PSYD50: Current Topics in Memory & Cognition

Week 1: Introduction to the course

Cognitive Neuroscience of Memory

Cognitive Neuroscience of Memory

- Goals of course
  - Explore a few of the current 'hot topics' in cognitive neuroscience memory research.
  - Develop critical analysis skills.
    - Evaluate strengths and weakness of evidence.
    - Reconcile conflicting data and theories.
    - Formulate own conclusions.
  - Develop presentation skills.
    - Written.
    - Spoken.

Cognitive Neuroscience of Memory

- Class format
  - 6 groups.
    - Work requirements in weeks 3 – 8 depend on grouping.
  - 3 controversial topics, each over 2 weeks.
    - Article readings.
    - Critique papers & debates.
    - Final written assignment
  - Synthesis class
  - 1 amnesia movie.
  - Episodic memory rehabilitation.
  - Reading will be assigned on a week-by-week basis.

Date	Topic
September 3	**Overview of syllabus** **Introduction to the course** Laying the foundations: fundamental anatomy, techniques and theories.
September 10	**Writing a critique paper** A practical session based on two contradicting papers. Note on oral presentations
September 17	**Recollection & Familiarity I** Introducing key concepts and discussion of 2 research articles.
September 24	**Recollection & Familiarity** II Debate: group 1 vs. group 2. *Groups 3, 4, 5, 6 recollection/familiarity critique paper due.*
October 1	**Long-term & short-term memory I** Introducing key concepts and discussion of 2 research articles.
October 8	**Long-term & short-term memory II** Debate: group 3 vs. group 4. *Groups 1, 2, 5, 6 recollection/familiarity critique paper due.*
October 15	Reading week - no class.
October 22	**Memory & perception I** Introducing key concepts and discussion of 2 research articles
October 29	**Memory & perception II** Debate: group 5 vs. group 6. *Groups 1, 2, 3, 4 recollection/familiarity critique paper due.*
November 5	**Synthesis: so what does the medial temporal lobe do?** General discussion and information session on final paper.
November 12	No class.
November 19	**Memory in popular culture** Amnesia movie.
November 26	**Improving episodic memory** Discussion of research articles and amnesia movie.
December 2	*All students final written assignment due.*

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- Assessment
  - 10% Class participation:
    - 4% Attendance.
    - 6% Contributions to class discussion.
      - 1% No contributions.
      - 3% Occasional thoughtful questions and comments.
      - 6% Consistently timely and thoughtful questions and comments.

Cognitive Neuroscience of Memory

- Assessment
  - 2 x 15% Critique papers:
    - 5% Structure & clarity.
      - Clear, concise, expository prose style: Logical organization and logical progression; Effective transitions; Appropriate tone (not colloquial)
    - 5% Accuracy.
      - Accurate description of studies and representation of literature; Conformity with APA guidelines; Appropriate citations and at least 2 additional supporting articles; Accurate quotations and reference section; Spelling and grammar.
    - 5% Critical analysis.
      - Original and creative intellectual contribution; Argument well defended; Appropriate opinions; Synthesis of readings; Suggestions for future directions.

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- Assessment
  - 15% Oral presentation:
    - 10 minute presentation focused on single article describing the theoretical background of the study, the methods and findings of the study, the strengths (and potential weaknesses) of the study, and why the study is important evidence for the theoretical viewpoint it supports.
    - 5% Structure & clarity.
      - Clear, concise delivery; Logical organization and progression of material.
    - 5% Accuracy.
      - Accurate description of research and representation of literature.
    - 5% Critical analysis.
      - Original and creative intellectual contribution; Argument well defended; Appropriate opinions; Suggestions for future directions.

Cognitive Neuroscience of Memory

- Assessment
  - 45% Final written assignment:
    - Expanded version of critique paper encompassing multiple papers
    - For each student, topic of paper will be the same as that for oral presentation. Titles will be assigned week 8.
    - 15% Structure & clarity.
    - 15% Accuracy.
    - 15% Critical analysis.

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- Other important issues
  - Office hours
    - **SW413 Tuesdays 2 – 4 pm**
  - Email contact
    - **psyd50.utsc@gmail.com**
  - I'm here to help
    - But please be patient.

Cognitive Neuroscience of Memory

- Other important issues
  - Late assignments
    - Assignments due via email before start of class on deadline days.
    - Late assignments due to legitimate, documented emergencies will not incur a penalty.
    - Every 24 hours that paper is late, 10% will be docked off the final mark.
      - For Sep 24th deadline , a paper handed in past 11am on Sep 25th will only receive 90% of the mark the quality of the work deserves, a paper handed in past 11am on Sep 26th will only receive 80% of the mark the quality of the work deserves, and so forth.

Cognitive Neuroscience of Memory

- Other important issues
  - Contesting assignment grades
    - Not encouraged.
    - Marking has subjective component but please trust my judgement.
  - If you feel particularly aggrieved
    - Request within 2 weeks of receiving grade.
    - Grade may go up or down.
    - Arbitrary requests will not be considered.

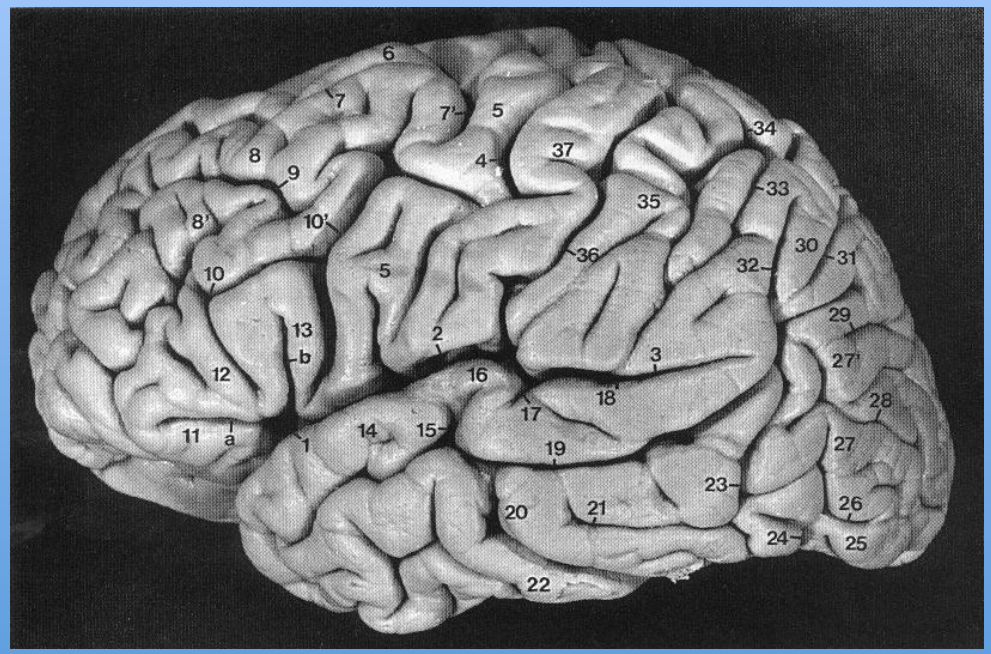
Establishing some foundations…

- Anatomical
  - Key regions
- Methods
  - Key techniques
- Theory
  - Key ideas

Anatomical foundations

Superior/dorsal

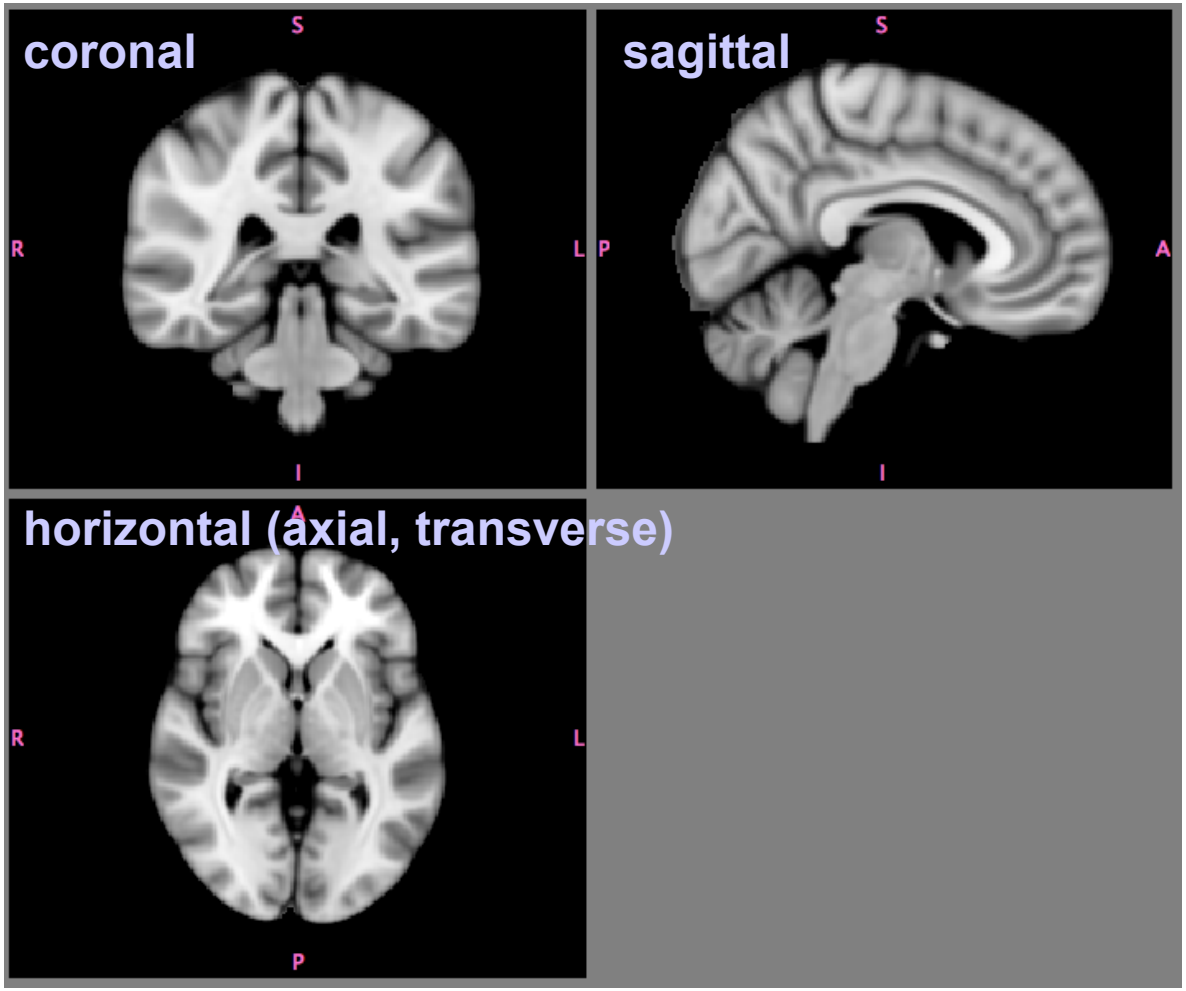
Anterior/
rostral



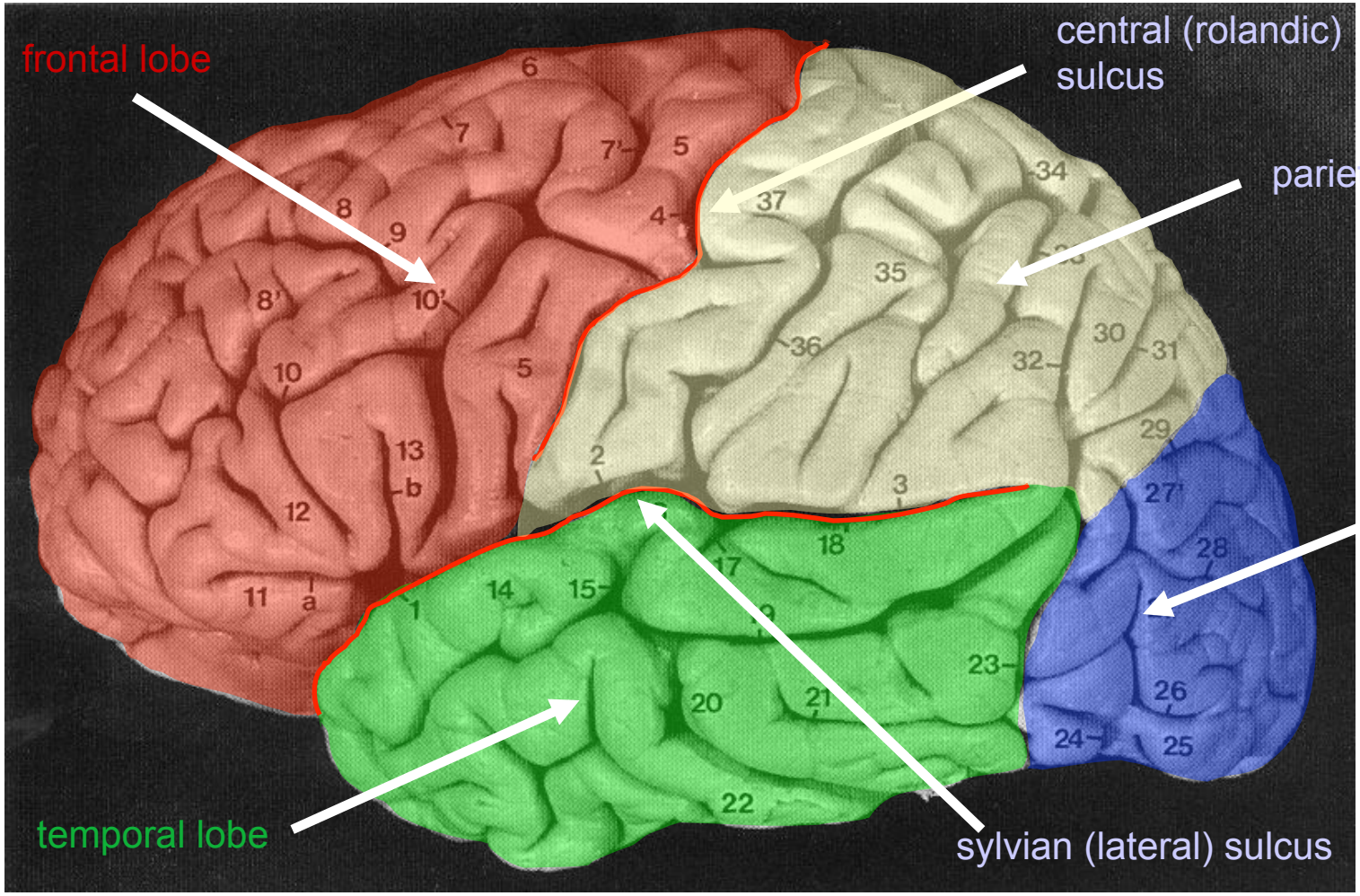
Posterior
/caudal

Inferior/ventral

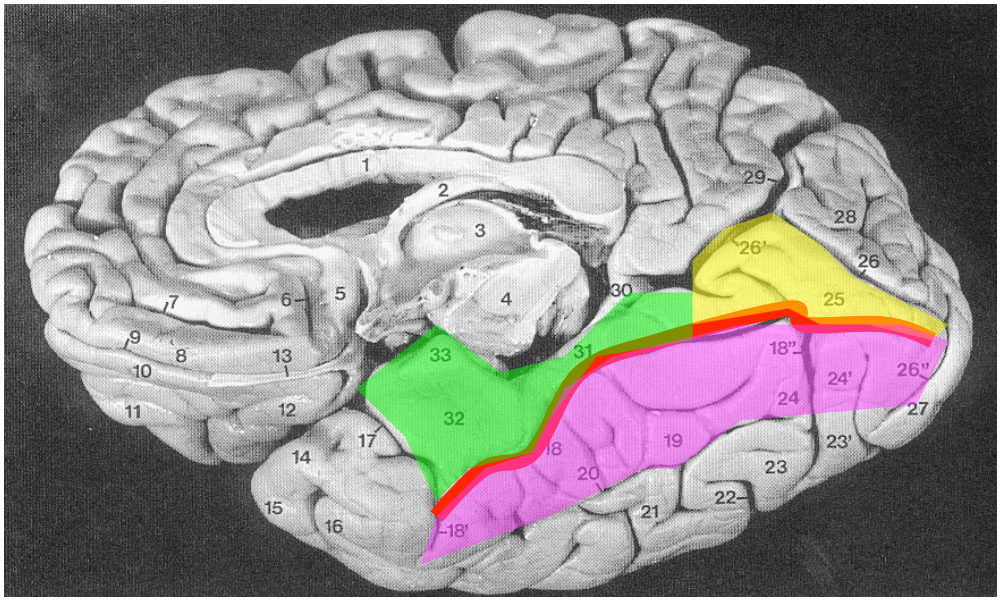
Anatomical foundations

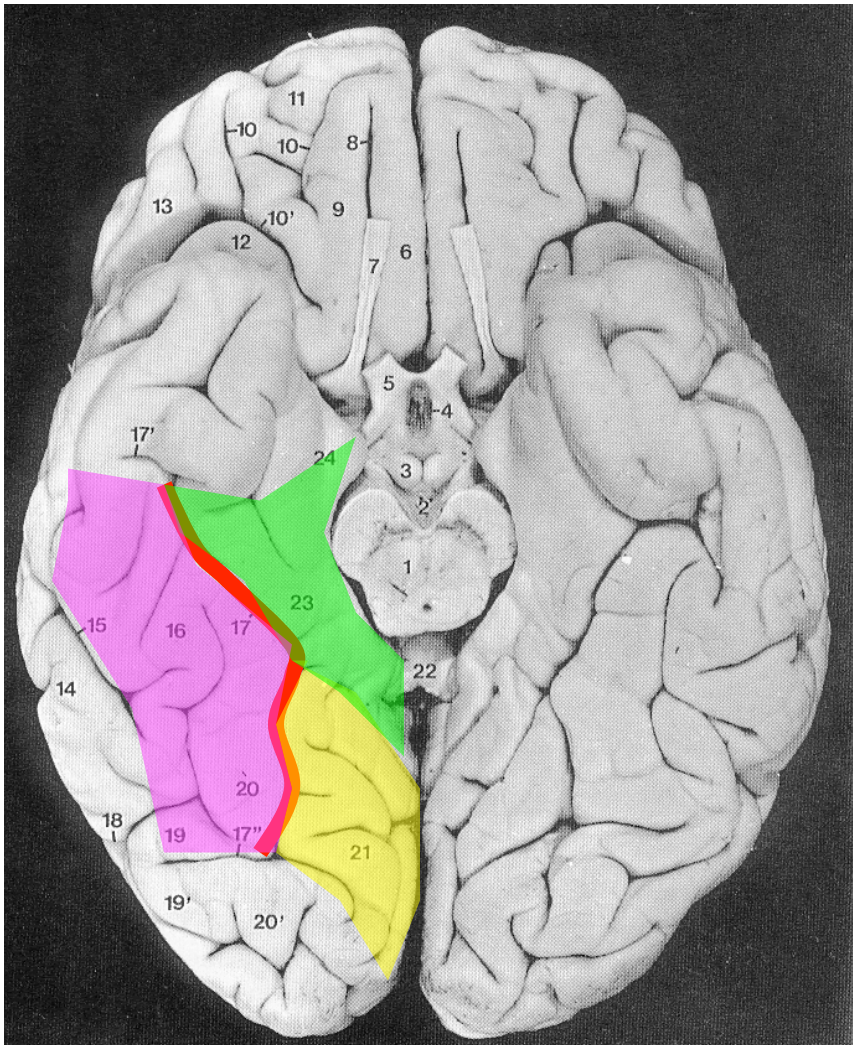


Anatomical foundations



Anatomical foundations



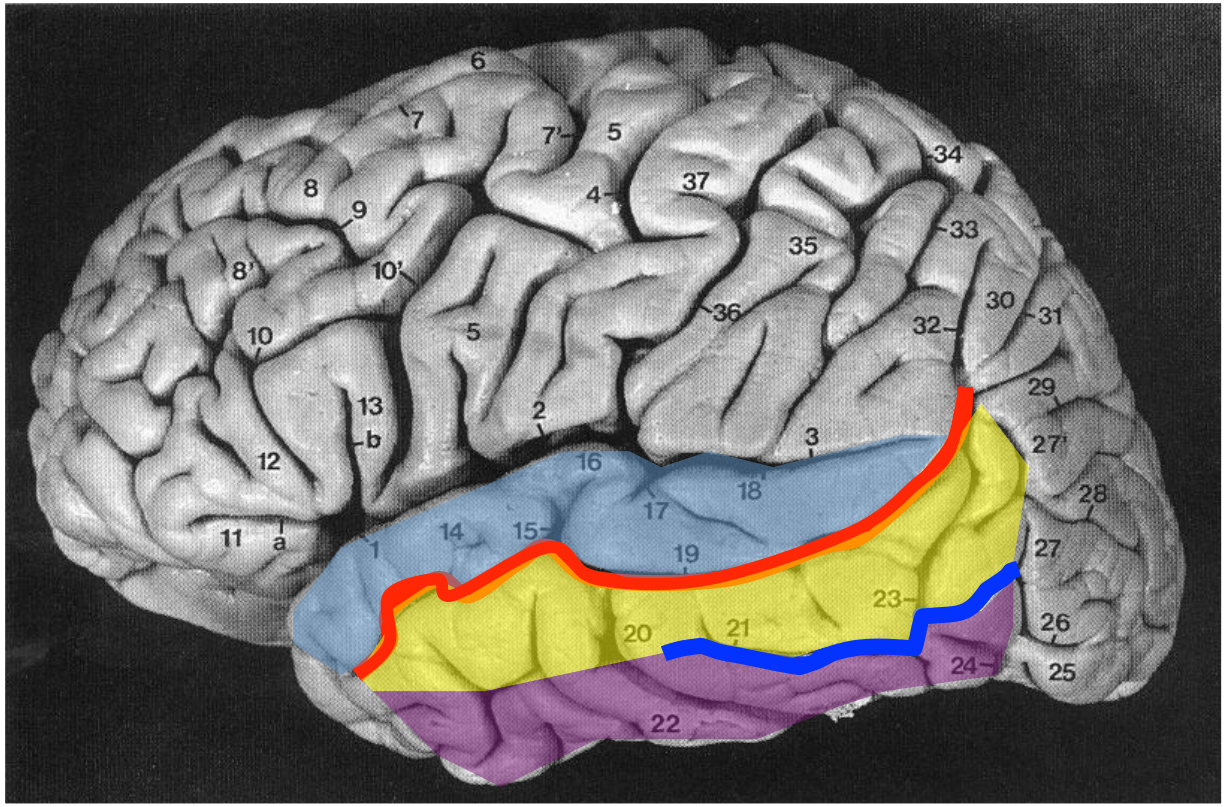


- Collateral sulcus
  - Divides lingual (yellow) and parahippocampal (green) gyri from fusiform gyrus (pink)

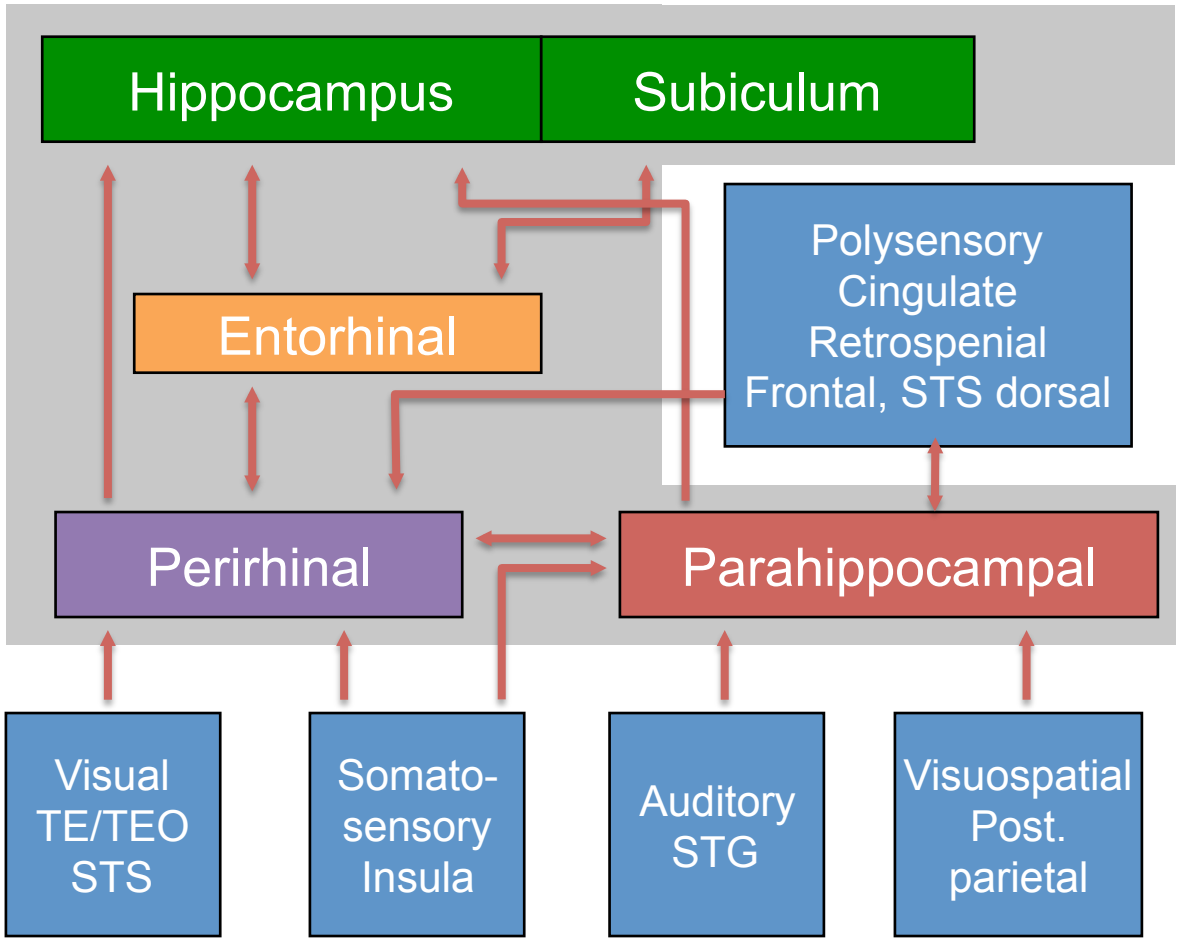
Anatomical foundations

Superior Temporal Sulcus (red)
Divides superior temporal gyrus (blue) from middle temporal gyrus (yellow).

Inferior Temporal Sulcus (blue)
Not usually very continuous.
Divides middle temporal gyrus from inferior temporal gyrus (purple).



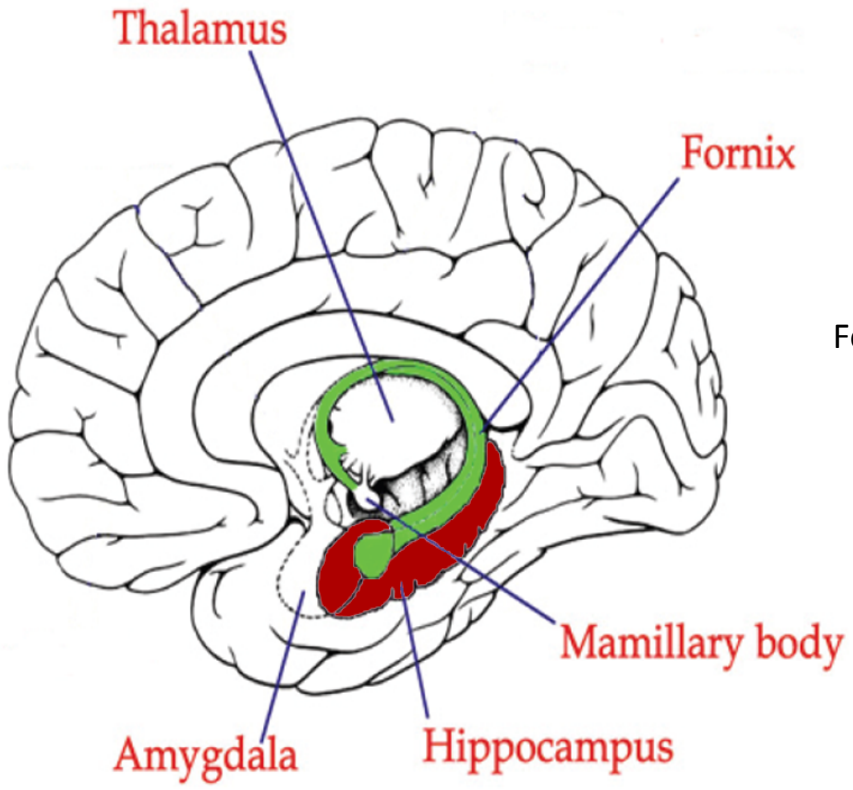
Anatomic foundations

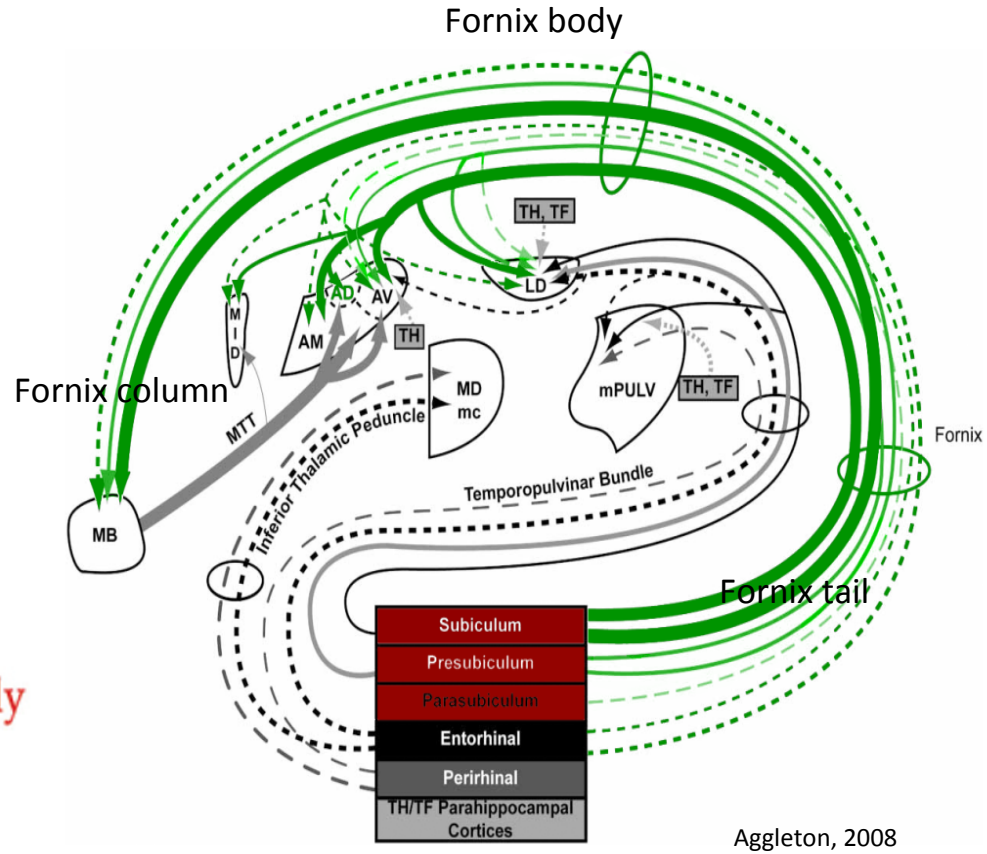


Medial Temporal Lobe (MTL)

Current work: white matter

- MTL & connectivity

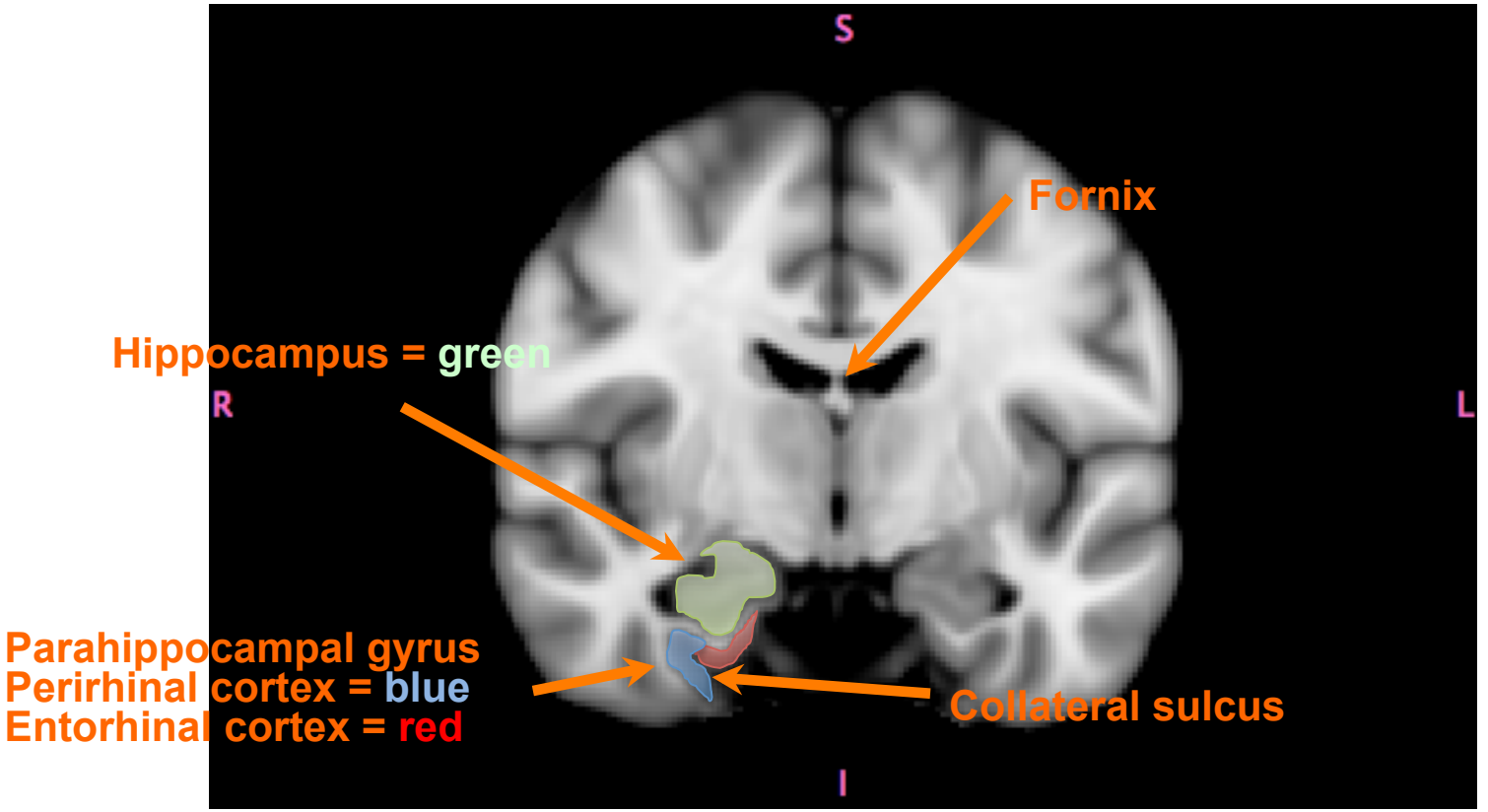




Aggleton, 2008

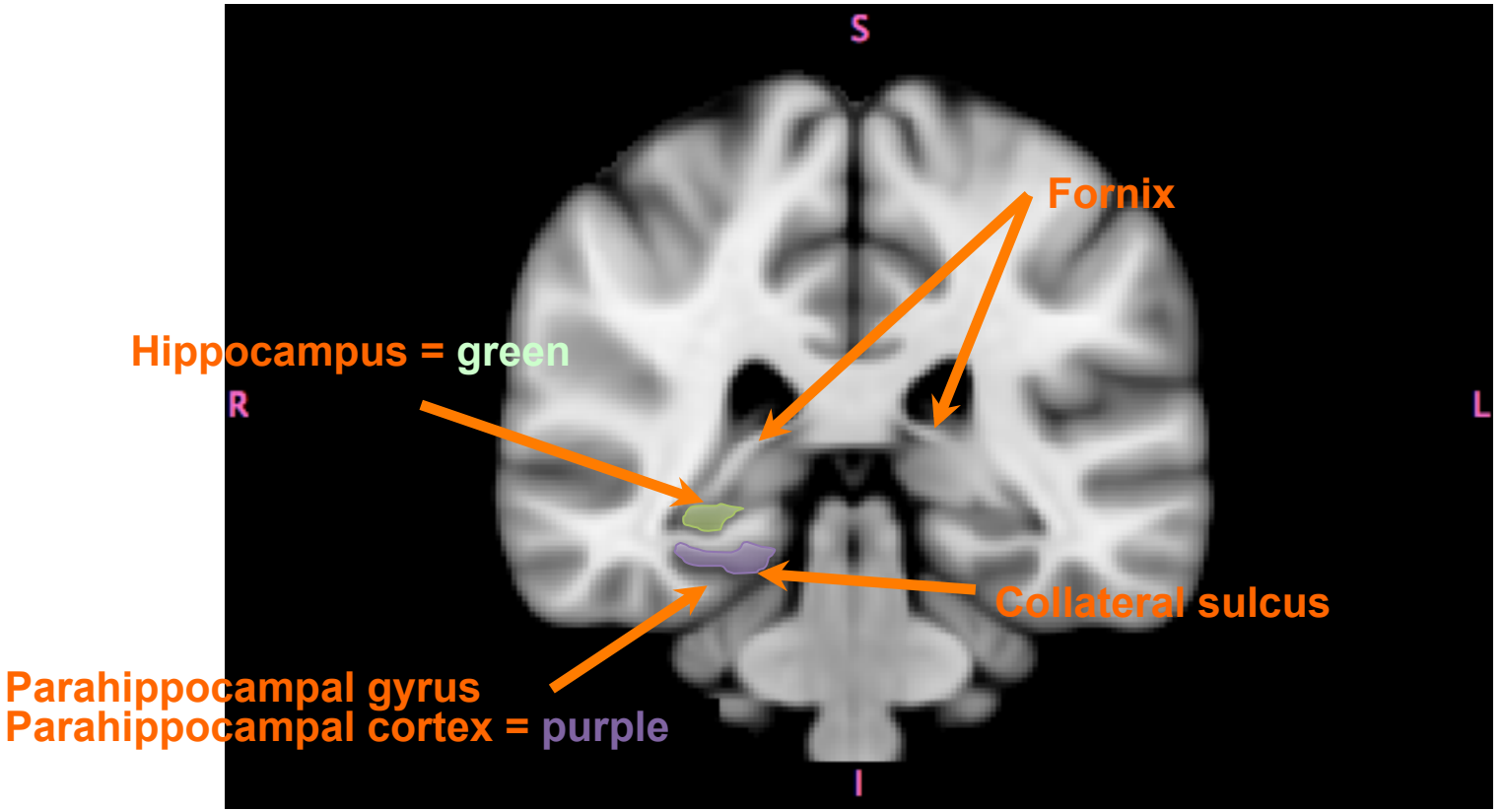
Anatomical foundations

- Anterior medial temporal lobe (MTL)



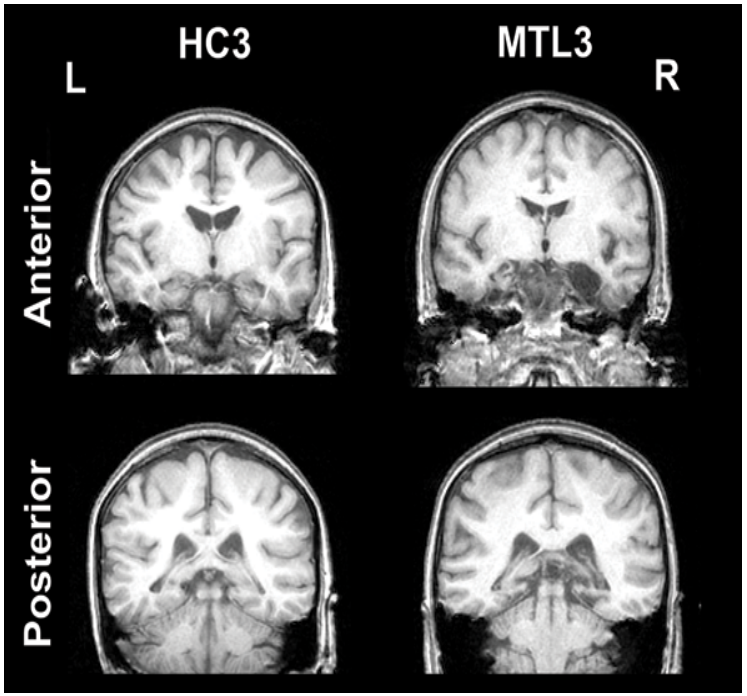
Anatomical foundations

- Posterior medial temporal lobe (MTL)



Methodological foundations

- Lesion method
  - If damage to area **X** impairs cognitive process **A**, then area **X** is critical for process **A**.



Methodological foundations

- Single dissociation
  - **Patient 1 damage to Region X**
    - **Deficit to cognitive process A**
  - **Patient 2 damage to Region X & Y**
    - **Deficit to cognitive process A & B**

- ***Conclude:***
  - ***Region X critical for A***
  - ***Region Y critical for B***
  - ***A & B separate but cannot conclude independence***

Methodological foundations

- Double dissociation
  - **Patient 1 damage to Region X**
    - **Deficit to cognitive process A**
  - **Patient 2 damage to Region Y**
    - **Deficit to cognitive process B**

- ***Conclude:***
  - ***Region X critical for A***
  - ***Region Y critical for B***
  - ***A & B are independent***

Methodological foundations

- Lesion approach (+)
  - Identifies area that is **critical** to a process.

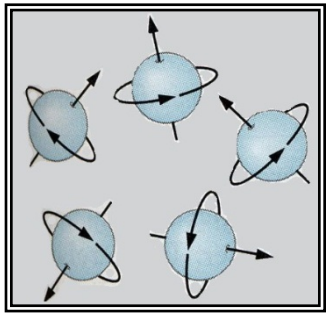
- Lesion approach (-)
  - Lesions are rarely limited to area of interest.
    - Undetected damage due to disease/brain injury?
  - Does lesion cause dysfunction in other areas?
    - Brain regions are components of networks
  - Is a damaged region where impaired cognitive process is subserved or merely where important connections are between other regions critical for the impaired process?

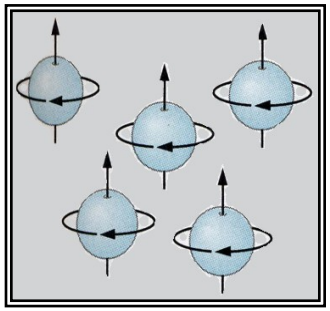
Methodological foundations

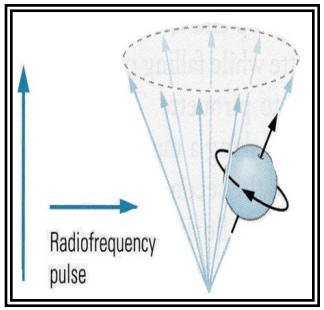
- Neuroimaging
  - Magnetic resonance Imaging (MRI)
    - Relies on powerful magnet.
    - Provides structural and functional data.
  - Positron Emission Tomography (PET)
    - Relies on radioactivity.
    - Provides functional data.

Methodological foundations

- Structural MRI
- Many organic elements are magnetic
  - Hydrogen most abundant human body
- Protons spin around a random axis
- When placed in a magnetic field the protons become aligned in parallel
- Resonance: A Radio Frequency (RF) pulse (pulse sequence) is used in MRI to push protons out of alignment with the magnetic field
- The time it takes for protons to revert to original state is measured through head coil
- Protons relax at different rates in different tissues, which produces a gradient that is reconstructed to give the signal





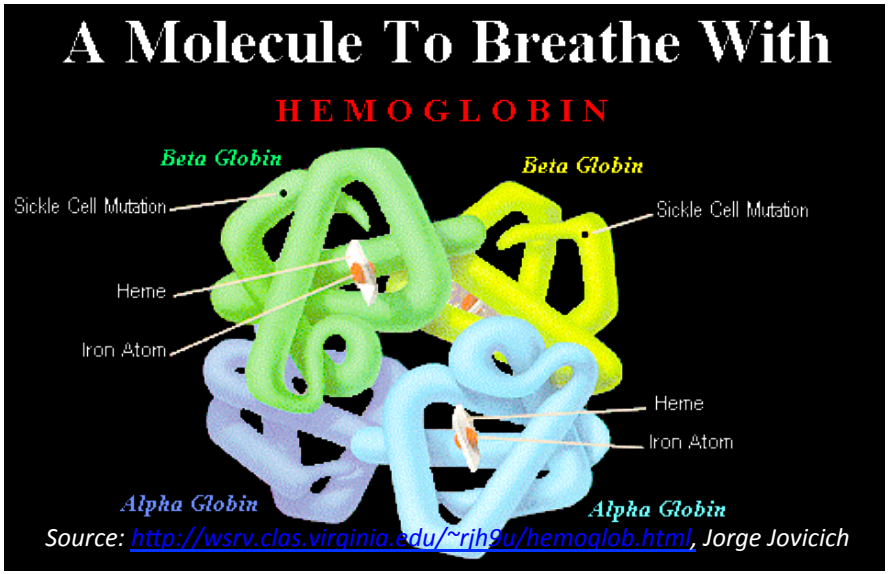


Methodological foundations

- Structural MRI
  - For assessing brain damage in patients.
    - **Manual methods**
      - Volumetrics – measuring volumes of individual brain regions identified manually.
    - **Automated methods**
      - Voxel based morphometry – computational methods that compare brain regions automatically.
  - For localising brain activity as deduced from functional neuroimaging data (MRI or PET).

Methodological foundations

- Functional MRI (fMRI)



Hemoglobin (Hgb)

4 globin chains, each with a heme group

Each heme group has an iron atom (Fe)

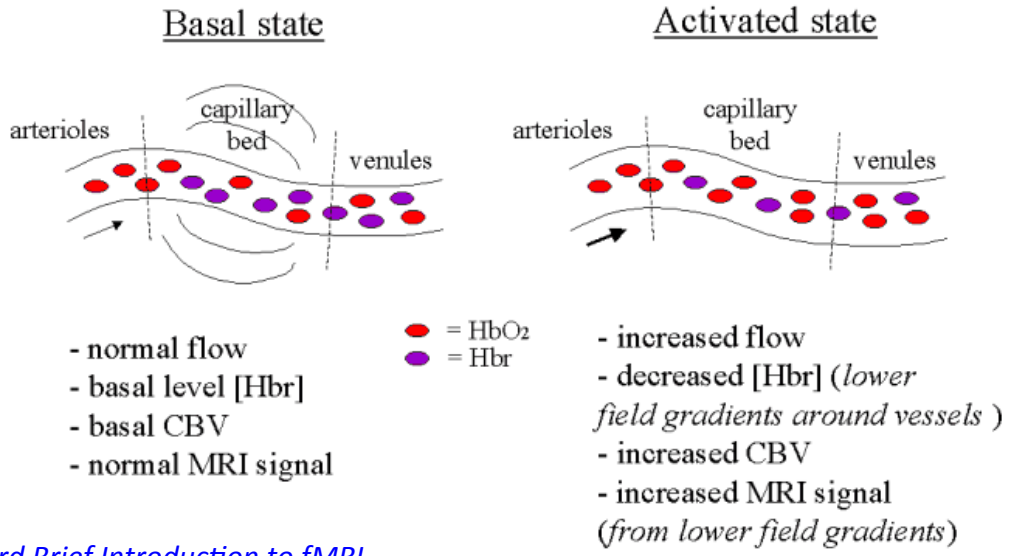
Each heme group can attach an oxygen atom (O_2)

Oxy-Hgb (four O_2) is diamagnetic → small magnetic effect

Deoxy-Hgb is paramagnetic → larger magnetic effect

Methodological foundations

- Functional MRI (fMRI)
  - Blood Oxygenation Level Dependent signal (BOLD)

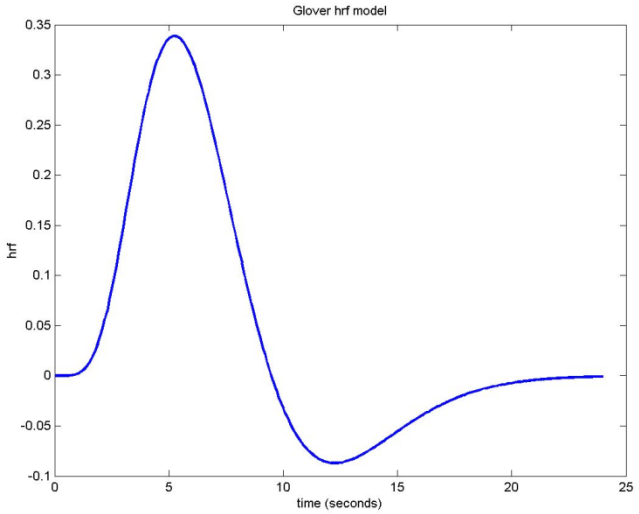


Source: FMRIB, Oxford Brief Introduction to fMRI

neural activity ➔ ↑ blood flow ➔ ↑ oxyhemoglobin ➔ ↑ MR signal

Methodological foundations

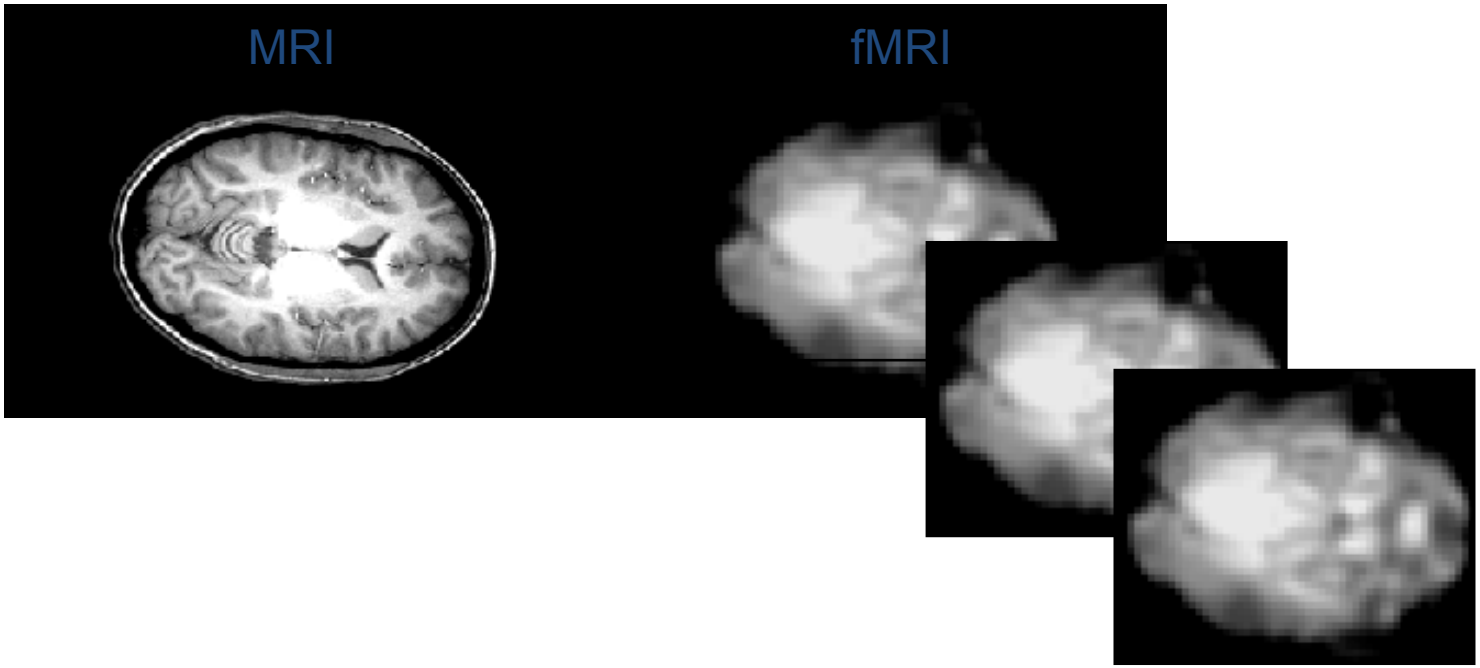
- Hemodynamic response (HR)
  - Blood flow change
  - Neural response: milliseconds
  - HR: peaks 5-10 s post stimulus
    - Starts 2s after stim presented
    - Sluggish!



- Block designs
  - Examine extended HR across same trial type (stimuli of a given trial type are presented in blocks)
- Event-related designs (ER)
  - HR for individual trials
  - ER allows examination of trial specific HR

Methodological foundations

- Combining structural MRI & fMRI



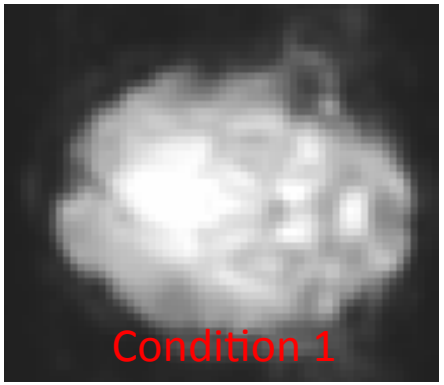
...

- High resolution (1 mm
- One image

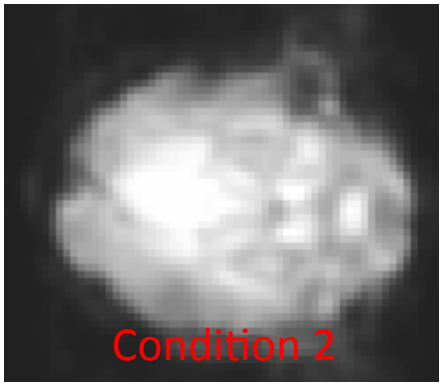
- Low resolution (~ 3 mm
- Many images (e.g. every 2 s for 5 minutes)

Methodological foundations

Functional images



minus



SUBTRACTION METHOD

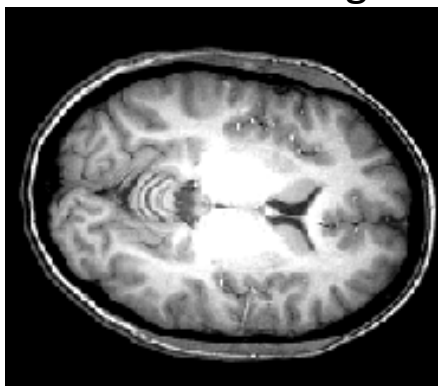
fMRI detects a **CHANGE** in signal from one condition to another. Thus, must always contrast 2 conditions.

Condition 1: Process A and B
Condition 2: Process B

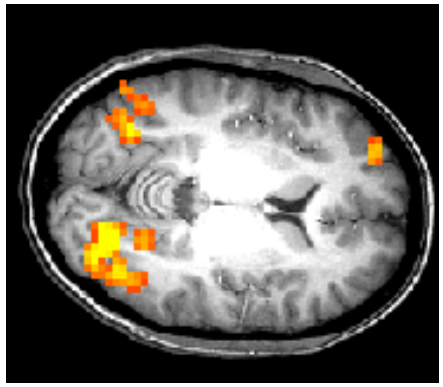
Condition 1 – Condition 2 = Process A

Overlay statistical map of difference on anatomical image

Anatomical image



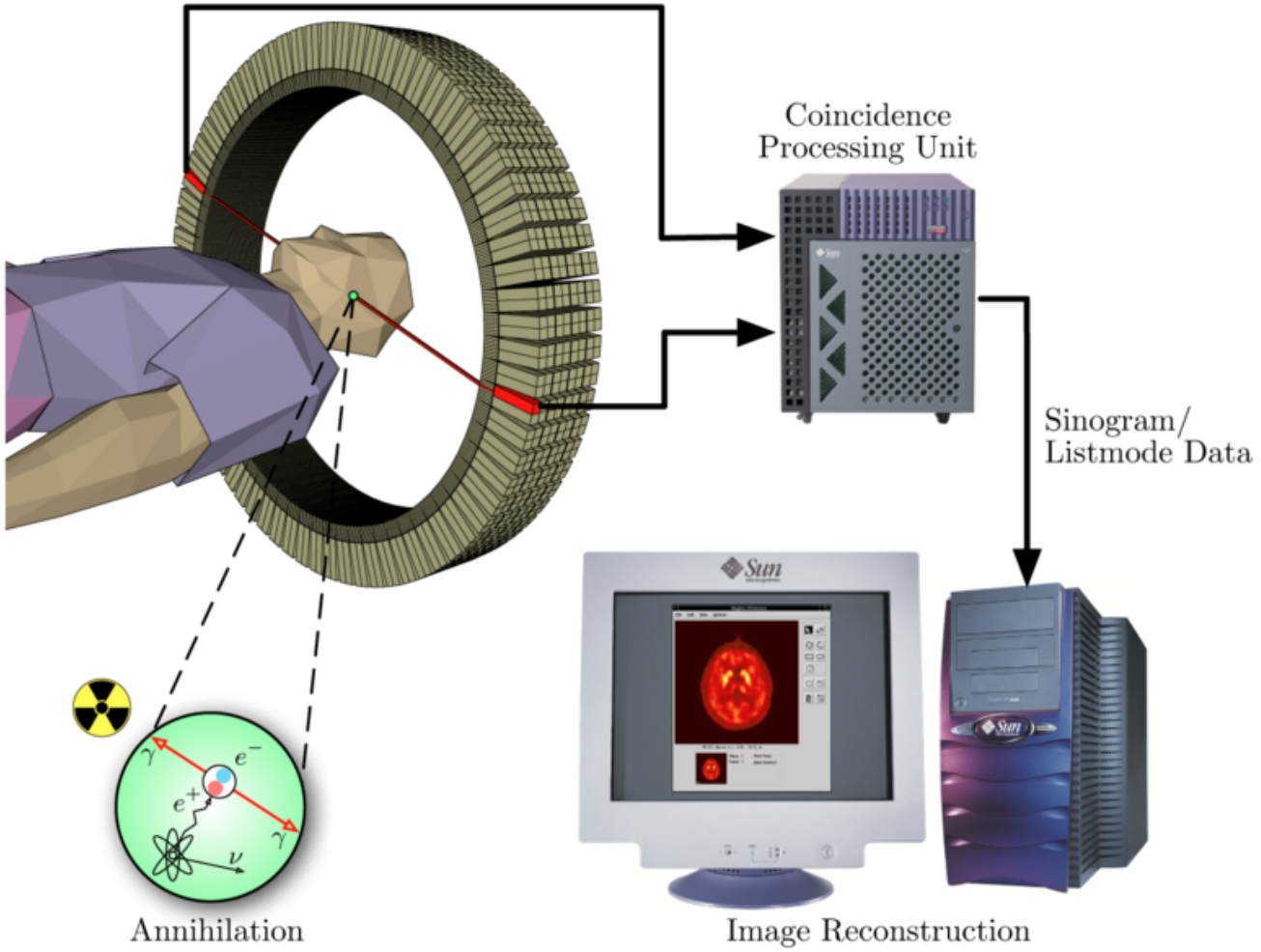
Rendered results



Methodological foundations

- Positron Emission Tomography (PET)
  - Measures regional changes in cerebral blood flow (rCBF).
  - Measures rCBF over a few minute period.
    - Often relies on substraction technique and blocked designs.
  - Radioactive isotopes tracers introduced into body.
    - Isotopes rapidly decay → this decay is measured to produce the signal
    - Common isotopes
      - Fluorodeoxyglucose (FDG); Radioactive water - H_2O^{15}

Methodological foundations



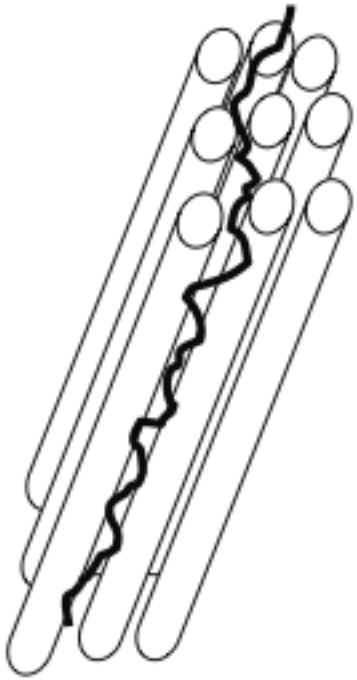
Methodological foundations

- Functional neuroimaging (+)
  - Non-invasive (MRI).
  - Multiple sessions with same subject.
  - High spatial resolution (MRI > PET).
  - Relatively good temporal resolution (MRI > PET).

- Functional neuroimaging (-)
  - **Correlational.**
  - Temporal resolution can be better.
  - Expensive.
  - Magnetic field susceptible to distortion in some brain regions (MRI).
  - Radiation involved (PET).

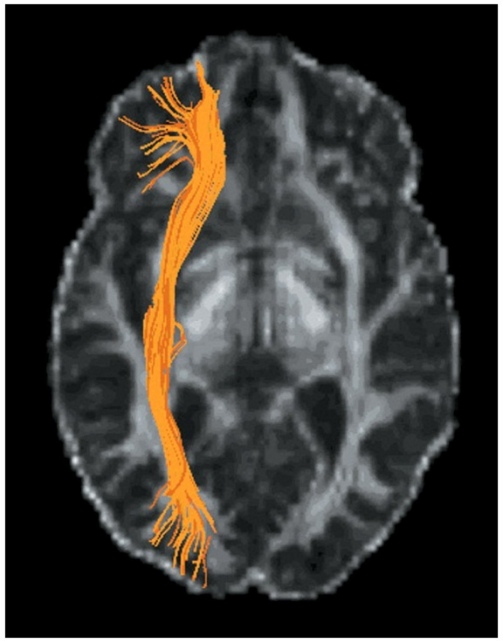
Methodological foundations

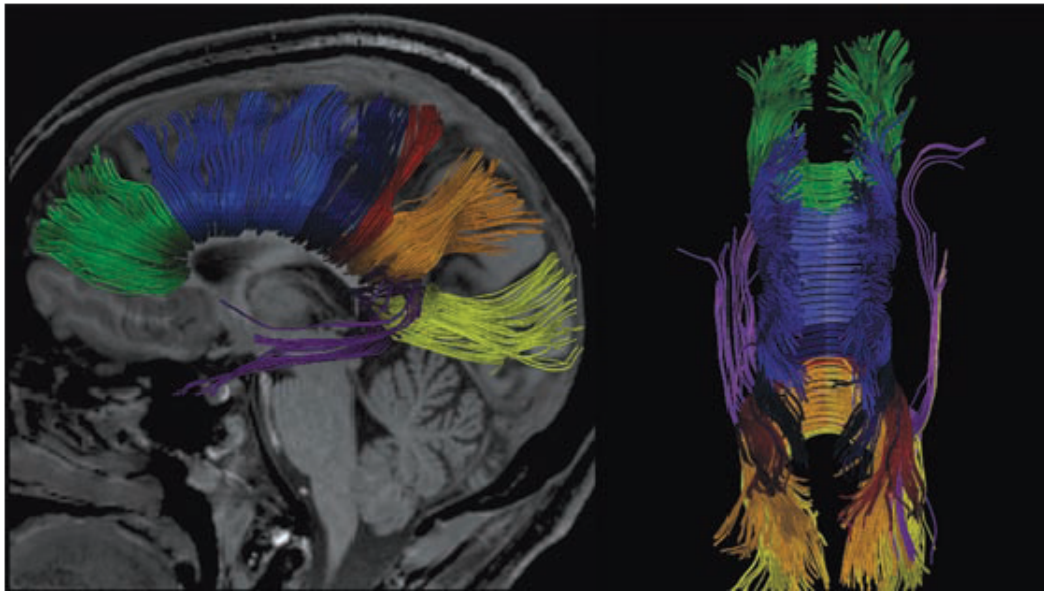
- Diffusion tensor imaging (DTI)
  - Provides information about connections between brain regions
  - Relies on water diffusion
    - Greater diffusion along than across fibres
  - Fractional Anisotropy (FA)
    - Microstructure integrity of white matter
    - 1 = along one axis; 0 = multi-directional



Methodological foundations

- Diffusion tensor imaging (DTI)





Theoretical foundations

Multiple types of memory processes

+

Multiple brain regions

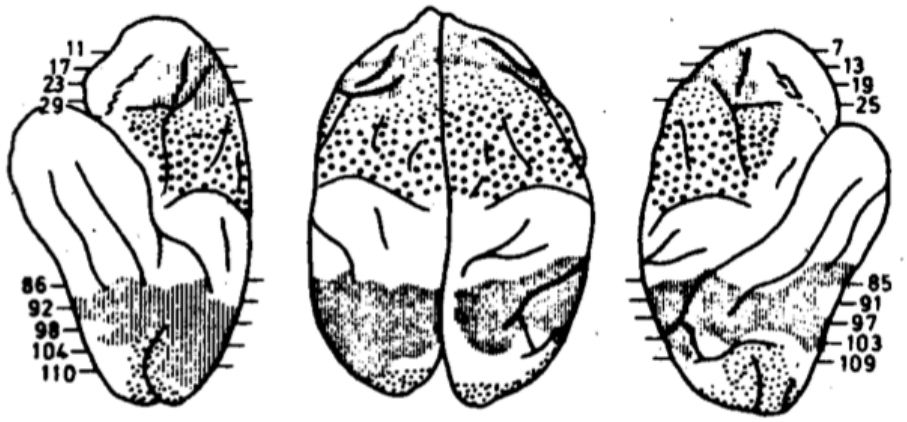
=

Theoretical confusion!

Theoretical foundations

- Historically…

Karl Lashley (1890-1958)



Theoretical foundations

- Historically…

> ***"It is not possible to demonstrate the isolated localization of a memory trace anywhere within the nervous system. Limited regions may be essential for learning or retention of a particular activity, but within such regions the parts and functionally equivalent. The engram is represented throughout the region."***
>
> ***"The so-called associative areas are not storehouses for specific memories. They seem to be concerned with modes of organization and with general facilitation or maintenance of the level of vigilance. The defects which occur after their destruction are not amnesias but difficulties in the performance of tasks which involve abstraction and generalization, or conflict of purposes."***
>
> Lashley, 1950

Theoretical foundations

- Patient HM

- Case details:
  - Minor seizures started at 10 years old
  - Major seizures at 16
  - Medication were not controlling seizures
  - At 27: Surgery to remove his medial temporal lobe bilaterally

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H. M., an Unforgettable Amnesiac, Dies at 82

By BENEDICT CAREY
Published: December 4, 2008

He knew his name. That much he could remember.

He knew that his father's family came from Thibodaux, La., and his mother was from Ireland, and he knew about the 1929 stock market crash and World War II and life in the 1940s.

But he could remember almost nothing after that.

In 1953, he underwent an experimental brain operation in Hartford to correct a seizure

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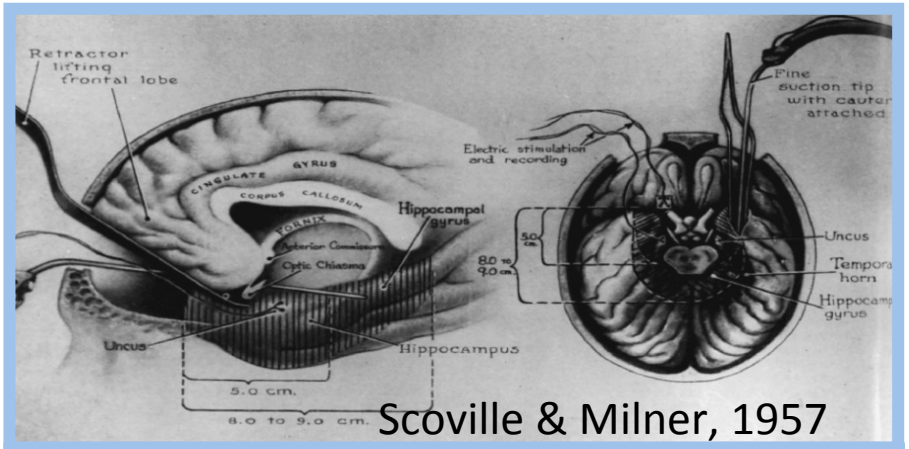
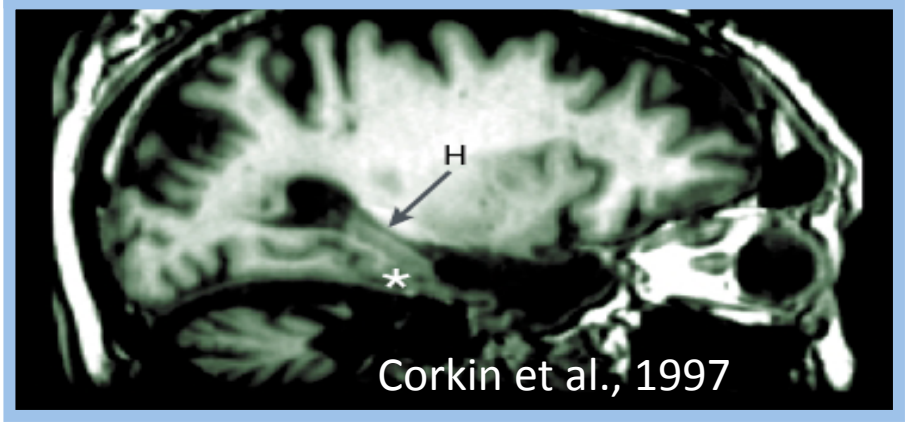
Theoretical foundations

- Removal of bilateral medial temporal lobe (MTL)



Scoville & Milner, 1957



Corkin et al., 1997

William Scoville
1906 - 1984

Brenda Milner
b 1918

Theoretical foundations

- Result of this surgery
  - **Global amnesia**
    - **Anterograde** amnesia:
      - Unable to form new declarative long-term memories.
        - » Episodic.
        - » Semantic.
    - **Retrograde** amnesia:
      - Unable to retrieve any declarative memories from the 11 years before surgery.

Theoretical foundations

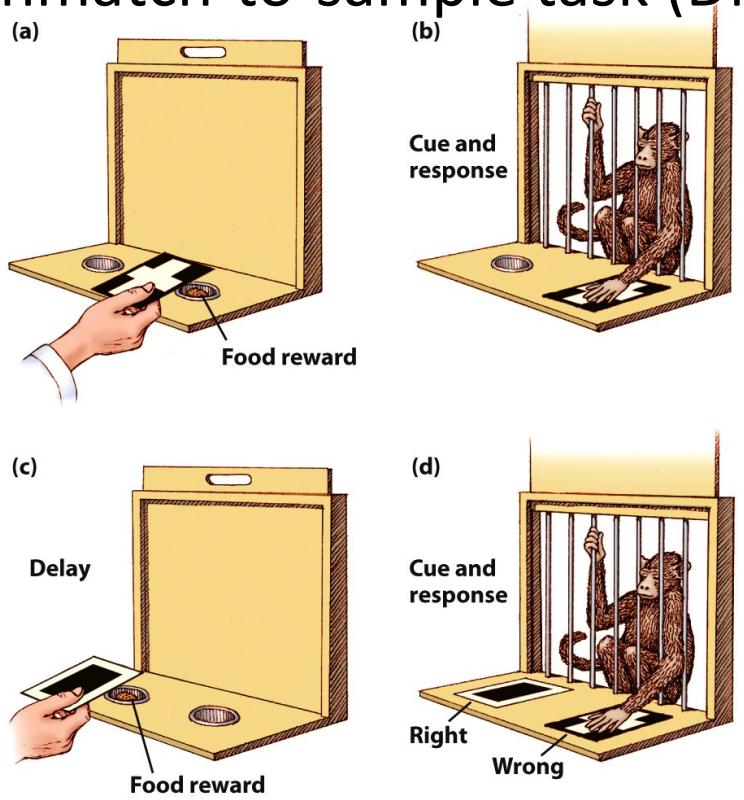
- Result of this surgery:
  - **Other aspects of memory & cognition are preserved**
    - Short-term/working memory
    - Procedural/non-declarative memory
    - Language, visuospatial perception, attention, etc.
    - ***A "pure" disorder of long-term memory?***
  - In combination with 8 other cases:

"These observations suggest a positive relationship between the extent of destruction to the hippocampal complex specifically and the degree of memory impairment."

Scoville & Milner, 1957

Theoretical foundations

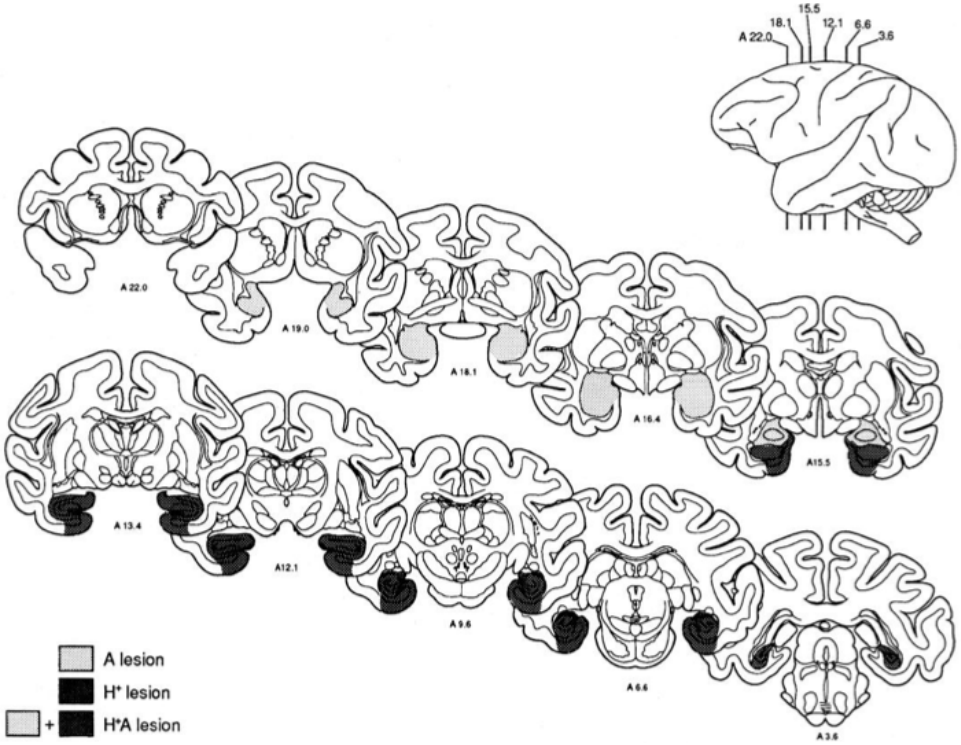
- Convergent animal work
  - Delayed nonmatch-to-sample task (DNMTS)

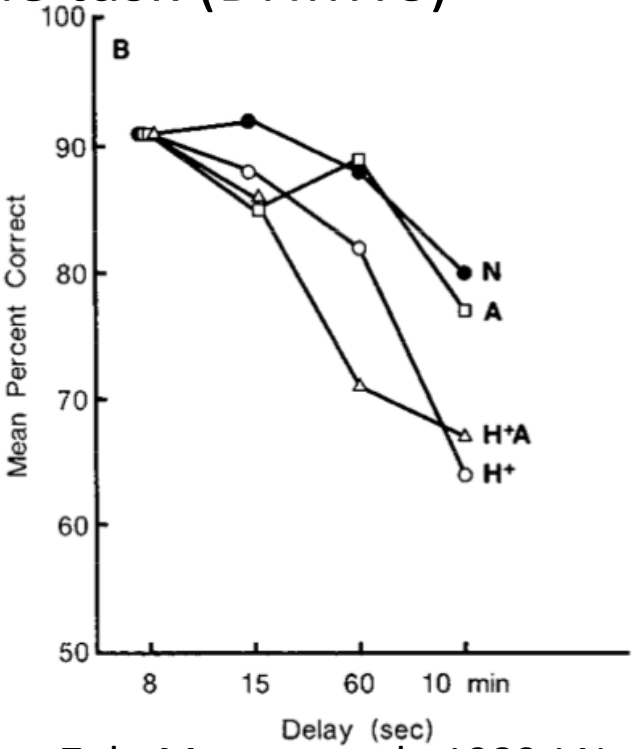


Mishkin, 1978 Nature

Theoretical foundations

- Convergent animal work
  - Delayed nonmatch-to-sample task (DNMTS)

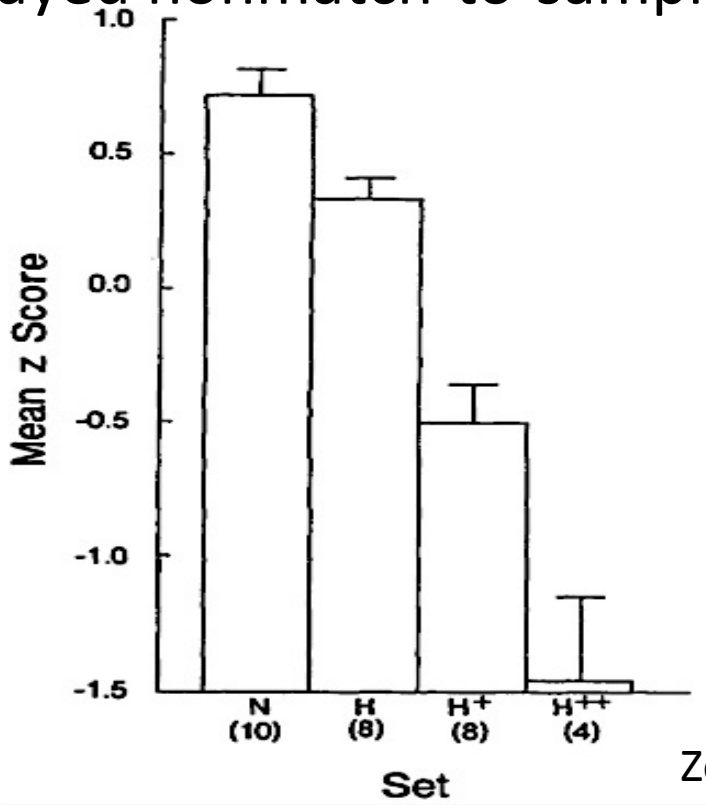




Zola-Morgan et al., 1989 J Neurosci

Theoretical foundations

- Convergent animal work
  - Delayed nonmatch-to-sample task (DNMTS)



Zola-Morgan et al., 1994 Hippocampus

Theoretical foundations

- **MTL = unitary long-term memory system**
  - All structures = Declarative memory (Squire & Zola-Morgan, 1991; Squire et al., 2004; Wixted & Squire, 2011).
  - No segregation of function across structures.
  - Degree of memory impairment ∞ lesion size.

REALLY???