Round 17: Memory

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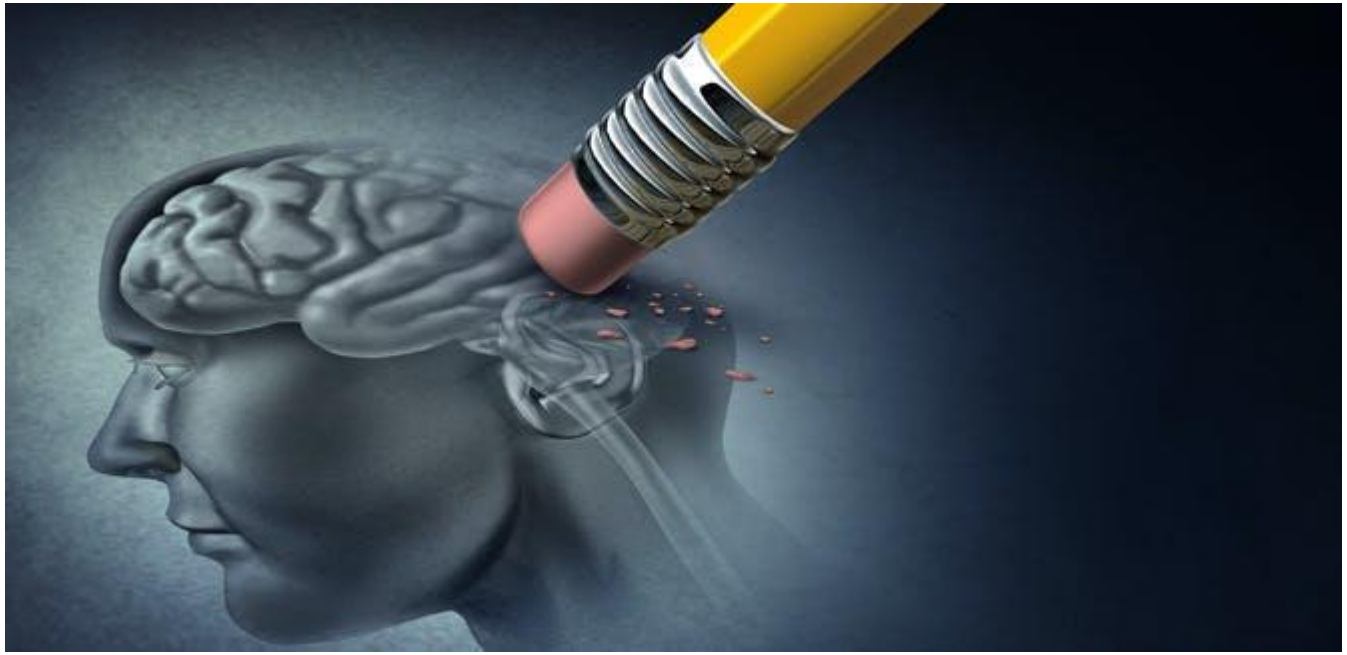
04/01/2021

Memory

- Feelings, emotions, and thoughts occur in the present. Memory is a time machine that allows consciousness to travel back in time.

- Defines who we are by integrating our experiences into a coherent autobiography.



Stages of Memory

- Register information received through sensory channels

- Encode
  - Process for identification and association
  - Left Prefrontal regions
  - Limbic system evaluates for relevance
    - Links/associates with other information

Stages of Memory

- Store
  - Cerebral cortex & limbic system
    - Hippocampus & entorhinal cortex necessary for binding
    - Left hemisphere stores primarily verbal or general knowledge
    - Right hemisphere stores nonverbal & autobiographical information “experiential”
  - Represented in distributed form

- Retrieve
  - Prefrontotemporopolar network
  - Right Prefrontal regions
  - Limbic system

Types of Memory

- Iconic/Echoic
  - Unimodal sensory areas
  - Retain information for milliseconds
- Short-term & Working memory
  - Parietal & Prefrontal areas
    - Dorsolateral prefrontal (DLPFC)
  - Online retention of 7+/- 2 items
  - Lasts up to a few minutes

Types of Memory

- Long-term memory
  - Lifelong retention of information
  - **Implicit (Unconscious)**
    - Inferred indirectly through faster performance on certain tasks (e.g., priming, conditioning)
    - Procedural
      - Motor skills
      - Damaged with basal ganglia & cerebellar lesions
  - **Explicit/Declarative (Conscious)**
    - Semantic/Factual
      - General facts
      - Damaged with lesion of left frontotemporopolar region
    - Episodic
      - Personal, autobiographical
      - Damaged with lesion of right frontotemporopolar region

Memory Assessment

- Free Recall
  - What do you remember?
- Cued Recall
  - P_____
  - B ____
  - G _____

- Recognition
  - Did you see any of these objects?
    - Dog
    - Ice cream
    - Lamp
    - Woman
    - Chair
    - Saxophone
    - Bed
    - Alarm clock
    - Teddy bear
    - Taxi

1	Shoe
2	Motorcycle
3	Record player
4	Coke bottle
5	Computer
6	Heart
7	Taxi
8	Car
9	Woman
10	House

Serial Position Effect

- Primacy Effect
  - Tendency to remember the beginning of a sequence
- Recency Effect
  - Tendency to remember the end of a sequence

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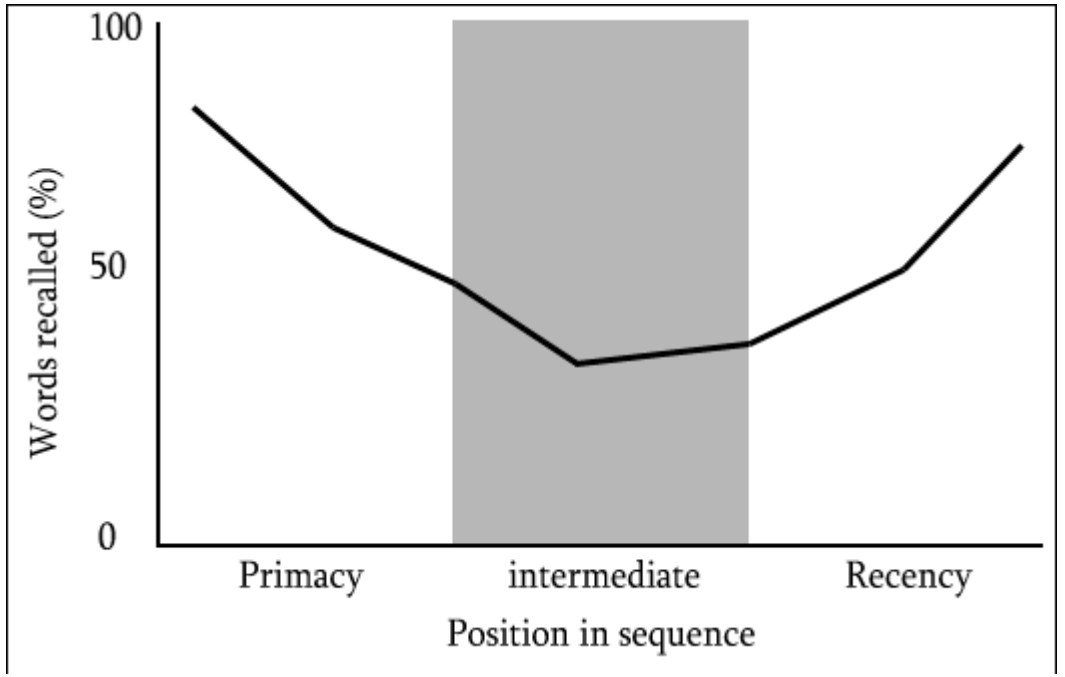
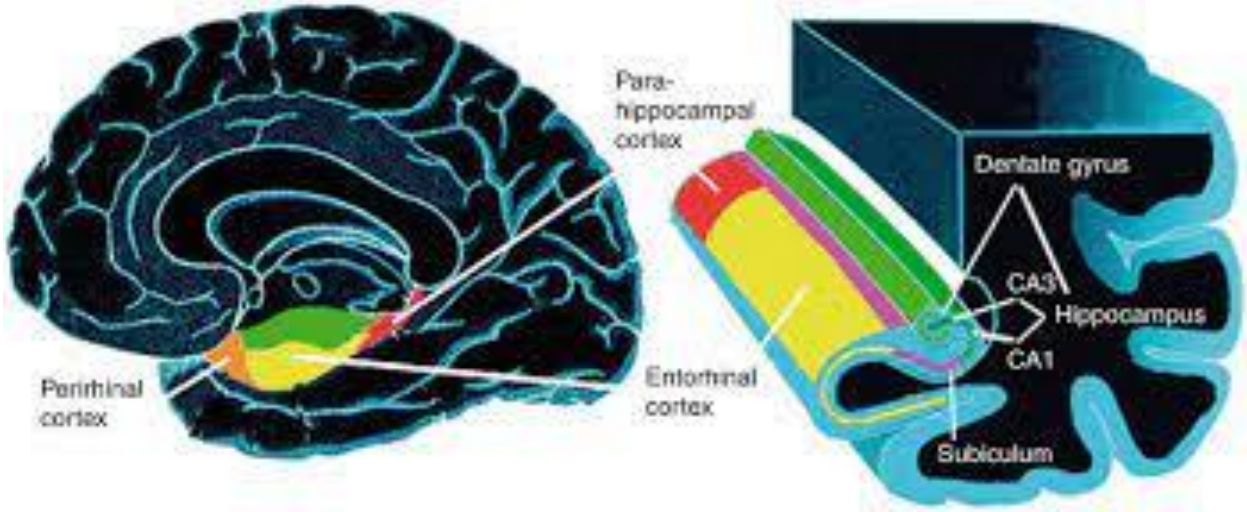


What is a Memory?

- Engram
  - The pattern of cell firing that makes up a memory
    - Distributed storage
      - What you see is stored in visual cortex
      - What you heard stored in auditory context
      - What you felt physically stored in somatosensory cortex
      - How you felt emotionally stored in amygdala

- Hippocampal-Entorhinal complex
  - Establishes a directory for binding & searching for distributed information



How are memories made?

- Hebbian Learning
  - “Neurons that fire together, wire together”
    - Forms a network of distributed activity
    - Temporal coherence of neural activity within a set of simultaneously active & reciprocally interconnected neurons produces a record that can be used for subsequent reactivation of the entire response set in response to the activation of one of the components
- Long-term potentiation
  - Encourages more receptors on post-synaptic neuron
  - Pre-synaptic neuron to release more transmitter (glutamate)
  - Allows less activity from the presynaptic neuron to trigger an action potential in the post synaptic neuron
    - Forget
      - If connections are not strengthened
      - “Neurons that fire apart, wire apart”
      - Targeted forgetting
        - Occurs during sleep
        - Tenuous connections that are not reinforced are removed
        - Removing unimportant information

Memory

- Why is learning/memory so difficult?
  - Limited number of neurons
  - Already occupied with previously stored information
  - New information needs to be written on top of or incorporated into the existing scaffold
    - To encode & access new information and experiences, fragile and initially sparse linkages have to be established, nurtured, and inserted into the matrix of existing information

Mnemonics

- How do you insert new information into the existing knowledge matrix?
  - Method of Loci/Memory palace (Cicero, Ancient Greece)
    - Contextual anchors

Let’s remember the periodic table of elements:

1. Hydrogen
2. Helium
3. Lithium
4. Beryllium

Memory

- Why is learning/memory so difficult?
  - Amount of new information is boundless
  - Your brain must protect itself by remembering only the most important information

  - Filter 1: The Attentional System
    - Selects behaviorally relevant information for further consideration

  - Filter 2: The Limbic System
    - Behaviorally relevant information is stored in initially transient form that induces a small amount of neural change in the association cortices
      - Allows new information to enter associative readjustments before being assimilated into a more permenant form
      - Allows competition so only the “fittest” survive and occupy limited synaptic space
      - Forgetting easy – unless emotionally salient

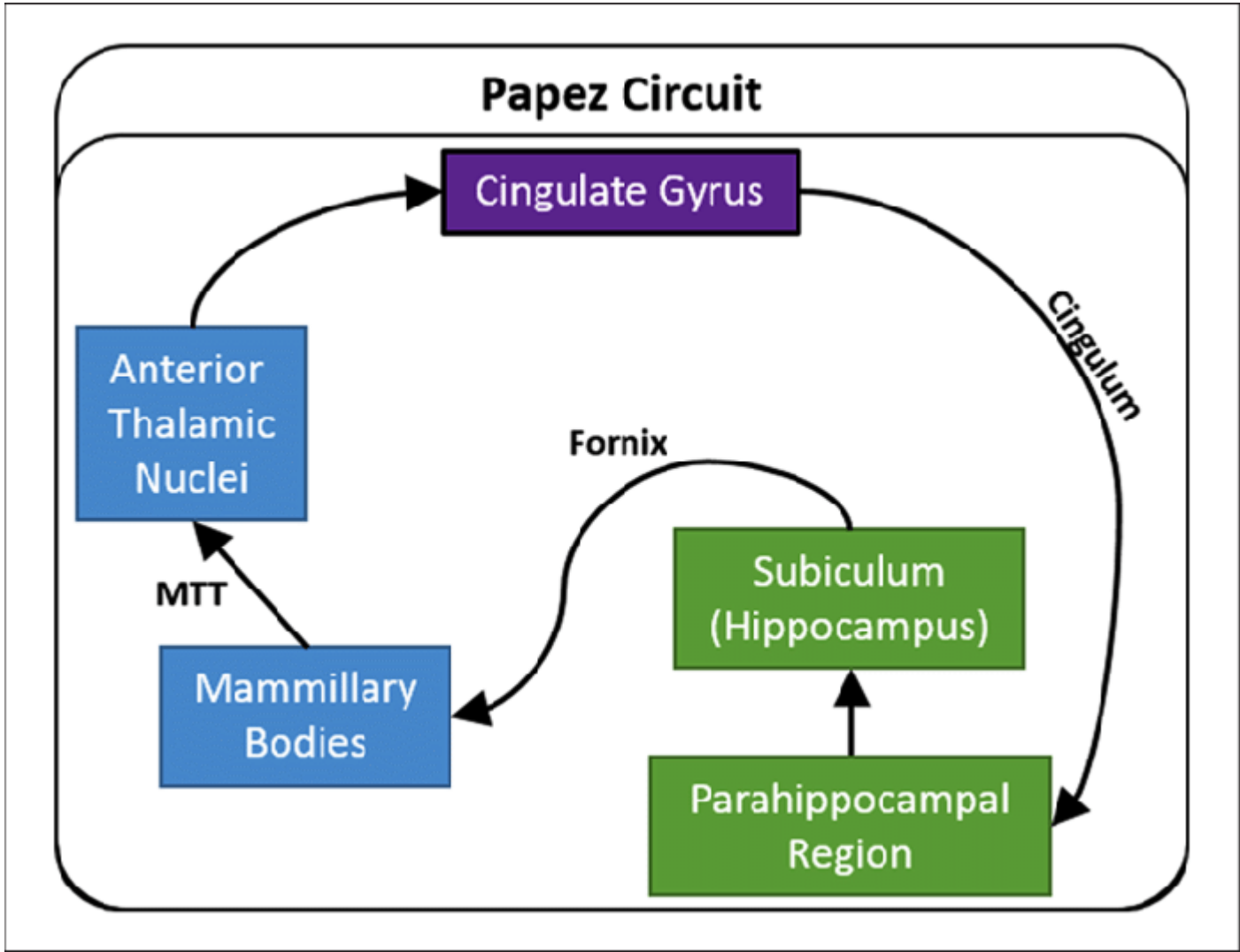
Role of the Limbic System

- Why does the limbic system play such a crucial role in memory?
  - Evolution
    - Memory's initial function was probably related to recalling contingencies regarding food and danger
      - Remember where to get the best food & avoid being hurt or eaten
    - Memory started expanding beyond immediate survival
    - Ensuring that information with high emotional or motivational relevance enjoys a competitive advantage

      - At first, the initially fragile and sparse linkages of the neural pattern depend on the limbic system for maintenance and coherent retrieval

The Limbic System: Memory & Learning

- Memory & Learning
  - Papez Circuit
    - Subiculum -> fornix -> mamillary bodies -> thalamus -> cingulate gyrus
      - Paraphypocampal gyrus -> entorhinal cortex -> hippocampus dentate gyrus -> subiculum
      - Prefrontal cortex – involve memory with thoughts & decision making



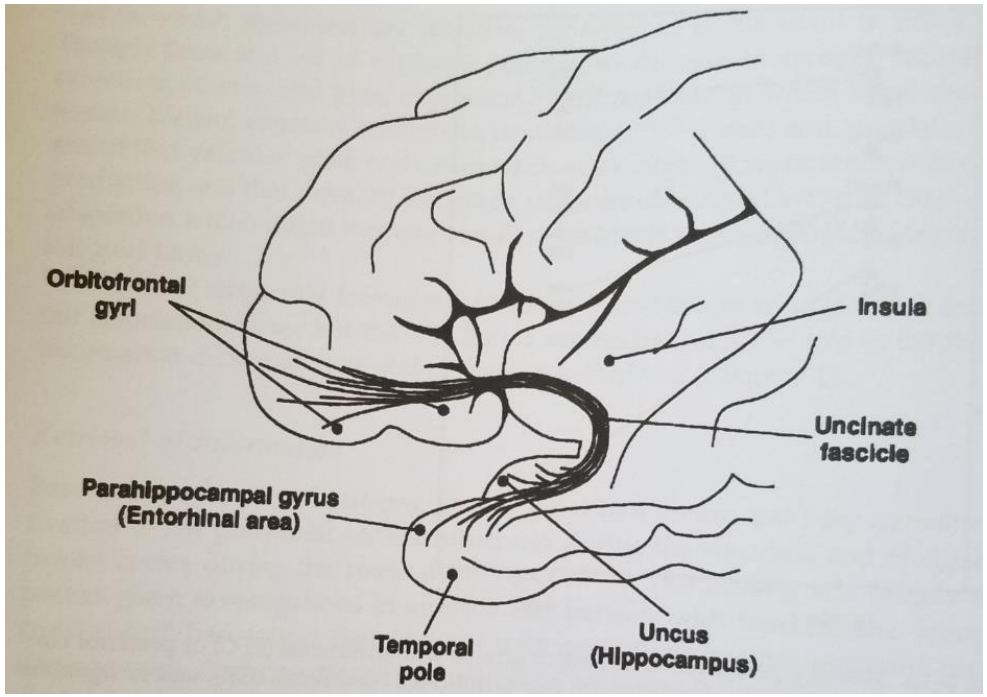
Role of the Prefrontal Cortex

- Frontal lobe participation in memory related tasks
  - Reconstruction of context and temporal order
  - On-line manipulation of encoding & retrieval
  - Associative search of internal data stores
  - Provides contextual constraints to keep reconstructed memories within the bounds of possibility
- Damage to Frontal Lobes
  - Undermines the effectiveness of encoding & retrieval
  - Causes impoverished associative linkages that are necessary for reconstucting context and temporal order
  - Decreases speed of searching internal stores
  - Increases tendency to confabulate

Memory Retrieval

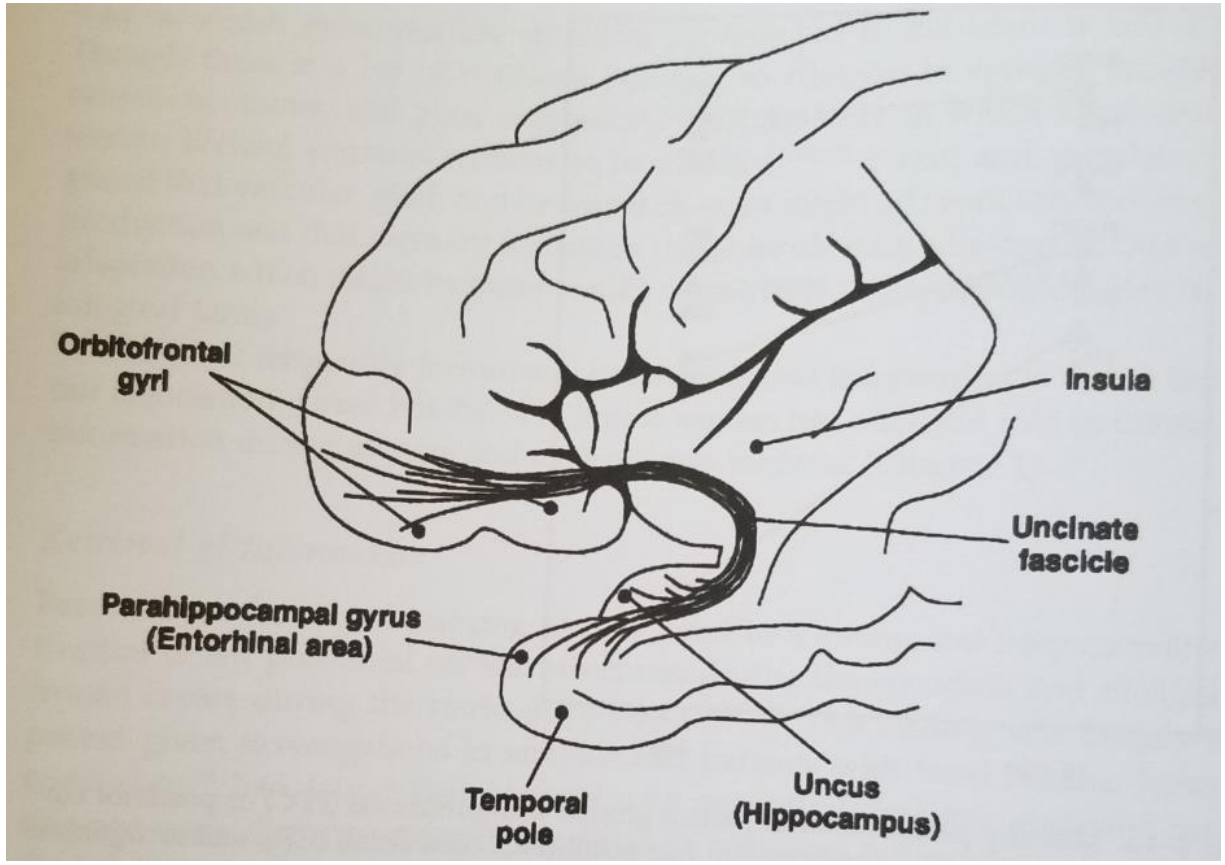
- As additional linkages become established through reciprocal connections with transmodal and unimodal areas the information becomes less dependent on limbic system and can be accessed through numerous associations & approaches which may bypass the hippocampus- entorhinal complex

- Network involved in retrieving old memories
  - Task requirements:
    - Will initiation
    - Selection of information among competing alternatives
    - Post retrieval monitoring process



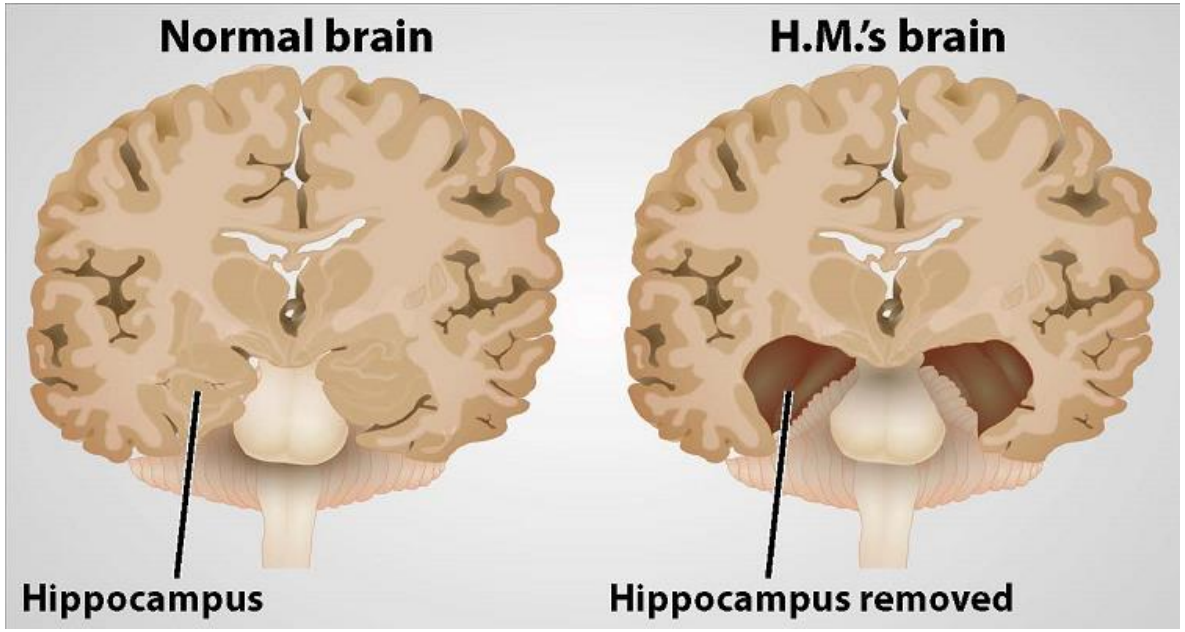
Amnesias

- Retrograde Amnesia
  - Inability to retrieve information that had been stored prior to the onset of the amnesia
    - May be due to the loss of the information (Alzheimers)
    - May be due to inability to retrieve the information
    - Associated with damage to Temporopolar regions
      - Temporopolar regions & its connections with the limbic system coordinates access to memories that are encoded in association regions



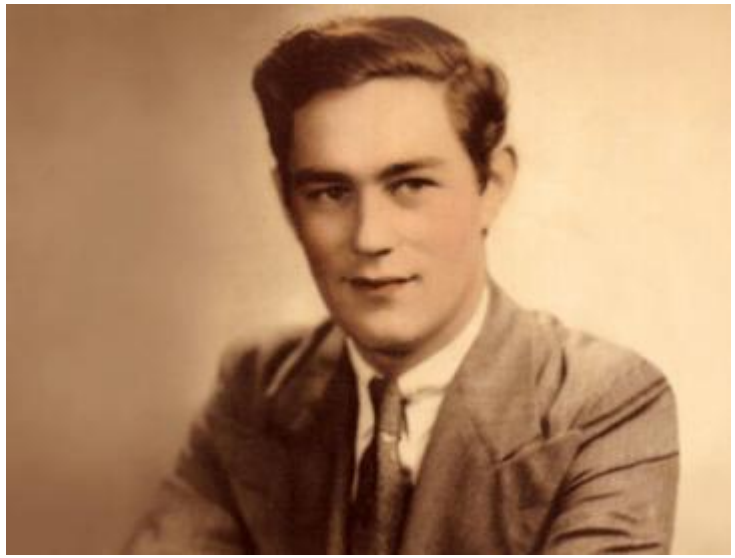
Amnesias

- Anterograde Amnesia
  - Inability to acquire new information for long-term storage and retrieval
  - Hippocampus necessary for memory consolidation
    - Papez Circuit

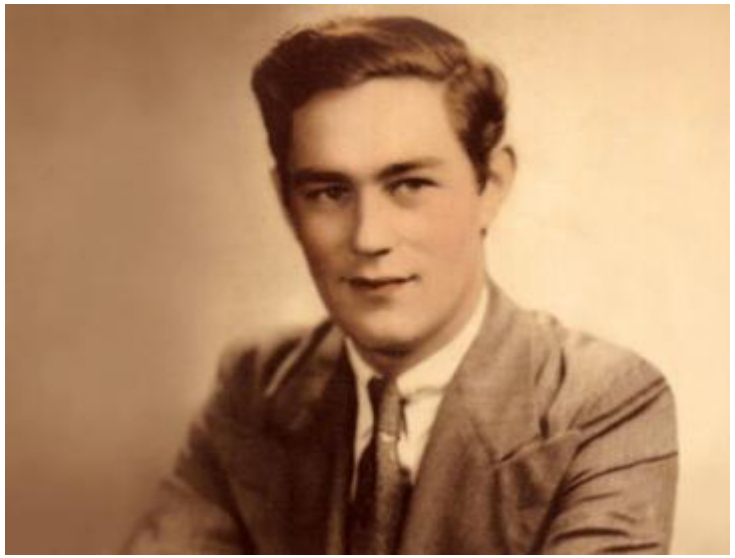


- HM – head trauma -> seizures
- 1953 – William Scoville neurosurgeon removed HM's Hippocampus

- Seizures disappeared, no change in personality, even increase in IQ
- Unable to form new long-term memories

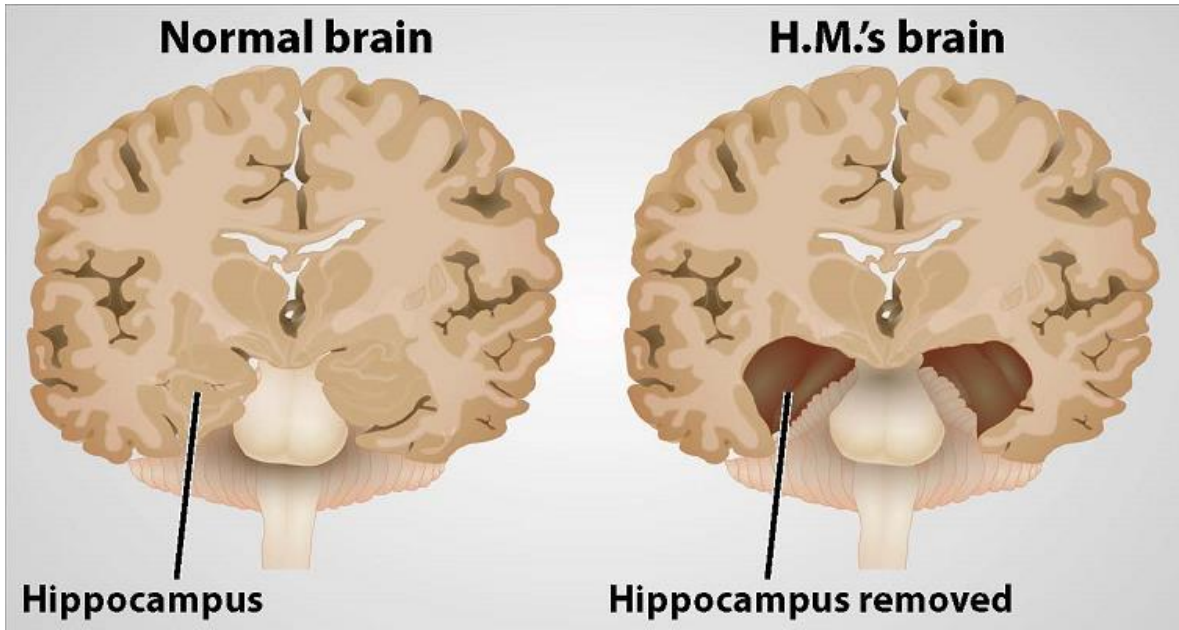


Amnesias



- Short-term/Working memory intact
  - Could remember things for about 15 mins by repeating information to himself

- Implicit memory intact
  - Procedural motor knowledge relies on different mechanisms
  - Procedural memory relies more on basal ganglia and cerebellum
  - Distinction between “knowing that” & “knowing how”




AA4
Energizer
ULTIMATE
LITHIUM
20
#1
LONGEST
LASTING
BATTERY
LA PILE
LA PLUS
DURABLE

Neurofeedback Treatments

- Standardized Protocols
  - Reward increases in alpha, specifically upper alpha, over sensory motor strip
    - SMR (12-15)
    - SMR/theta & SMR/beta ratios
      - Better cued recall performance & semantic working memory
  - Increase low beta and decrease theta & high beta
    - Improved working memory

- Our Approach
  - Individualized NFB protocol based on EEG brain map
    - Reducing specific excesses in whatever band necessary
    - Increasing connectivity
      - Frontal regions for working memory temporal/parietal for general memory
  - Vielight gamma - Photobiomodulation
    - Stimulate mitochondrial respiration & ATP synthesis
    - Improved memory and motor control

Thank You

https://www.researchgate.net/publication/10937788_The_effect_of_training_distinct_neurofeedback_protocols_on_aspects_of_cognitive_performance