information held for short periods while physiological changes needed for long-term memory are made
  - Limited capacity (7 +/- 2 items) **5-9 items can be held at a time**
  - Susceptible to distraction, requires active rehearsal to maintain **chunking, etc. can improve**
  - Information loss occurs through displacement (something new pushes it out) or through decay.
  - Info in short-term memory either gets discarded or moves to other stage of memory
    - Primacy/recency memory effects support this distinction- you tend to remember items at the beginning or end of a sequence better than items in the middle

Summary
limited capacity, labile + susceptible to distraction, + either bumped out or transitioned to long term

Defining Memory by How Long it Lasts (II)

- **Long-term memory:** relatively stable, can last lifetime of organism
  - Potentially unlimited capacity
  - Can be active or passive; Sometimes we study to remember information, other times just witnessing events ingrain it into memory
  - Information can be forgotten or recalled inaccurately

- **Consolidation:** transferring of information from short to longer-term memory
  - involves physical changes in the way neurons are connected and/or communicate with each other



physical changes make it easier to reactivate that memory

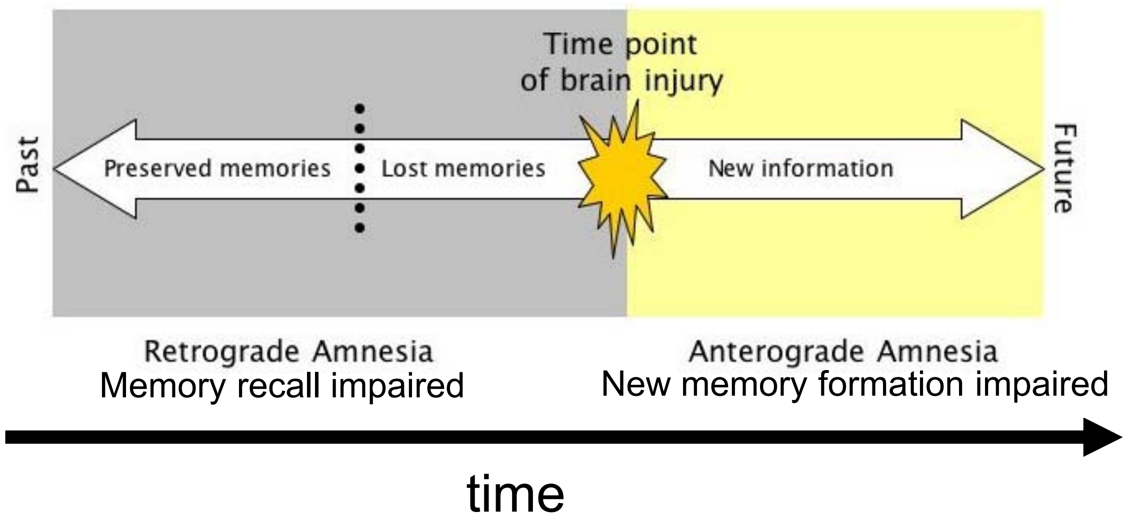
Amnesia

- Certain brain injuries or drugs can impair the encoding, consolidation or retrieval of long-term memories (amnesia)

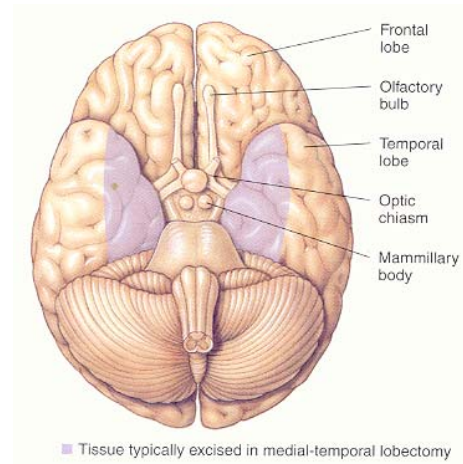
characterized by type of info lost relative to time of brain injury

- Categorized by information lost *relative to the time of brain insult*
  - Loss of memory for events just prior to an injury is called **Retrograde Amnesia** (information did not get from short-term memory into long-term memory).
  - An inability to form new memories after an injury is called **Anterograde Amnesia**

retrograde amnesia = movie amnesia

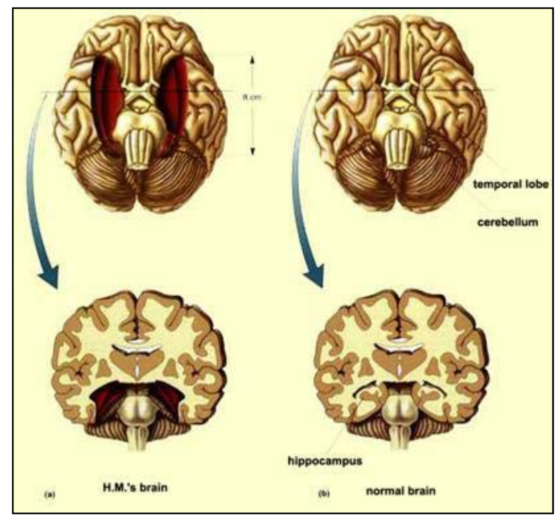


Patient H.M.



- Henry Molaison (H.M.) had intractable epilepsy, seizures originating bilaterally in medial temporal lobes
- Surgeons remove both medial temporal lobes. Included most of the **hippocampus**, **amygdala**, and adjacent **temporal cortex**.
- **Post surgery**: seizures were all but eliminated by the surgery. (IQ actually increased from 104 to 118 post-surgery)
- First (and last) patient to have bilateral temporal lobectomy-it caused severe **anterograde amnesia**. He could not form new memories.
  – Also showed retrograde amnesia for ~3 years prior to surgery
- H.M. had normal short-term memory, but couldn't transfer information to long-term memory. Everything was forgotten the moment his attention shifted.

30 second loop; talking about his gun collection, he would only talk about the same 2-3 guns



HM normal

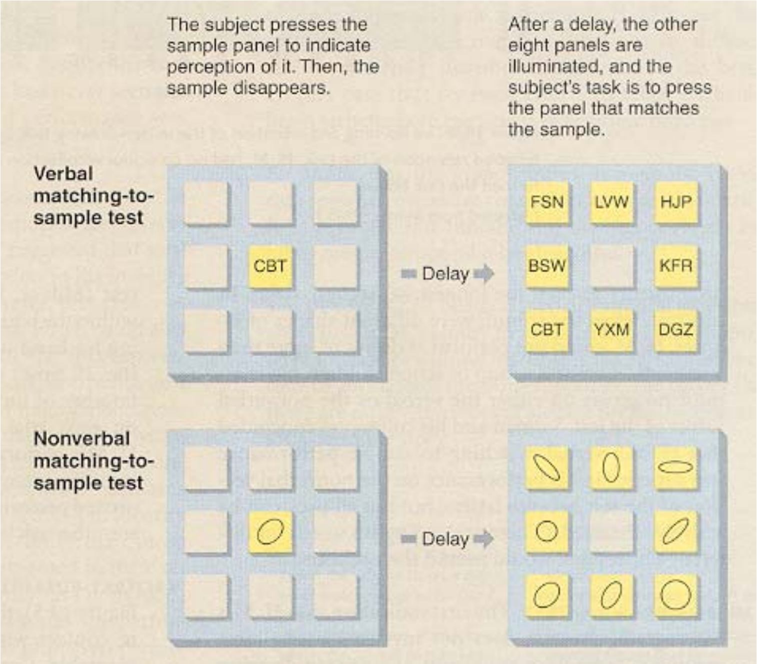
What H.M. Could Not Do

- **Digit Span + 1 Test**: present 5 digits, have subject repeat back correctly. Keep adding number of digits to remember until subject makes errors.
  - H.M. could do up to 8 digits –relatively intact short term memory.

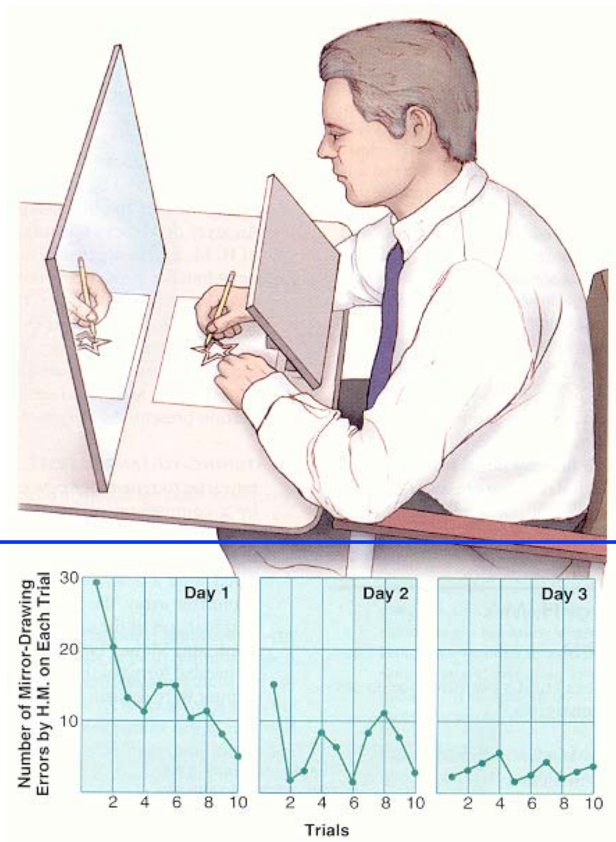
5-40 second delay

- **Matching to Sample:**
  - Longest delay used is 40 seconds. H.M. had no difficulty if allowed to repeat the letters. Distract him, impairment
  - Impaired on non-verbal version of this test. Intervals greater than 5 seconds disrupt his ability to do task b/c he cannot easily use repetition to remember the sample

was repeating letters over and over until recall



What H.M. COULD do



- H.M could learn a variety of motor skills, but COULD NOT recall learning it

somewhat difficult; drawing in reverse takes some practice

- **E.g.: Mirror Drawing Task**: subject must redraw object from reflection in mirror.
  - H.M.'s performance on the task improved over a 7-day period even though **he claimed never to have seen the task before each of the 7-days**.
- Thus, he COULD form some types of long-term memories **(NONdeclarative or procedural memories)**
  - Patients with damage to the **striatum** show the opposite pattern of deficits, cannot learn new skills, but remember the events
- He could ALSO *gradually* learn new facts (semantic memories), but could not recall learning them

could eventually learn how old he was (from repeatedly seeing self in mirror)

left notes for self, could eventually become long-term memories

would make up reasons why he was good at task despite "never doing it before"

striatum damage; cannot learn new skills but remember trying them (opposite HM)

H.M. Summary

2-stage model not proven prior to HM

- Poor performance on long-term, but not on short-term memory tasks
  – supports the two stage model for memory formation.

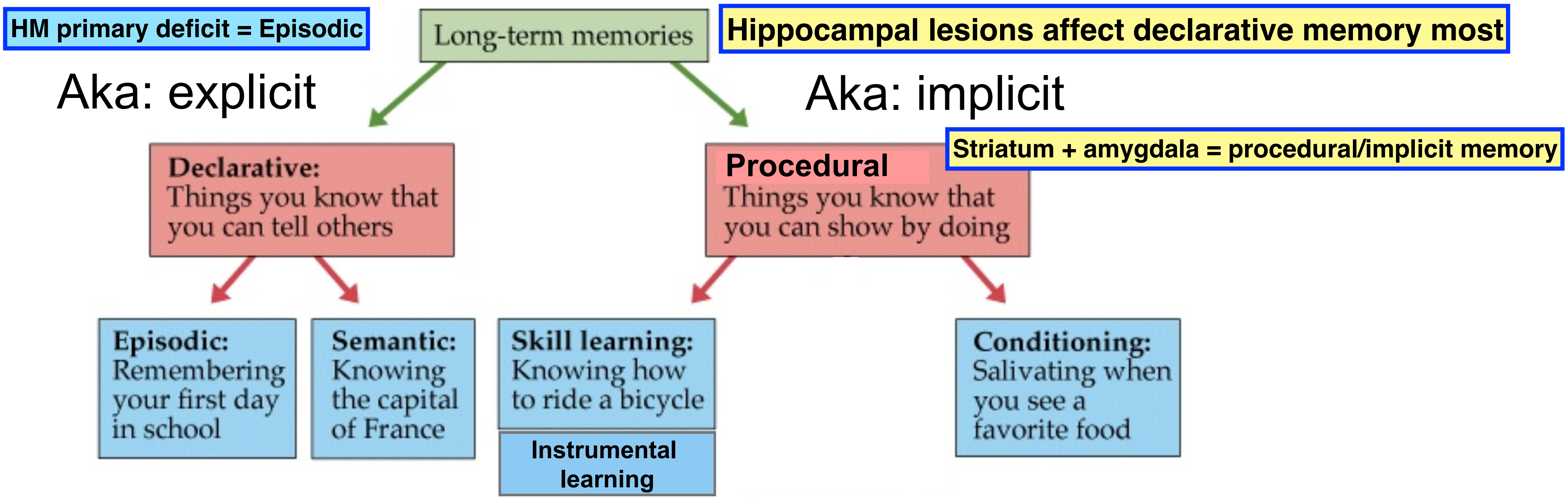
- Main problem was consolidating new memories from short-term to long-term storage.
  – Suggests that memories can be stored elsewhere, but the **hippocampus** is crucial for converting memories to long-term storage

Hippocampus = consolidator of most memory types

however…
Skill learning not mediated by hipp.

- H.M. could learn some types of tasks (e.g. skill learning) Thus…
  – 1) not all types of learning and memory are mediated by the hippocampus
  – 2) memory systems can be dissociated by the **type** of information being stored (as well as how long it lasts)

Defining Memory by Type of Info Stored



•We now know hippocampal lesions in humans cause a selective deficit in **declarative (or explicit)** memory, and leave procedural (non-declarative **implicit**) memory intact

•Regions such as the striatum (skill/instrumental learning) and amygdala (conditioning) mediate certain types of procedural memory

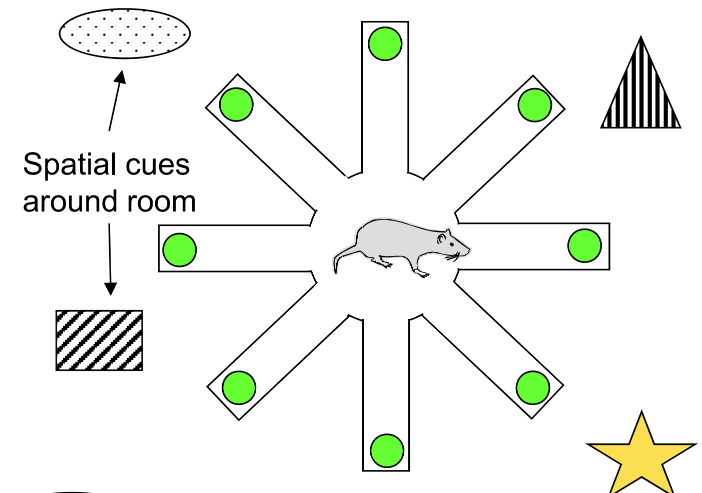
•This is primarily for human memory: animals cannot "declare" what they remember

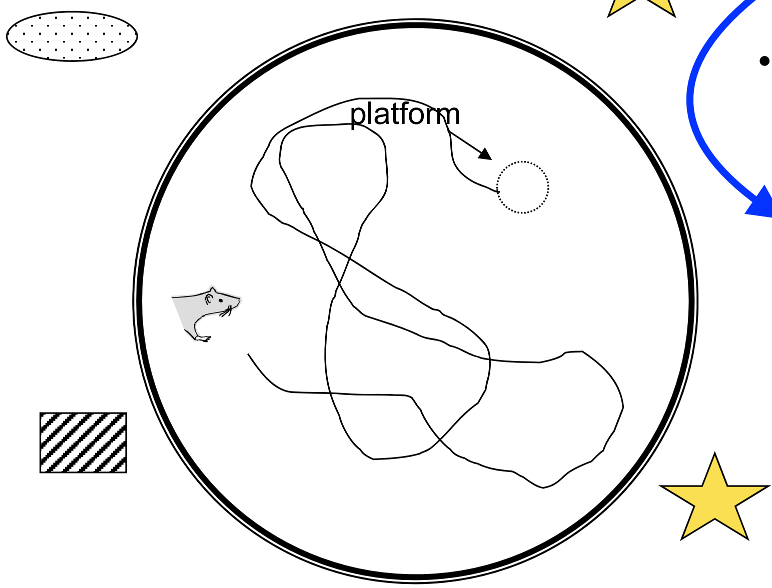
relative location of 2 or more stimuli– spatial cues– is how rat navigates piece of food at end of each arm: normal rats don't return to arms they've already been

Stan is expert in radial arm maze

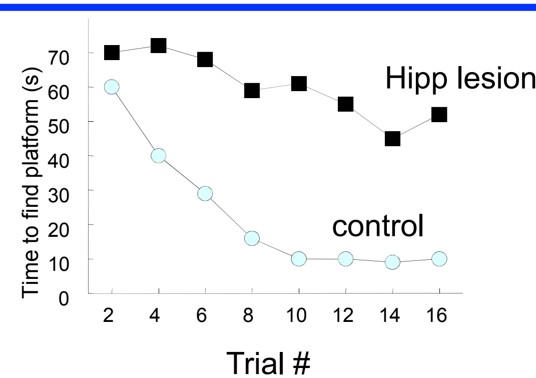
usually just check one arm at the end after all empty (aka make 1 error)–although this is just to postpone returning to cage :) not looking for food

Hippocampus and Spatial Memory



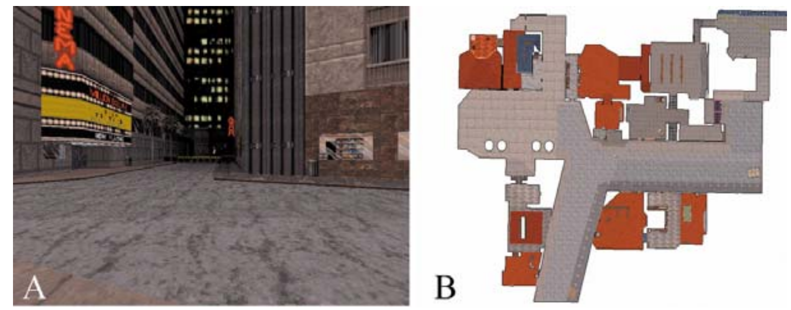


- Radial Arm Maze: rat navigates around maze to locate food using spatial cues around room
  - Rats remember where they've been, do not re-enter arms
  - Hippocampal lesions cause rats to make more errors – keep re-entering arms they've been to
- Morris Water Maze: pool filled with opaque water: escape platform hidden under surface
  - Rat must use spatial cues to navigate to platform
  - Normal rats learn to find platform quickly
  - Hippocampal lesioned rats never learn to find **hidden** platform efficiently (but no impairment if platform is visible)
- **The hippocampus is critical for learning about relationships between different stimuli**

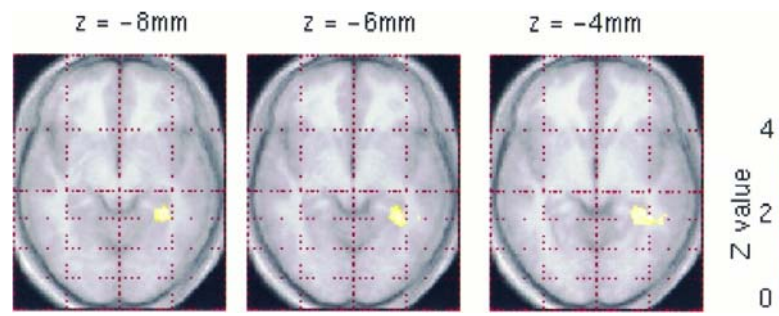


Human Hippocampus and Spatial Memory

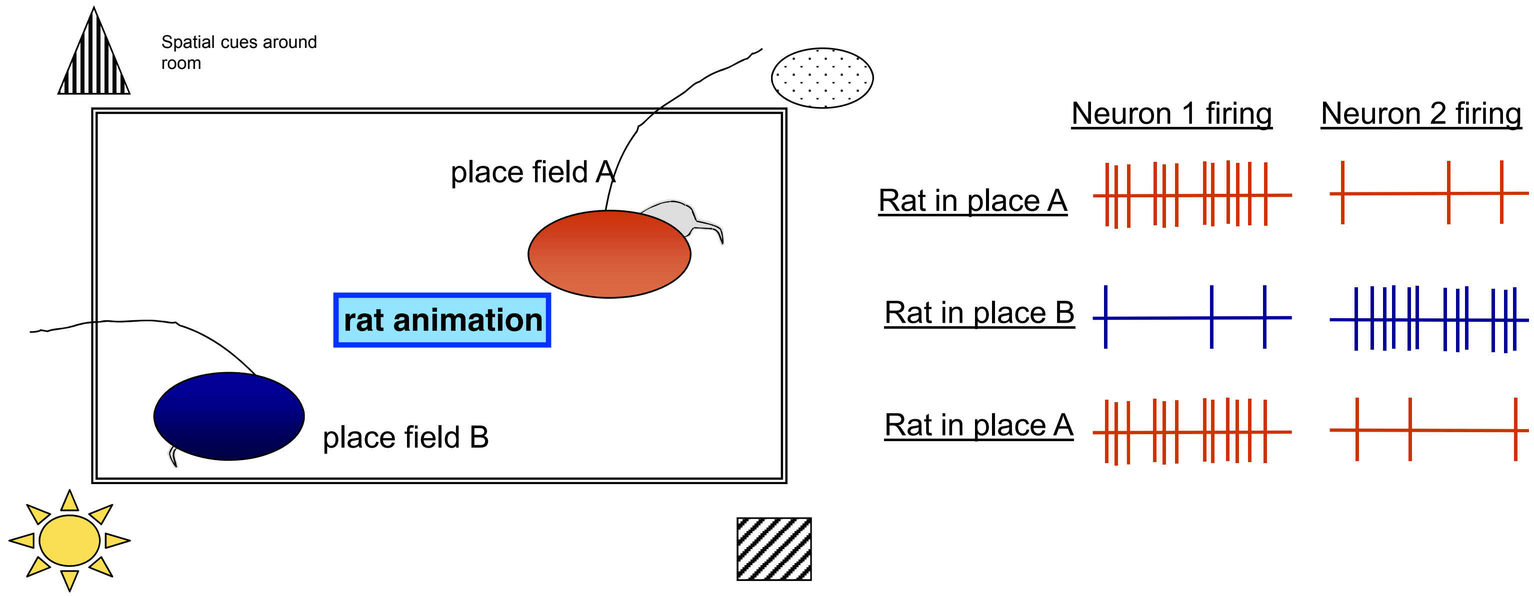
- Studies using virtual 3-D environments:
  - Humans w/ hippocampal damage are impaired when navigating through space and remembering routes
  - Imaging studies in healthy individuals show increased activity in hippocampus when people learning routes in virtual environment



- Taxi drivers show ↑ hippocampal activation when recalling taxi routes
  - Recall of landmarks that drivers did not know = no hippocampal activation



Hippocampal "Place Cells" (I)



- Different hippocampal neurons fire preferentially when animal is in one particular location (called a "place field)
  - Separate groups of cells encode for different locations in environment
  - Reorienting spatial cues causes place fields to reorganize (neurons fire in different locations relative to the position of the different cues)

place fields shift in accordance with spatial cues

Rat video

Hippocampal “Place Cells” (II)

- Different hippocampal neurons fire preferentially when animal is in one particular location
  - Recordings from multiple neurons simultaneously show that hippocampus forms a “map” of the environment
  - Manipulations that disrupt place cell firing disrupt spatial navigation and spatial memory
  - **Firing of hippocampal neurons encodes relations between different stimuli in the environment**

Activity of 8 different hippocampal neurons
(red=high activity blue=low activity)