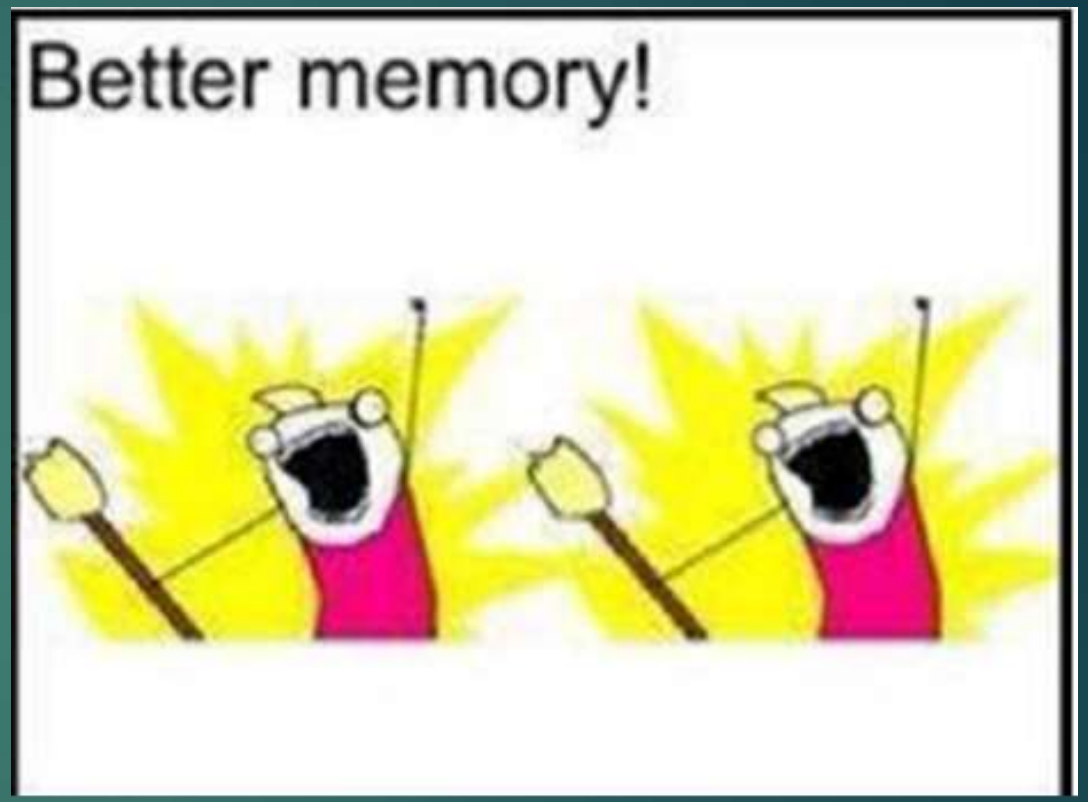
How We Learn: Memory & the Brain

or Where did I put those keys?

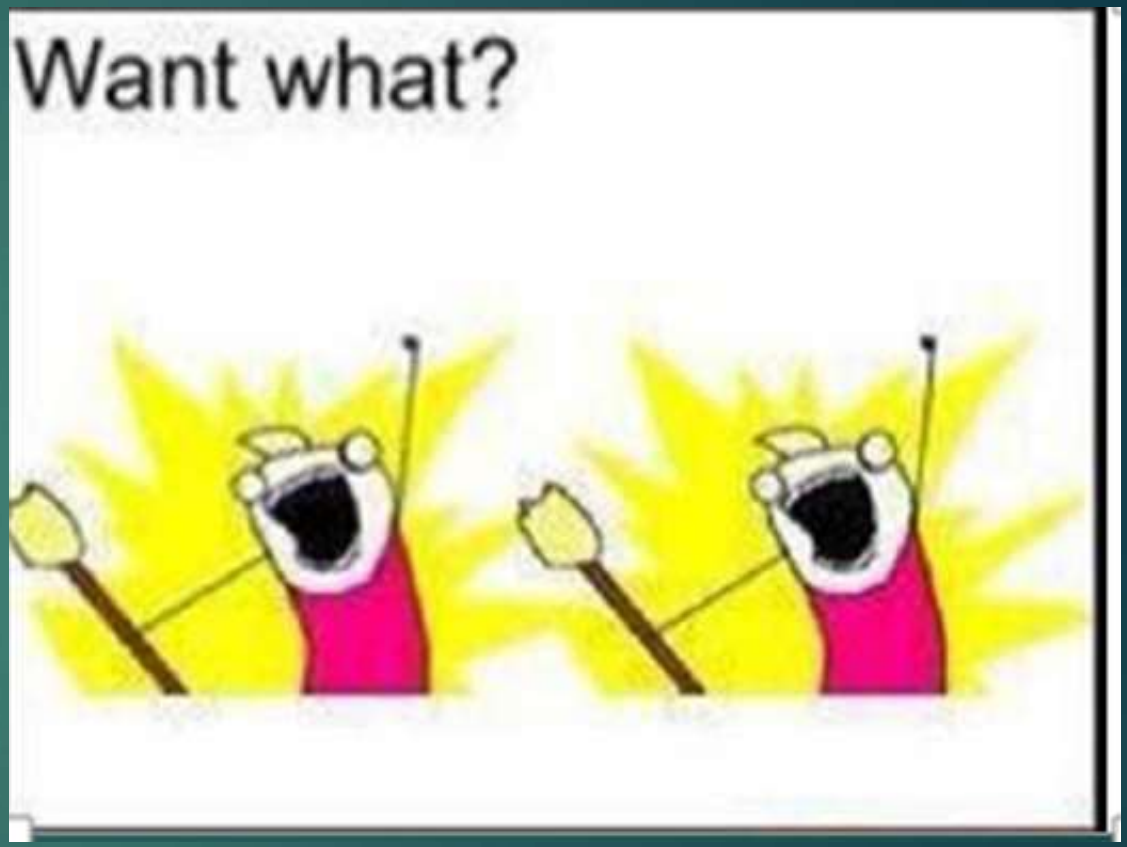
CHARLES J. VELLA, PHD

2018


What do we want?


Better memory!


When do we want it?


Want what?

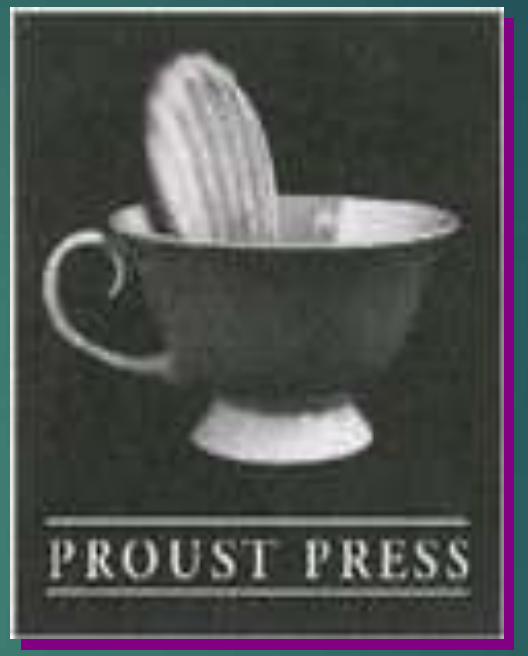
Proust & his Madeleine: Olfaction and Memory

"I raised to my lips a spoonful of the tea in which I had soaked a morsel of the cake. No sooner had the warm liquid mixed with the crumbs touch my palate than a shudder ran trough me and I sopped, intent upon the extraordinary thing that was happening to me. An exquisite pleasure invaded my senses..... And suddenly the memory revealed itself. “

Marcel Proust

À la recherche du temps perdu (known in English as: *In Search of Lost Time* or *Remembrance of Things Past*):

7 Volumes, 4000 pp.



Proustian Effect: fragrances elicit more emotional and evocative memories than other memory cues

Study: Proustian Products are Preferred: The Relationship Between Odor-Evoked Memory and Product Evaluation: Lotions preferred if they evoke personal emotional memories

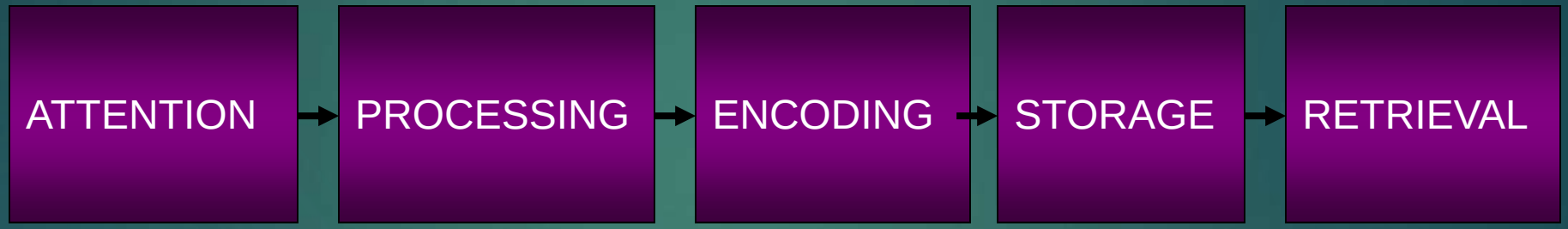
Memory

- Determines your sense of self
- Determines your ability to plan for future
- Enables you to remember your past

Learning: Ability to learn new things

Learning is a restless, piecemeal, subconscious, sneaky process that occurs all the time, when we are awake and when we are asleep.

Older Explanation of Memory



William James: *"My experience is what I agree to attend to.“*

Tip #1: There is no memory without first paying attention.

Multiple Historical Metaphors for Memory based on then current technology

- In Plato's Theaetetus, metaphor of a stamp on wax
- 1904 the German scholar Richard Semon: the engram.
- Photograph
- Tape recorder
- Mirror
- Hard drive
- Neural network

False Assumption: perfect image or recording, lasts forever

Purpose of Memory

- We think of memory as a record of our past experience.
- But the idea is not just to store information; it's to store relevant information.
- Memory is the use of our experience to guide future behavior.
- We process memory in order to solve problems and to do social interactions.
- Things we should learn from, things that are particularly important or that have strong emotions tied to them, may be things that are going to be important in the future.
- What's important for future behavior

Evolution of Memory

- Memory evolved, via natural selection, to enhance survival and reproductive fitness.
- Events that potentially effected our survival lead to superior long-term retention, i.e. visual and traumatic memory.
- Memory is constructive, especially sensitive to visual imagery and processing of meaning.
- Memory is inherently associative; we link new info to what we know.

J. Nairne & J. Pandeirada, Cur. Dir. In Psy. Sc., 2008

Cambrian: 500 MYA

- Olfaction (smell), locomotion & spatial position initially drove the development of memory
- Hippocampus (brain's memory central) is highly connected to smell
- Hippocampus has place (spatial) cells
- It specializes in connecting new to old information

Evolution of Memory 2: We have a primate brain

On African savannah, 2 M years ago*, Homo erectus*: Hunted, gathered, avoided predators; Memory = Survival

- Used all Sensory systems: Touch, Vision, Smell, Hearing, Taste
- Visualspatial location memory for food location and predator detection
- Visual & emotional memory for any past trauma (predator avoidance)
- Visual & olfactory memory of foods, esp. those that make you sick
- Recall ability for only few dozen members of our group: facial recognition; memory for socially appropriate, moral, behavior; sexual interaction
- Context was everything: more visual context, more cues, better memory
  - Memory still works this way

Memory now:
Tasks not evolved for, but now need to remember

- Dates
- Names
- Social Security number
- Telephone numbers
- Addresses
- Facts for an exam
- Pin codes
- Shopping lists
- Facebook friends
- Parking lot floor number

Tip #2: Best way to remember things is to encode them into the format that your primate brain was good at processing (use visual & contextual images).

Tip #3: Using categories increases memory

- Remember: chair, tiger, couch, elephant, bookcase, lion, table, zebra

  - Remind yourself of the category:
  - Furniture: chair, couch, bookcase, table
  - Animals: tiger, elephant, lion, zebra

Memory: A Current Review

Memory: The most common neurological complaint

Memory: The foundation of cognition and self identity

Memory: Not a unitary process

Multiple memory systems with different brain sites

Diverse Nomenclature

Memory: A reconstruction, not a replay, reproduction or perfect image

Memory is not one thing or in one place in your brain; it is not a single process

There are patients who exhibit memory dissociations:

1 – No new factual learning, but normal behavioral learning

2 – Impaired short term Working Memory, but normal long term memory (LTM)

3 – Impaired LTM, but normal Working Memory

4 – No recognition memory of vegetables, but intact knowledge of how to cook them

5 – No knowledge of inanimate objects, but normal knowledge of animate objects

6 – New skill learning (i.e. riding a bicycle), but failure to remember where, when, and under what conditions skill was learned.

Memory in the Movies

Best film on amnesia;
Error: Planning

Error: Engram
Location

Rashomon:
One of the Great films of all time:
Whose memory is correct?

Amnesia in the Movies

- **Rashoman**
- **Spellbound (Peck & Bergman)**
- **Anastasia**
- **Paycheck**
- **Memento**
- **50 First Dates**
- **Bourne Identity**
- **Long Kiss Goodnight**
- **Manchurian Candidate**
- **Eternal Sunshine of the Spotless Mind**
- **Finding Nemo**
- **The Majestic**
- **Mulholland Drive**
- **Paris, Texas**
- **The Lookout (accurate)**
- **Unknown White Male (Fugue)**

Memory on TV & in the Movies

- Most amnestic (inability to remember) conditions in films bear little relation to reality.

- Although clinically rare, profound amnesia is a common cinematic device

S. Baxendale, *BMJ*. 2004:
“Memories aren't made of this: amnesia at the movies”

Memory on TV & in the Movies 2

- In the movies, **Traumatic Brain Injury results in a profound loss of memory for the past with intact new learning**,
  - the **exact opposite of neurologically based amnesia** (no new learning and a small loss of past memories)

- At the cinema, **two head injuries are better than one**. One of the commonest "cures" for an amnesic syndrome sustained as a result of a severe head injury is another head injury.

- In most films **memories are not lost, just made temporarily inaccessible**. Recovery of memory is possible, via various unlikely means.

Long Term Memory: Human Brain's Memory Capacity

Number of Neurons: 86 billion

Number of Glial Cells: 86 billion

Number of neuronal synapses: 10^{13} (10 trillion)

Number of neuronal impulses transmitted in a lifetime: 10^{23} (100 sextillion)

For comparison: Library of Congress has only 32 trillion bytes of info in 530 miles of selves

Our brain could hold 3 million TV shows

LTM: storage of vast amounts of information, coded by perception and meaning; no upper limit; we never run out of memory space

Simonides of Ceos: Inventor of the Memory Palace/method of loci

- Greek lyric poet (556-468 BC): Classic tale of his attending a banquet where he recited a poem and then was called out by 2 visitors; banquet hall roof collapsed killing everyone inside; all bodies crushed beyond recognition.
- Bereaved relatives could not identify any of the bodies until Simonides returned and correlated their identities to their positions (*loci* in Latin) at the main table before his departure.
- He later drew on this experience to develop the 'memory theater' or 'memory palace', a system for mnemonics.
- According to Cicero, Themistocles wasn't much impressed with the poet's invention: "I would rather a technique of forgetting, for I remember what I would rather not remember and cannot forget what I would rather forget."

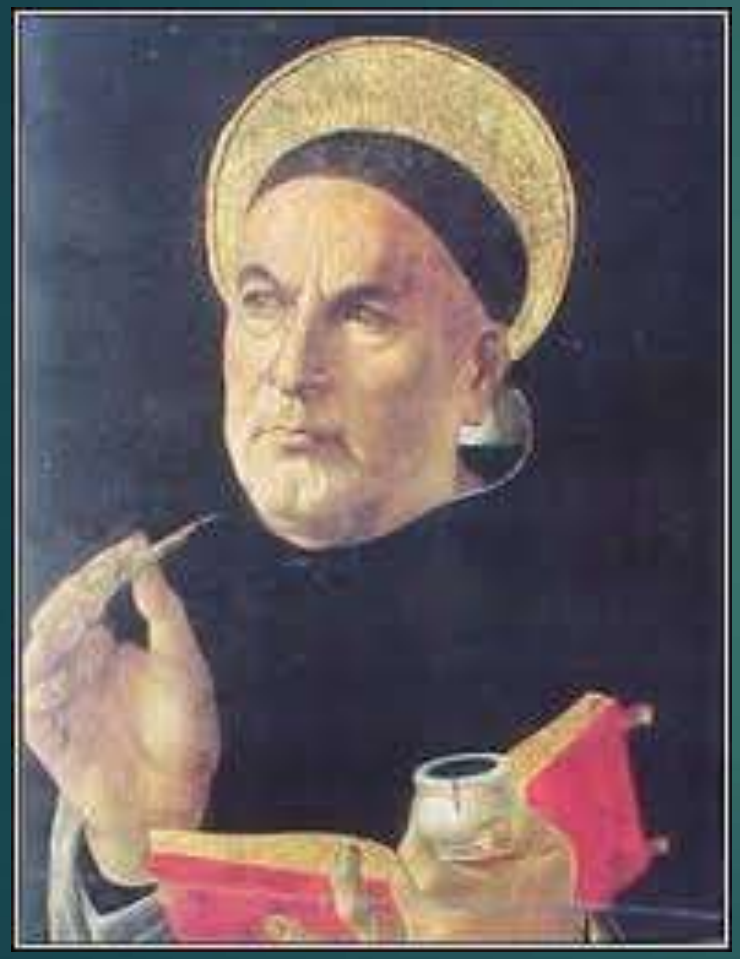
Most powerful memory technique: Method of loci

- The oldest known mnemonic strategy is called the method of loci ("loci" is the plural of locus, which means location, or place).
- It's based on the assumption that you can best remember places that you are familiar with, so if you can link something you need to remember with a place that you know very well, the location will serve as a clue that will help you to remember.
- It is possible to remember anything by associating it with a visual image of a location.
- Dating back to about 500 b.c., it was the most popular mnemonic system until about the mid-1600s, when the phonetic and peg systems were introduced.

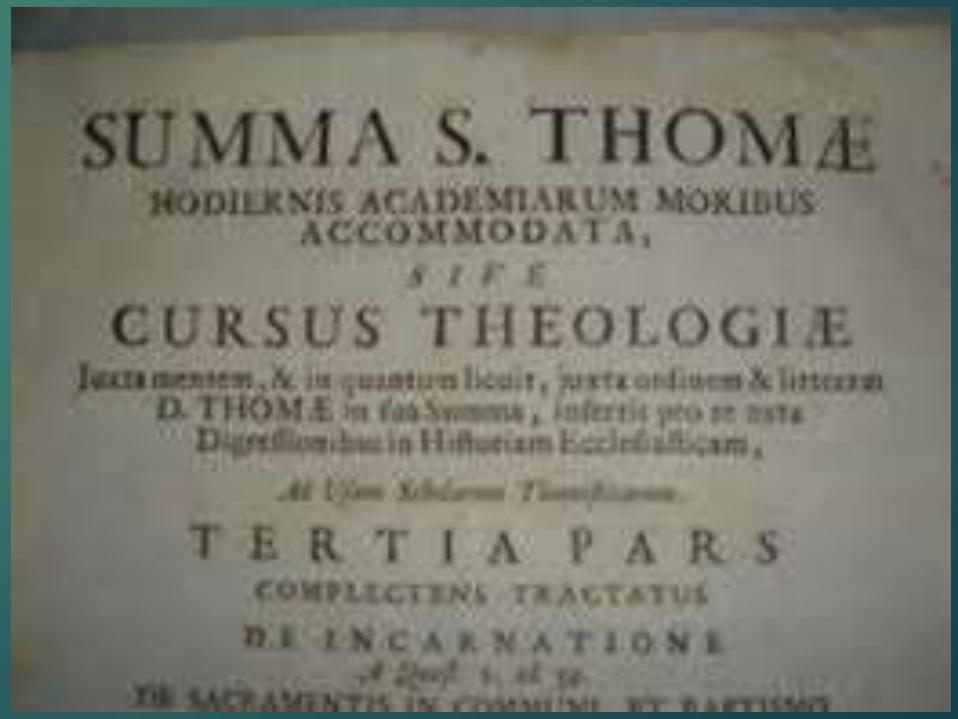
Tip #4: Method of loci

- Think of a place you know well, such as your own house.
- Visualize a series of locations in the place in logical order. For example, picture the path you normally take in your house to get from the front door to the back door. Begin at the front door, go through the hall, turn into the living room, proceed through the dining room and into the kitchen, and so on. As you enter each location, move logically and consistently in the same direction, from one side of the room to the other. Each piece of furniture could serve as an additional location.
- Place each item that you want to remember at one of the locations.
- When you want to remember the items, simply visualize your house and go through it room by room in your mind. Each item that you associated with a specific location in your house should spring to mind as you mentally make your way through your home.
- Remember, the more creative and visually vivid your ideas, the better.

Thomas Aquinas: (1265–1274)
Lived during age of mnemonics



Dictated the *Summa Theologica* (3100 pp) from memory


SUMMA S. THOMÆ

HODIERNIS ACADEMIARUM MORIBUS ACCOMMODATA,

SIVE

CURSUS THEOLOGIÆ

Juxta mentem, & in quantum licuit, juxta ordinem & litteram D. THOMÆ in ejus Summa, insertis pro re nata Digressionibus in Historiam Ecclesiasticam,

Ad Usum Scholarum Thomisticarum.

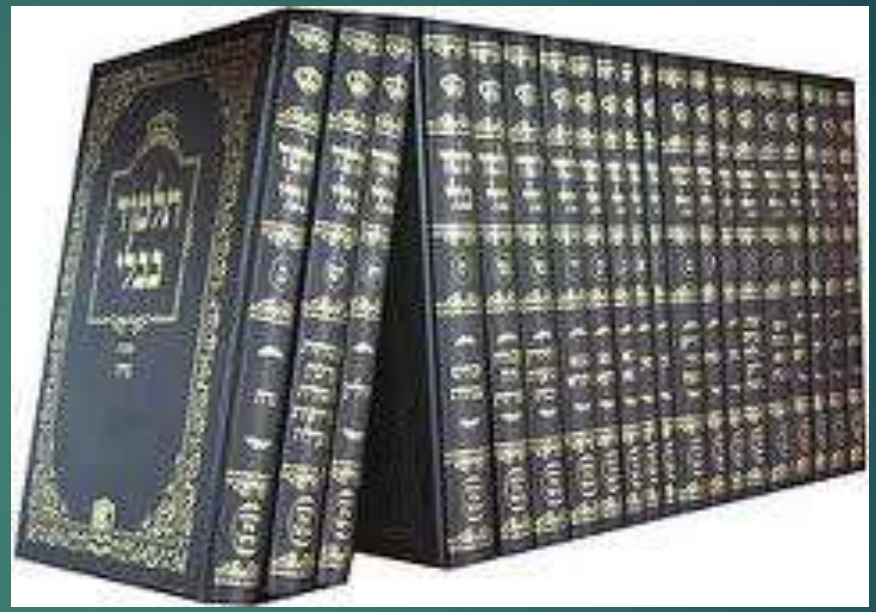
TERTIA PARS

COMPLECTENS TRACTATUS

DE INCARNATIONE

DE SACRAMENTIS IN COMMUNI, ET BAPTISMO

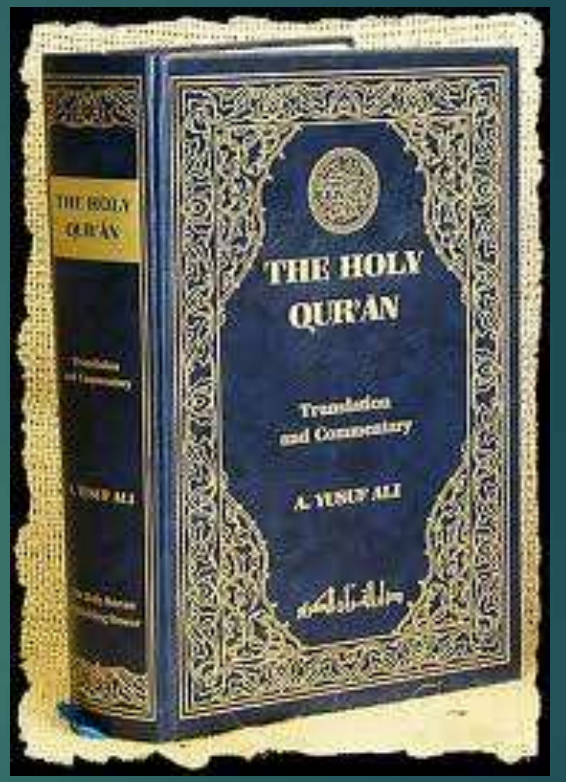
Jewish Talmudic Scholars:
Single minded perseverance in their studies



Stories of ultra-Orthodox Jews who memorized all 5,422 pages of the Babylonian Talmud so thoroughly that when a pin was stuck through any of the Talmud's 63 books, they could tell you which words it passed through on every page.

1917 *Psych Review*: group of Polish Talmudic scholars (Shass Pollak) who did this

Islamic Koran Scholars

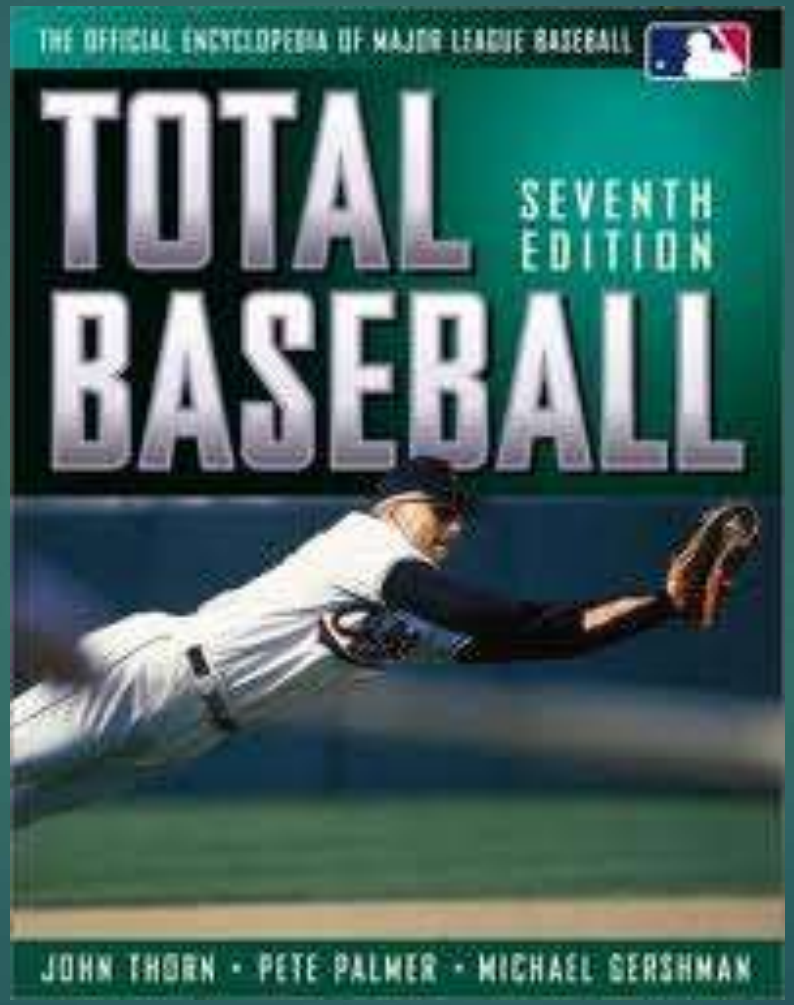


West African griots: Oral genealogists

Oral genealogists

Walking history books, preserving their ancient stories and traditions through song

Baseball fanatics



Great human memorization ability

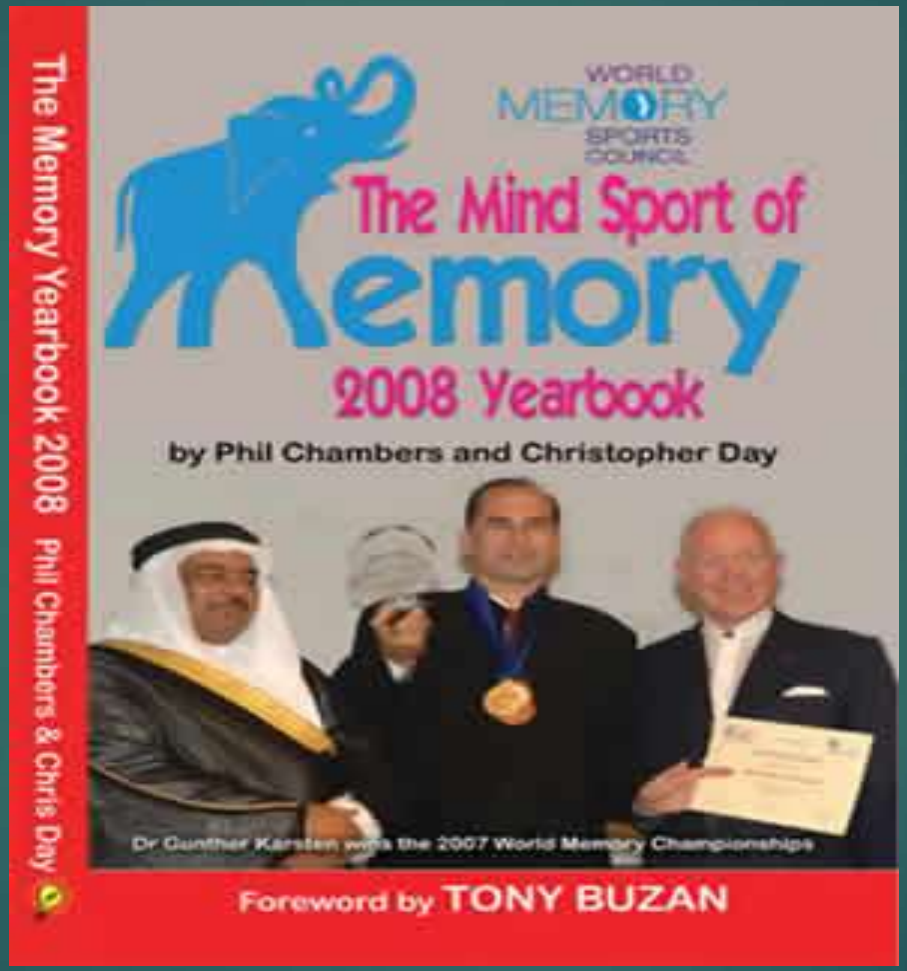
- Despite these prior examples of great memory ability, there is continuing question of whether there is such a thing as photographic or eidetic memory, without the use of mnemonics (learned memory techniques).

- Current opinion: photographic memory has never been scientifically demonstrated to exist.

That is what it takes to become a world memory champ.

Could you memorize the exact order of a deck of cards during the 53 seconds it takes elevator to get to the top of Empire State Building?

World Memory Championships



http://www.memorise.org/index.htm

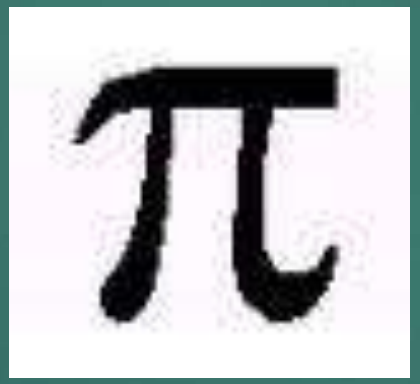
USA National Memory Championship

- March 13, 2007, New York: Joshua Foer memorized the order of a deck of cards in 1 minute 40 seconds
- World Champions: 1 deck in 30 seconds
- To attain the rank of grand master of memory, you must be able to perform three feats. You have to memorize:
  - 1,000 digits in under an hour,
  - Precise order of 10 shuffled decks of playing cards in the same amount of time,
  - 1 shuffled deck in less than two minutes.
  - 36 grand masters of memory in the world; but they have normal memory functioning otherwise
  - FMRI = R hippocampus activation

Moonwalking with Einstein - Joshua Foer

Greatest Feats of Memory

- Oct 4, 2006:
  - Akira Haraguchi, age 60,
  - Recited *Pi* to 100,000 decimal places from memory in 16 hours



  - Later forgot most of it
  - He assigned kana sound symbols to numbers, allowing for the memorization of Pi as a collection of stories.

Mnemonic Training (Memory Palace) Reshapes Brain Networks to Support Superior Memory

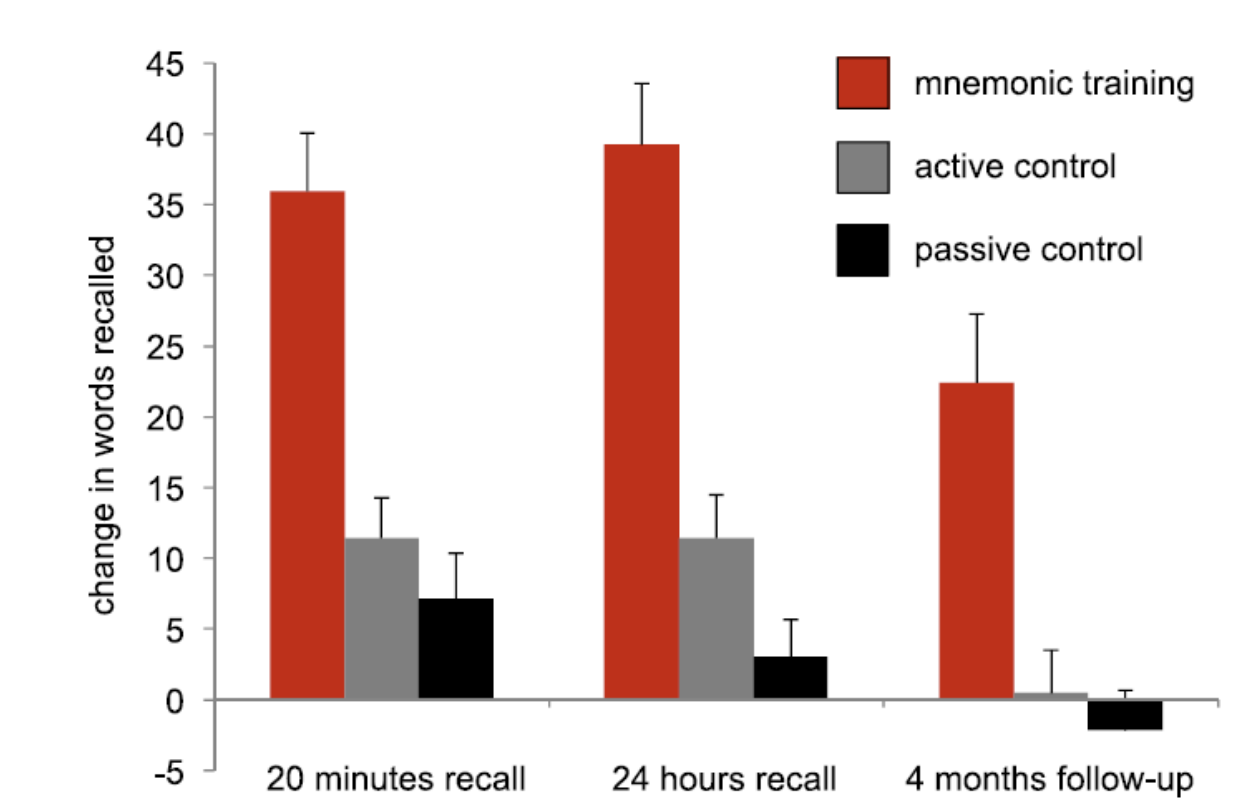


Figure 2. Mnemonic Training Has Potent and Enduring Effects on Memory Capacity

(https://memocamp.com/)

Mnemonic Training Reshapes Brain Networks to Support Superior Memory

- 2017 study: matched 23 elite memory champions with control subjects based on age, gender and IQ. Both groups underwent a series of brain scans including anatomical scans and functional magnetic resonance imaging (fMRI) during a resting state—one in which subjects were not doing anything—and during a memory task.
- Memory champions did not differ from the controls in any particular brain region, but rather had different patterns of brain connectivity (FC)during resting-state and task-based fMRI scans (medial & right dlPFC & memory areas/default mode network, visual networks, and the MTL)
- 2nd study: Experimental subjects underwent six weeks of intense memory training (https://memocamp.com/) for half an hour each day using the method of loci strategy still popular with memory champions: They learned how to map new information such as numbers or names onto familiar spatial locations such as those in their homes
- Experimental subjects improved significantly at memory tasks (whereas neither control group improved), yet did not exhibit any structural brain changes. Most robustly increased FC among the right DLPFC, the MPFC, and structures of the MTL in expert users of mnemonics and in naive subjects after mnemonic training.

Martin Dresler et al., Nature, 2017

Hyperthymesia: Super memory

- Solomon V. Shereshevskii: A journalist who never took notes. Editor was disturbed and sent him to Luria for testing.

- S. used two “strategies” or abilities typical of mnemonists:

  - Rich synesthesia-like quality to his perception of stimuli - leads to stronger associative links: sounds had shapes, colors; letters had taste, fragrance
  - Vivid and elaborate visual imagery of things he should remember

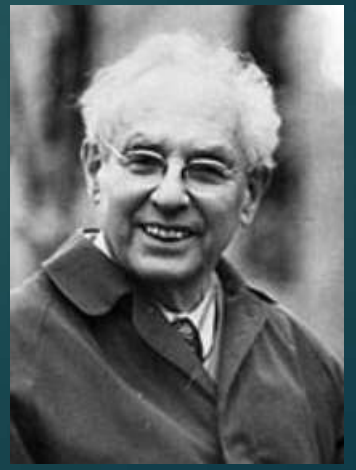
- Lacked normal forgetting filter. Had poor EF (problem solving).

Alexander Luria, *Mind of a Mnemonist*: Study of Russian Journalist, Solomon Veniaminovich Shereshevskii

6	6	8	0
5	4	3	2
1	6	8	4
7	9	3	5
4	2	3	7
3	8	9	1
1	0	0	2
3	4	5	1
2	7	6	8
1	9	2	6
2	9	6	7
5	5	2	0
x	0	1	x

Note: With only 2 to 3 min study of such a table, S. was able to reproduce it in reverse order, horizontally, or vertically, or to reproduce the diagonals.

Shereshevskii



Luria

Highly Superior Autobiographical Memory: Hyperthymestic syndrome: excessive (hyper) and remembering (thymesis)

- Jill Price, Brad Williams,Rick Baron, Bob Petrella, Marilu Henner, a star of the hit TV show 'Taxi'; 56 known
- What day of month did the Loma Prieta earthquake occur?
- All together in James McGaugh & Dr. Larry Cahill's lab: When he asked the group when a 7.1 earthquake hit the San Francisco-Oakland area, all replied, "October 17th, 1989."

- Perfect recollection of events of everyday of their lives
- Only 2 of 55 in the United States have successful marriages

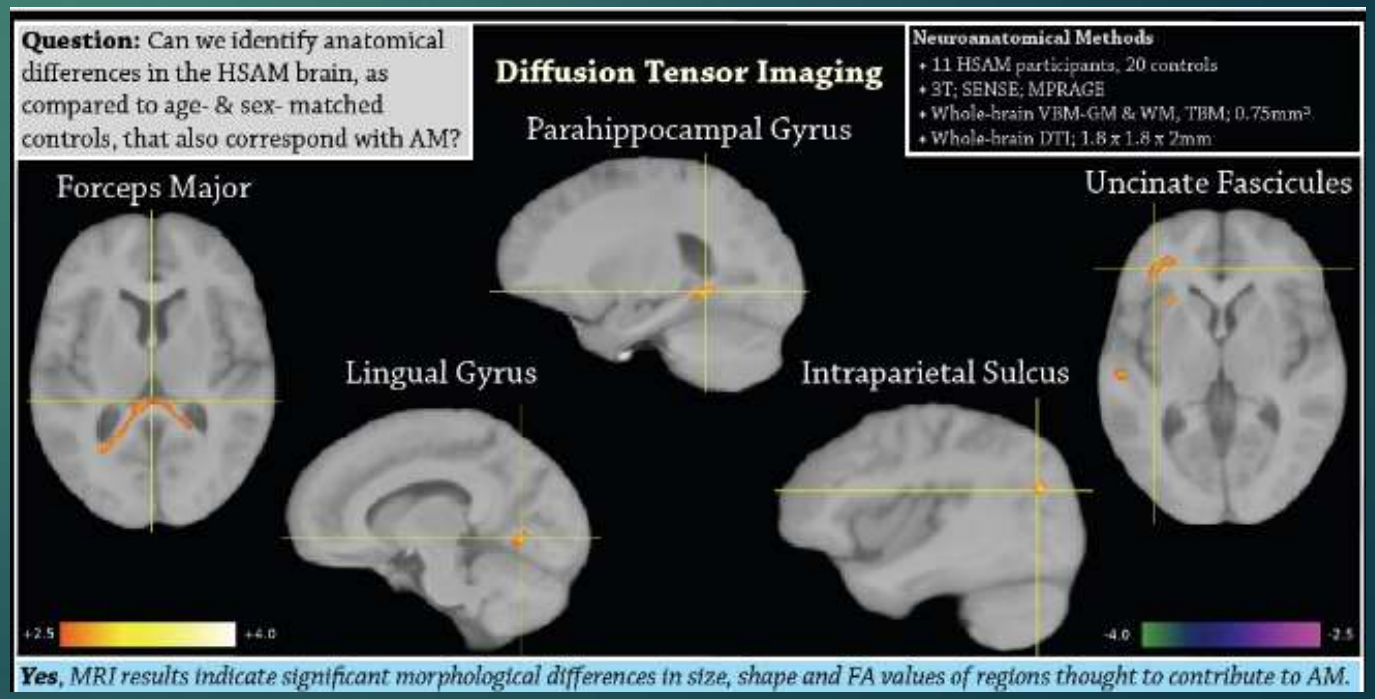
Interest in topic is important

(Parker, McGaugh, 2006; Cahill,)

HSAM: highly superior autobiographical memory

- Significantly larger left temporal-parietal junction & left posterior insula, as well as the lentiform nucleus (obsessive-compulsive disorder link).
- No particular ability underpins HSAM; HSAM had far superior memory of distant past; no better at acquiring memory (not superior learners); but are better at retaining memories; have habitual rehearsal of their past.
- Often show obsessive behavior (tendency to hoard things or avoid germs), though none have been diagnosed with OCD. They habitually recall and reflect on their lives; a unique form of OCD.

- They do not exhibit better cognition in other realms, incl. other forms of memory.
- Genetic



Severely Deficient Autobiographical Memory (SDAM)

- 3 healthy, high functioning adults with the reverse pattern: lifelong severely deficient autobiographical memory (SDAM) with otherwise preserved cognitive function.

- Self-reported selective inability to vividly recollect personally experienced events from a first-person perspective; no fMRI activation of normal areas for episodic memory

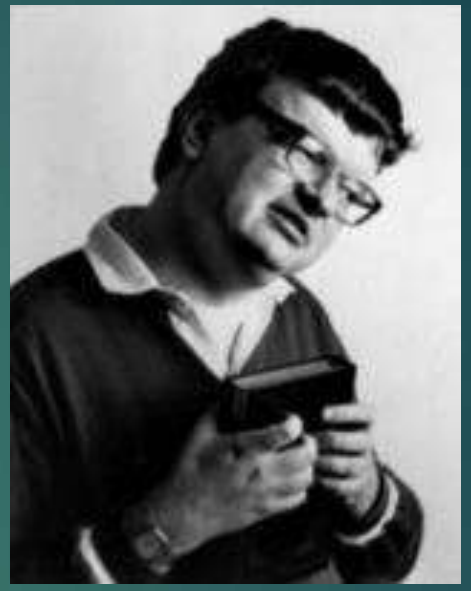
- With the exception of complex figure recall, standard neuropsychological measures of recognition, cued recall, and free recall were normal and even superior in some of the SDAM cases.

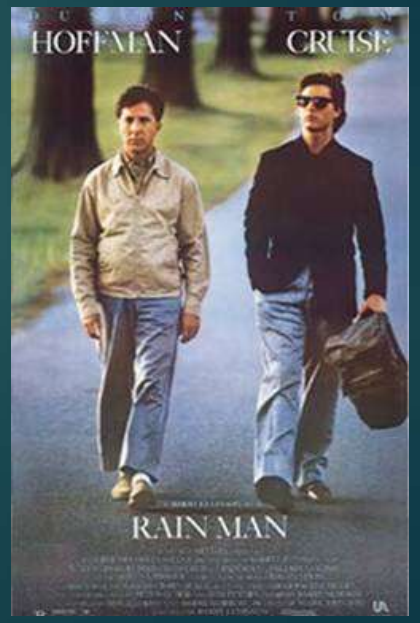
- Normal performance on everyday mnemonic tasks mediated by non-episodic processes.

Daniela J. Palombo, et al., , 2015

Rain Man: Autistic Savant Kim Peek

- Claim that he memorized every page of the 9,000-plus books he has read at 8 to 12 seconds per page (each eye reads its own page independently); never scientifically researched
- No corpus callosum
- Fewer than 25 prodigious savants living: Leslie Lemke (music), Alonzo Clemens (sculpting), Richard Wawro (painting), Stephen Wiltshire (drawing), Tony DeBlois (music)
- Non-normal brains: always profound memory ability in savants, with severe deficits in other cognitive domains



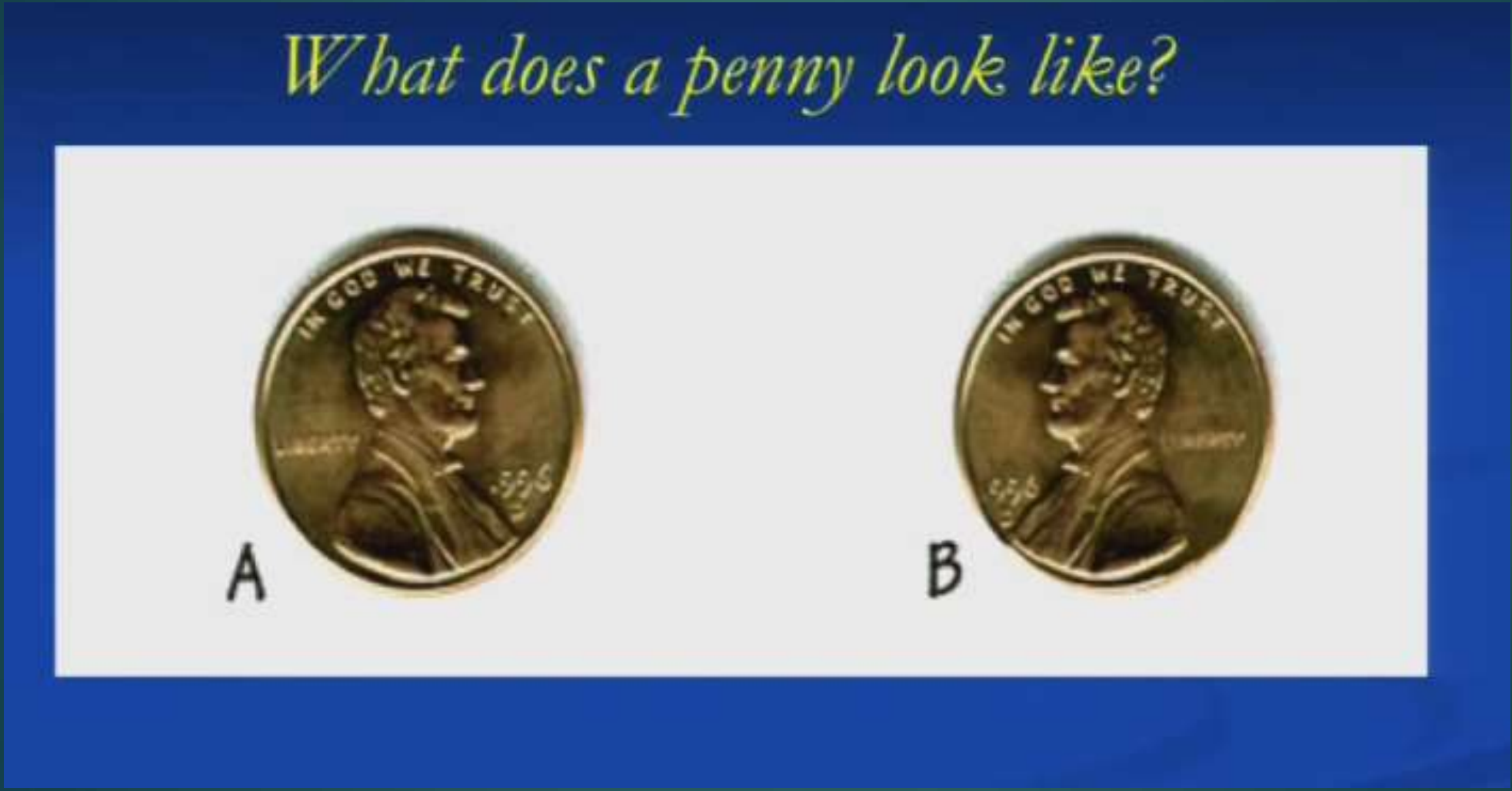


Artist Stephen Wiltshire Recreates View Of London After Just One flight over the city

Memory in Birds

- The Nutcracker and Western Scrub Jay (birds) can remember:
  - thousands of food cache locations over a year:
  - when and where they hide food,
  - whether they are being watched at the time.

Penny: Repeat encounters do not a memory make



And the correct answer…

All other US coins point to the left.

Answer: A

Memory Task

Read List 1

What was the main theme of the words?

40% of people include “sleep” for List 1 if asked to remember the list

List 1

Bed
Rest
Awake
Tired
Dream
Wake
Snooze
Blanket
Doze
Slumber
Snore
Nap
Peace
Yawn
Drowsy

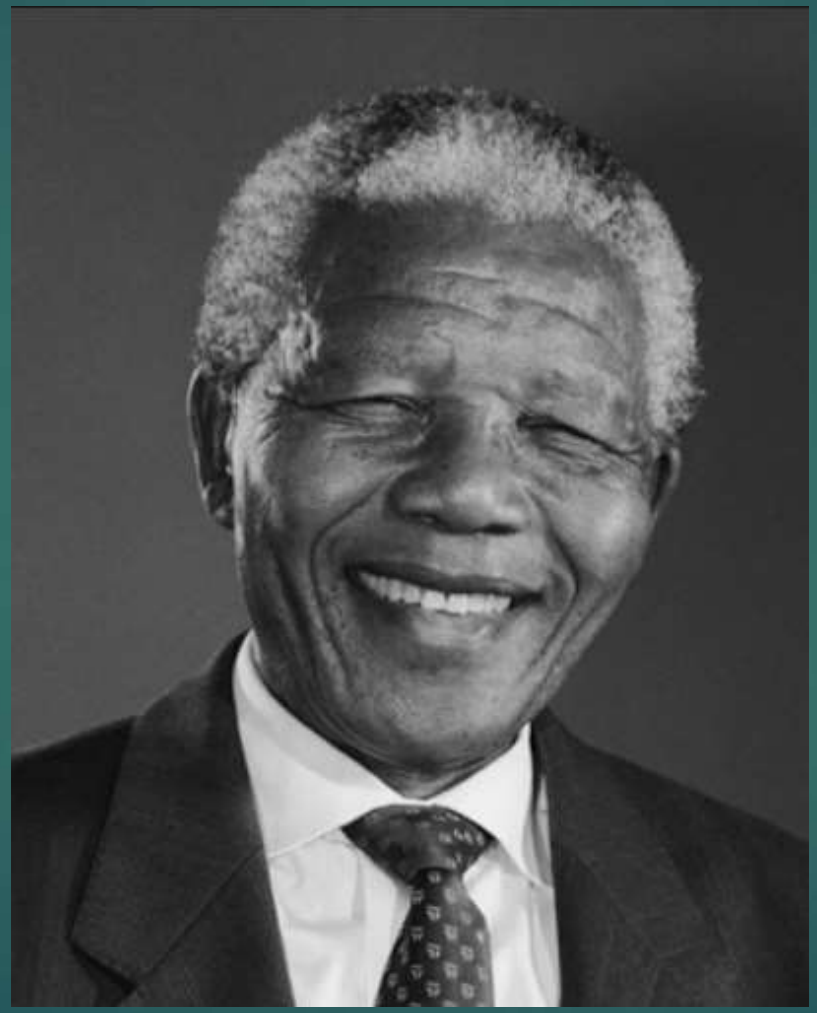
Example of creating false memory

Your memory is amazing

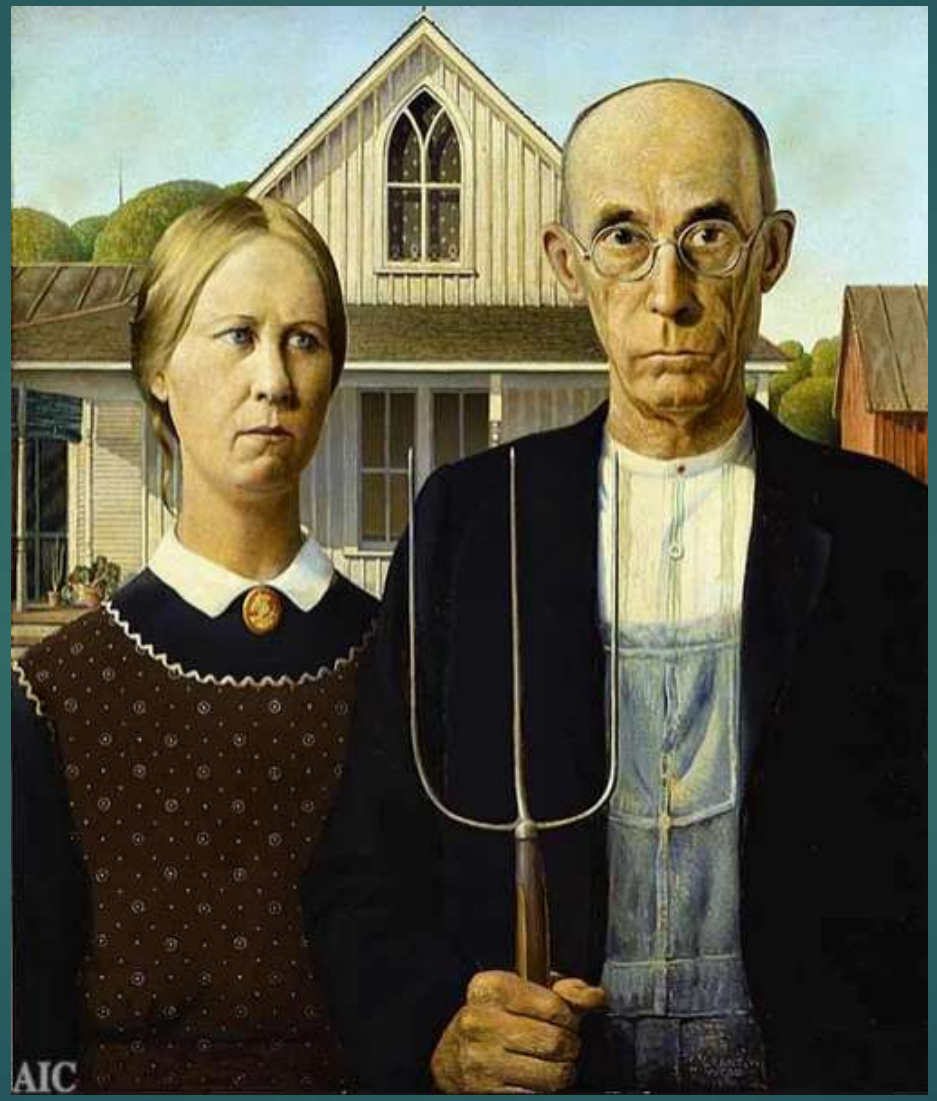
I want you to look at 15 pictures.

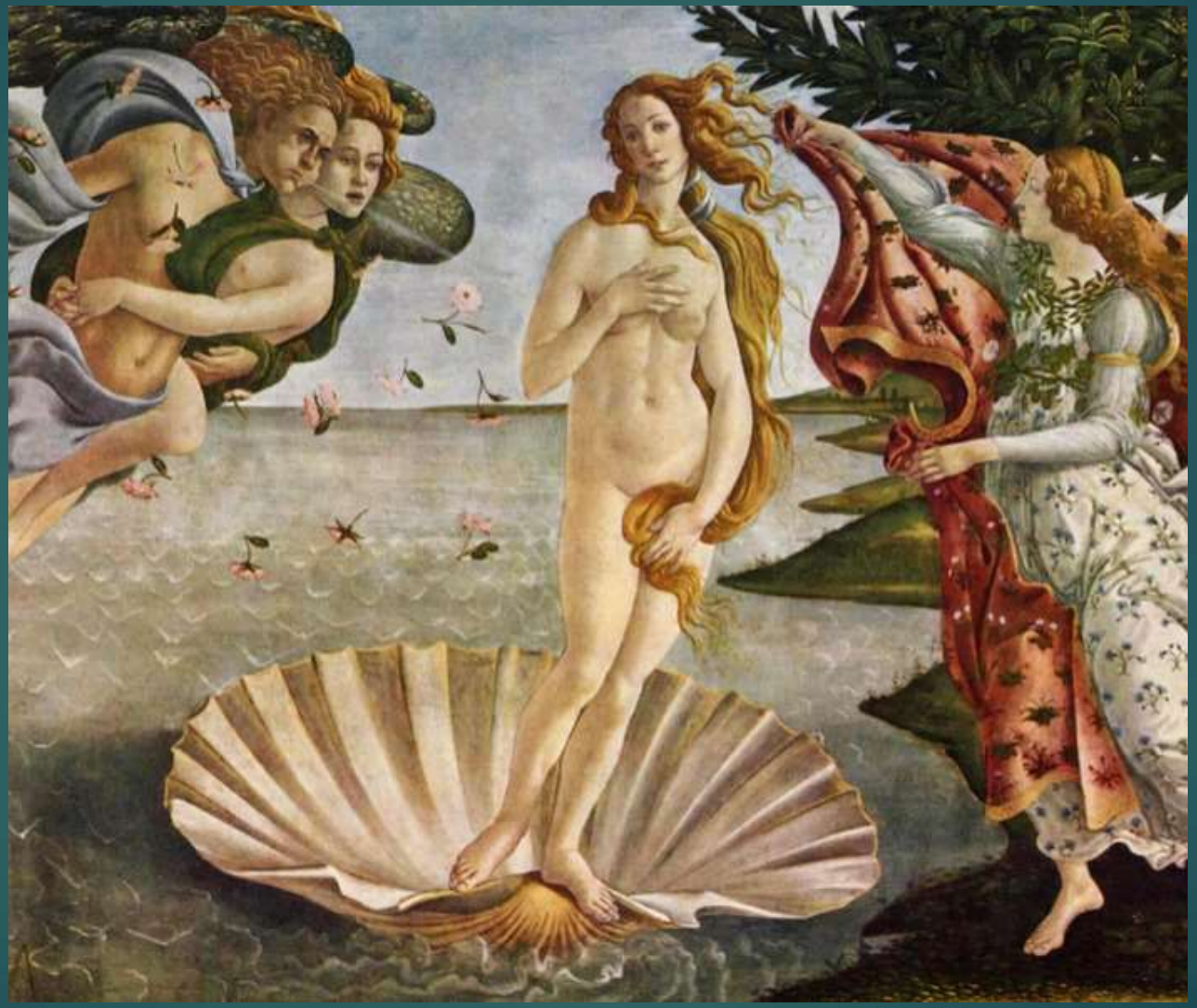
They will appear quickly.

Just keep looking at the screen.




Everett Collection / Rex Features


AIC



Modern Era of Memory in the Lab: Herman Ebbinghaus

In 1885, Ebbinghaus published first scientific paper on memory: *Über das Gedächtnis (Memory: A Contribution to Experimental Psychology)*

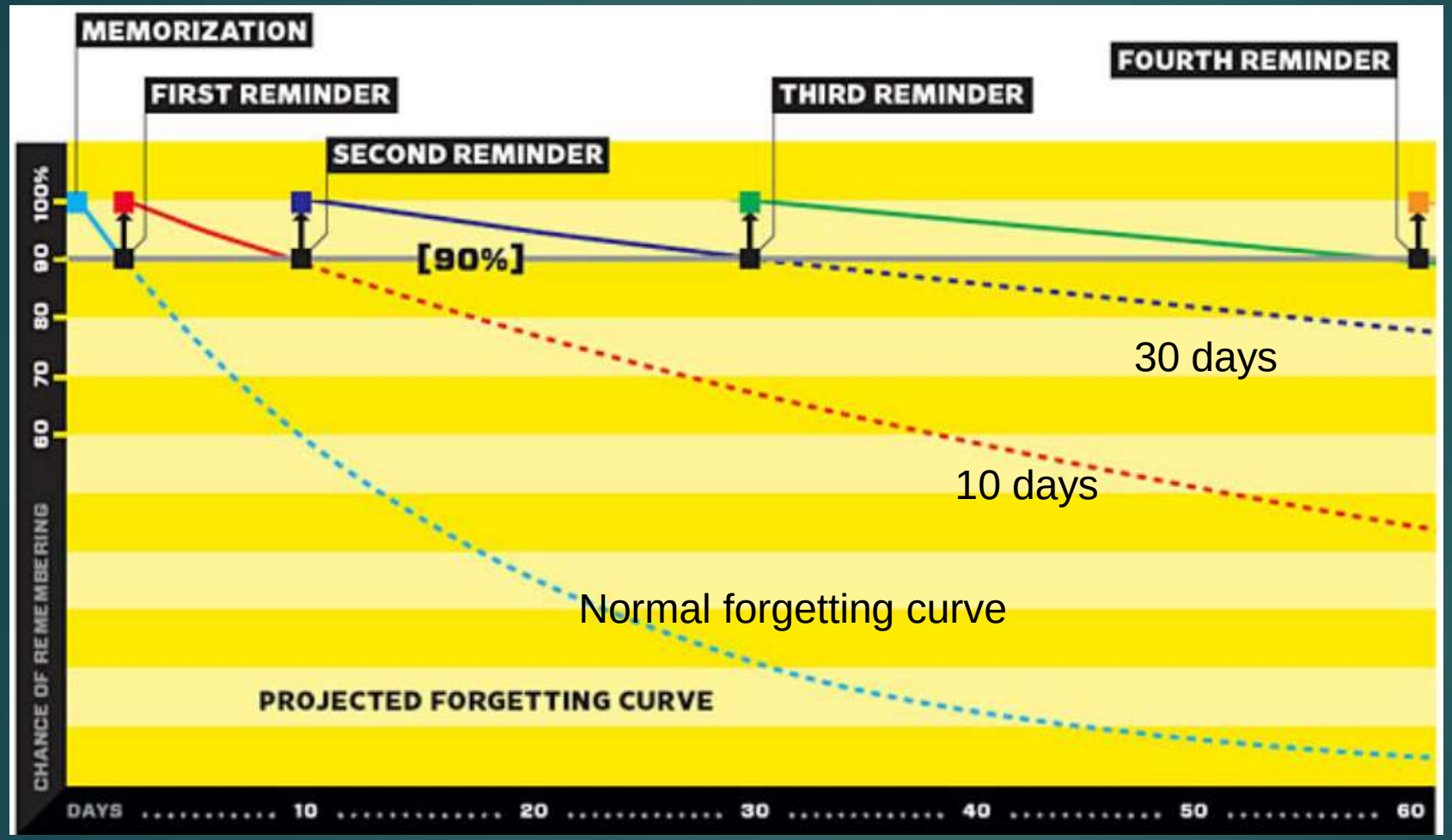
A Masochist: Created 2,300 new nonsense syllables (i.e. Rur, Hal, Mek, Bes, Sok, Dus) and memorized them

More practice sessions produced more retention, and slower rate of forgetting

Ebbinghaus's Discoveries and Contributions

- Learning curve: The more repetitions of a memory, the better the recall
- Distributed practice/Spaced repetition effect: We learn better if we spread it out over time, not cramming the night before.
- Forgetting Curve: Forget more as time passes; more rapid initially, but the rate of forgetting slows as time increases
- He invented tests of memory: recall, recognition, percent savings (less time to relearn)
- Sleep effect : forgetting is reduced when sleep occurred in the retention interval

Tip #5: Rehearsal (repetition) increases memory



4 spaced repetitions increases memory by 90%)

Even better: Spacing out repetitions significantly improves retention.

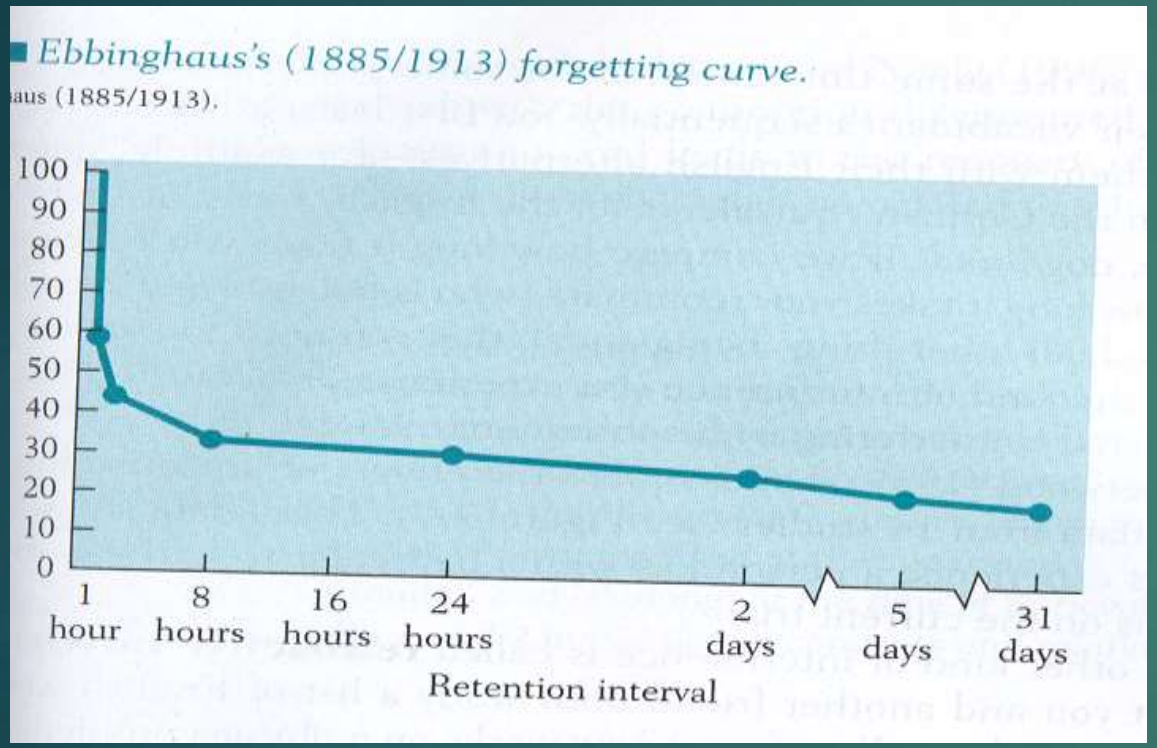
Forgetting is really important for memory

- The prevailing idea in neurobiology when it comes to memories has been that remembering information is king.
- The real goal of memory is to optimize decision-making.
- The best thing for storing memories is to not memorize absolutely everything. The point of memory is to make you an intelligent person who can make decisions given the current circumstances, and an important aspect in helping you do that is being able to forget some information
- It's important that the brain forgets irrelevant details and instead focuses on the stuff that's going to help make decisions in the real world.
- It's often been assumed that an inability to remember comes down to a failure of the mechanisms involved in storing or recalling information.
- There are mechanisms that promote memory loss, and that these are distinct from those involved in storing information

Forgetting 2

- Neurogenesis (growth of new neurons in the hippocampus) seems to promote forgetting. Forgetting in childhood may play a role in why adults typically do not have memories for events that occurred before the age of four years old (childhood amnesia).
- So why do we forget:
  - 1 - In a constantly changing world old information becomes outdated and not as important to remember.
  - 2 - As in computer AI regularization, In order to make generalizations based on large amounts of data, there must be some forgetting of details in the data involved in order to prioritize the core information that is necessary for decisions.

Forgetting Curve: Time reduces Recall



The Forgetting curve:
People forget:
42% after 20 min
56% after one hour,
64% after about 9 hours,
67% after one day,
72% after 2 days,
75% after 6 days
79% after 31 days
Maintain after 2 days

Information is lost over time when there is no attempt to retain it

One function of sleep? To Forget

- Sleep may help the brain prune back unneeded synapses: to forget some of the things we learn each day.
- In order to learn, we have to grow connections, or synapses, between the neurons in our brains. We store new memories in these networks
- Brain produces more synapses than required.
- Gene Homer1A appears to turn on the synapse pruning machinery.
- Sleep helps us remove unneeded synapses

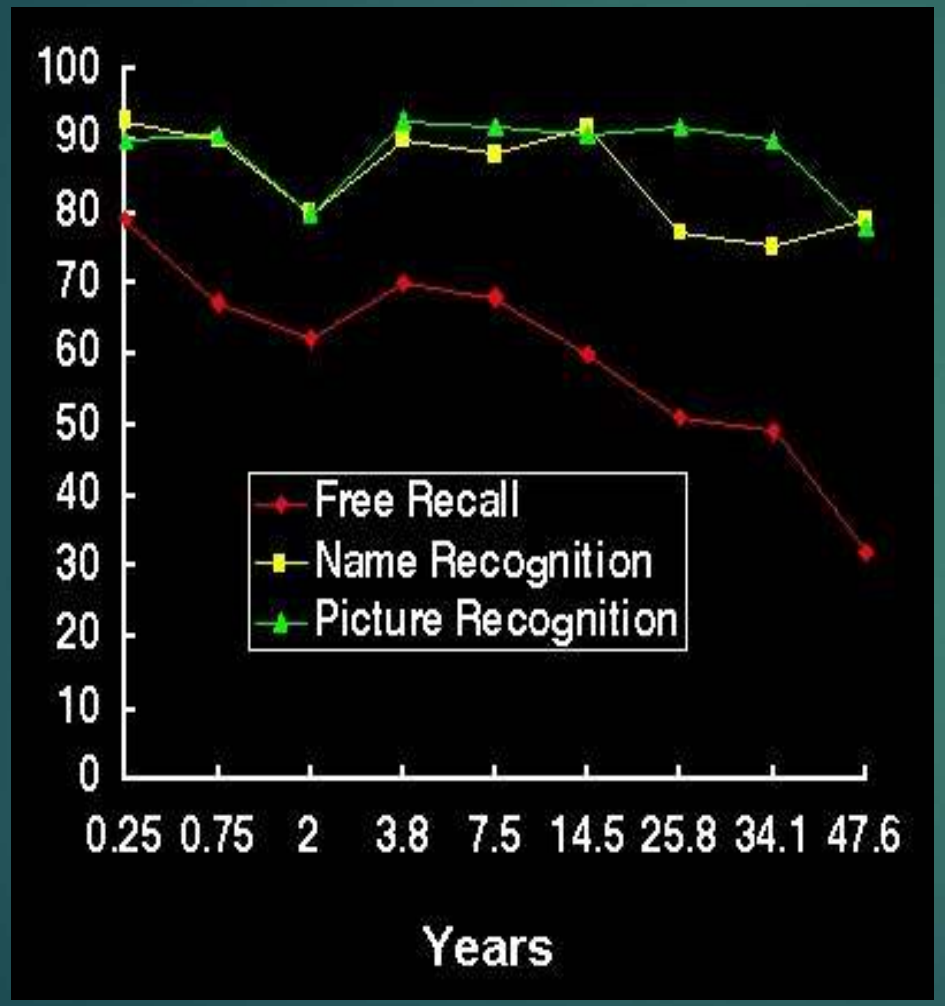
The Power of Forgetting

- Benefit of forgetting:
  - Bjork & Bjork:
  - Any technique that causes forgetting is a “desirable difficulty” in that it forces the brain to work harder to dig up a memory or skill and that added work intensifies subsequent retrieval and storage strength

Things We Normally Forget

“Forgetting Symptom”	Percentage
Telephone numbers	58%
People’s names	48%
Where car is parked	32%
Where car keys are	31%
Groceries	28%
Reason for entering room	27%
Directions	24%
Appointments	20%
Store location in mall	20%
Lose items around the house	17%
Wallet	17%
Content of daily conversations	17%

Spontaneous Recall and Cued Recognition of High School Classmates



Picture recognition is best;

Name recognition is good;

Free recall is worse

Bahrick et al., 1975

Tip #6 – Harder it takes you to retrieve, better the memory

- Try to remember some people in your past
- Remembering and naming a person increases both types of memory strengths; forgetting for awhile can add to memory strength; harder you work to retrieve, greater the increase in both types of memory strengths
- Old info remains in memory & can be relearned;
- Self testing increases storage strength

Neuroplasticity: new synaptic connections

- Memory: Connections between neurons rewire based on experiences
- Brain is less ‘hard-wired’ than we used to believe
  - Neuroplasticity is fundamental property of brain:
    - Capacity of nervous system to modify its organization
    - Changes in neuronal structure and function is the result of experience
    - Changes largely within the synapse

Synaptic changes store memories

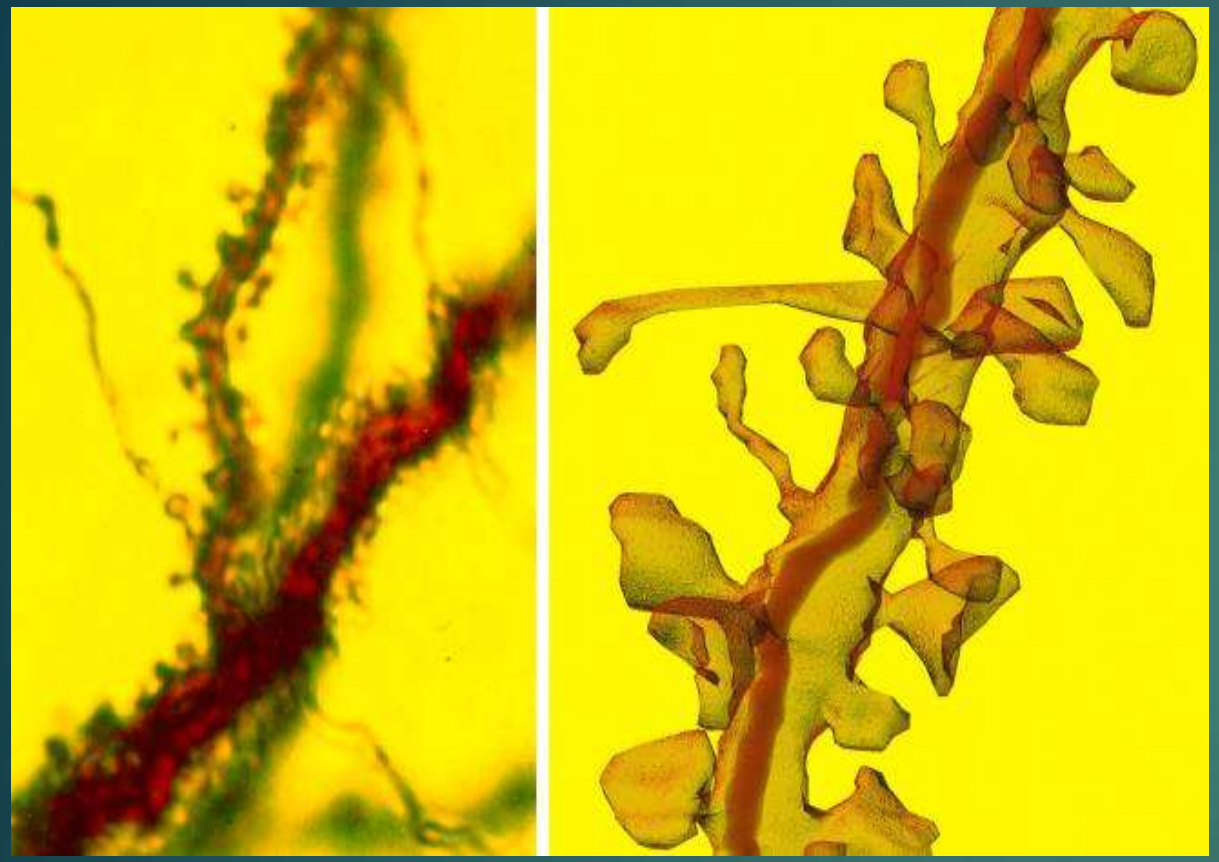
- Current dominant theory: Long-term potentiation (LTP)
  - Long lasting increase in synaptic strength between neurons following high-frequency stimulation
  - Electrical stimulation results in neuron sensitization and enhanced response

- "*The molecular and cellular changes mediating the induction of LTP in the hippocampus are widely considered to provide a basis for memory*" (McGaugh, 2000)

Memory in Brain

- **Hebb Rule**:
  - If neurons fire together, they wire together. Memory is formed by neuronal interactions.
  - If synapse between 2 neurons repeatedly activates, the postsynaptic neuron fires and structure or chemistry of synapse will change

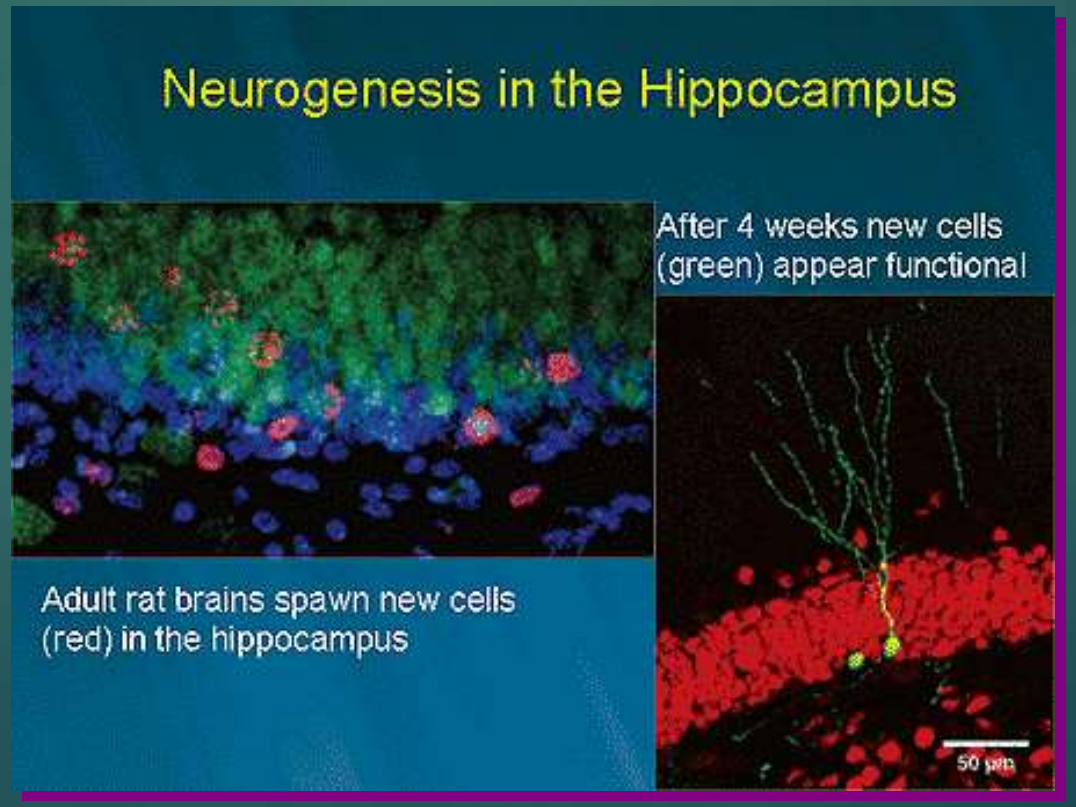
Dendrites under Electron Microscope



Dendrites connect via synapse to other neuron & receives info.
Highly dynamic: can appear in hours to days and also disappear

Neurogenesis

- Neurogenesis: growth of new neurons in the adult brain; Stem cells can become new adult neurons;
- 1,400 cells a day, esp. in dentate gyrus of hippocampus



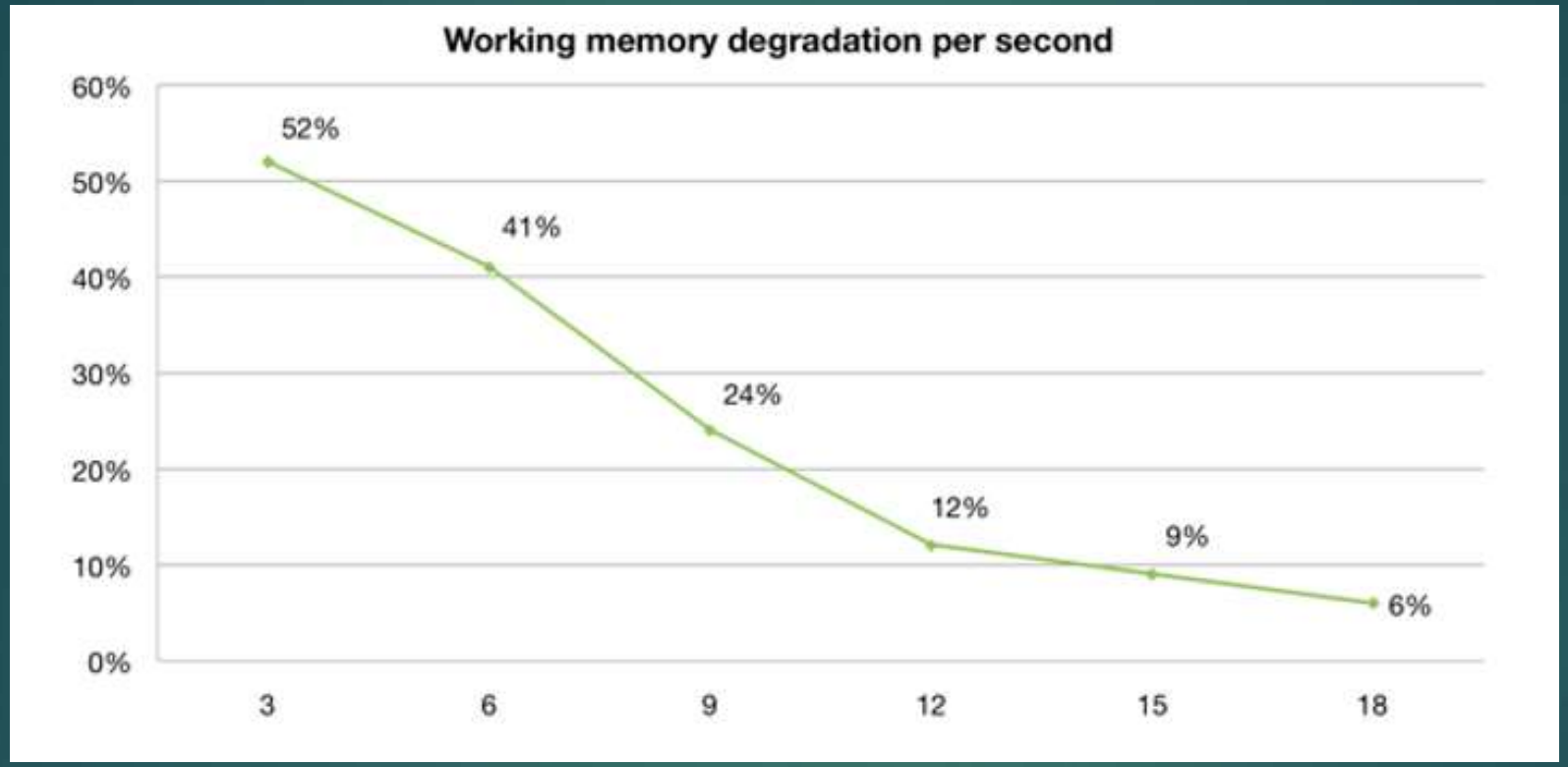
There are multiple memory systems in the brain

- 1 Working Memory: short term: telephone number
- 2 Factual (Declarative) Memory:
  - Episodic (Personal) Memory: first kiss
  - Semantic (Knowledge) Memory: Cleopatra
- 3 Behavioral Memory: How to…
- 4 Prospective Memory: remembering future intention

Short Term Memory/Working Memory = 7 +/- 2

- **STM or WM**= limited short term capacity storage, maintained via rehearsal;
- Temporary storage and manipulation of information
- Capacity: Miller's Constant -- 7 +/- 2
- Modern Research: Seven for digits, around six for letters, and around five for words
- Decays if unrehearsed in 20 seconds
- Time to use a phone number

Working Memory degrades, especially with distraction

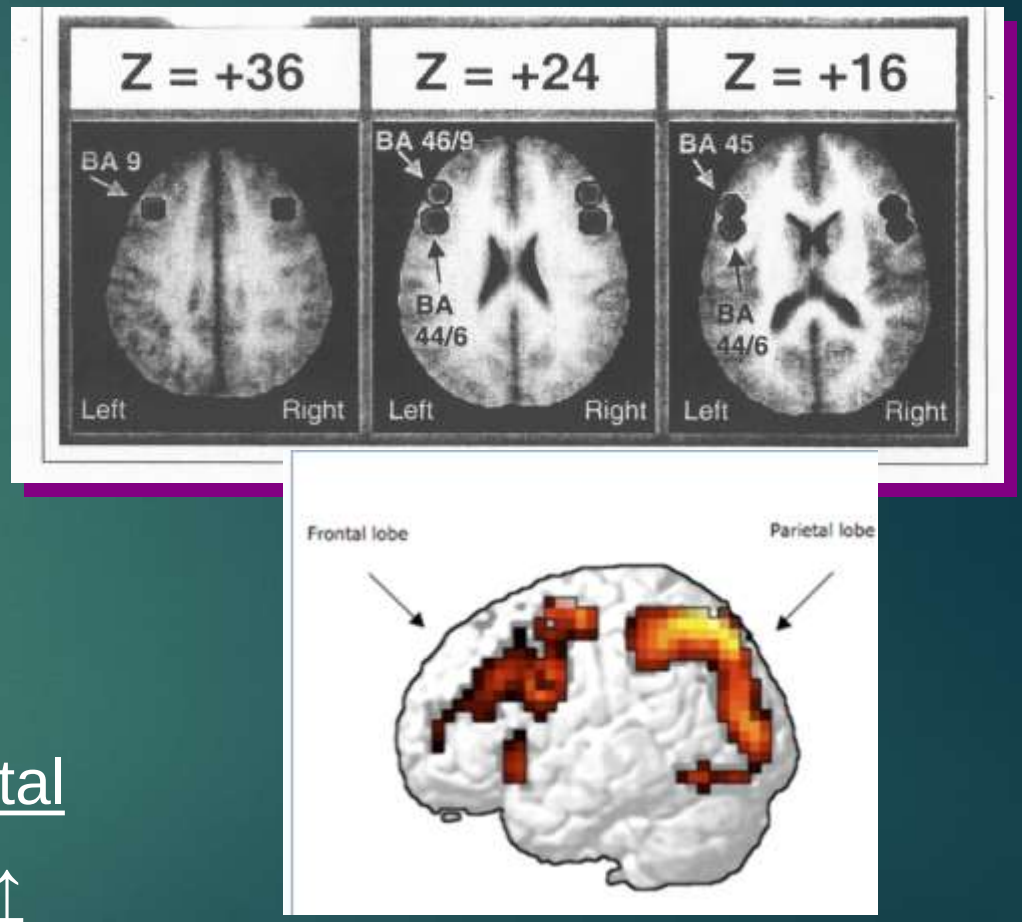


After 15 seconds, less than 10% of original memory is preserved.
Memory degradation occurs after seconds, not minutes.
Distractions cause dramatic losses in WM.

Neuroanatomy of Working Memory

Dorsolateral Prefrontal Working Memory (WM):

- Neurons turn on during delay period (~ 1 min)
- Good WM requires optimal dopamine function
- Most WM tasks use a network of PFC and parietal areas. During WM task connectivity b/w areas ↑↑



P. Goldman-Rakic (1995)

WM can hold only so much info: choking up

- WM correlates with higher IQ and academic achievement.
- High pressure testing situations can cause person to choke up under pressure
- Worrying about a situation (such as solving an arithmetic problem in front of a group of people) takes up the WM that is available for figuring out the math problem

Tip #7: Defeat Stereotype threat

- Negative stereotypes hinder stigmatized individuals' performance on difficult tasks.

- Examples: being reminded you are African American before a test; reminded that you are elderly before a memory test; that you are a woman before a math test

- Threat leads to lower than normal ability performance by reducing WM capacity

- Tip: Writing about your thoughts and feelings about an upcoming math exam for 10 minutes, improves test performance.

Childhood Poverty: Worse Working Memory

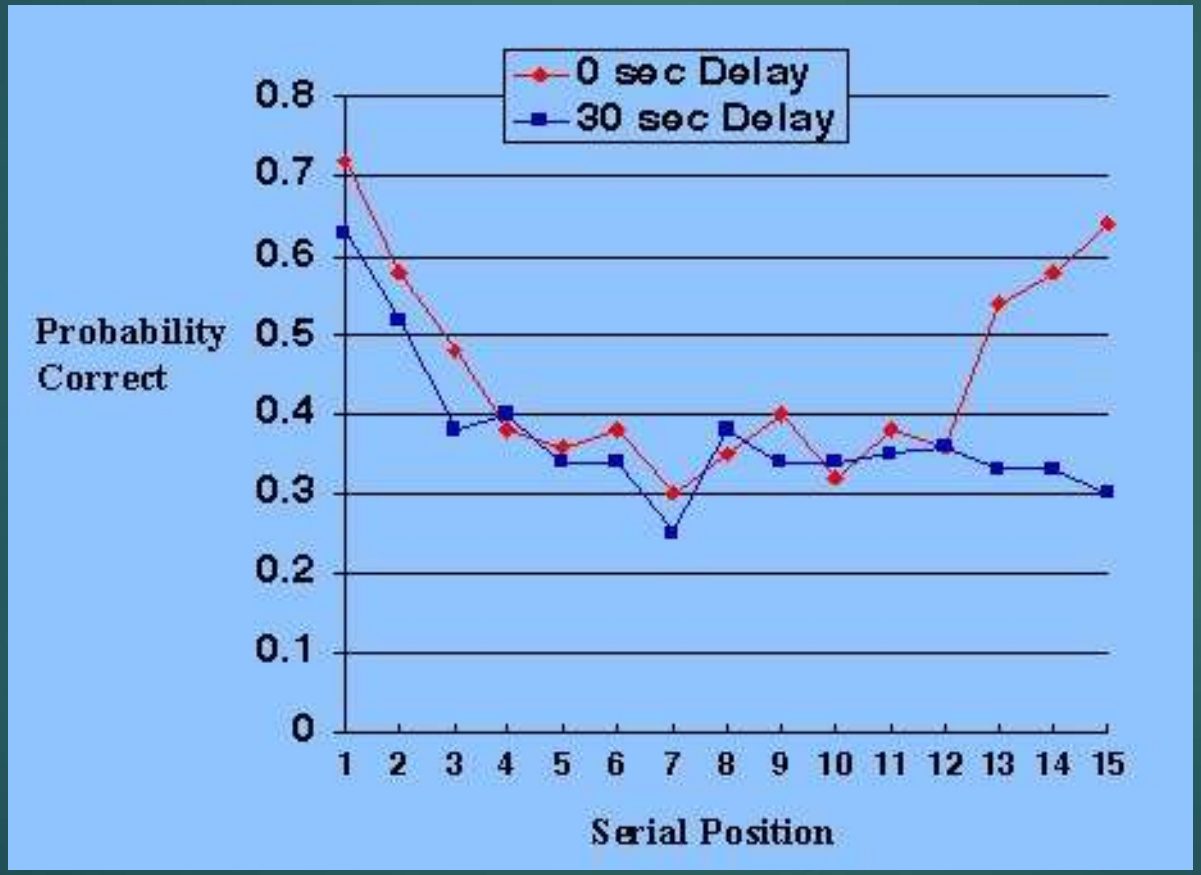
- Chronic stress from growing up poor appears to have a direct impact on working memory.

- The longer the children lived in poverty:
  - the higher their stress load
  - the lower they tended to score on working-memory tests.
  - Those who spent their entire childhood in poverty scored about 20 percent lower on working memory than those who were never poor;
  - 20% thinner cortex

G. Evans, 2009

Tip #8: Serial Position Effect

We remember 1st and last parts better than the middle



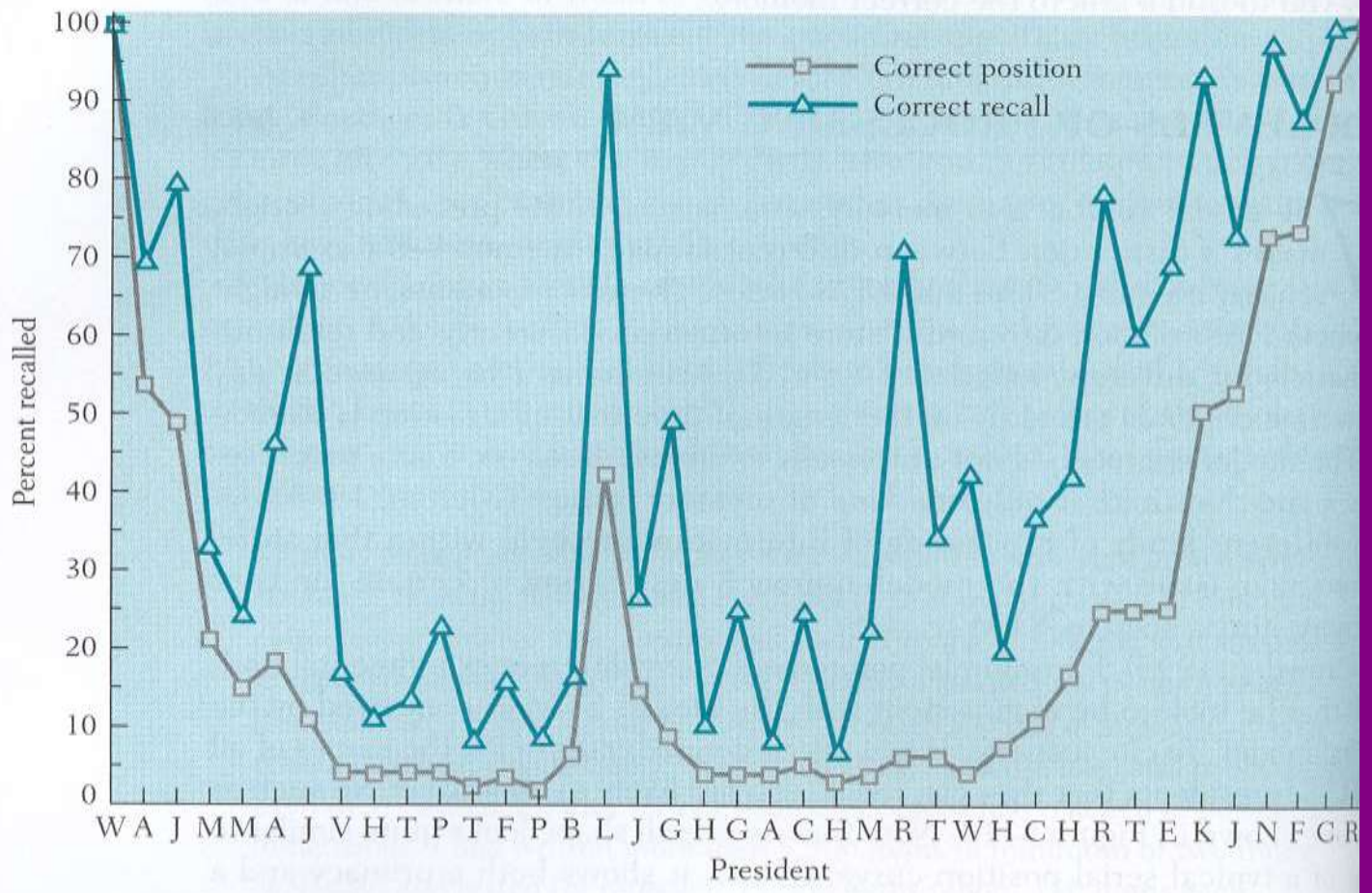
0 sec. delay

30 sec delay

Memory impaired remember only last part.

Unusual Recall of United States Presidents

FIGURE 5–10 ■ *Recall of the names of U.S. presidents as a function of their ordinal position.*
SOURCE: Crowder (1993, p. 143).

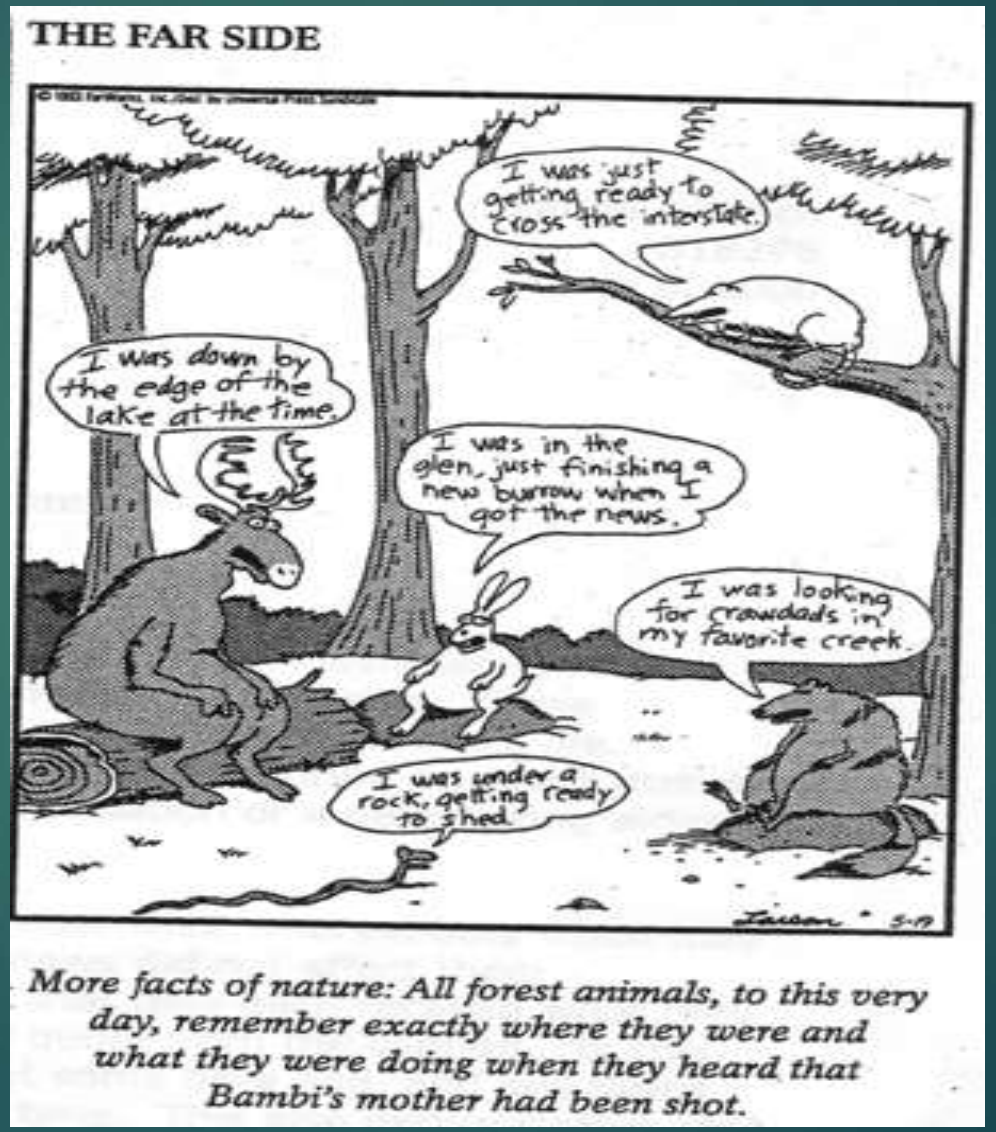


“An impression may be so exciting emotionally as almost to leave a scar upon the cerebral tissues.”

William James (1890)

Flashbulb Memory: My Daughter Lea at age 4 & Bambi's mother

All animals know where they were when Bambi's mother died.

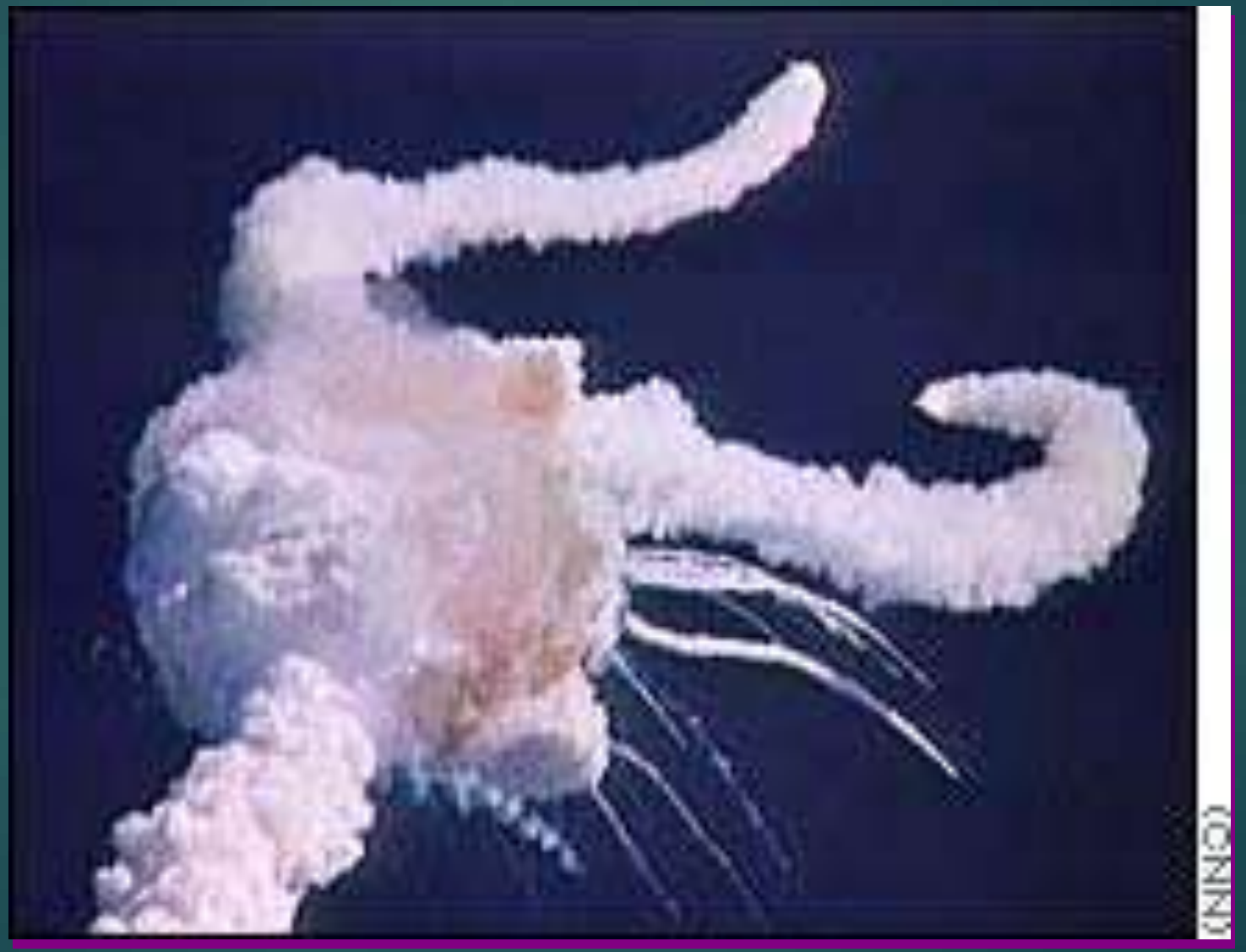


Flashbulb Memory 1: Nov. 22, 1963 - JFK

CJV: 2 pm in classroom two at Mission San Luis Rey College

Flashbulb Memory 2: April 4,1968 – MLK Jr

Flashbulb Memory 3: 1986 - Challenger



Flashbulb Memory 4: 1989 – Loma Prieta

Flashbulb Memory 5: 9/11/2001

9/11/ 2001: 97% of Americans "can remember exactly where they were or what they were doing the moment they heard about the attacks"

Tip #9: More emotional an event, the better the recall

- Flashbulb Memories - Where were you when: JFK or MLK killed, Challenger (1/26/86), O.J. Trial Decision, 1989 SF earthquake, 9/11/2001, cancer dx, trauma happened
- Flashbulb Memory: what, where, who with, doing what
- Traumatic memories are basically really intense flashbulb memories.
- Marked by vividness, immediacy, visual primacy and emotionally intensity
- More emotional the reaction (Amygdala), stronger the memory
- But can become distorted

Trauma and Memory

- Severe personal trauma: rape, assault, etc.

- Traumatic Memory: fragmentary sensory components of traumatic event with no linguistic narrative of event (Implicit memory; mediated by Amygdala, not Hippocampus);

- As a result, these memories are generalized and decontextualized.

Development of Memory

- Infants
  - recognize mother within hours;
  - deferred imitation by 1 year;
  - references to past events by age 2;
  - recall at 2-3 locked to vocabulary level
- Capacity: WM increases with age

  (age 4 = 3 items; age 12= 7 items)
- Rehearsal ability develops from age 5 to 10
- Use of memory categorization to remember develops

Patricia J. Bauer, 2007

Development of Memory 2

- Parental reminiscing style influences child's autobiographical memory: talking a lot, questions, details, emotions

- Adult women have longer, more detailed, more vivid, more emotionally laden autobiographical memories than men

- Individuals from Western cultures have earlier age of first memory and have longer and more detailed memories of childhood than those from Asian cultures (related to social emphasis on importance of the individual vs. social)

Fivush & Nelson, 2004

The Location of the Engram

- What is Long Term Memory: Perceptual experience is stored as the outcome of the specific sensory perceptual processing operation and in the same areas involved in the original perception and analysis of the event.

- The increased probability of a network firing a similar pattern is how network of neurons “remembers.”

- Locus of storage determined by sensory modality relevant to original learning and nature of the information, i.e. shape, color, function

The Location of the Engram

- Distributed Network of associations: Memory is located in multiple locations corresponding to specific sensory aspects located in different sensory areas via sensory network activation

- Synaptic pathway reinforcement as creator of our long term memories via long term potentiation.

- Location of LTM: All over the brain: Posterior Occipital, Parietal, Temporal lobes, Frontal (for motor programs); & BG and Cerebellum

Brain and Memory

- Multiple brain regions are involved in encoding a new memory
- Consolidation of memory involves the hippocampus and the prefrontal areas; eventually latter takes over memory retrieval
- LTM storage occurs in the cortex, where the memory was first processed and held in short-term memory.

Tip #10: Self Generation effect

- If you personally generate a memory, you will remember it better.
  30% better recall post self generation

- Example:
  - Read: Garbage – Waste vs.
  - Generate (fill in the blank): Quarrel - F_ght

- Talk about it to others or in front of mirror or use flashcards

Neuroanatomy of Memory Functioning

Hippocampus: Dentate, CA1, CA3

Entorhinal Cortex

Subiculum: 1st 15 seconds

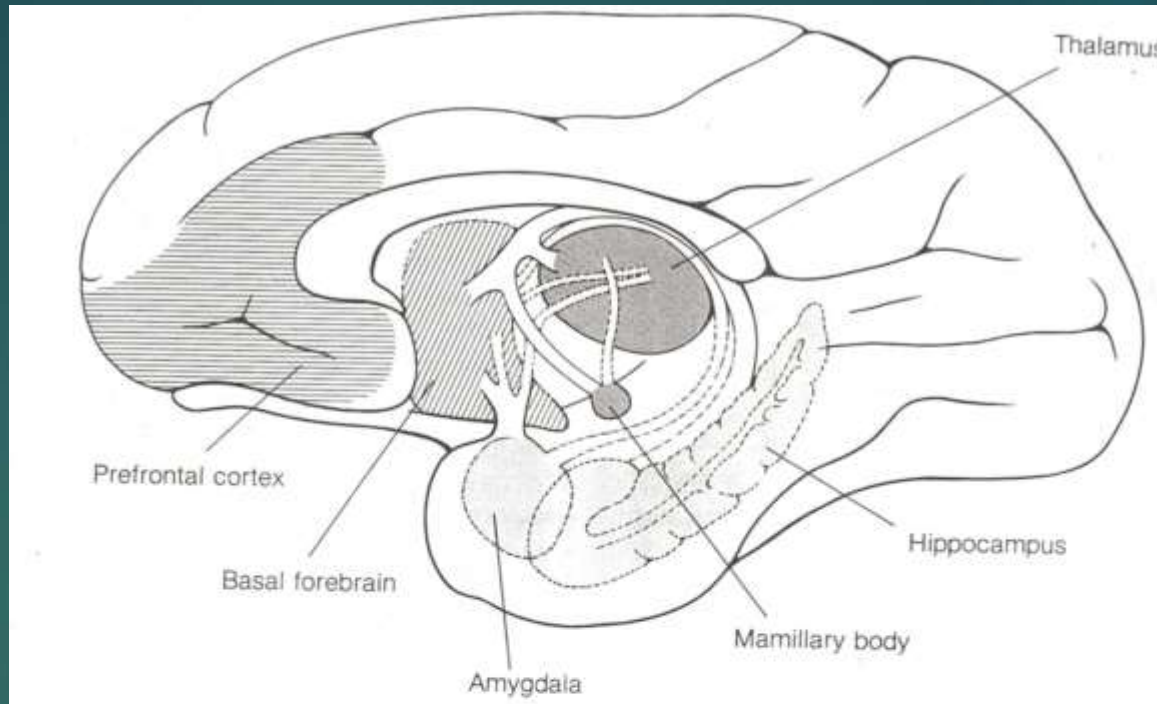
Parahippocampal Cortex

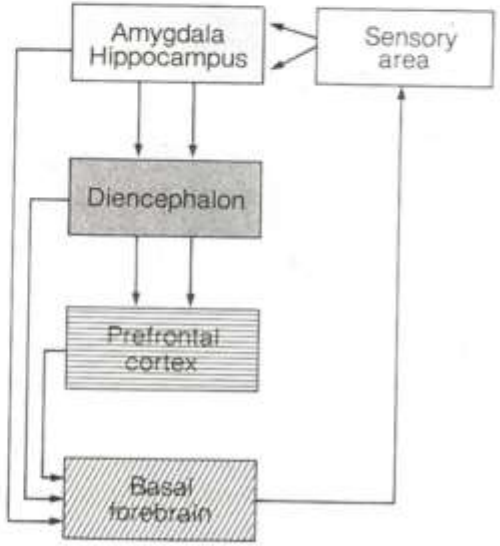
Perirhinal Cortex

Amygdala

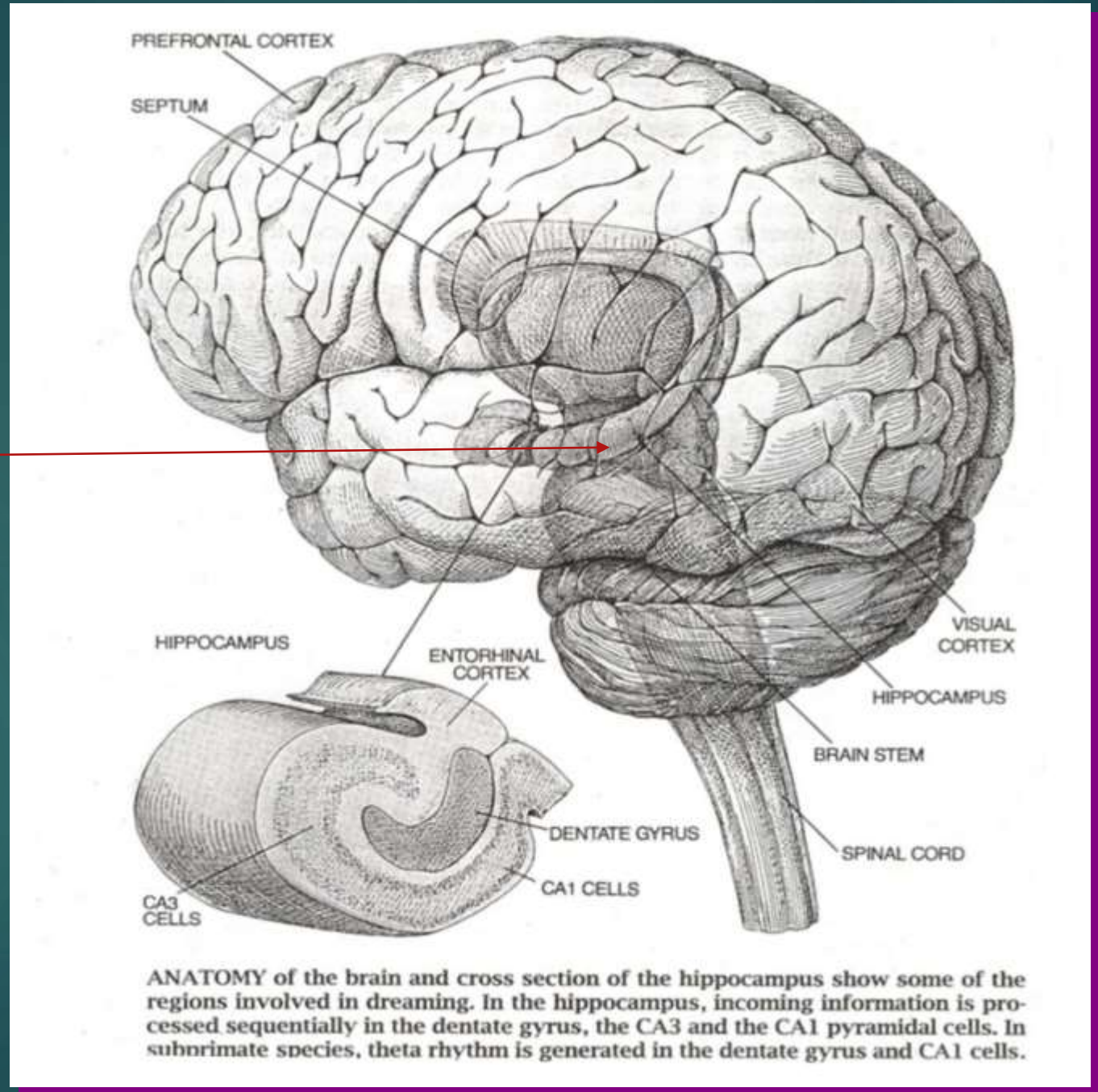
Diencephalon: Thalamus & Hypothalamus: Mammillary Bodies

Ventromedial Prefrontal & Basal Forebrain

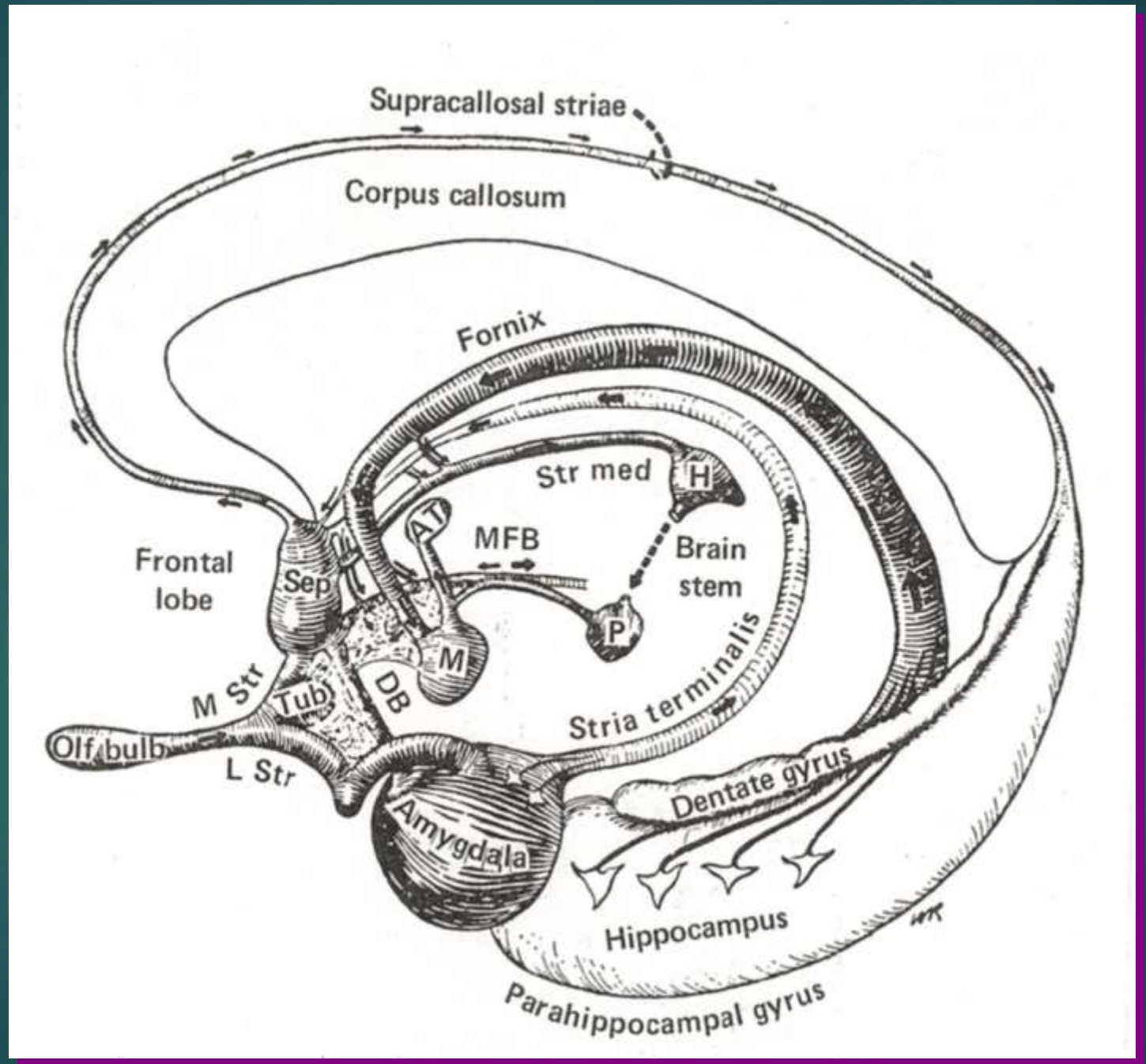

Thalamus
Prefrontal cortex
Basal forebrain
Amygdala
Mamillary body
Hippocampus


Amygdala
Hippocampus
Sensory area
Diencephalon
Prefrontal cortex
Basal forebrain

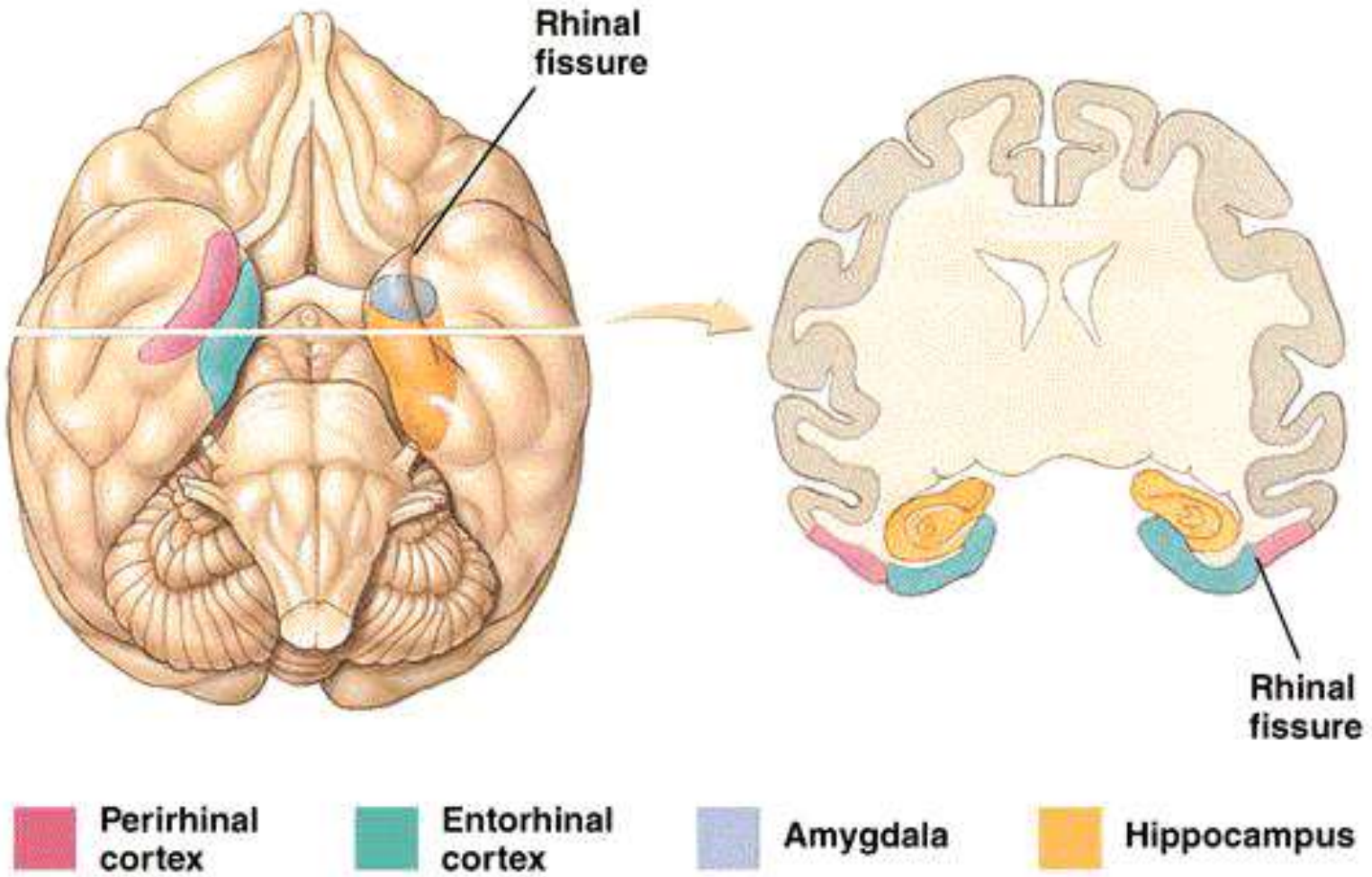
Hippocampus



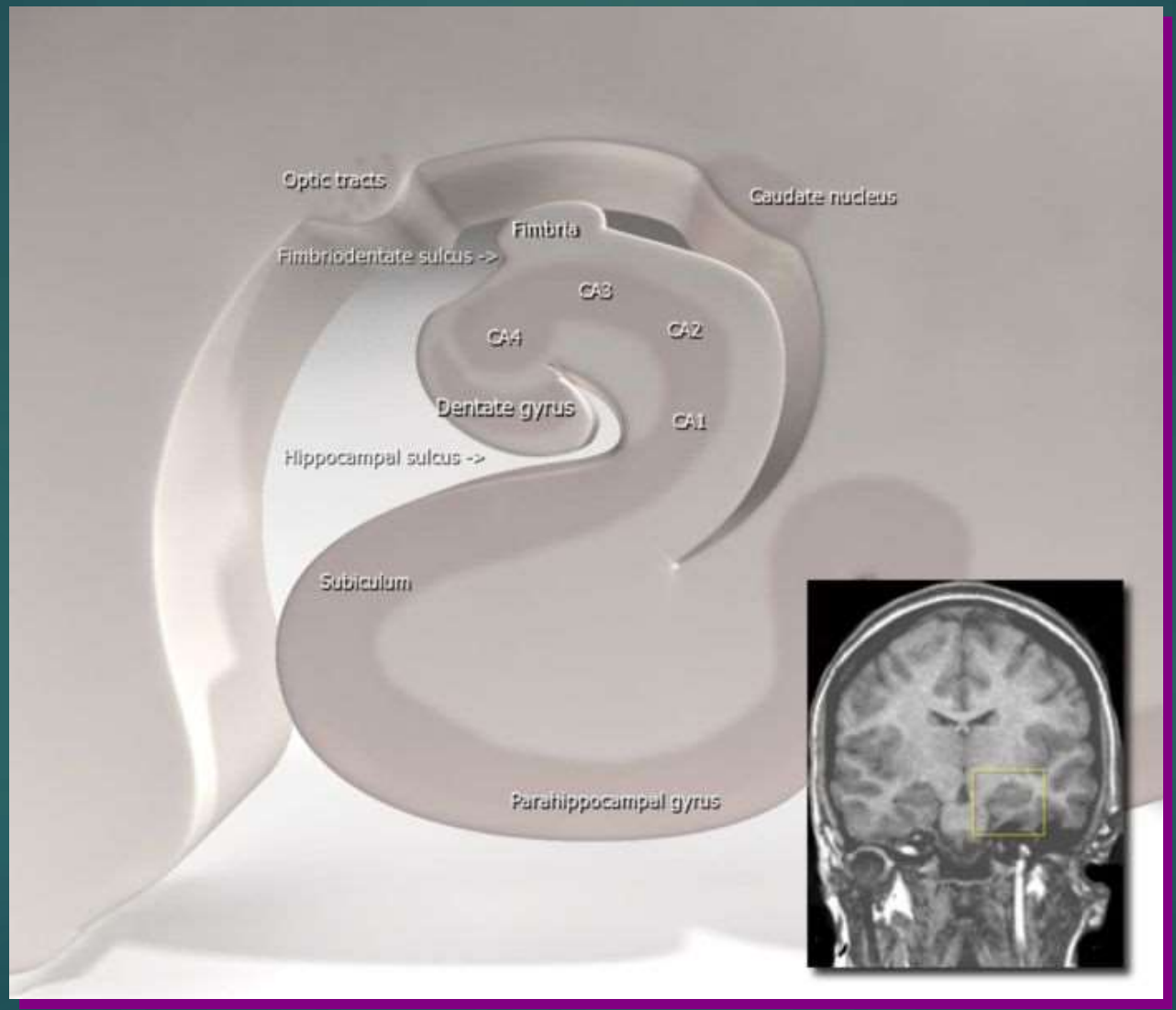
ANATOMY of the brain and cross section of the hippocampus show some of the regions involved in dreaming. In the hippocampus, incoming information is processed sequentially in the dentate gyrus, the CA3 and the CA1 pyramidal cells. In subprimate species, theta rhythm is generated in the dentate gyrus and CA1 cells.


Supracallosal striae
Corpus callosum
Fornix
Str med
H
AT
MFB
Brain
stem
Frontal
lobe
Sep
P
M
M Str
Tub
DB
Stria terminalis
Olf bulb
L Str
Dentate gyrus
Amygdala
Hippocampus
Parahippocampal gyrus

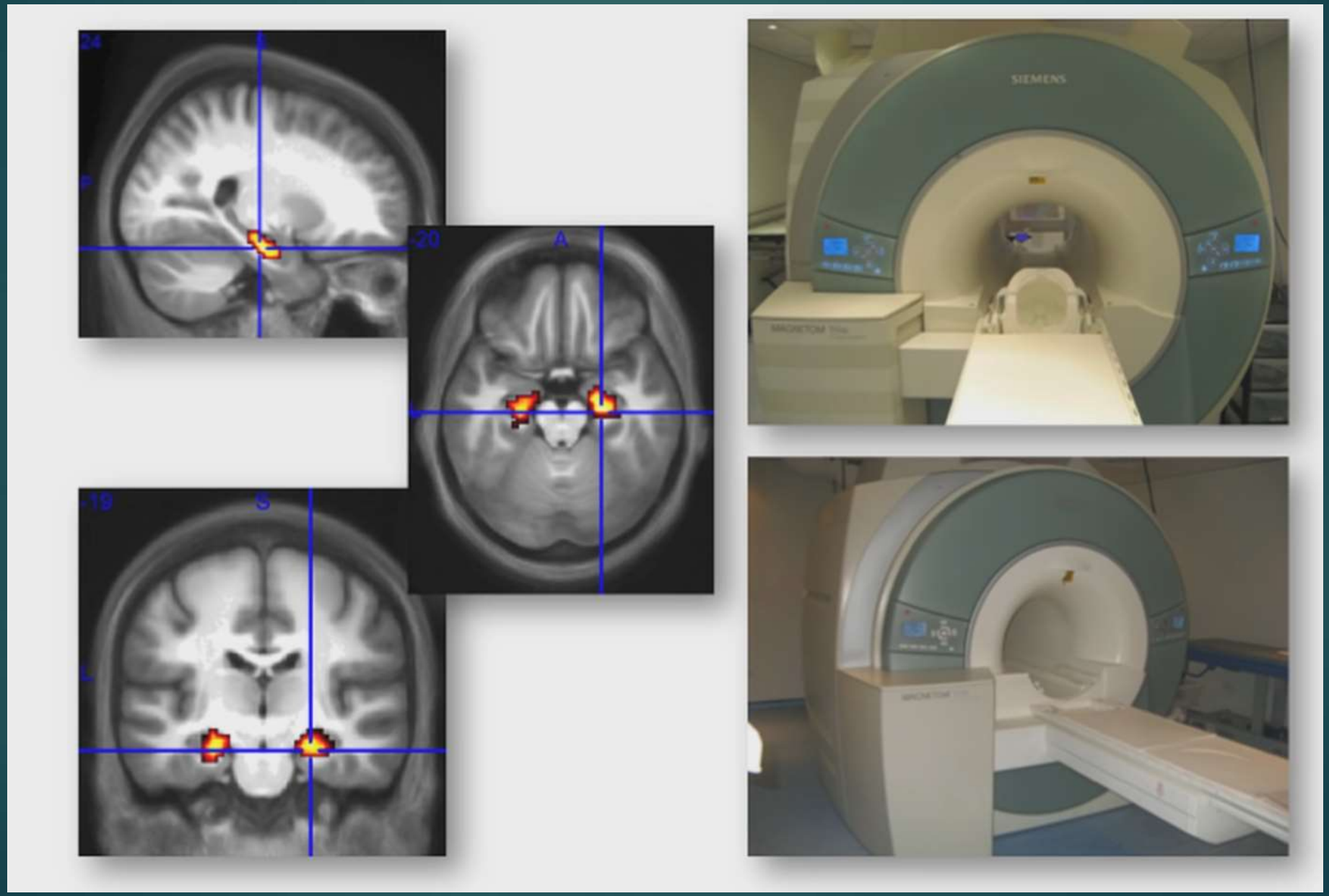
► The Three Major Structures of the Medial Temporal Lobe



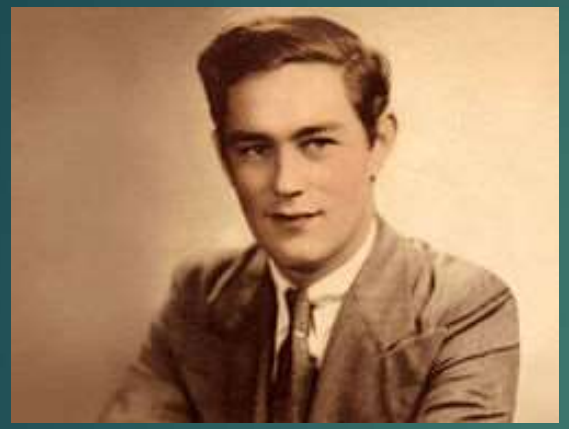
Hippocampus, Subiculum, Parahippocampal Gyrus

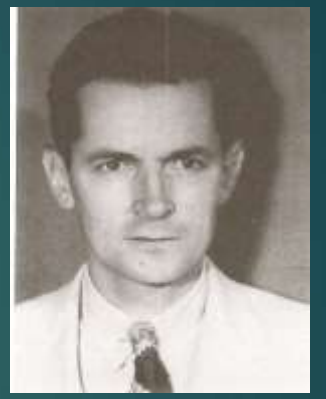


Recalling past experiences activates hippocampus on fMRI



Henry Gustav Molaison, 1926-2008





William Scoville MD

Brenda Milner PhD

Patient H. M.

The most important patient in the history of neuroscience.
100 researchers studied him

***Permanent Present Tense* -** Suzanne Corkin

H.M.

- Because of his severe epilepsy (due to bike accident at age 10) that had foci in the medial temporal lobe, he had a bilateral medial temporal lobectomy in 1953.
- The good news was that it greatly reduced his epileptic problems.
- The bad news was that he showed a severe anterograde amnesia – no more new learning.
- In last 54 years, 100 investigators have studied him.

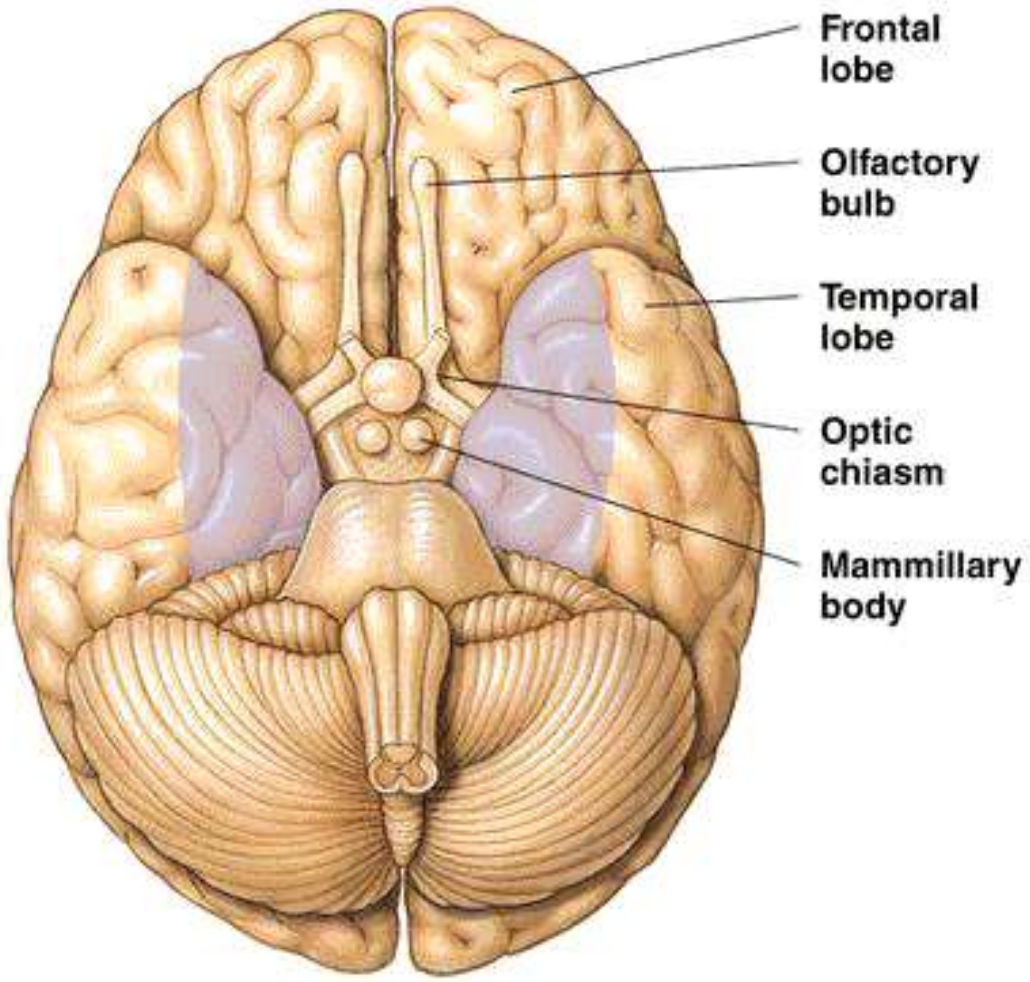
Milner et al., 1968; Corkin, *Perfect Present*

H.M. 2

- Absence szs at 10; GM szs at 16; bilateral medial temporal surgery at 27
- H.M.'s fame began in 1957 with publication of Scoville & Milner's paper, "Loss of recent memory after bilateral hippocampal lesions." (cited 1744 x since 1957)
- Their conclusion: Severity of amnesia (loss of new learning ability) correlates with size of hippocampal removal

Scoville & Milner, *JNNP,* 1957

► Medial Temporal Lobectomy



Assessment of H.M.

Brenda Milner

Suzanne Corkin

H.M.’s brain was sliced into 2400 pieces on internet

Hippocampus

- Important for formation of new episodic (personal) memories
- Important for encoding perceptual aspects of memories
  - Novel events, places, and stimuli
- Important for declarative memory
  - Involved in recollection, but not familiarity

H.M.’s Hippocampal Amnesia

- Global declarative (factual) amnesia, irrespective of:
  - Kind of memory test
  - Kind of verbal, visual, spatial stimuli (words, digits, faces, tones, mazes, events)
  - Kind of sensory modality (5 senses)

- Deficit episodic (personal) and semantic (knowledge) memory

- But Normal
  - working memory
  - language (lexical and grammatical) processing
  - Premorbid semantic knowledge

Knowledge Gained from H.M.

- Memory is not simply and diffusely represented across the brain
- Importance of hippocampus
- STM (WM) and LTM are different forms of memory
- Need medial temporal lobes for memory encoding and consolidation
- Two memory systems discovered: Declarative (Explicit) vs. Behavioral (Procedural) memory:

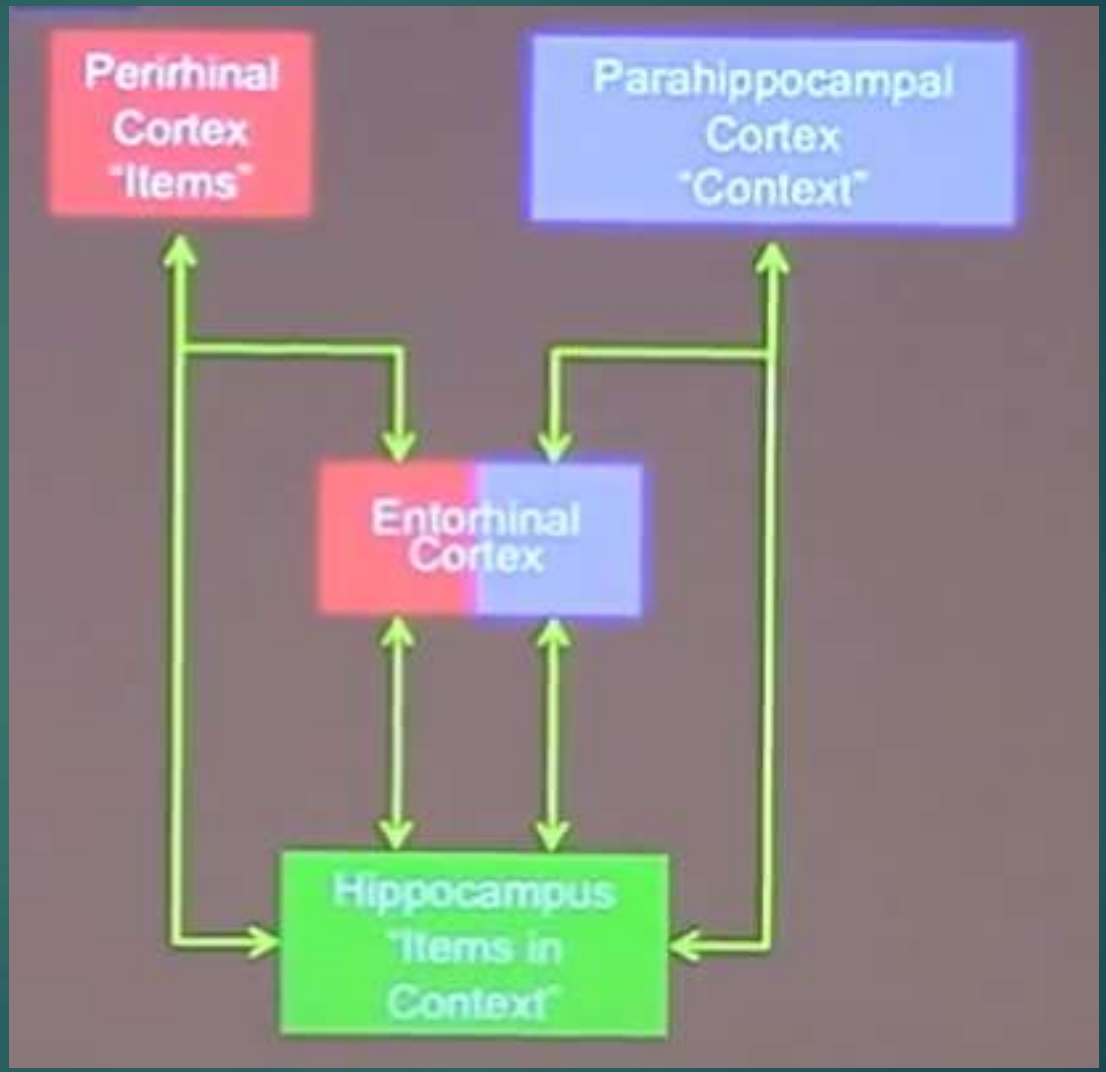
Role of Hippocampus 2

- Spatial information: right hippocampus is larger in taxi drivers
- Anterior hippocampus indexes generic novelty: adds new to old info
- Posterior hippocampal responses index familiarity to stimuli that have behavioral relevance

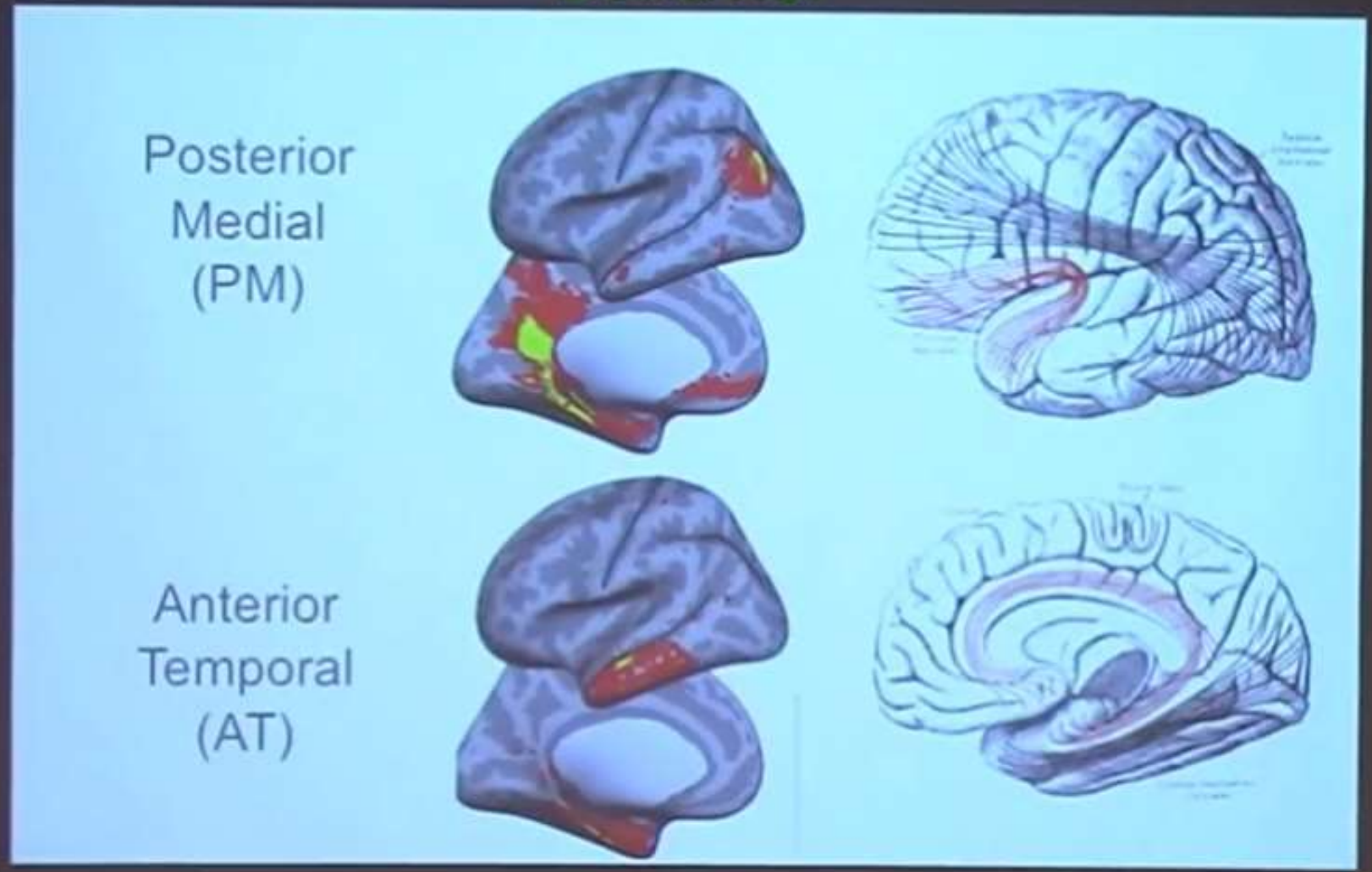
What, Where, When: a network of memory systems

Hippocampus captures the context:

I had dinner (what)
last Thursday (when)
at Chez Panisse (where)

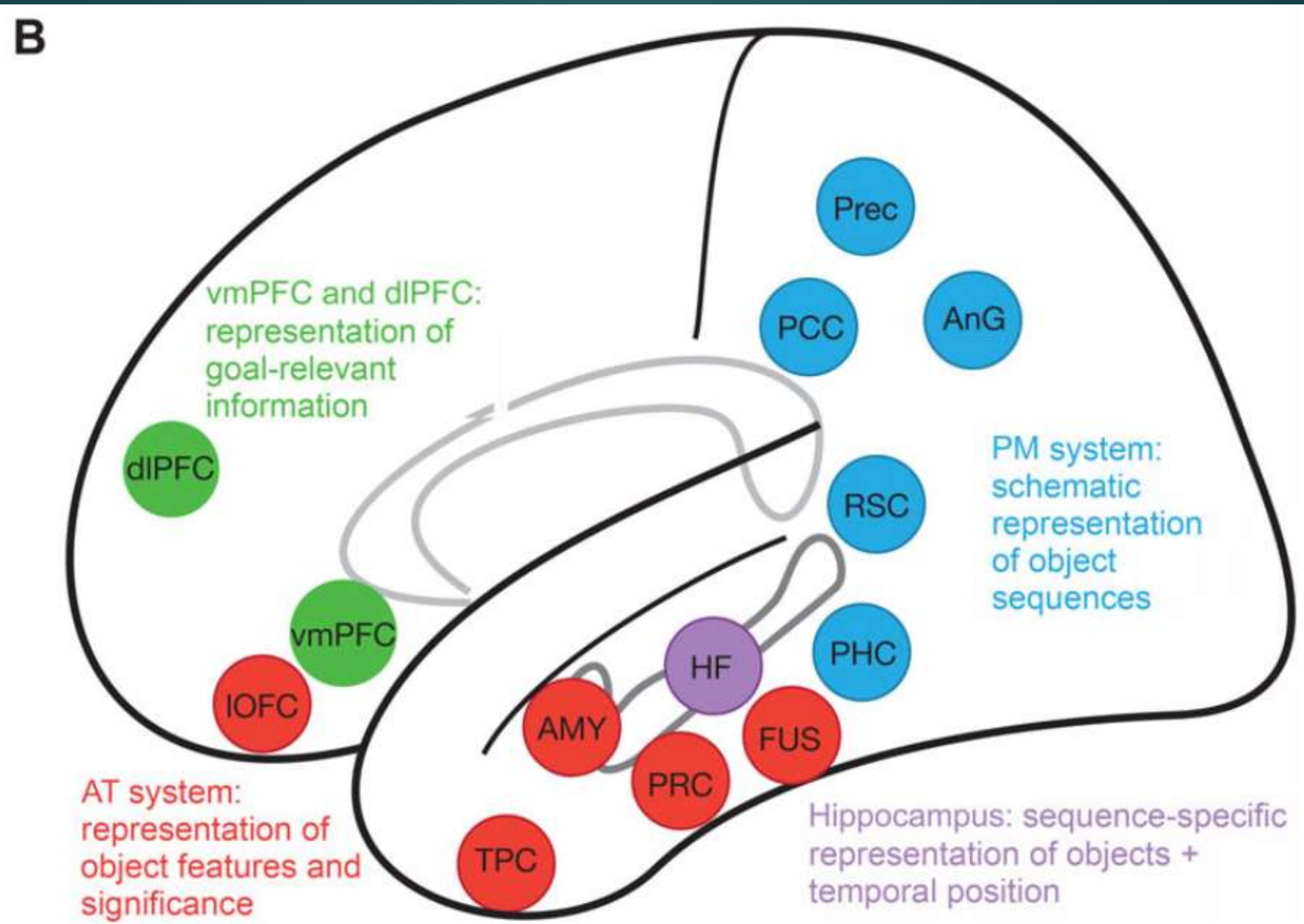


Two Pathways for Memory-Guided Behavior



Kahn et al., (2008). J. Neurophys.

Libby, Ekstrom, Ragland, & Ranganath (2012) J. Neurosci.


B
vmPFC and dlPFC:
representation of
goal-relevant
information
dlPFC
vmPFC
lOFC
AT system:
representation of
object features and
significance
Prec
PCC
AnG
RSC
PM system:
schematic
representation
of object
sequences
HF
PHC
AMY
FUS
PRC
TPC
Hippocampus: sequence-specific
representation of objects +
temporal position

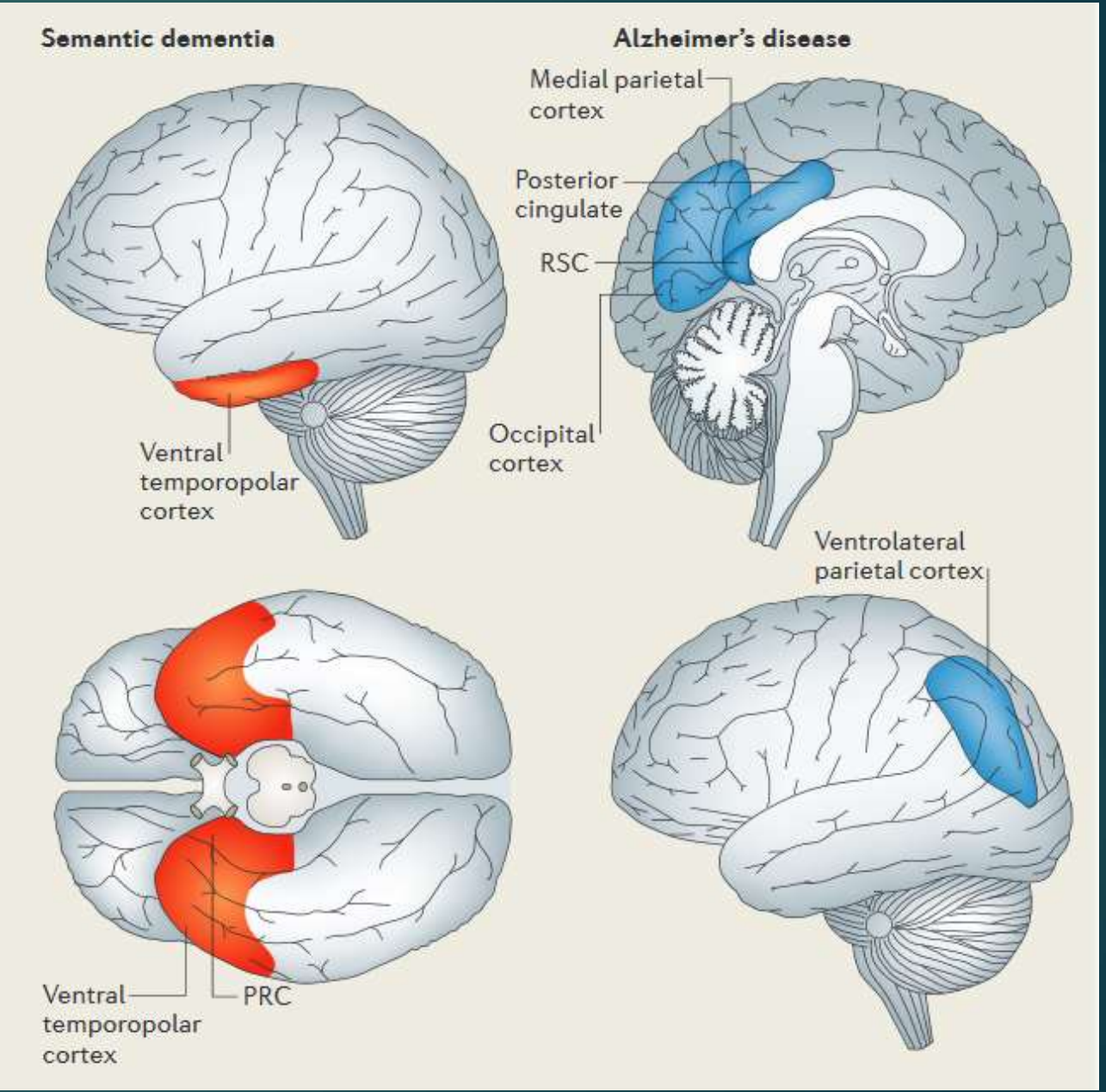
Context

Anterior Temporal = specific items, semantic & familiarity network for Semantic Dementia & Herpes Simplex Encephalopathy & cortical atrophy in patients with temporal lobe epilepsy

Posterior Medial = contexts, episodic & recollection, DNM network for AD & Korsakoff's

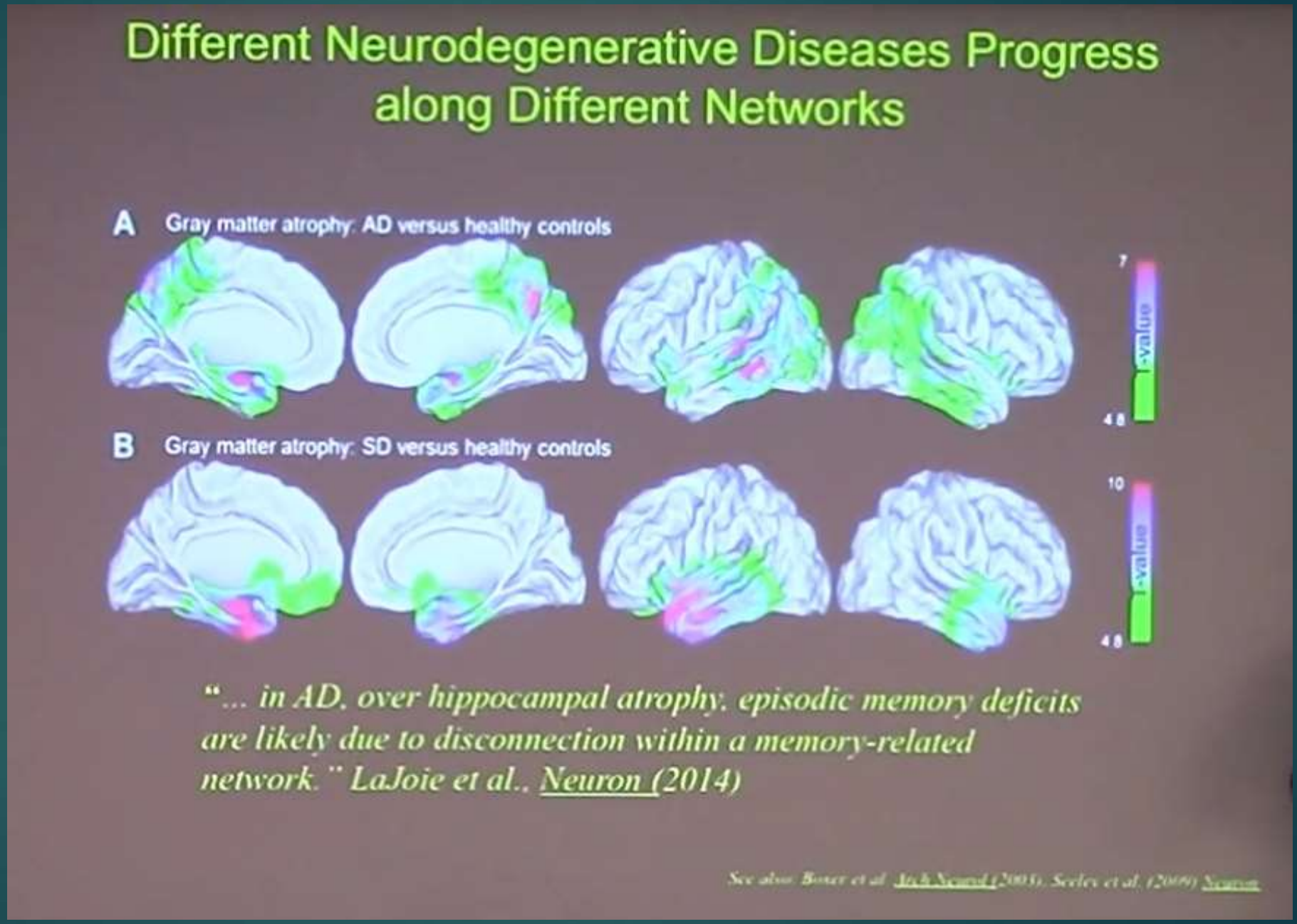
AT network

PM network



A= the Posterior Medial System – Episodic Memory: Alzheimer's

B – the Anterior Temporal System – Semantic Dementia



Neuroplasticity: Experience changes our brains: London Taxi Drivers

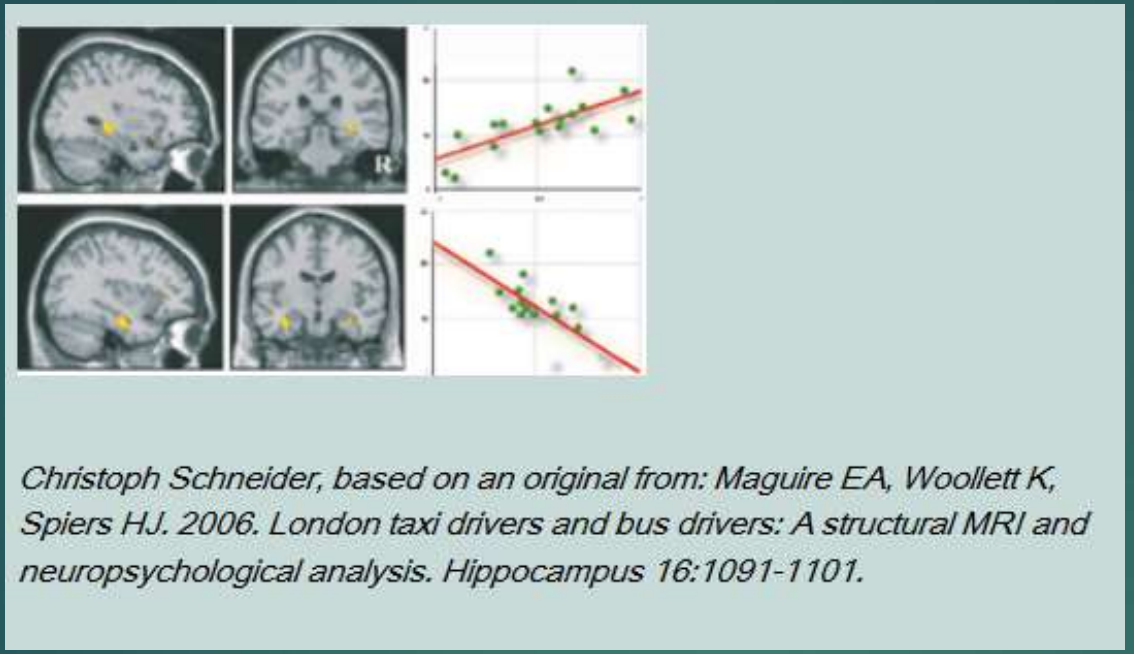
If you lived in London, and wanted to grow your hippocampus, which driving job would you choose?

Knowledge exam: 3 of 10 pass

25,000 streets
1400 landmarks

Study of London Taxi cab drivers (vs. bus drivers): To earn their licenses, cab drivers in training spend three to four years driving around the city on mopeds, memorizing a labyrinth of 25,000 streets within a 10-kilometer radius of Charing Cross train station, as well as thousands of tourist attractions and hot spots. "The Knowledge" exams that only about 50 percent of hopefuls pass.

Larger Right Posterior Hippocampus in London Taxi Drivers: 7% larger , but otherwise normal memory



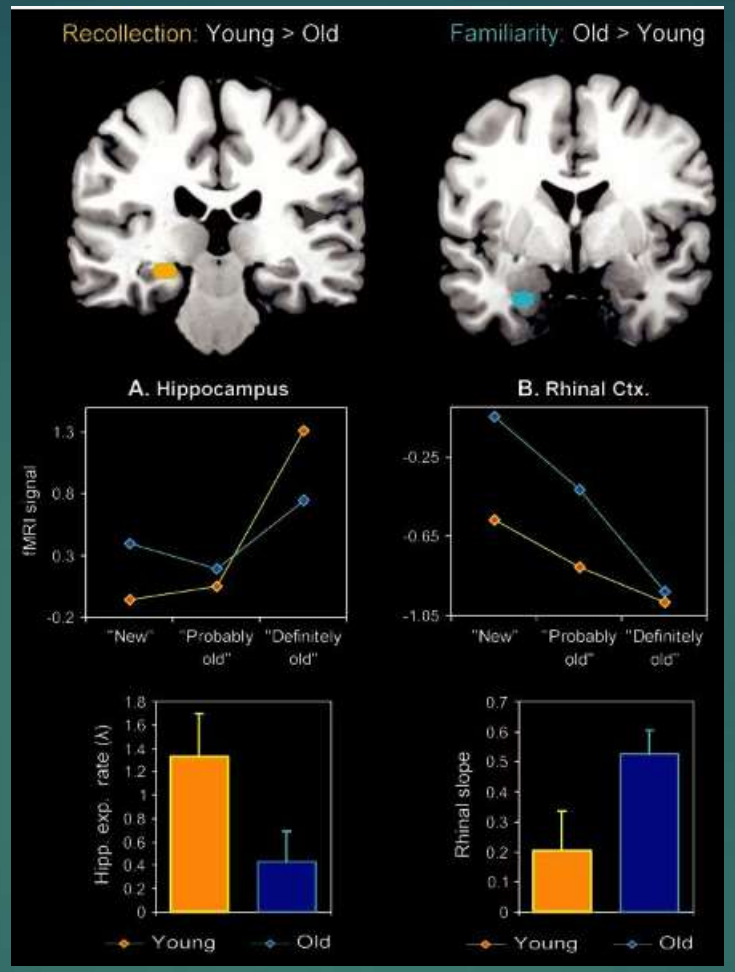
Christoph Schneider, based on an original from: Maguire EA, Woollett K, Spiers HJ. 2006. London taxi drivers and bus drivers: A structural MRI and neuropsychological analysis. Hippocampus 16:1091-1101.

Enlarged the posterior hippocampus at the expense of the anterior

London taxi drivers who earned their licenses performed far better than those who failed—even though they had performed equally four years earlier. And MRIs showed that the successful trainees' hippocampi had grown over time.

The successful trainees did not perform better on all tests of memory, however. Licensed taxi drivers did worse than non-taxi drivers on the Rey-Osterrieth Complex Figure Test.

Aging decreases recollection in hippocampus



Aging increases familiarity in perirhinal cortex

The effects of aging:
Recollection in the hippocampus was decreased by aging,

Familiarity in the rhinal cortex was increased by aging.

Amnesia: Present = Past ≠ Future; no time travel or future

- Amnesia: inability to record and store new information.
- If we have amnesia, you lose ability to make a plan.
- Plans are our memories of what we intend to do.
- People with amnesia live in the present and in the long past.
- Cannot imagine a scene of what might happen to them in the future; can imagine an object, but not a scene

D. Addis, et al., Psy. Sc, 2008

Role of Hippocampus

- Hippocampus is needed temporarily to bind together distributed sites in neocortex that together represent a whole memory.
- Index, search engine to database of memory
- Novelty detector: compares incoming sensory info to stored knowledge; if difference, triggers dopamine increase.
- Specialty is binding new to old information
- Ceases to play a crucial role in the retention of a specific memory after about 2 years.

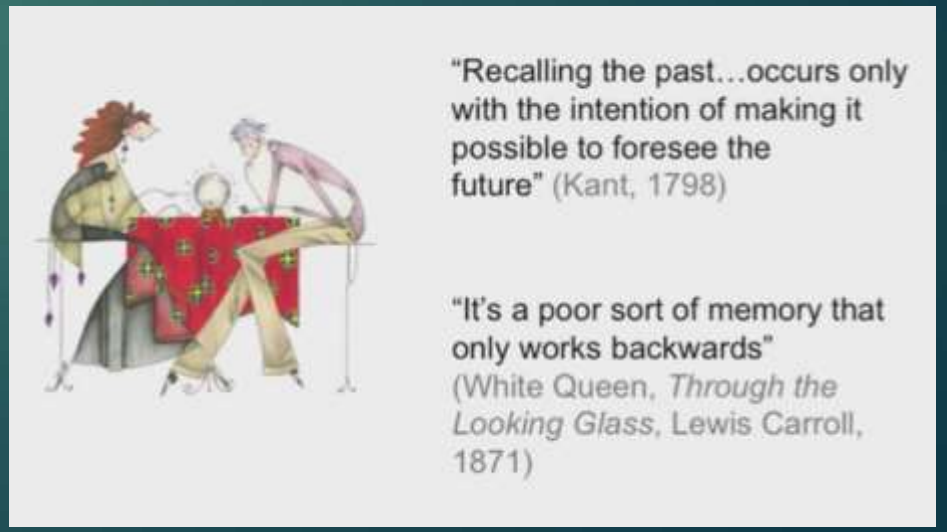
Hippocampus & Prefrontal Cortex Work Together

- The hippocampus is our memory search engine,
- The prefrontal cortex is the filter determining which memory is the most relevant.
- Storing information alone is not enough for a good memory.
- PFC gives you ability to access the relevant information without being distracted by similar competing pieces of information.

Role of Hippocampus: Future prediction –
"It's a poor sort of memory that only works backwards"

- Actual reason for memory and function of hippocampus: memory is not about the past; it's about the future

- Memory is about helping predict and infer from previous experience and prior knowledge, what to do next, where to go, what to expect, & how to survive



Memory retrieval is a reconstruction

Memory is not an exact storehouse or copy, i.e. apple not located in 1 neuron, not byte on hard drive

Memory is an active, reconstructive process, that can be constructed, elaborated, distorted, and lost.

Factual Memory: Remembering What…

- Fact Memory
- Explicit information
- Remembering faces
- Remembering telephone numbers
- Remembering names
- Recalling dates
- Visualizing maps and locations

Declarative Memory:
Medial Temporal/hippocampus and Frontal Diencephalon

- Initial input into LTM: both episodic & semantic
- Fast process
- Conscious & Effortful
- Specialty: 1 trial rapid acquisition
- Sensory multimodal
- Poor reliability (forget; retrieval errors)

Episodic Personal Memory:
Mental Time Travel - Need Frontal Lobe

- Episodic or Specific Event Memory:
  - Who, what, where, when, how?
- Memory for personal experience
- Where, when, how of acquisition of the memory
- Personal, subjective experience
- Temporally and spatially dated
- Context of a memory

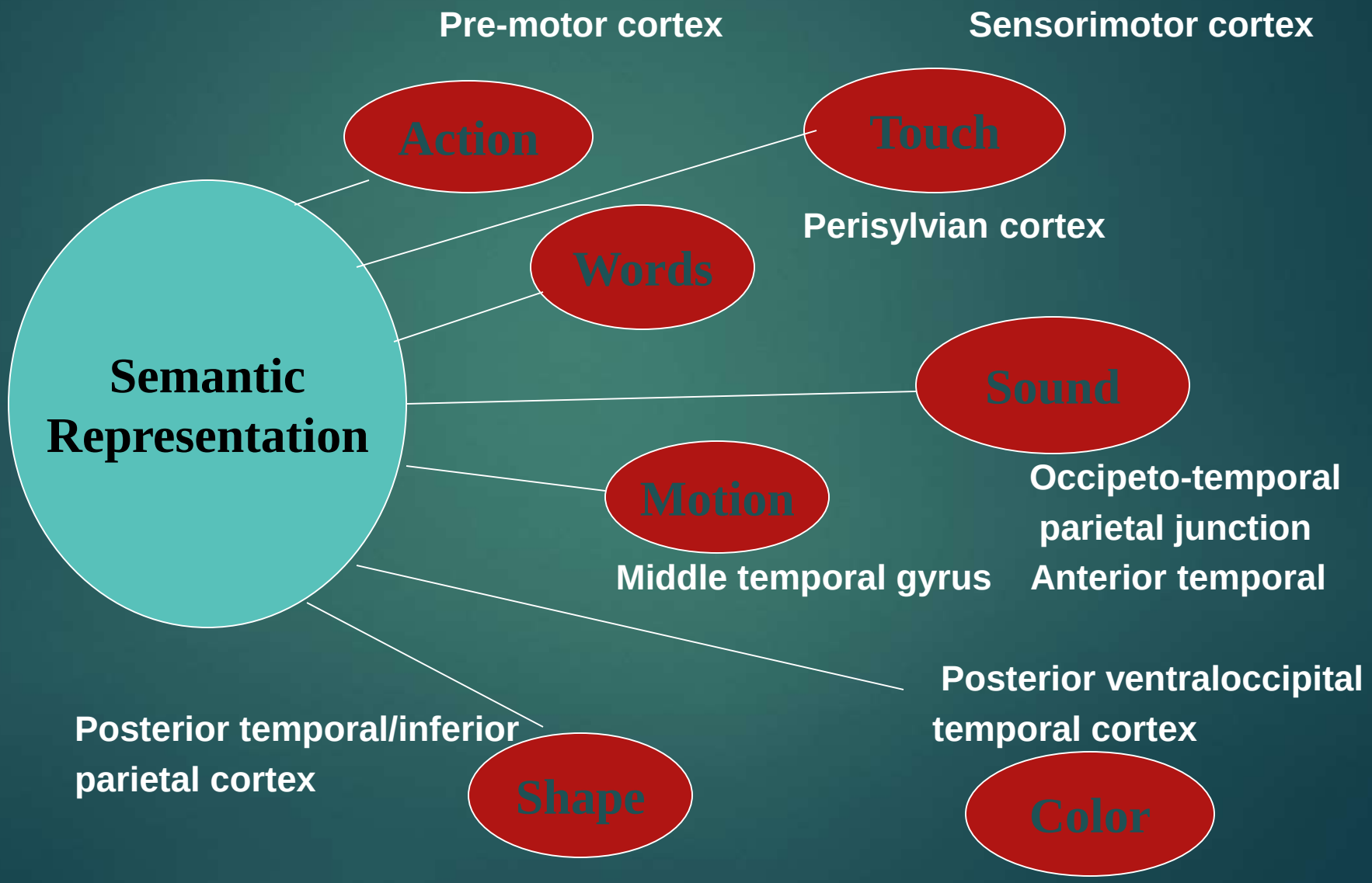
- Requires Frontal processing & bilateral anterior and right posterior hippocampus

Tulving, 1972,1983, 2002

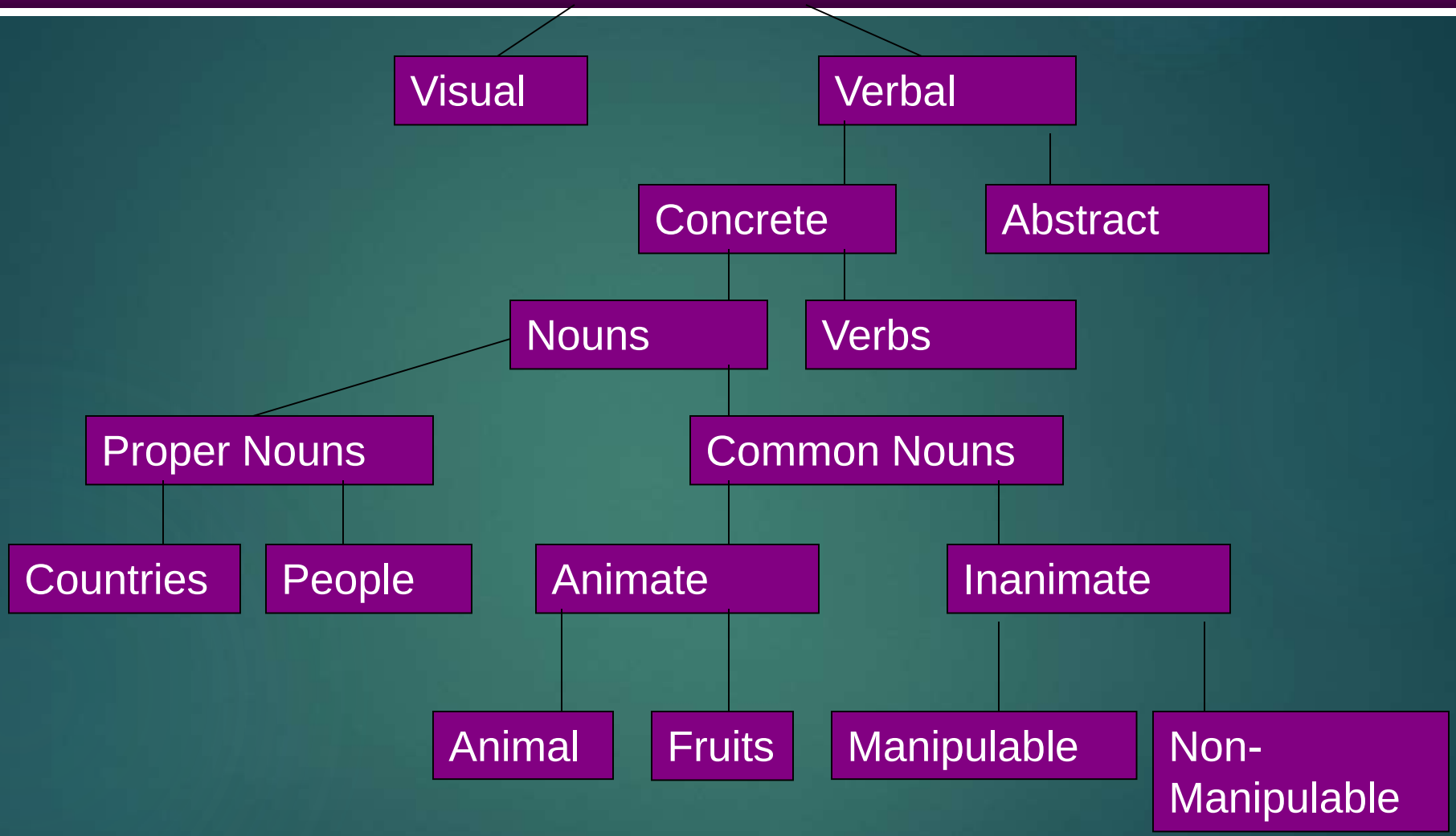
Semantic Memory: Knowledge

- Our Knowledge: What we "know"
- General Knowledge
  i.e. Cleopatra, 1492, Buddha
- Organization based on meaning, semantic networks
  - lexical (Animal Naming)
  - 1st letters of words (FAS)
- Research results from Fluent Dysphasia and Visual Dissociative Agnosias cases

Locations of Semantic Memory



Topography of Semantic Knowledge revealed by strokes



Other Known Categories: indoor / outdoor, vegetables

Tip #11: More meaningful a memory, the better we remember it

Schachter: Depth of Processing Theory

Level of Processing	Type of Encoding	Example
Shallow	Structural/visual	Written in upper or lower case letters?
Intermediate	Phonemic/acoustic	Does word rhyme with bog, bar, etc.?
Deep	Semantic (meaning of a word)	“Does the word go in this sentence: You buy candy in a _____ .”

Memory is better if it is meaningful

- All better memory is based on association, elaboration, & deep encoding

- Baker/baker paradox:
  - Show same picture of man;
  - 1 told he is a baker; 1 told his surname is Baker;
  - Being told profession always produces better memory (baker has larger context of associations)

- To make something memorable, you first have to make it meaningful.

Joshua Foer:
Moonwalking With Einstein: The Art and Science of Remembering

Tip: Remembering names

- Meet man named Ronald wearing loud shirt who is a car salesman who loves fishing and wants to sell fishing gear
- You need to create a web of associations.
- First, you should repeat any name said to you. “Ronald, why do you love fishing.”
- Link the name you have just learnt to something you already know. Ronald Reagan was president.
- Link their name to something else about them. Ronald McDonald always wore bright colors.
- Imagine Ronald McDonald hitting Ronald Reagan with a fish.

Use your visual imagination

- 1 What was the man’s name?
- 2 What kind of shirt was he wearing?
- 3 What did he like to do?

Old vs new advice about learning

- Classic recommendation for studying and memorizing a topic: Find a quiet, isolated study space and study same topic for several hours and later review your underlined or highlighted material, especially on the night before the test; and review your material by rereading it.

- New research says: Learning is more powerful with distractions, quitting before you're done, having distraction periods, taking a test before you know anything, mixing up the learning, changing locations, spacing study times, finding meaning, napping, and falling asleep.

How we learn by Benedict Carey

What does not work in learning

- Reviewing highlighted text
- Rereading text: you crucially fail to know that you have not learned specific material
- Only by testing do you realize what you do not know

Tip #12: Repeatedly self test yourself

- "Retrieval practice"—correctly producing a studied item—increases the likelihood that you'll get it right the next time.
- Repeated retrieval is good for memory.
- Testing is a memory strengthener.
- Self Testing or retrieval practice = forces you to choose an answer and gives you immediate feedback about what you know or do not know
- Self-testing offers an accurate assessment of what has not been learned and whether one needs to keep studying.

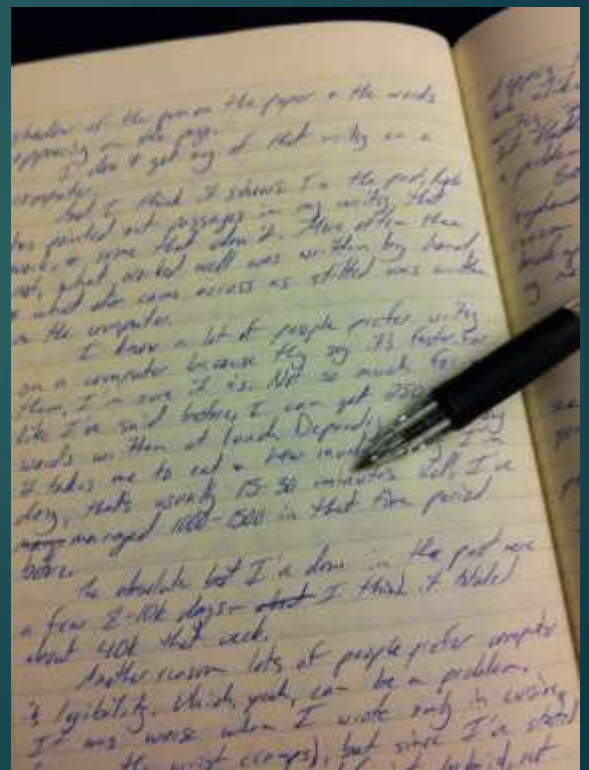
Karpicke, Science, 2008

New Research

- New research says: Learning is more powerful
  - with distractions,
  - having distraction periods,
  - taking a test before you know anything,
  - mixing up the learning,
  - changing locations,
  - spacing study times,
  - finding meaning,
  - napping,
  - falling asleep.

The Pen Is Mightier Than the Keyboard
Advantages of Longhand Over Laptop Note Taking

- Taking notes on laptops rather than in longhand is common, but may not help your memory.
- Even when laptops are used solely to take notes, they may still be impairing learning because their use results in shallower processing.
- In three studies, students who took notes on laptops performed worse on conceptual questions than students who took notes longhand.
- Whereas taking more notes can be beneficial, laptop note takers' tendency to transcribe lectures verbatim rather than processing information and reframing it in their own words is detrimental to learning.



Tip #14: Chunking – mentally grouping details

- **Chunking** (adding meaning) leads to better recall

- N L B I A T F C S R M V

  Versus

- N F L- C B S- I R A- M T V

- Examples: Your phone number or Social Security number

Coming Up Next:
Example of Procedural Memory

- Old typewriting skills are procedural memory

Over learned Skill

Procedural/Behavioral Memory: Remembering how…

- Skills, habits
- Playing a musical instrument
- Playing sports
- Riding a bicycle, driving a car
- Reading mirror-reversed word
- Playing Chess, bridge
- Grammatical structures
- Interpersonal Skills
- Depression
- Transference in psychotherapy
- Cognitive Behavioral Therapy

Procedural/Implicit/Nondeclarative Memory

- Heterogeneous systems: perceptual systems, striatum, cerebellum
- Gradual behavioral repetition culminates in unconscious behavioral change
- No access to learning episode or context
- Reliable, highly resistant to change
- Sensory modal hyper specific (typing ≠ piano)

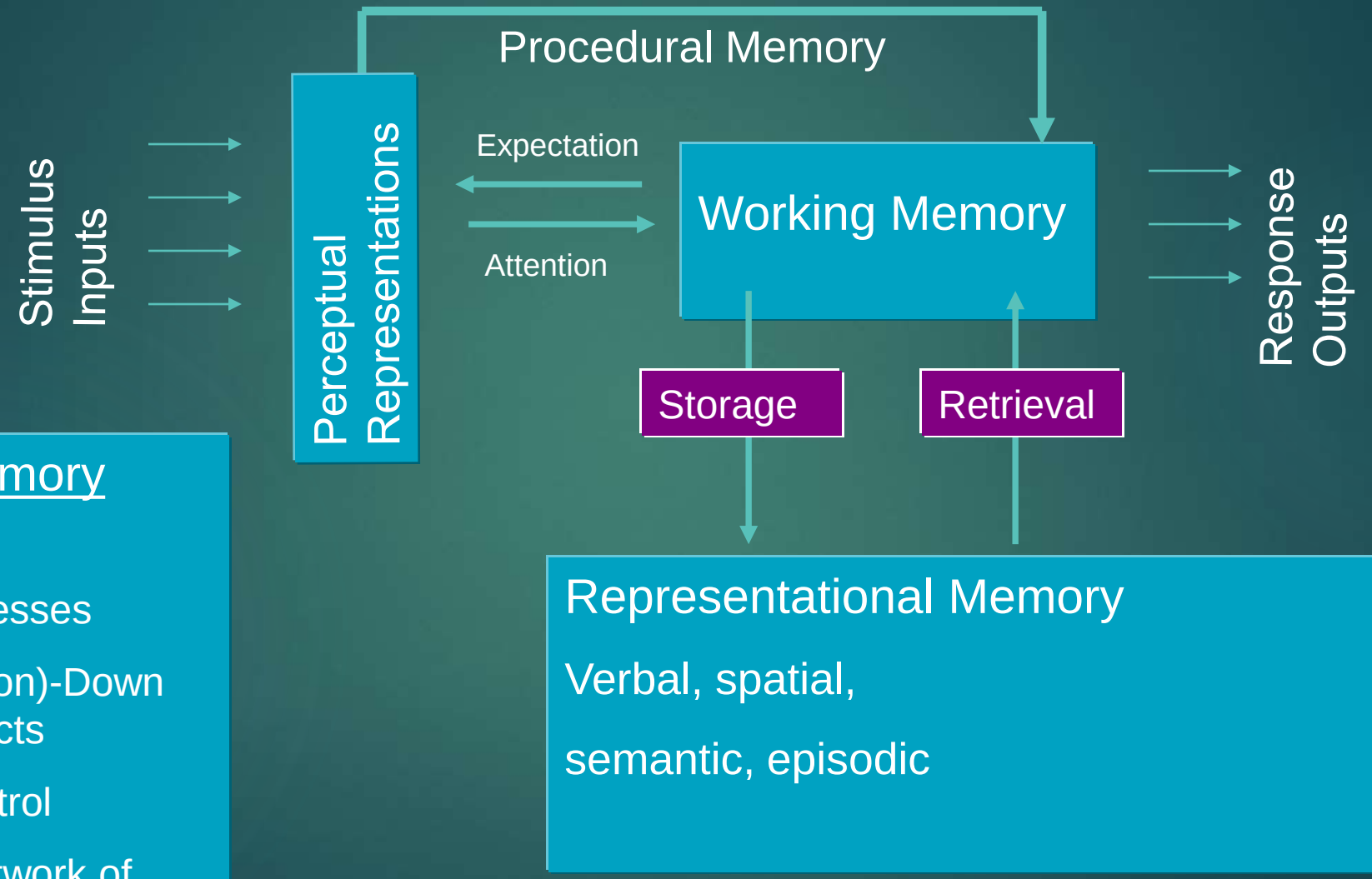
Tip #15: For behavioral memory: Do it – don't think about it.

- Yogi Berra (NY Yankee catcher & manager) and Behavioral Memory:
  "You can't think and hit a baseball at the same time."

- If you make an implicit process explicit, you can wreck it.

- Lesson: Do it. Don't think about it.

An Information Processing Model of Memory



Revised Memory Model

Dynamic Processes

Top (Expectation)-Down (Sensory) Effects

Executive Control

Distributed Network of Associations

Source: A.P. Shimamura, 2003

Will ____ improve my memory?

Maybe if you believe:

- Ginkgo Biloba
- Fish Oil
- Vitamin B12
- *Blueberries*

It depends:

- Brain Games
- Puzzles
- Action Video Games

Most promising:

- Aerobic Exercise
- Sleep
- Motivation to learn

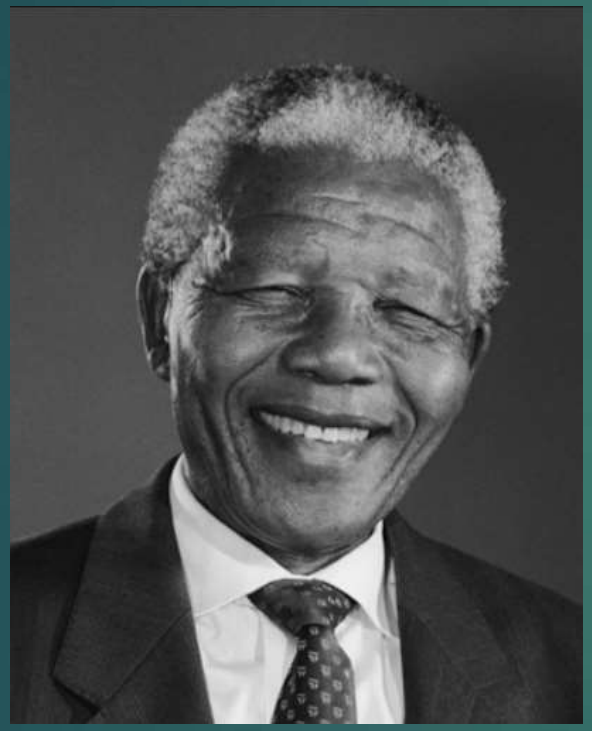
What to avoid:

- Chronic Stress
- Hypertension
- Diabetes

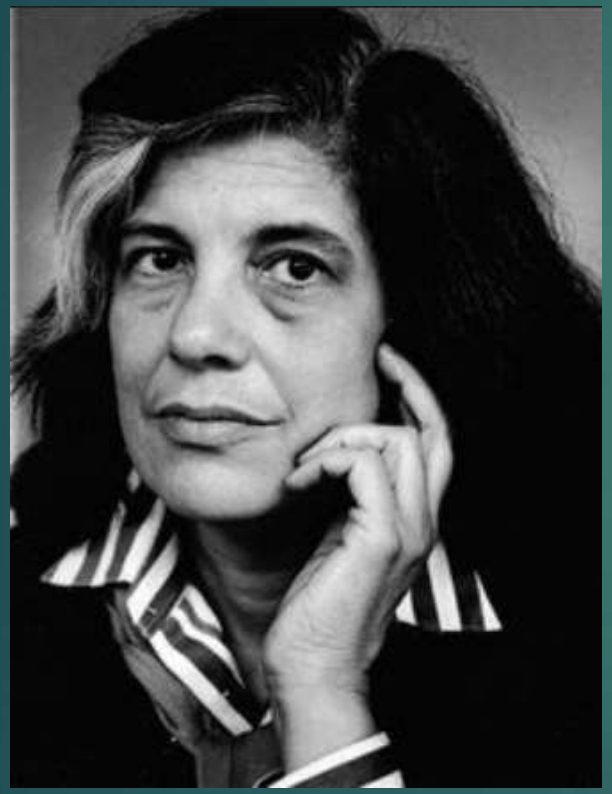
Remember those 15 pictures you saw before?

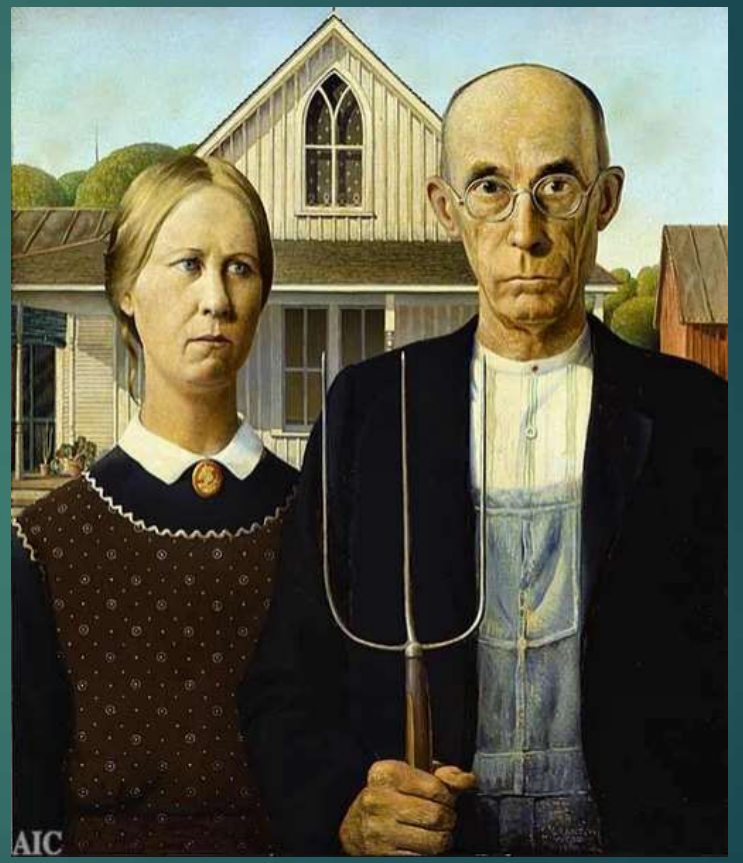
Which of next 2 pictures was the one presented 30 minutes ago?

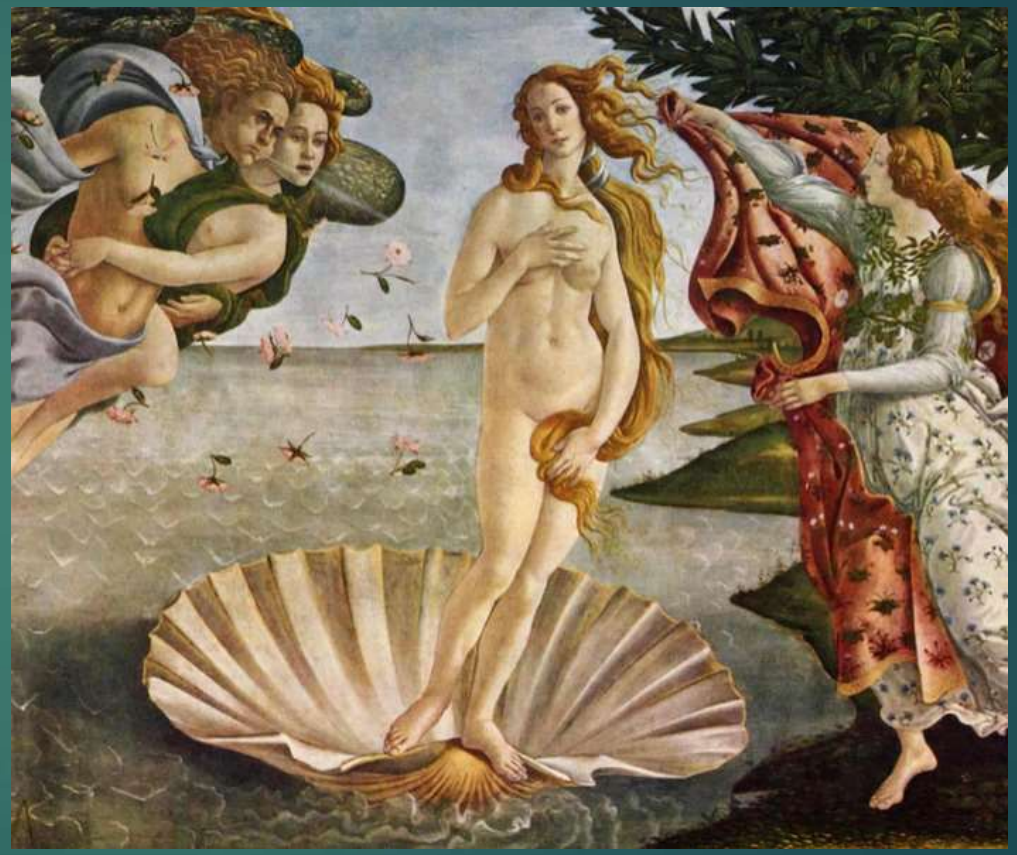
This symbol () will identify which picture you saw before after you look at the two pictures.




Everett Collection / Rex Features




AIC



Oh sorry. That was yesterday!

I assume you remembered all of the 15 pictures. Correct?
Your visual memory is amazing!

Tip #16: Use Visual Imagery to remember

Picture superiority effect in Memory

- Almost perfect memory for visual images.
- Pictures are remembered better than words
- Studies for 30 years: picture superiority effect has demonstrated that subjects are more likely to remember items if they are presented as pictures versus words
- Older individuals use this phenomena more than younger
- Standing (1973): 10,000 images over 5 days; 2 days later, 2 image choice, 83% recognition of original images
- MIT study: 2000 images for 3 seconds in 2.5 hours; 92% accuracy

Shepard, 1976; Mintzer & Snodgrass, 1999

Example of using visual imagery to remember a name: New psychologist at work: Christy Hogan

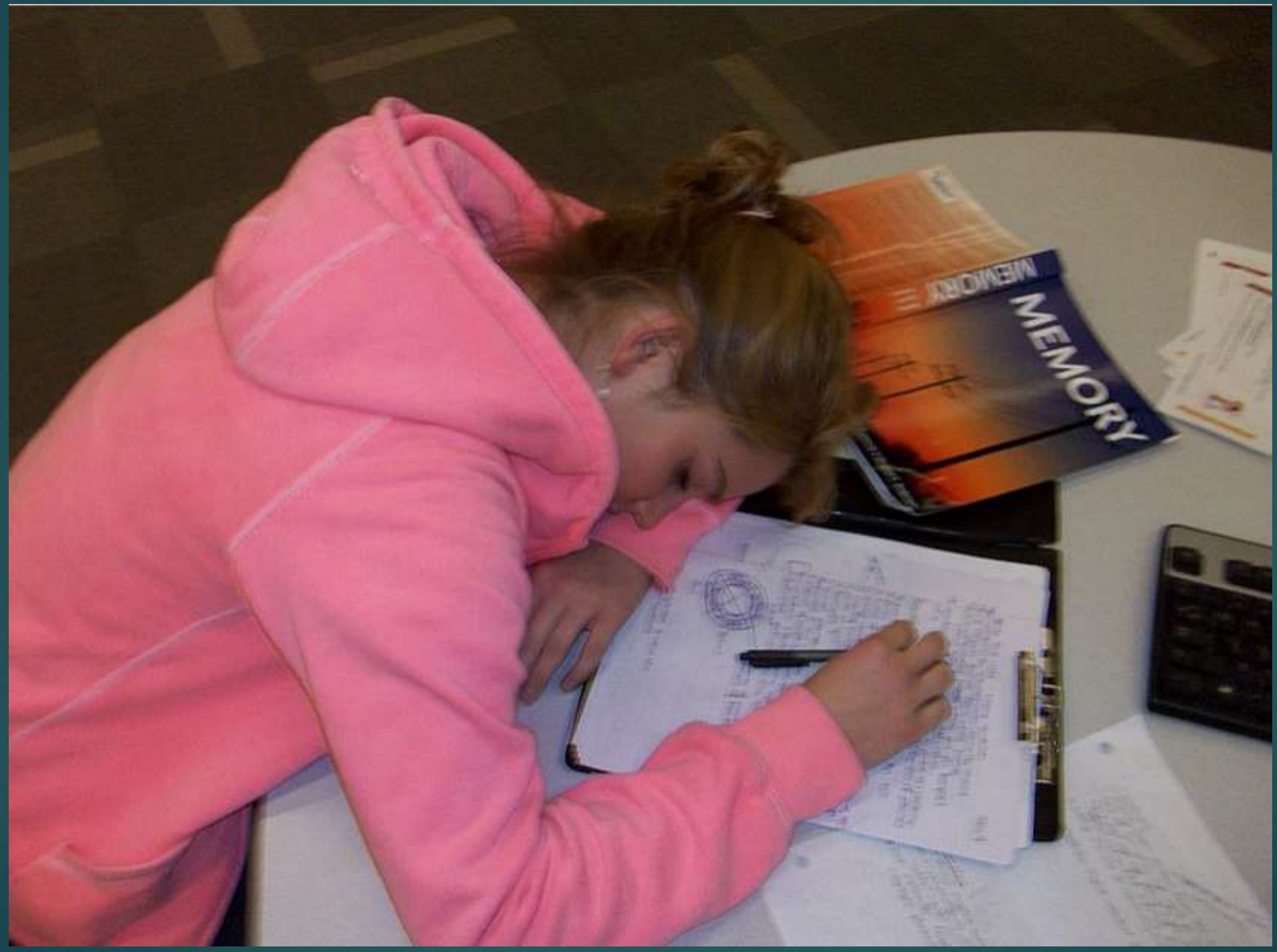
+

Tip #17: To Sleep is to Remember:
Primary function of sleep is to consolidate memory

- Waking brain optimizes memory encoding (get them into storage)
- Sleep optimizes memory consolidation (make them permanent)
- Sleep: repeated reactivation of the new memories during off-line time (sleep)
- Current Conclusion: Sleep improves retention & comprehension of what one has studied the day before. Memory improvements with sleep = 10 to 30% better.

Giuditta et al., 1995; Mednick, et al., 2003

Napping and memory



A Nap is as good as a Night

- Naps of 60 or 90 minutes contain slow wave deep sleep and REM.
- People who study in the morning (any type of factual content) do ~30 percent better on an evening test if they had a 60 minute nap than if they haven't.
- 90 minute nap significantly enhances prior procedural learning, i.e. dance sequences, piano sequences, etc.;
- A 60 to 90 minute nap may give same benefits in memory consolidation that you would from sleeping for 8 hours at night.

Sara Mednick, et al., 2003

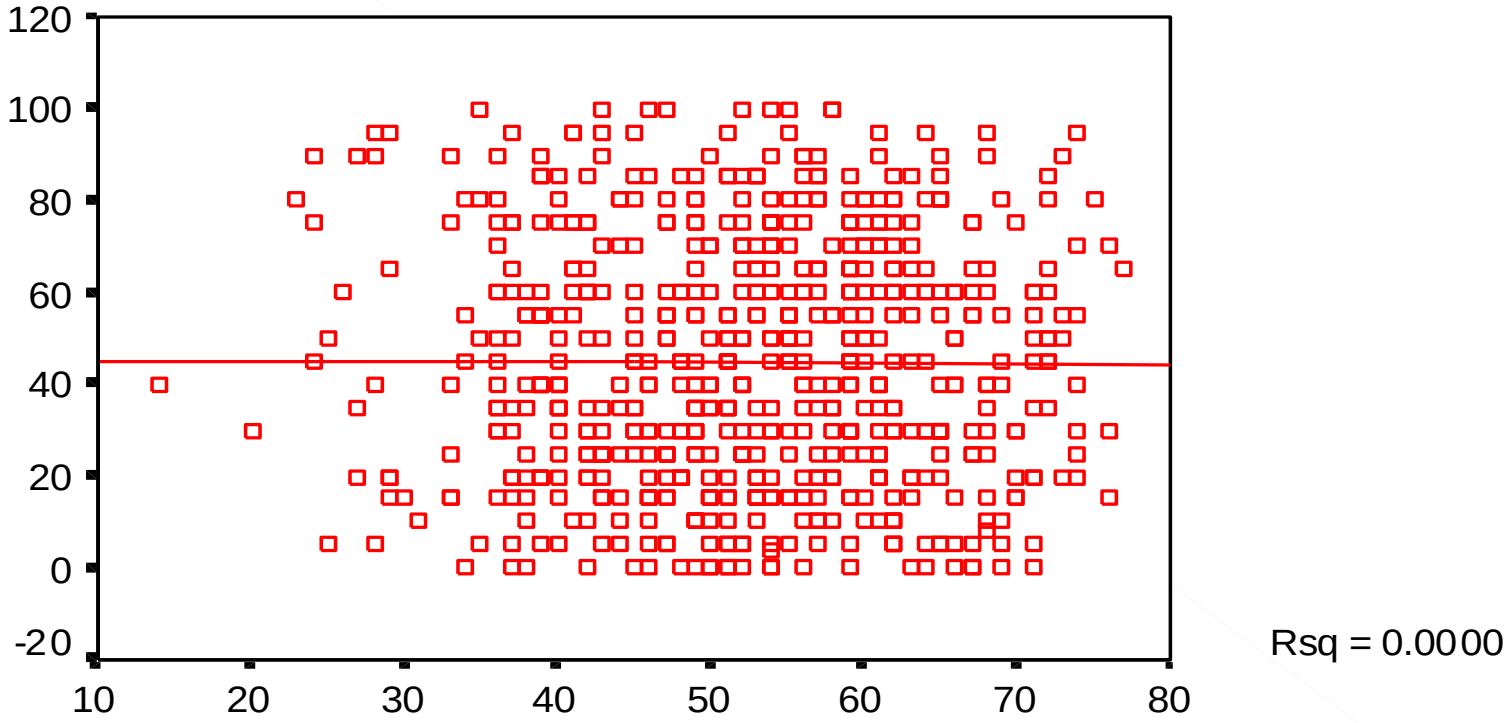

"ON THE CONTRARY, I CAN'T RECALL A THING FROM FIFTY YEARS AGO, BUT I REMEMBER EXACTLY WHAT I HAD FOR LUNCH YESTERDAY."

Phillip's Milk of Amnesia

for people who can't remember shit.

Verbal memory complaints versus verbal memory test scores

Zero correlation in 995 cases



Green, 2003

Age related memory Decline

Number recalled after 1 trial

Normal Aging and Memory

- Intact Working Memory, Semantic Memory
- Decrease in how much factual info you can learn, but normal forgetting rates: Learn less items, but don't forget them

  Recall: 12 new words, age 20,

  7 new words, age 80
- Frontal memory effects increase
- Name-Face recognition decreases

Older have nicer pasts

2nd third

- Older people tend to see the past through rose-colored glasses
  - remember fewer negative images than younger participants
  - reduced interactions between the amygdala and the hippocampus, when shown negative images.

- Seniors are able to regulate emotion better than younger people, so they are less affected by upsetting events.

Memory Testing Tips

- Worried well (Attention vs. Memory):
  - If you forget where you put your car keys, don't worry.
  - If you forget you own a car, worry.
- Many “memory” problems are attention glitches: where are the keys
- Rarely see an Alzheimer’s patient come alone and voluntarily to my office
- Note the use of partners as external memory prostheses.

Neuropathology of Memory Functioning

- **Dementias:**
  - Alzheimer's
  - Parkinsonism
  - Huntington's
  - Pick's
  - Creutzfeldt-Jacob's
- **Infections:**
  - Encephalitis, esp.
    - Herpes
  - Meningitis
- **Vascular:**
  - Stroke
- **Head Trauma**
- **Toxic/Metabolic:**
  - Korsakoff's
  - Chronic Alcoholism
- **Neurosurgery:**
  - Temporal Lobectomy
- ECT
- Epilepsy
- Anoxia/Hypoxia
- Brain Tumors
- Hodgkin's lymphoma (paraneoplastic syndrome: antibodies attack brain cells

Medial Temporal Amnesia: Alzheimer's, H.M., severe TBI

- Severe Anterograde Amnesia: No new learning
- Some period of Retrograde Amnesia: loss some old memories; keep oldest memories, but not just made new memories

Anterograde Amnesia = No new learning

- Perceive but do not record
- Do not know they have a memory problem
- New person is always a stranger
- No memory for meals
- Eternal present, no worry, no plans
- Able to learn new behaviors, but they don’t know that they know how
- Don’t read stories: can’t keep sequences in mind, or scenes

Anterograde Amnesia

- Affects LTM, new learning
- Impairs factual and episodic new learning
- Impairs new learning in all sensory modalities

But…

- Spares Working Memory
- Spares prior General Knowledge
- Spares behavioral memory
- Music memory spared

TGA: Transient Global Amnesia

- Sudden loss of memory
- Know their identities, but cannot retain recent memory, where they were and how they got there. They show no other symptoms.
- TGA usually occurs after the person engages in strenuous activity -- such as having sex, vigorously exercising, suddenly immersing into icy or hot water, straining to dig a stuck car or even bumping the head.
- The unifying thing about each of them is they produce a sudden and significant change in blood flow
- Levitra, which is a pill for erectile dysfunction, lists TGA as a possible adverse reaction.

Prospective Memory: Remembering a delayed intention

- PM = remember to execute an intention at an appropriate later time
- First you must form the intention, then remember it, then activate it at the right time
- Research: Airline industry – major cause of pilot error
- Relies upon executive (frontal) as well as mnemonic (hippocampal)resources.
- Rostral prefrontal cortex (Brodmann's area 10) plays a critical role in prospective memory (remembering to do something after a delay).

Prospective Memory

- Prospective memory is one of the best predictors of the ability to live independently

- Serious prospective memory failures can hinder the performance of instrumental activities of daily living (IADLs; e.g., medication adherence).

Herpes Encephalitis: AA & RA

- N = 10: Dense amnesia in 60%, and a less severe anterograde memory impairment in the others.
- Severity of amnesia related with severity of damage to medical limbic system structures such as the hippocampus, with bilateral damage

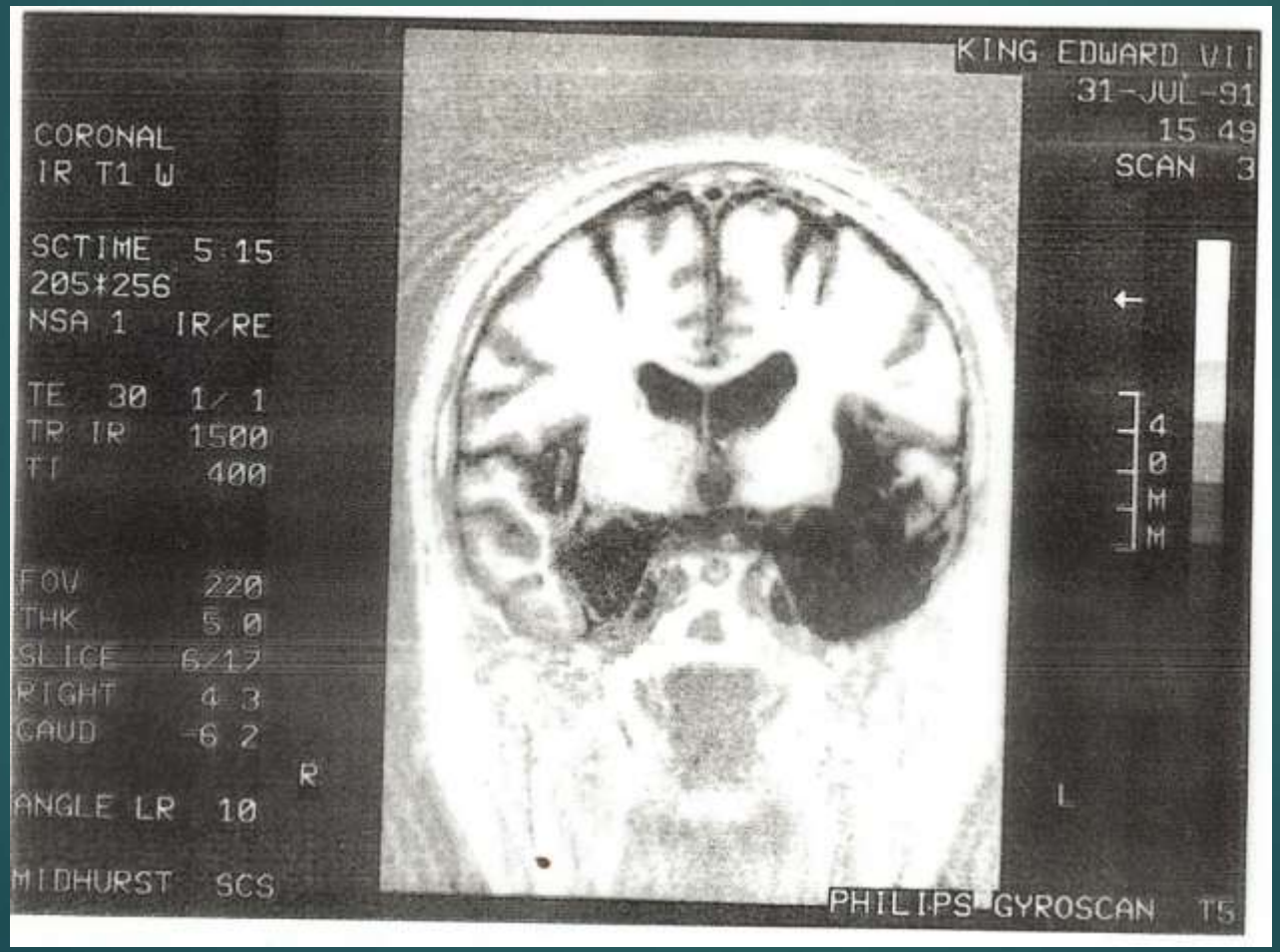
Kapur, 1994

Famous Amnesia Cases: Clive Wearing

- One of the worst cases of amnesia; due to Herpes simplex encephalitis, 1985:
- Conductor, encyclopedic musicologist and BBC music producer
- Severe AA and RA (90 second sensory store); normal implicit memory
- Plays Piano and Harpsichord and conducts and reads music
- Diary:

8:31 AM: Now I am really, completely awake.
9:06 AM: Now I am perfectly, overwhelmingly awake.
9:34 AM: Now I am superlatively, actually awake.

Clive Wearing CT:
No Left Temporal or Hippocampus



Medial Temporal Amnesia:
Alzheimer's, H.M., severe TBI

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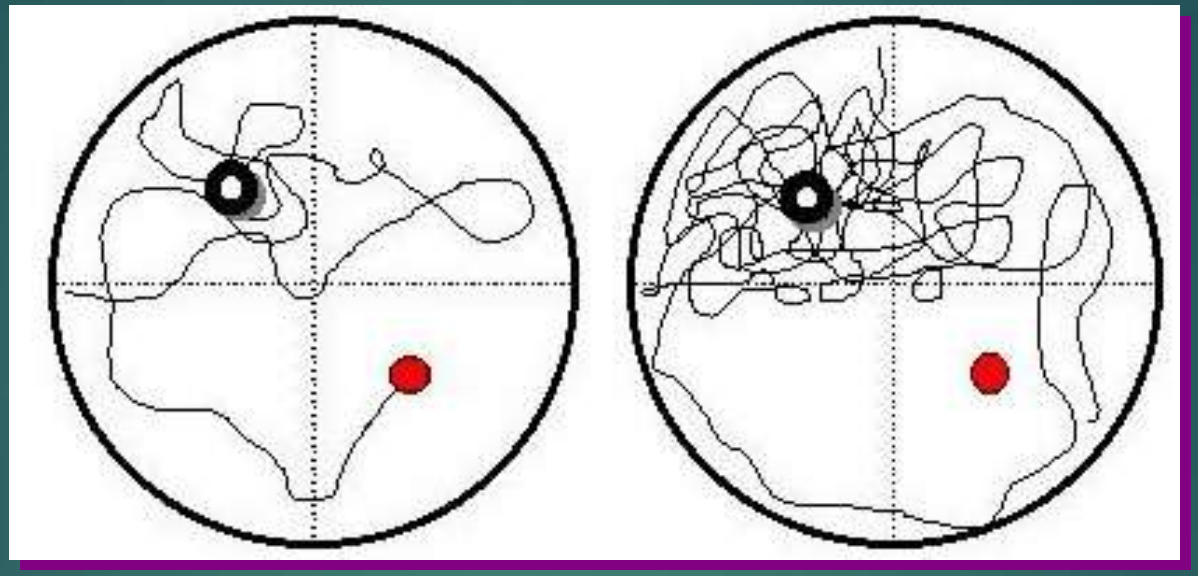
Gender and Memory

- Women superior in memory:
  - episodic memory.
  - Verbal episodic memory tasks, such as remembering words, objects, faces, pictures or everyday events
  - location of car keys
  - remembering faces, especially of females
  - remembering tasks requiring little to no verbal processing, such as recognition of familiar odors
  - remember better if info given by male baritone voice
- Female episodic memory advantage increases when women utilize verbal abilities and decreases when visuospatial abilities are required
- Men outperformed women in remembering symbolic, visuospatial information.

A. Herlitz & J Rehnman, Psych. Science, 2008

Memory and Alcohol: Finding the new spot

Normal Control



Binger

The black, open circle is the old location and the solid red circle is the new location. Control rats (left) rapidly altered their behavior to find the new location.

Weeks after treatment when alcohol was no longer present, binge treated rats (right) perseverated on the old location. They never found the new location.

Korsakoff's Syndrome: chronic alcoholism

- Damage to the mediodorsal nuclei of the thalamus and mammilary bodies via
  - thiamine deficiency
  - fencing foils (Case N.A.) via nostril
  - snooker cues (Case B.J.) via nostril

- Anterograde and retrograde amnesia.

- If frontal deficits: lack of awareness of deficits (anosognosia)

Traumatic Brain Injury

- TBI: Most common cause of amnesia (permanent loss of new learning)
- PTA: Post Traumatic Amnesia (post confusion, retrograde amnesia for events prior to injury and anterograde amnesia for the accident itself and for all future learning)
- Often significant and permanent Anterograde amnesia and minor Retrograde amnesia

ADHD and Memory

- Impaired Working Memory and Sustained Attention
  i.e. Digit Span Backwards, IVA test
- Frontal executive dysfunctions
  i.e. WCST
- Trial one on list learning impaired:
  i.e. CVLT2
- One time only memory exposure poor, i.e. conversations

Alzheimer's Disease

- Age 85 = 37% of population
- No new learning (amnesia).
- Rapid forgetting is core feature
- Intrusions and False Positives increase
- Semantic Knowledge deterioration
- Working Memory and implicit memory deficits occur later.

Normal Memory Decline vs. Alzheimer's

- Normal aging:
  - Dentate gyrus of hippocampus more impaired
  - Entorhinal cortex is relatively spared
- In Alzheimer's disease, it's almost exactly reversed.
- Physical exercise and lower blood sugar improve dentate gyrus functioning

Small, 2008

Tip #18 : Physical exercise protects memory

- The Dentate gyrus linked to diabetes implicated blood glucose as a pathogenic mechanism
- The Entorhinal cortex (CA1 & subiculum) linked to infarcts suggested transient hypoperfusion as a pathogenic mechanism
- These results show how diseases of late life differentially target the hippocampus, identify elevations in blood glucose as a contributing cause of age-related memory decline
- Physical exercise is a protection for good memory in older people

Risk Factors for Memory Decline

- Age: greatest risk factor
- Genetics/family hx – 3-4 fold increased risk; earlier, faster
- TBI: 2 x if moder-severe; WWII soldiers – 10x
- Down's syndrome
- MCI
- High blood levels of homocysteine (heavy diet of meat) : 2x
- Apolipoprotein (Epo4)
- Gender: women (live longer) > men
- Pot belly in middle age (2.7 greater risk)
- Not finishing high school (80 % greater risk vs. completion)
- Prolonged stress = more fibrillary tangles
- Chronic worry = 40% more MCI
- Obesity (42% greater dementia; 80% Alz); being underweight (36%)

Memory Killers

- Cardiovascular conditions
- Smoking
- Malnutrition (Thiamine/B1↓↓)
- Binge drinking
- No exercise

Subcortical Neurocognitive Disorders (Dementias)

- Huntington's, Parkinson's, HIV, MS:

- Normal encoding
- Poor spontaneous recall
- Normal recognition (cues help)

- Some Behavioral Memory deficits

Cancer

- N = 1,305 participants reported they had cancer or a history of cancer. 14% of participants who had cancer reported memory impairment
- Brain releases anti-inflammatory proteins to fight cancer that can affect brain
- People with a history of cancer have a 40 percent greater likelihood of experiencing memory problems that interfere with daily functioning.
- “Cancer related cognitive dysfunction," suggesting that it goes beyond the "chemobrain" label

Pascal Jean-Pierre, 2010

Electroconvulsive Shock

- Temporary Anterograde Amnesia
- Retrograde amnesia
- Subsequent work showed that the amnesia gradients may stretch back as long as 3 years.

Depression and Memory

- Decrease in Working Memory
- Effort decreases
- Normal Acquisition/encoding
- Decreased spontaneous recall
- Normal recognition memory
- Memory complaints!

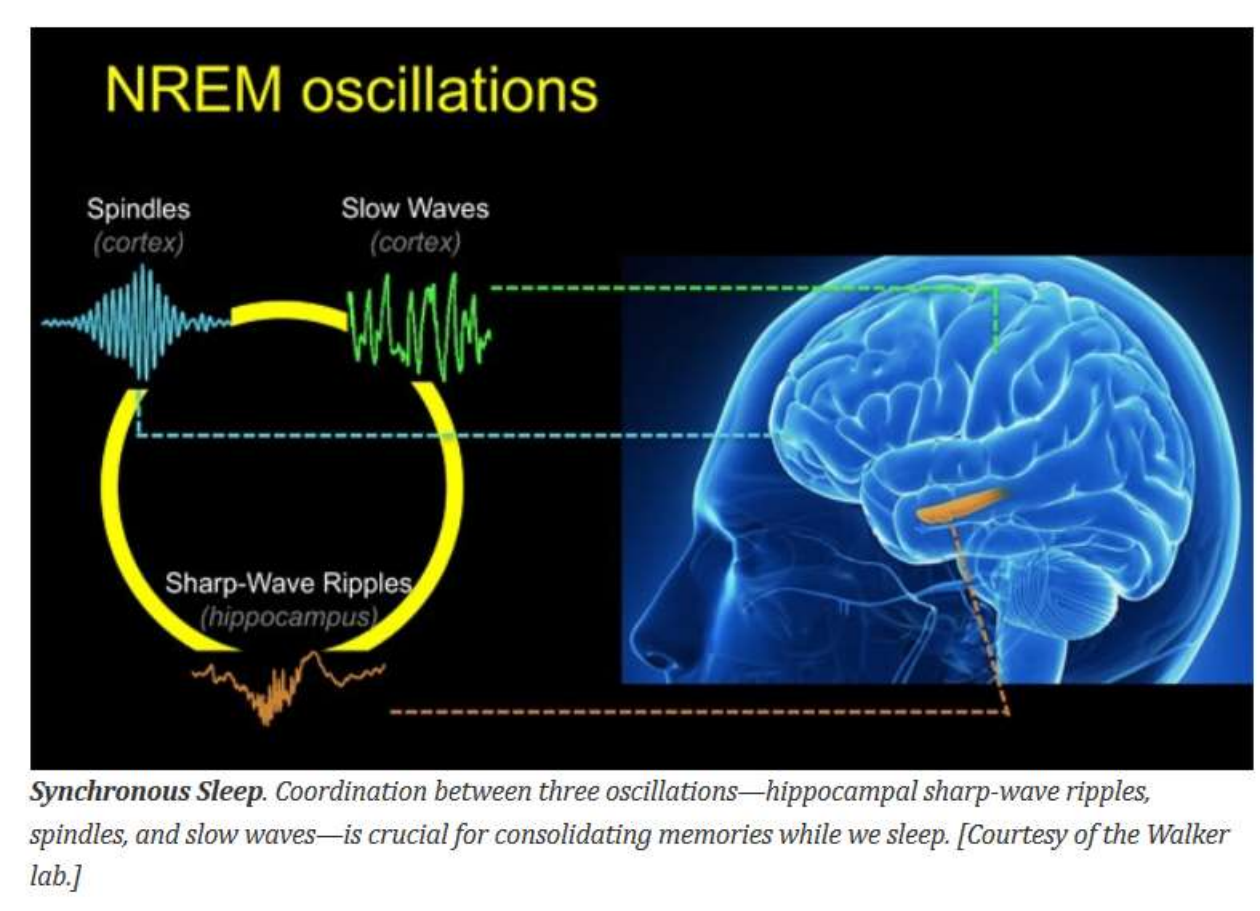
Hippocampal Atrophy in Mood Disorders

- The relationship between severe depression and the hippocampus is essentially toxic.
- The more intense the history of depression, the smaller the hippocampus.
- Hippocampal size is inversely correlated with illness duration, number of hospitalizations, recurrences.
- Decreased neurogenesis may underlie hippocampal atrophy

Gorwood, et al., AJP, 2008

Antidepressants: Increase Hippocampal Volume

STM to LTM transfer during sleep



***Synchronous Sleep**. Coordination between three oscillations—hippocampal sharp-wave ripples, spindles, and slow waves—is crucial for consolidating memories while we sleep. [Courtesy of the Walker lab.]*

- Aging disrupts the neural activity that solidifies memories during sleep.
- Alzheimer's pathology also alters memory-consolidating neuronal waves during sleep.
- Skimping on sleep kills neurons in mice and pumps up p-tau.
- Non-rapid eye movement sleep makes up about 80 percent of our sleeping hours. During NREM sleep, a trio of neuronal oscillations coordinates to consolidate memories formed during the day
- when these both align with the hippocampal sharp wave, then the brain is poised to convert short-term memories to long-term ones
- Sleep loss increases BA & Tau.

The more out of synch the two oscillations were, the worse the person performed on the memory task. Increases with age due to atrophy of medial prefrontal cortex

Curiosity

- Neuromodulators like dopamine improve memory functioning
- Enhanced learning during states of high curiosity
- The more curious you are, the more dopamine expressed

Schizophrenia and Memory

- Working Memory deficit (dopamine effect)
- Executive dysfunction
- Episodic Memory impairment
- Cognitive Types:
  - 35% ~Normal
  - 50% Subcortical Type: poor free recall, normal recognition
  - 15% Cortical Dementia Type: poor free recall and recognition
- No use of semantic categorization
- Normal Procedural memory
- Cognitive deficits predict life outcome better than psychiatric symptoms

Schizophrenia and Hippocampal Atrophy

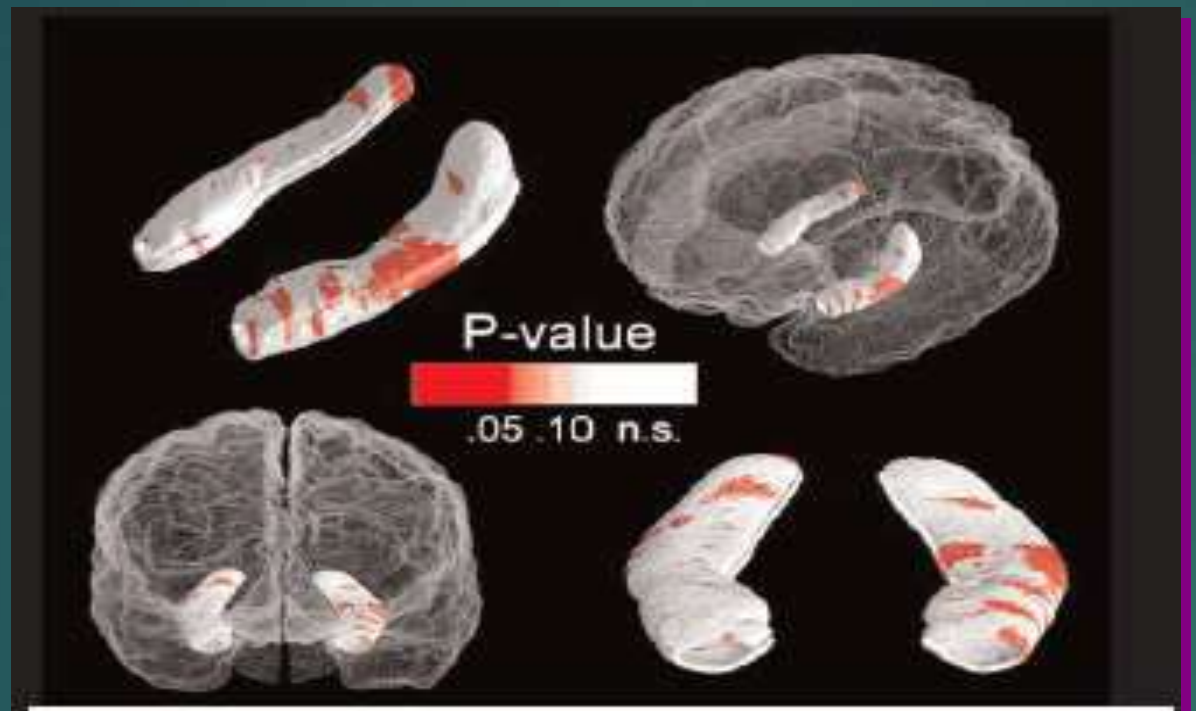
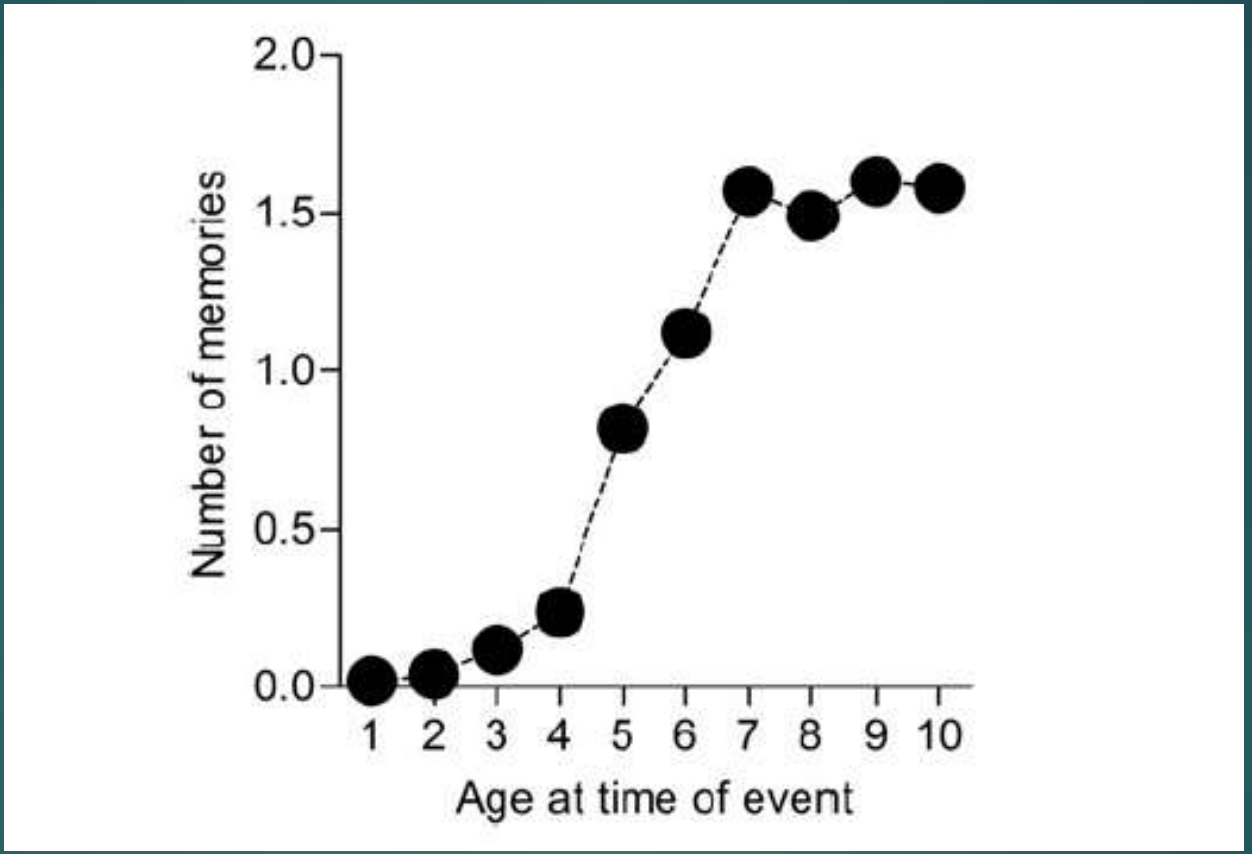


Figure 2. Statistical mapping of deformations in the hippocampal formation that distinguish individuals with schizophrenia (n = 62) from healthy volunteers (n = 60). Note that the deformations (corresponding to volume reductions) in patients are most prominent in the mid-to-anterior hippocampus and appear greater in the left hemisphere.

Infantile Amnesia

- Adults rarely recall memories before age of 3-4
- Continuous autobiographical memory from age 3 1/2
- Old theory: Availability of verbal encoding in childhood correlated to later verbal expression of memory in adulthood
- New theory: high neurogenesis levels negatively regulate the ability to form enduring memories, most likely by replacing synaptic connections in preexisting hippocampal memory circuits
- But animals also exhibit infantile amnesia; no language involved

Infantile Amnesia 2



Distribution of autobiographical memories from the first decade of life showing two phases of infantile amnesia. Participants (20, 35, and 70 yr of age) reported very few memories before the age of three. The number of memories reported to have occurred from the ages of 3–7 yr increased linearly and leveled off from 7–10 yr of age.

More Neurogenesis with Exercise

New dentate gyrus hippocampus neurons, in mice that have unlimited access to wheels and running, is twice that in mice living in standard cages. Exercise related to blood flow: more fit, more blood flow oxygenation.

Factors that Decrease Neurogenesis

- Aging
- Recurrent Major Depression
- Disrupted sleep
- Chronic Stress
- Chronically high Cortisol
- Radiation
- TBI

Factors that Increase Neurogenesis

- Physical Exercise
- Antidepressants (in depressed & normals) (> in young than old)
- Fewer calories consumed
- Fasting
- Type of food content (omega-3 fatty acids from algae)
- Anti-depressants & ECT

Neurogenesis and Prozac

- 4-6 week lag time of SSRIs for full antidepressant effect

- Lag time due to time it takes Serotonin to stimulate neurogenesis in hippocampus
- More new neurons in dentate gyrus of hippocampus
- More dendrites as well

R. Hen, J Neuroscience, 2008

Psychogenic Amnesia: Dissociative Fugue

- Loss of autobiographic information or personal identity in absence of dementia or delirium; Victims lose only the memories tied to their identity; a loss of episodic memory.
- Never neurologically based (except most severe dementia)
- Characterized in part by sudden and unexpected travel combined with an inability to recall one's past
- First case: Ansel Bourne, a Rhode Island preacher in 1887. Its most famous sufferer is the fictional Jason Bourne, the secret agent made flesh on film by Matt Damon.

Memories are reconstructions, not replays

- Memories are:
  - Not recordings, but rather re-codings, reconstructions
  - They are not audio or visual recordings, but a recoded blend of events from the external world, as interpreted by each person's unique cognitive schemata/inferences.
  - False and misleading information can be integrated into memory.

Memory is Malleable

- Every time we recall a past event, its encoding in our neuronal synapses becomes malleable, and thus potentially subject to change.

- Every time you test newly learned material you add new contexts.

Conversations can alter existing memories

- Every time you tell a story from memory, and change a detail, there is possibility that you will remember that version, not the original version.
- Conversations intervening between initial encoding and subsequent remembering can provide a context for speakers to implant new memories, alter existing ones, and induce forgetting—in themselves and in their listeners
- Social taboos about what to say and not to say in a conversation may play a noteworthy role in shaping memories, particularly collective memories, through socially shared retrieval-induced forgetting

Hirst & Echterhoff, 2008

Eyewitness Testimony

- Jury Trial: witness points to defendant and says “It’s him.”
- Eyewitness testimony, especially if confident, has disproportionate effect on belief by juror
- But memory can be altered by presenting misdirecting questions
- Answering the question “How fast was the white sports car going when it passed the barn while traveling along the country road?” increases witnesses’ later reports of having seen a nonexistent barn in an earlier video (Loftus, 1975, p. 566).
- Studies: Convincing evidence that eyewitness testimony is poor.

Fallibility and malleability of memory

- Convictions based on false memory: 300 people have been convicted and disproved by DNA data; 75% due to faulty eye witness testimony
- Memory is not a recording device; it is constructive & reconstructive
- Question: car hit vs car smashed – people remember broken glass for latter
- Yield or stop sign
- Police feeding misleading information causes distorted memory
- Implanted false memory: lost in the mall – 25% recall; nearly drowned, attached by dog (50%), satanic abuse, sick as child due to dill pickle (later did not want)
- Memory, like liberty, is a fragile thing.

Memory Wars: Repressed Memory vs False Memories

- Controversy surrounding repressed memory came to a head in the 1990s.

- Some believe that traumatic memories could be repressed for years only to be recovered later in therapy, others questioned the concept, noting that lack of scientific evidence in support of repressed memory.

- Gap between clinicians and researchers:
  - 60-80% of clinicians, psychoanalysts, and therapists: traumatic memories are often repressed and can be retrieved in therapy,
  - less than 30% of research-oriented psychologists.

- Belief in repressed memory is still prevalent among the general public.

Implanted False Memory

Implanted False Memories 1:
Lost in Mall at age 6

People remembered or knew they had met Bugs Bunny when they visited Disneyland

Except for the fact that Bugs is Warner Brothers character

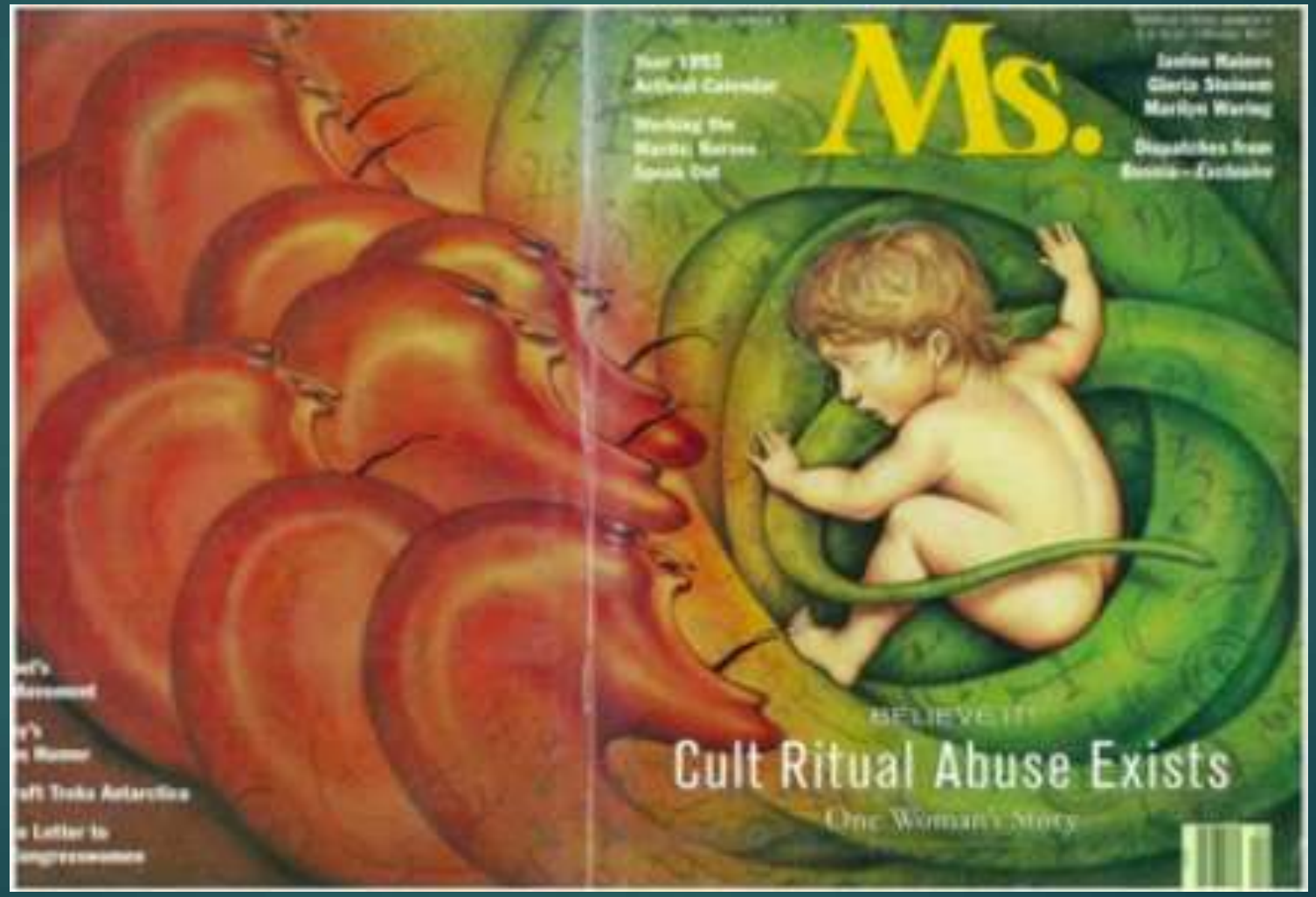
Implanted False Memories in studies

Near drowning

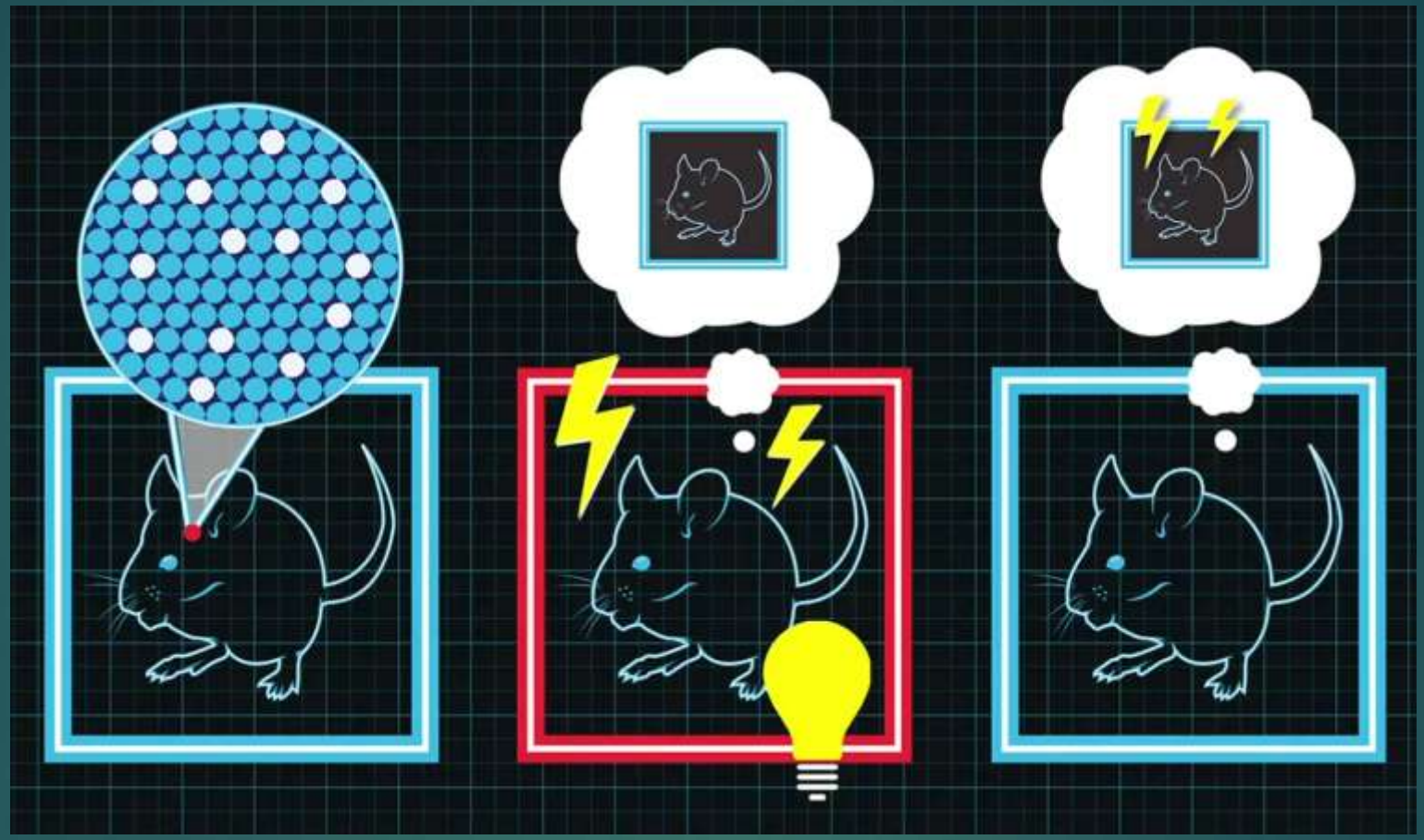
Attack by vicious dog

Demonic possession

Ritual Satanic Abuse: Therapeutic Invention



Can now create a false memory in a mouse



- Three steps to plant a fake memory in a mouse. First, let the mouse build a real memory of a safe room (left). Second, put the mouse in a room with an electrified floor. Shock the mouse — but add the memory of the shock to the memory of the first room. Third, put the mouse back in the safe room — which the mouse now incorrectly “remembers” as dangerous.

Credit: courtesy of Evan Wondolowski/Collective Next

Repressed Memory Controversy

- Brain has no spam filter for false vs. true memories.
- According to - Rosanne Arnold, on "Oprah“:
  "When someone asks you, "Where you sexually abused as a child?" there are only two answers: One of them is "yes," and one of them is "I don't know." You can't say "no."
- Elizabeth Loftus: Memory is distortable, malleable; eye witness/leading question effects
- Lenore Terr: The severer the abuse, the more repressed memory
- James McGaugh: decades of research on war induced PTSD: More traumatic an event, the more the recall – emotional arousal solidifies memory; need to recall future threat

Trauma and Memory

- Amnesia for traumatic event occurs in some victims for every type of trauma.
- Childhood sexual abuse had highest degree of total amnesia (19-38%)
- Age and dose related: The younger at time of trauma and more prolonged the trauma, greater level of significant amnesia

Loftus, 94; Williams, 94; van der Kolk, 96

1996 Crime Victims Compensation Program in WA: Recovered Memory Therapy – Be Careful

- 183 claims of repressed memories of childhood abuse:
- 100% report torture/mutilation (no evidence), 97% satanic ritual abuse; 76% infant cannibalism; 69% torture with spiders
- 100% in therapy 3-5 years after 1st memory
- 10% SI before therapy; 67% following therapy
- 7% hospitalizations → 37%; self mutilation 3% →27%;
- 83% employed → 10% employed 3 y into therapy
- 77% married → 48% divorced/separated
- 23% lost parental custody
- 100% estranged from families

Trauma and Memory

Conclusions:

Traumatic events are most often not repressed or forgotten

It is harder to forget trauma than to repress it.

False memory can be formed by suggestion (therapists can induce false memory)

Autobiographical memory is not a video camera, faithfully recording events; it is malleable by latter events and questions.

You can't trust memory in a tortured brain

- Coercive interrogation techniques to extract information from terrorist suspects
- Extreme stress has a deleterious effect on the frontal lobe and is associated with the production of false memories.
- The hippocampus and prefrontal cortex, are rich in receptors for hormones that are activated by stress and sleep deprivation and which have been shown to have deleterious effects on memory.
- Studies of extreme stress with Special Forces Soldiers have found that recall of previously-learned information was impaired after stress occurred.

O'Mara et al., 2009

PTSD and Memory

- Decreased hippocampal volume (7-25%): Vietnam Vets with most combat, women with repeated sexual abuse,
- Unclear if it is cause or consequence of PTSD (probably a risk factor).
- Extreme Amygdala arousal disrupts hippocampal function, leaving memory to be stored as affective states or sensorimotor memories
- Amygdala mediated memories are more indelible (PTSD, borderline PD)

Intrusive memory removal via Tetris after a trauma

- If you have intrusive memories:
- Play Tetris
- Playing Tetris for 2-3 hours after a trauma, reduces PTSD sxs
- It also has been shown to control other intrusive thoughts
- Both Tetris and a memory cannot be in the same WM space

Medications for PTSD Reduction

- **Paxil** increases verbal declarative memory and hippocampal volume in PTSD

- Pitman (2002): **Propanolol** (40 mg qid) within 6 hours of trauma (10 day course) ; a beta-adrenergic (epinephrine) blocker
- 50% reduction in PTSD sxs; fewer nightmares & flashbacks
- Intravenous administration of **hydrocortisone** over a period of 6 days plus taper decreases the incidence of PTSD
- Quickly giving **morphine** to wounded troops: 53 percent lower risk of PTSD

- These drugs don't erase memory — rather, they prevent the overproduction of stress hormones that encode attached fear response.

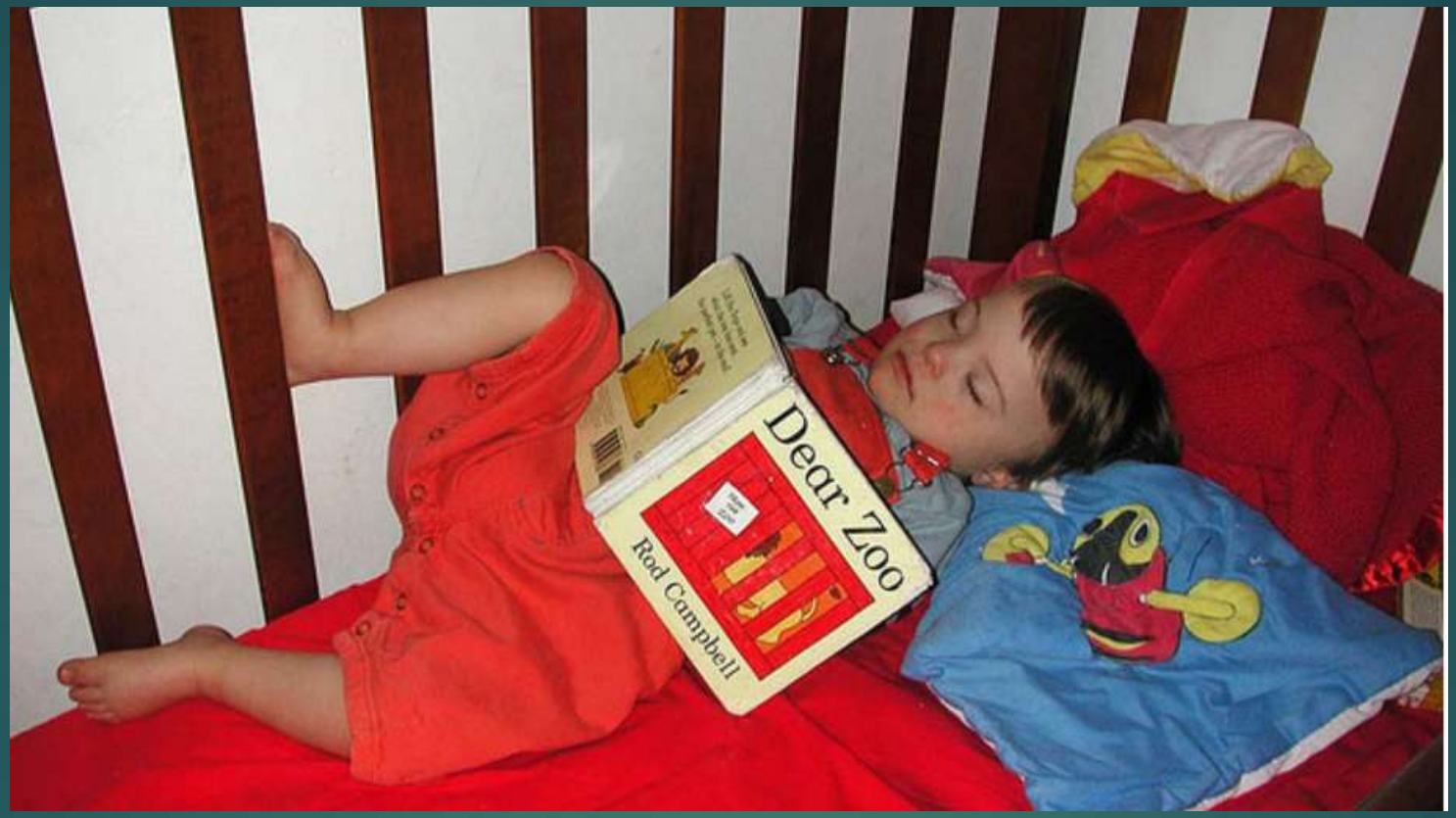
A. Brunet, 2009; Herbst, 2004:

Erasing memories: Reconsolidation of Memory

- Rats were shocked when tone played. They froze in fear.
- Days after consolidation of memory, tone replayed to reactive this memory.
- Drug given to prevent Amygdala from creating storage proteins.
- Rats stopped reacting to tone.
- Proving that some long term memory can be erased.

Nader, 2000

Learning Strategies



Unfortunately, learning through book osmosis doesn't make the learning strategies list.

Memory Tips

- Pay attention and don't get distracted. Attention is first step into memory.
- Make it a habit. When you put your keys down, stop and say out loud, "I'm putting my keys on my dresser."
- Memory box or place: same place all time
- Create a visual cue, i.e. milk carton by door
- Repetition: When you meet people at a party and they give you their names, focus on the name and nothing else, and practice using that name in conversation, by saying the name back. Add a visual cue.

Memory Tips

- Most important: Repeated self testing

- Spaced, repeated practice, not cramming night before
  - Speed-packing a cheap suitcase -- it holds its new load for a while, then most everything falls out.

  - When the neural suitcase is packed carefully and gradually, it holds its contents for far, far longer.

Learning from our Mistakes

- We learn more from our mistakes than from our successes
- Faster recognition of situations (brain signal appears only 1/10th of a second later) in which we previously made an error
- Errors result in better learning

Aristotle on Practice

“We are what we repeatedly do.

Excellence, then, is not an act, but a habit.”

10,000 Hour Rule: Practice Makes Perfect

- Dr. K. Anders Ericsson: became curious about 7 +/- 2; With 20 hours practice, 20 digits; 200 hrs = 80 digits
- He investigated chess grandmasters and the stars of the PGA tour, Scrabble champions and brain surgeons, concert pianists and circus acrobats: average IQ of people at the top of their field
- Talent comes from learning by doing. When Ericsson studied classical pianists, he found that the winners of competitions had practiced over 10,000 hours by the age of 20, while less accomplished performers only practiced between 2,000 and 5,000 hours.

- The best performers are almost always the ones who practice the most.

- See *Outliers: The Story of Success* by Malcolm Gladwell

Tip #19 : Move around/change the context of learning

- State-dependent or context-dependent learning:
  - Recall is best when retrieval environment is the same as learning environment, i.e. scuba diving, being drunk, etc.

Tip #20: The more cues, the better the learning

- The more places in which you study the same material, the better the later recall.

- Most people remember more if they vary their study or practice location. More environments in which you rehearse, the more lasting memory.

- Study: Students studied a list of 44 words for same amount of time in either in 1 or 2 rooms. When tested 3 hours later for 10 minutes in new room: 1 room = 16 word recall; 2 room = 24 word recall; 40% increase in recall from change of venue

Tip #21: Spacing Out: Break up study time

- Cramming isn't useless. The all nighter is time tested student behavior. Cramming is like overstuffing a cheap suitcase. Contents hold for awhile, then all falls out. You will not remember the material next semester. Massed practice (cramming) results in only one context.

- Distributed learning or the spacing effect: 50% better memory

- Spacing: Better retrieval if spaced learning, results in multiple contexts.

- Breaking up study or practice time (dividing it into 2 or 3 sessions instead of 1) is far more effective for learning than cramming.

- Spacing study time is the most powerful and reliable technique known to science to deepen and extend memory.

Spacing it for a given test date

Time to Test	First Study Interval
1 week	1-2 days: today, tomorrow, day before test
1 month	1 week: today, 1 week, day before
3 months	2 weeks
6 months	3 weeks
1 year	1 month

The further away the exam, larger the optimal interval between sessions 1 and 2.
Optimal first Interval declines as a proportion of time-to-test.
If in a week, best interval is a day or 2.
If in six months, 3 to 5 weeks. For most situations, working with intervals of 1 day, 2 days, or 1 week. You will retain the material for much longer.

Wiseheart & Pashler, 2008

Tip #22: Mix it up; do not repeatedly study same thing

- Bean bag experiment: 2 groups, both blindfolded (could look after they made throw); 1 group aimed at bull's eye 3 feet away; 1 group aimed at 2 targets (two feet & four feet away)
- Finally test was on a 3 foot target; Group 2 won with closer tosses

- Variation improves movement awareness; varied practice forces you to internalize rules of motor adjustment that apply to any hittable target

- Mixed or interrupted practice sessions more powerful than focused block practice (focusing on 1 skill at a time)

YouTube and Memory

- Stephen Wiltshire draws Rome from memory
- Clive Wearing: Living Without Memory

Internet Memory Sites

- Braingle: http://www.braingle.com/mind/memory.php
- Memory Gym:

  http://www.memorise.org/
- Helpguide: http://www.helpguide.org/life/improving_memory.htm

Have a good Week

Memory biography

- *How We Learn* by Benedict Carey
- *Perfect Present* by Suzanne Corkin
- *Moonwalking with Einstein* by Joshua Foe
- *Make it stick* by Peter Brown, Henry Roediger, Mark McDaniel
- *The Memory Book* by Harry Lorayne and Jerry Lucas
- *The Art of Memory* by Frances Yates

- Art of Memory Website: http://artofmemory.com/

- www.charlesjvellaphd.com
- Go to Public Lectures