

## Week 14

- KW 18 : Learning & Memory

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## KW 18 : Learning & Memory

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### Overview of Learning & Memory

- Short History of Learning & Amnesia
- Taxonomy of Memory Systems
- Patients “HM” & “KC”
- Long Term Memory Systems
  - Explicit
  - Implicit
  - Emotional Memory
- Short Term Memory
- Uncommon minds: Asperger’s and Savantism

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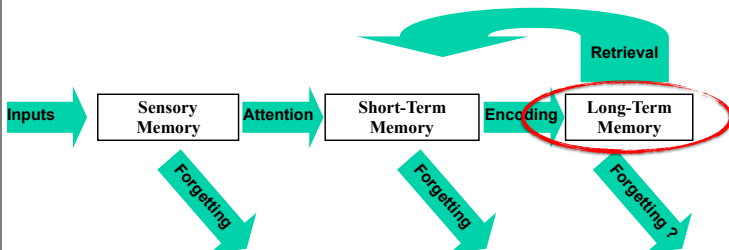
### History of Memory & Amnesia

- 1880s - Ebbinghaus - first formal studies of human memory
- 1900s - autopsies of brains with severe memory impairment
  - often showed medial temporal cortex atrophy
- 1916 - Karl Lashley - lesion studies in animals - behavioral measures (e.g. maze pathfinding)
  - unable to find specific site of “memory”, but more damage = more memory loss
  - “not possible to demonstrate the isolated localization of a memory trace...”
- (N.B: this may be why the result of HM’s surgery were a surprise)
- 1950s - HM and other patients

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### 3 Memory Systems



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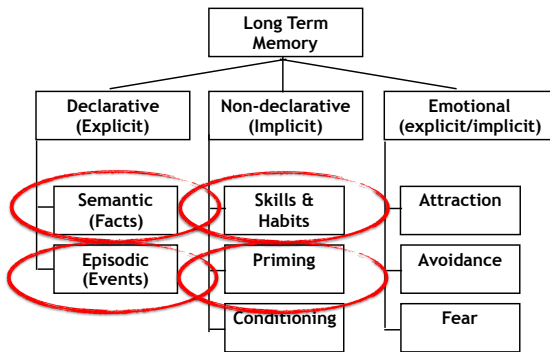
### Taxonomy of Human Memory Systems

- Sensory Memory
- Short Term Memory (Working Memory)
  - sensory, cognitive, motor
- Long Term Memory
  - Explicit (conscious)
    - Episodic (events)
      - personal, autobiographical
    - Semantic (facts)
      - general knowledge
  - Implicit (unconscious)
    - skills & habits, priming, conditioning
  - Emotional (conscious & unconscious)
    - attraction, avoidance, fear

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## Taxonomy of Long-Term Memories



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## Explicit Versus Implicit Memory

- Explicit (Declarative):
  - Knowledge that can be retrieved and then reflected on consciously.
    - Verbal, Visual
  - “Knowing That”
  - Example:
    - knowing a bicycle has two wheels
- Implicit (Nondeclarative):
  - Knowledge that can influence thought and behavior without needing conscious awareness.
  - “Knowing How”
    - actually being able to ride a bike

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## Episodic Versus Semantic Memory

- Episodic (Events):
  - Autobiographical memory-- stores personally experienced events -- “What did you do on your last birthday party?”
- Semantic (Facts):
  - Stores general world knowledge : concepts and categories -- “What is a birthday party?”

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## Amnesia

- Definition
- Causes
  - Infantile Amnesia
  - Fugue State
  - Transient Global Amnesia
  - Delirium, intoxication, drugs or ECT
- Common Kinds of Amnesia

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## Amnesia

- Loss of memory or memory abilities due to brain damage, disease, or other condition
- Usual Definitions:
  - affects conscious (explicit) episodic memory only
  - other forms of memory intact:
    - sensory memory normal
    - STM or Working Memory intact
    - Semantic memory intact
    - Implicit memory intact
  - Often permanent although temporary Amnesias are possible

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## Childhood (Infantile) Amnesia

- Infantile amnesia - lack of episodic memory for first few years of life
  - birth to 2.5 years: very few true memories
    - most “memories” are incorrect
  - 2.5 to 10 years : true memories mixed with false memories
  - 10+ years : memories are more adult-like
- Freud: due to trauma
- Modern thinking : memory systems undeveloped

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## Psychogenic or Dissociative Amnesia

- Uncommon
- Sudden onset following physical or psychological stress
- Most commonly, personal information is forgotten
  - Sometimes the patient is unable to recall anything about his or her past
- During memory loss cognitive skills are intact
- Recovery is usually complete within 48 hours
  - but cases lasting days or weeks have been documented
- Also known as
  - “Fugue State”
  - “soap opera amnesia”

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## Transient Global Amnesia

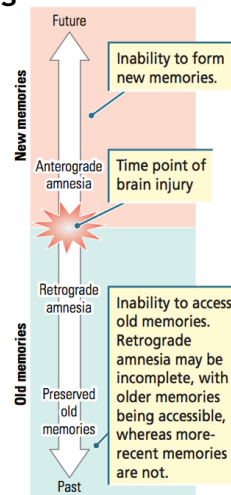
- Transient Global Amnesia
  - acute state
  - loss of old memories
  - inability to form new ones
- Causes?
  - concussion, migraine, hypoglycemia, seizure, stroke, drug intoxication, delirium

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## Anterograde vs. Retrograde

- Anterograde: Loss of memory for events after the injury
  - Caused by damage to the hippocampus and temporal lobes
  - Mechanism: Failure of Learning or Retrieval?
- Retrograde: Loss of memory for events before the injury
  - Most common with neural degenerative disorders (e.g., Alzheimer's)
  - often temporally-graded
  - Mechanism: Failure of Learning, or Retrieval?



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## K.C. (Kent Cochrane)

- Widespread brain injury, especially frontal regions, in a motorcycle accident.
- Complete loss of episodic memory “he cannot remember...a single thing he has ever done or experienced in the past... from either before or after his accident”
- Can not “time travel” - (can not imagine future or past events or plans) - loss of “autonoetic consciousness”
- Episodic: Amnesia -- Anterograde? Retrograde?
- Semantic: normal.
- Confabulation? -- brother’s funeral was “very sad”
- b. 1951, d. March 2014

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## Case History: “HM” (Henry Molaison)

- HM : 27 year old male with long history of epilepsy (worsening frequency & severity), post 7 year old bike accident
- Surgery: experimental, removed medial-temporal-lobe
- Results:
  - normal memory for life prior to surgery
  - above average IQ (118)
  - almost zero ability to learn new conscious information
    - after working 6 months at a new job, unable to recall a single detail, though he did learn to navigate within 2 blocks new home (8 yrs)
    - skill learning : preserved
    - emotional changes (reduced prosody & sensitivity to emotional stimuli)

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## H.M.

- Hippocampus removed on both sides (small, but important areas)
- Attention, STM and Retrieval of LTM for events before the surgery were intact
- IQ 118
- Complete Anterograde amnesia -- unable to learn form new episodic memories
- Implicit memory intact
  - Mirror-drawing performance improved, but zero memory of having practiced

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## K.C. vs. H.M.

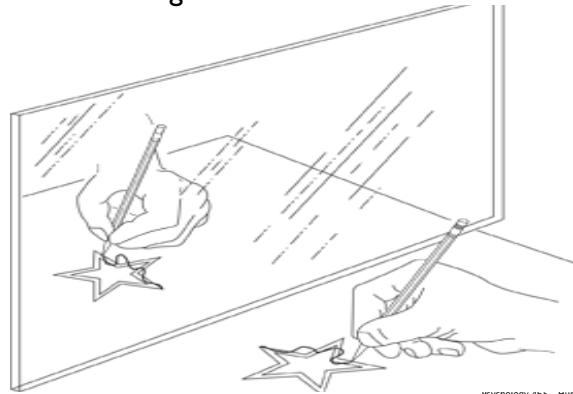
- Patient K.C.  
Episodic memory processes disrupted, but semantic memory processes intact.
- Patient H.M.  
Unable to transfer new information into LTM, but able to retrieve already stored memories from LTM.

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## Mirror Drawing Task

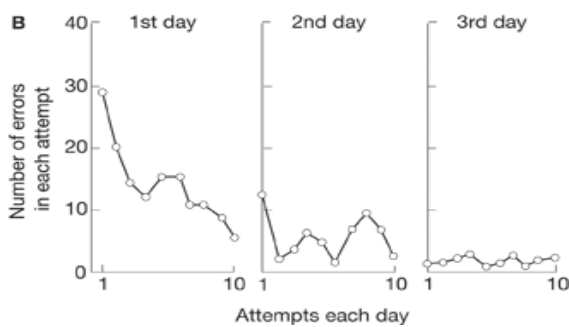
In this test, the subject's task is to trace between the two outlines of the star while viewing his or her hand in a mirror



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## Mirror Drawing Task



H.M. shows clear improvement in motor learning star task, showing implicit learning and memory - Yet he has no conscious (explicit) memory of the task.

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## H.M.

- Hippocampus is critical for transfer of explicit memories from STM to LTM
  - Gateway to LTM
  - Not a site of storage
- Amnesia is not due to injury of brain regions which process or store info

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## Retrograde Amnesia & Consolidation

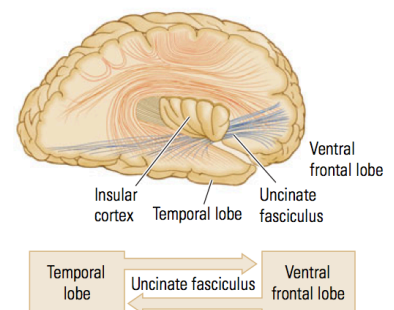
- Data
  - Patients with hippocampus damage show similar pattern
  - profound anterograde amnesia
  - moderate retrograde amnesia
    - time-dependent (aka "temporally graded")
- Theory:
  - hippocampus temporarily holds memories and helps consolidate them (move them to the cortex for permanent storage)

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## Neurobiology of Episodic Memory

- Temporal Lobe and Ventral frontal lobe
- Connected via uncinate fasciculus



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## Neurobiology of Explicit Memory

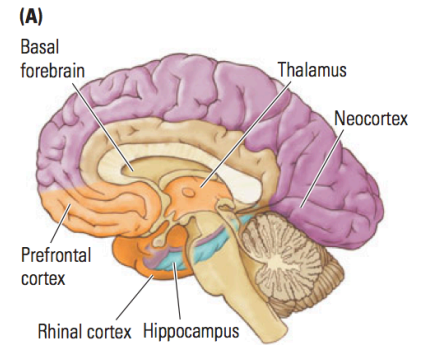
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## Neural Substrates of Explicit Memory

- Prefrontal Cortex
- Temporal Lobe
- Medial Thalamus
- Rest of cortex
- Brainstem

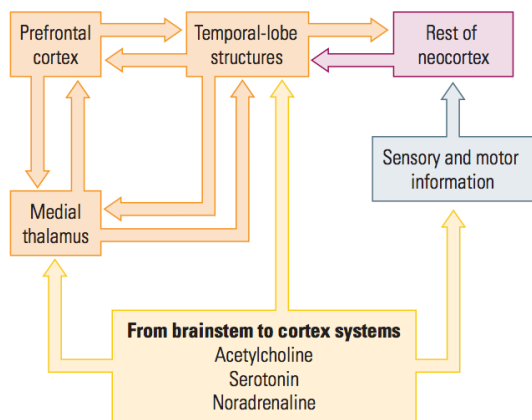
- Conclusions:
- Much of brain is involved



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## Neural Substrates of Explicit Memory



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## Explicit Memory : Focal Damage

- Focal damage to many areas can cause some form of explicit memory impairment
- Pattern of impairment follows pattern of damage
  - e.g. compare HM to KC

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## Explicit Memory : Diffuse Damage

- Diffuse damage also can cause explicit memory impairments
- Examples
  - Herpes Simplex Encephalitis
    - brain infection due to herpesvirus
    - tends to cause retrograde, and anterograde amnesia
  - Alzheimer's Disease
    - loss of ACh projections to cortex
    - first anterograde, then retrograde amnesia
  - Korsakoff's Syndrome
    - alcoholism that induces severe thiamine (B1) deficiency
    - confabulation is a major symptom

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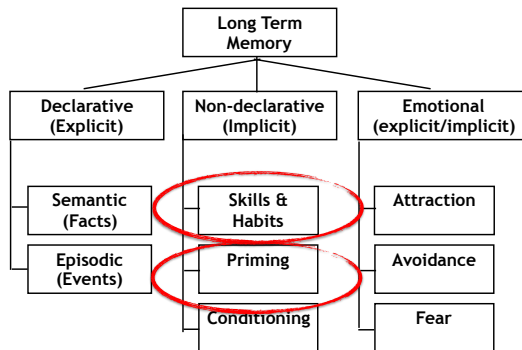
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## Neurobiology of Implicit Memory

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## Review: Taxonomy of Long-Term Memories



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## Priming : Implicit memory

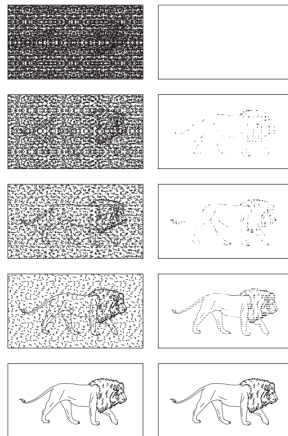
- Priming is usually spared in Amnesia
- Examples:
  - Gollin Incomplete Figures Test...
  - Word-Stem Completion...

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## Priming: Gollin Incomplete Figures Test

- Subjects see sequence of pictures to identify object
- On later repetition, reaction time & accuracy improve
- Effect independent of conscious (explicit) memory for test



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## Priming: Word-Stem Completion

- Subjects see sequence of words to remember.
- Later asked to fill in the blanks
- Words previously seen more likely to be used
- Effect independent of conscious (explicit) memory for test

Test 1 - learn list  
Table, box, carpet

Test 2 - fill in blank  
TAB\_\_\_\_  
BO\_\_\_\_  
CAR\_\_\_\_

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## Case “JK” : Implicit Amnesia

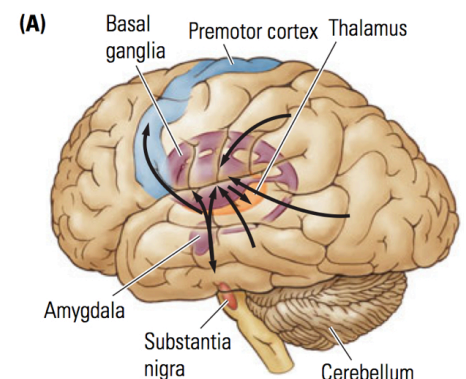
- Can people have amnesia for Implicit memories?
- JK, b 1914, above average IQ, worked as engineer for 45 years. When in 70s Dx. Parkinson’s disease.
- At 78 memory difficulties
  - difficulty recalling how to do common tasks:
  - turn on the lights
  - turn off the radio

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## Neural Substrates of Implicit Memory

- Basal Ganglia
- Ventral Thalamus
- Pre-motor Cortex
- Rest of cortex
- Substantia Nigra
- Cerebellum

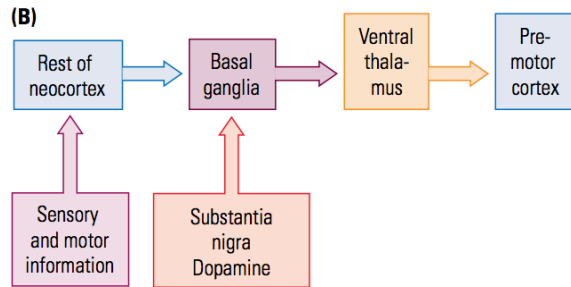


- Conclusions:
- Deep brain structures, associated with movement

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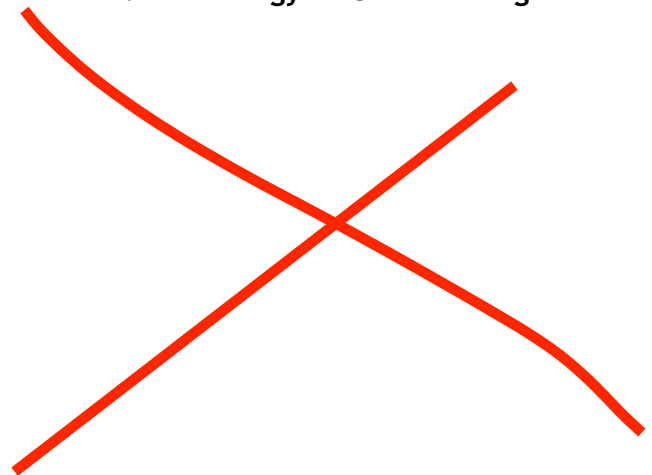
## Neural Substrates of Implicit Memory



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## Neurobiology of Conditioning



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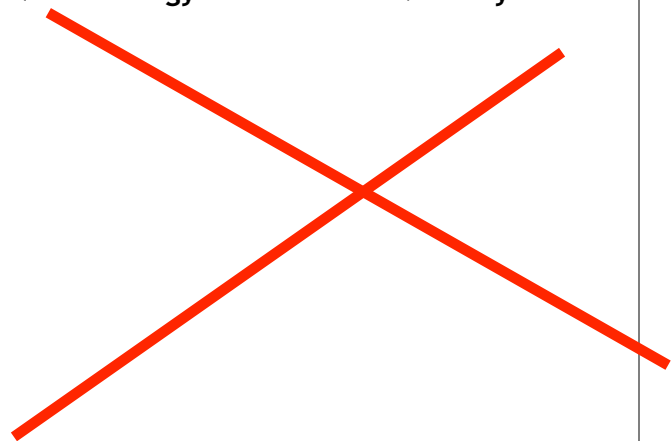
## Cerebellum - classical conditioning



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## Neurobiology of Emotional Memory



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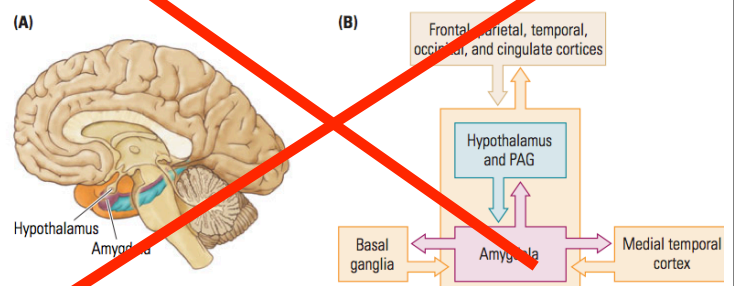
## Example : Fear conditioning

- Pairing of noxious or painful stimuli with neutral stimuli
- Establishes a conditioned “fear response”
- Example: Dr. Claparede had amnesic patient. Shook hands with a sharp pin in the hand. Eventually patient refused to shake Dr’s hand, but could not explain why

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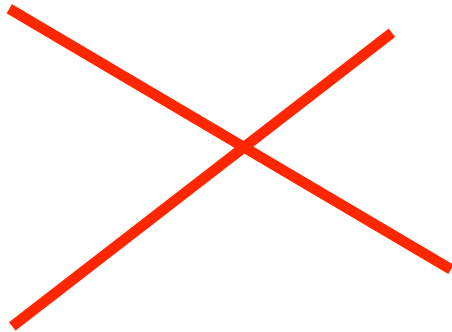
## Neural Substrates of Emotional Memory



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## Neurobiology of Short Term Memory

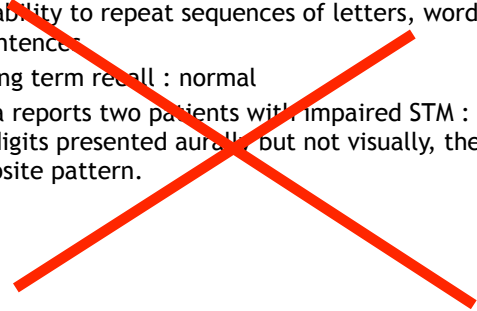


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## Short Term Memory patients

- Patient "KF"
  - Inability to repeat sequences of letters, words, digits, or sentences
  - Long term recall : normal
- Luria reports two patients with impaired STM : one impaired for digits presented aurally but not visually, the other has the opposite pattern.

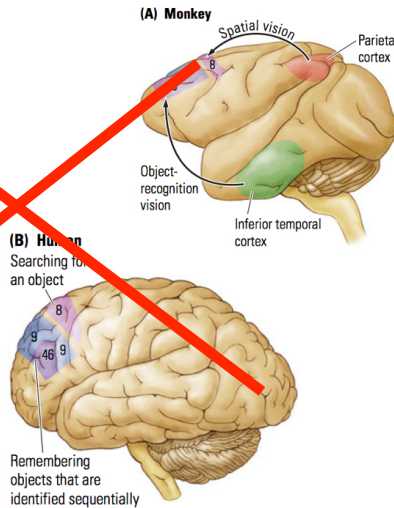


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## Neural Substrates of STM

- Areas 8, 9, 46
- Other cortical areas
- Conclusions:
- Primarily frontal-lobe and connected areas
- Multiple systems for different sensory modalities



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## Unusual Memory Abilities

- Savantism
  - Asperger's syndrome
  - Autism

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## Case History "S"

- S : a newspaper reporter studied by Luria
- incredible episodic memory
- could report, verbatim, an entire meeting
- Table (on right) after 2-3 minutes, could repeat forward, backwards, diagonal, etc. He remembered it 16 years later
- Luria felt he suffered in other areas - he was dull, superficial, lacked abstract thought, couldn't understand poetry...

**Table 18.1** Example of tables memorized by S.

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 minutes' study of such a table, S. was able to reproduce it in reverse order, horizontally, or vertically and to reproduce the diagonals.

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## Autism / Savantism

- Autism
  - spectrum of disorders characterized by impaired social interaction, restricted interests, obsessions, and repetitive behavior
  - Prevalence 1-2 out of 1000
  - Asperger's syndrome : an Autism-spectrum-disorder
- Savant Syndrome
  - One or more areas of mental brilliance or excellence.
  - About 50% are autistic, about 50% have developmental disorder, mental retardation, brain injury or disease
  - Very rare: perhaps 100 worldwide

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