Long-term Memory Assessment

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Introduction

• Memory?
  – The ability of storing and retrieving of what has been learned or experienced.
Memory Types

- Sensory Memory (< 1 sec)
- Short-term (working Memory) (20-30 sec)
- Long-term Memory (life time)

Explicit Memory (conscious)
- Declarative Memory (facts, events)
  - Episodic Memory (events, experiences)
  - Semantic Memory (facts, concepts)

Implicit Memory (unconscious)
- Procedural Memory (skills, tasks)
  - How to do things, like running, swimming
The three main processes involved in human memory are therefore encoding, storage and recall (retrieval). Additionally, the process of memory consolidation (which can be considered to be either part of the encoding process or the storage process).

**Memory Encoding:** It allows the perceived information of interest to be converted into a construct that can be stored within the brain, which can be later recalled.

**Memory Storage:** It allows to retain the encoded information in the brain.

**Memory Retrieval/Recall:** It refers to recollect the stored information from memory.
MEMORY MODEL

Environmental Stimuli → Sensory Memory → Short-term Memory → Long-term Memory

- Iconic Memory
- Gustatory Memory
- Echoic Memory
- Haptic Memory

Selective attention

Information that is not encoded gets forgotten

Storage → Retrieval

Information is forgotten due to interference, decay, or retrieval failure
Memory and Brain

1. Frontal lobe
   The frontal lobes store semantic and episodic memories.

2. Motor cortex
   The motor cortex is involved in storing procedural memories.

3. Cerebellum
   The cerebellum plays an important role in the storage of procedural memories.

4. Hippocampus
   The hippocampus plays a pivotal role in the formation of new long-term semantic and episodic memories.

5. Amygdala
   The amygdala is vital to the formation of new emotional memories.

6. Temporal lobe
   The temporal lobe is involved in the formation and storage of long-term semantic and episodic memories and contributes to the processing of new material in short-term memory.

7. Prefrontal cortex
   The prefrontal cortex is involved in the storage of short-term memories.
Role of Prefrontal and Temporal Lobe

Memory Diseases

Memory disorders can range from mild to severe, but they all result from some kind of neurological damage to the structures of the brain, thus hindering the storage, retention and recollection of memories.

- Mild Cognitive Impairment
- Vascular Dementia
- Mixed Dementia
- Parkinson’s Disease
- Dementia with Lewy Bodies
- Frontotemporal Dementia

http://www.cpmc.org/advanced/neurosciences/brainhealth/memory-causes.html
Memory Diseases

Alzheimer's is the most common form of dementia, a general term for memory loss and other intellectual abilities serious enough to interfere with daily life.

Normal levels of glucose metabolism in a PET scan (left), indicated in yellow and red. The levels of glucose metabolism in the brain are decreased in patients with mild cognitive impairment (middle) and with Alzheimer's disease (right). (Cindee Madison and Susan Landau/UC Berkeley)
Memory Assessment

• Why Memory Assessment?
  – To detect possible cognitive impairments
  – To assess severity of cognitive impairments and memory loss
  – To detect a patient needs further evaluation
Existing Techniques (1/2)

- Memory Assessment Scales (MAS)
  - MAS is based on manual and behavioural assessment
  - MAS is standardized for use with adults 18 to 90 years age
  - MAS assess three areas of Cognitive Functions
    - Attention, concentration and short-term memory
    - Learning and Immediate memory
    - Memory following a delay
  - MAS consists of 12 subtests, which are based on seven memory tasks
  - MAS requires normative data (843 adults data collected)
  - MAS needs professional training in neuropsychology and clinical psychology.

Existing Techniques (2/2)

• Wide Range Assessment of Memory and Learning, 2nd Edition (WRAML2 kit)
  – Developed by Pearson Education, Inc.
  – Measures memory functioning and learning
  – Age range 5 to 90 years
  – Paper and pencil based administration and hand scoring
  – One hour time required
  – Price $615.00

EEG Based Assessment

• First recorded by Hans Berger in 1929.

• EEG recordings are noninvasive, painless, do not interfere much with a human subject’s ability to move or perceive stimuli, are relatively low-cost.

• Electrodes measure voltage-differences at the scalp in the microvolt (μV) range.

• EEG provides insights of brain disorders including cognitive and memory impairments
EEG Frequencies

- EEG rhythms correlate with patterns of behavior (level of attentiveness, sleeping, waking, seizures, coma).

- Rhythms occur in **distinct frequency ranges**:
  - Gamma: 20-60 Hz (“cognitive” frequency band)
  - Beta: 14-20 Hz (activated cortex)
  - Alpha: 8-13 Hz (quiet waking)
  - Theta: 4-7 Hz (sleep stages)
  - Delta: less than 4 Hz (sleep stages, especially “deep sleep”)

- Higher frequencies: active processing, relatively de-synchronized activity (alert wakefulness, dream sleep).

- Lower frequencies: strongly synchronized activity (nondreaming sleep, coma).
EEG Signal

- Awake
- Light sleep
- REM sleep
- Deep sleep
- Cerebral death
Experimental Evidences for Long-term Memory Assessment using EEG
**Experiment Design**

**Control Variables**
- Fluid Intelligence
- Age (18-30 Years)
- Background Knowledge
- Education Grade (partially)
- Contents of Learning
- Experiment Environment

**Learning Contents**
- Human Anatomy & Physiology animated contents (2D and S3D)
- Duration of Contents 10 min (presented 3 times)

**3D Technology**
- Passive Polarized
- Screen 41 inch
- Distance 1.5 meter

**EEG Recording**
- Sample Size 68
- EGI EEG 128 Channels
- Sampling rate 250
- Reference Cz
Fluid Intelligence (RAPM)

Missing element in the pattern

Eight Options to choose the missing part

Raven’s Advance Progressive Matric Design
Thirty percent of trials contained target stimulus and seventy percent trials contained standard stimulus. The duration of the task was approximately 3.5 minutes.
Conclusion

• The findings of this study can be concluded participants can recollect long-term memory faster due to learning in 3D display as compared to 2D display.

• Another finding is that participants exposed to learning contents in 3D used more brain regions during recalling the memories as compared to the compared to participants exposed to 2D technology.

• The reasons of this widespread involvement of the brain network and faster recall in 3D group may be due to:
  – Depth perception (*additional information*)
  – Storage of information in many brain regions
  – High Attention (*Due to stereopsis in visualization*)
Conclusion ...

• The analysis of event related brain potentials P3 component presented variations in parietal site Pz related to memory performance
• High P3 amplitude at parietal site Pz was found in high ability group, who scored higher in the memory recall test as compared to low ability group
• Thus, it indicated P300 positive relationship with memory performance and general intelligence
Issues and Challenges

• Inter subjects variability
  – Age, gender, regional, health and lifestyle
• High complexity of Brain system
• Analysis and interpretation of Brain’s Data
• Limitations of brain imaging modalities
References