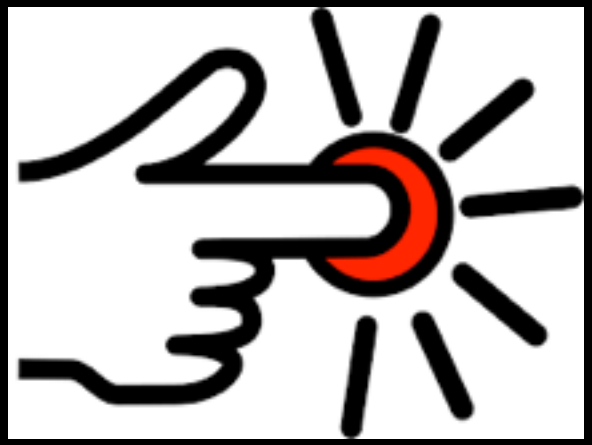
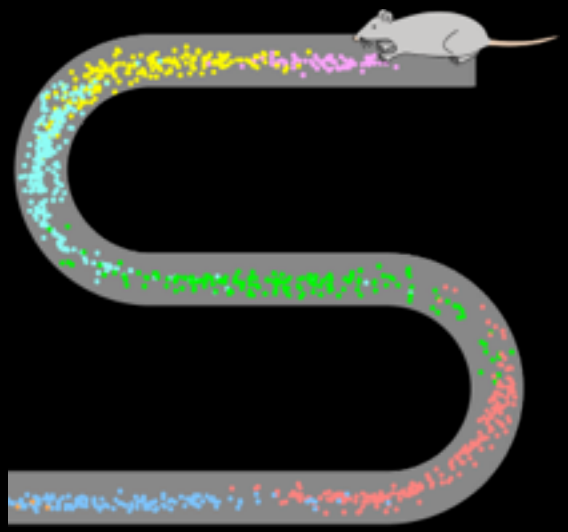
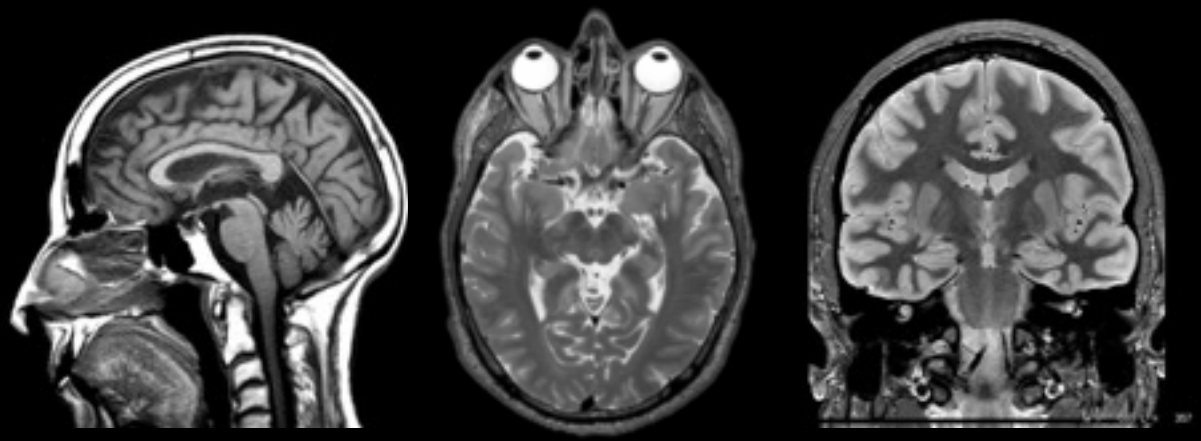
Experimental Methods & Working Memory







Outline

- Types of Experimental Evidence
- Working memory

Outline

How do we study Learning and Memory?

- Historical traditions
  - Birth of experimental psychology
  - Behaviorism
  - Cognitive revolution
- Types of experimental evidence
  - Behavior
  - Neuropsychology
  - Neurophysiology
- Neuroanatomy primer

Neuroimaging in Humans

Two types of brain imaging:

1) Structural imaging
   - Images the structure/composition of tissue
   - e.g., MRI; diffusion tensor imaging (DTI)

2) Functional imaging
   - Images brain function
   - e.g., functional MRI (fMRI)

Functional Neuroimaging

Electrophysiological

- Measure electrical or magnetic signals related to neural activity
  - Electroencephalography (EEG)
  - Magnetoencephalography (MEG)
- Better temporal resolution; worse spatial resolution

Hemodynamic

- Measure changes in blood flow, oxygenation, or metabolism correlated with neural activity
  - Positron emission tomography (PET)
  - functional MRI (fMRI)
- Worse temporal resolution; better spatial resolution

Functional Neuroimaging

- Both electrophysiological and hemodynamic techniques are *relative*
  - Brain is always active
  - To measure the brain's response to stimuli, need to compare two conditions (subtraction technique)
    - Condition 2 – Condition 1 = difference image

Neuroimaging “Subtractive” Logic

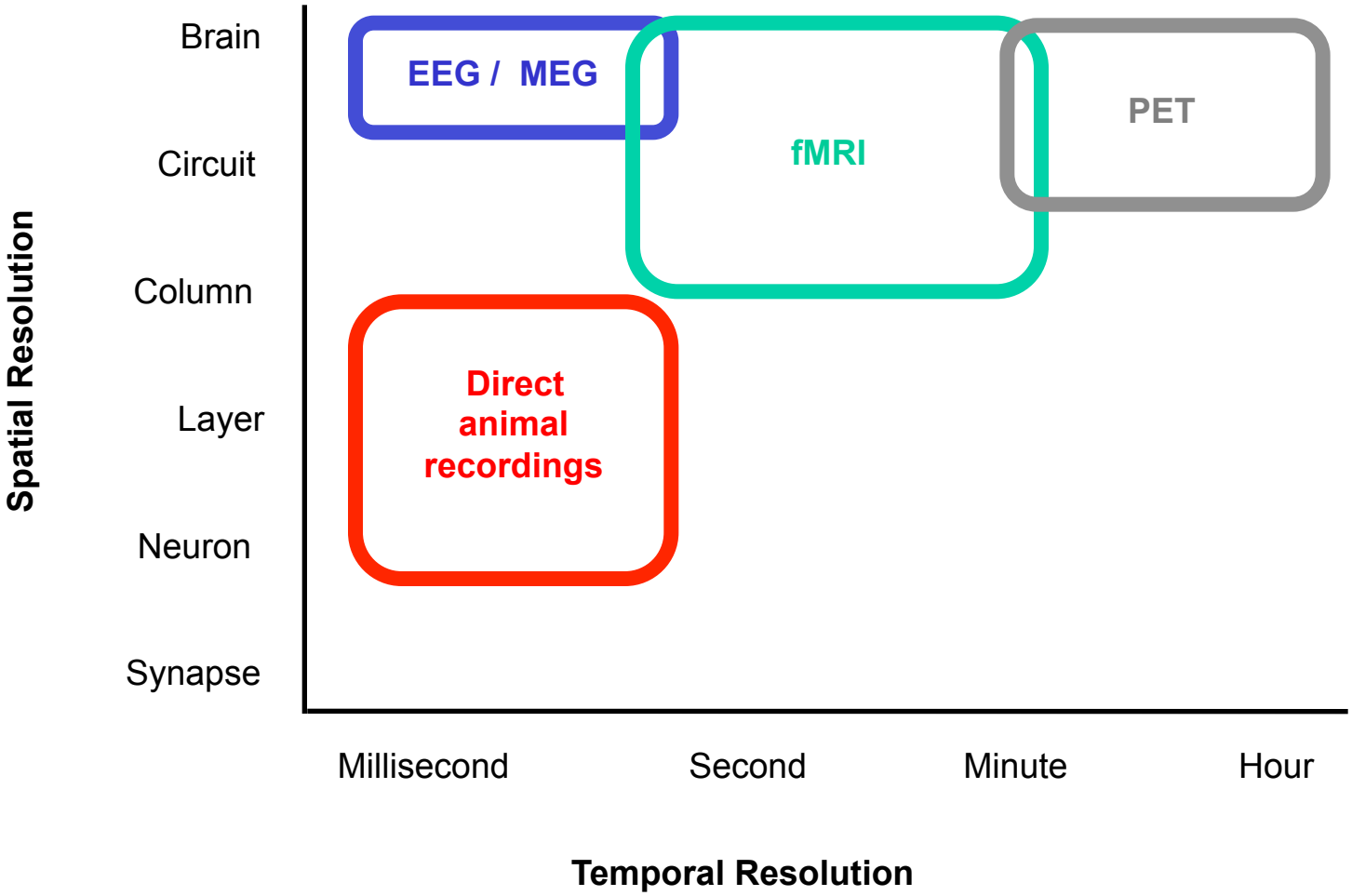
What regions are used for perceive faces?

Difference image: experimental condition – baseline condition

Functional Neuroimaging

- Pros
  - Non-invasive technique for measuring brain function in humans
  - Can evaluate function across multiple regions simultaneously
- Cons
  - Can’t tell you about causation, only correlation
  - Relative to direct animal recordings, relatively poor spatial resolution

Neurophysiology Summary



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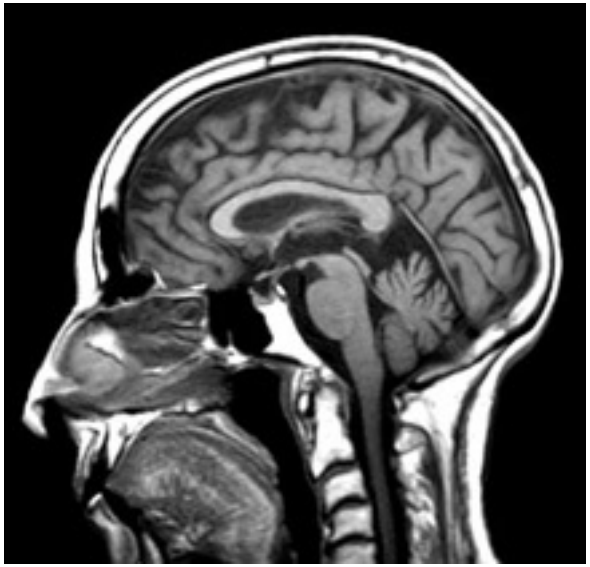
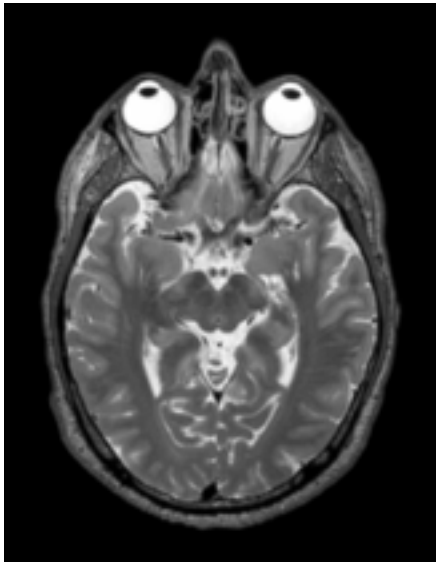
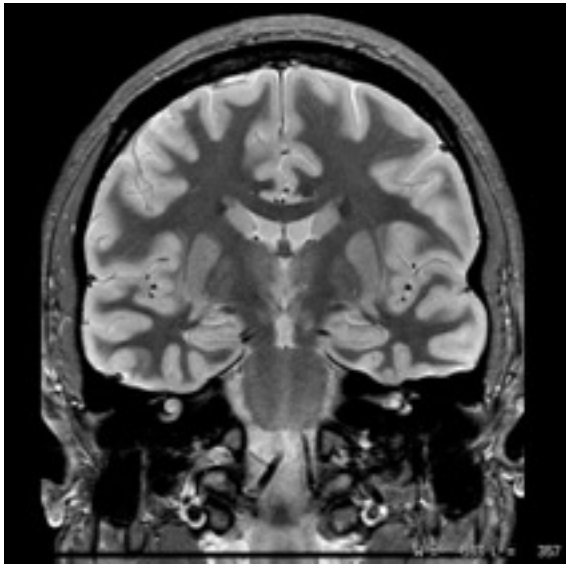
Brain Sections



Sagittal
(Brain from the side)

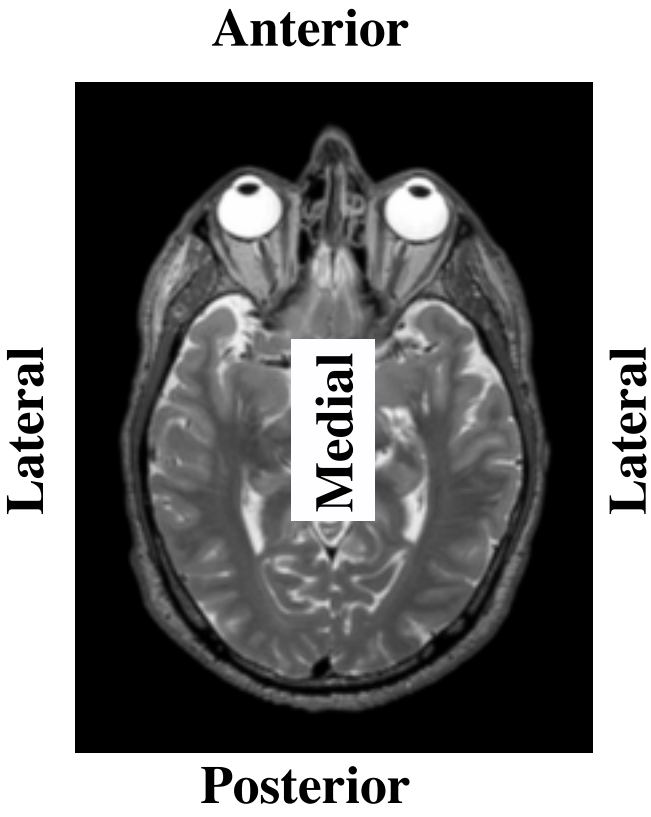


Horizontal / Axial
(Brain from above)



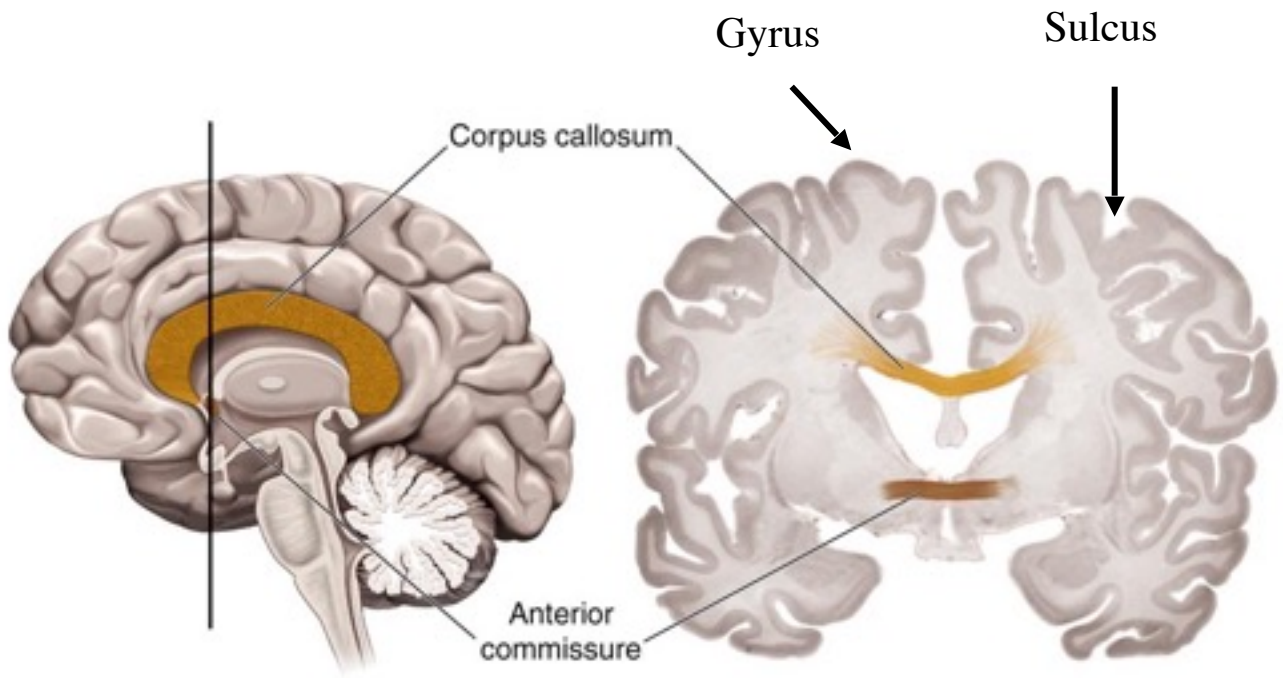
Coronal
(Brain from the front)

Directional Terminology

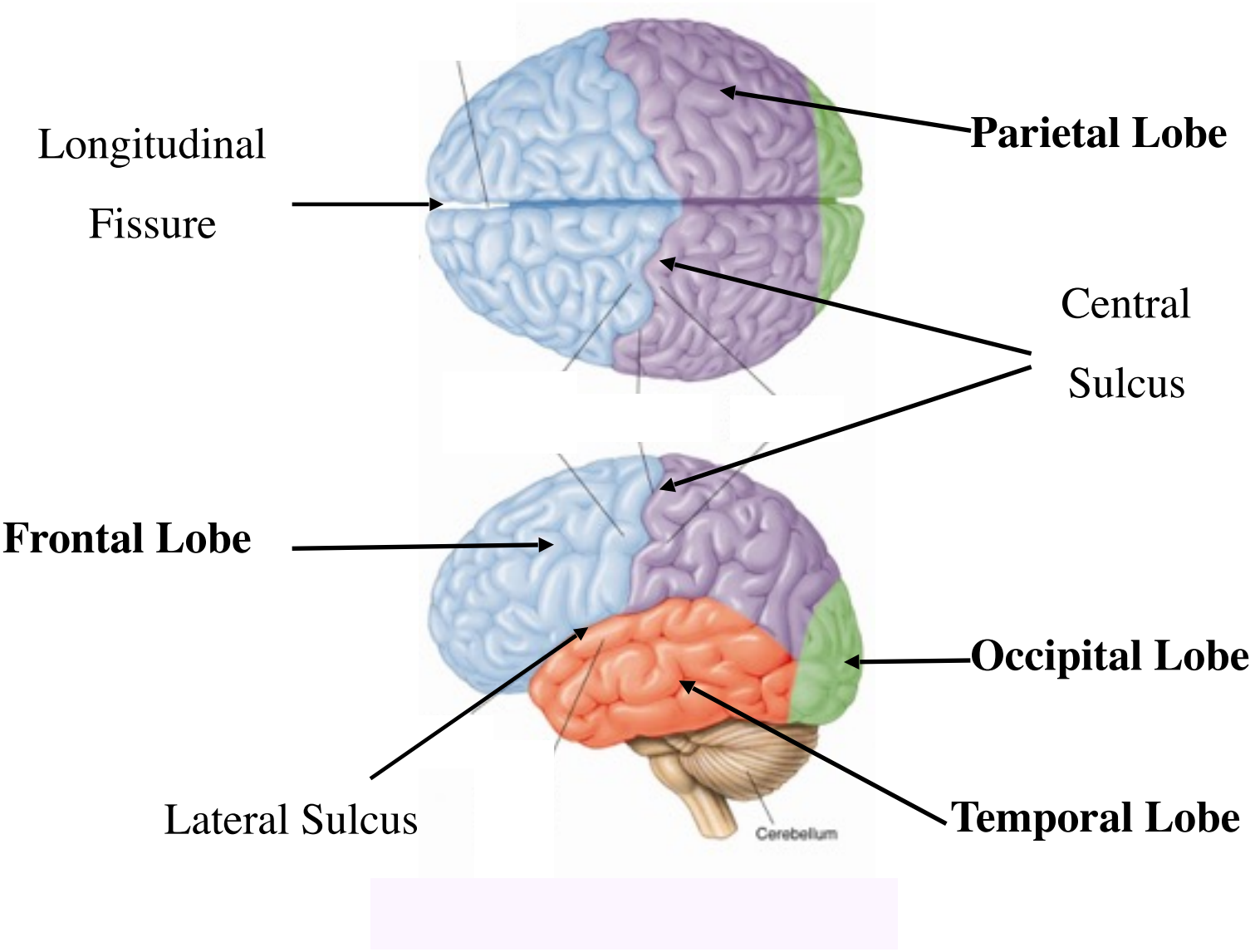


Cerebral Cortex

- Cortex (“bark”): outermost layer of the brain
- Deeply folded structure



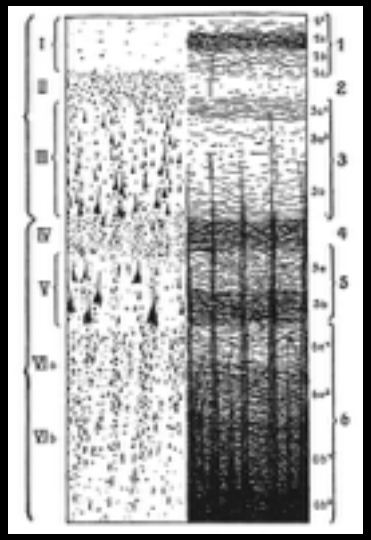
Cerebral Cortex



Anatomical Areas and Cytoarchitecture

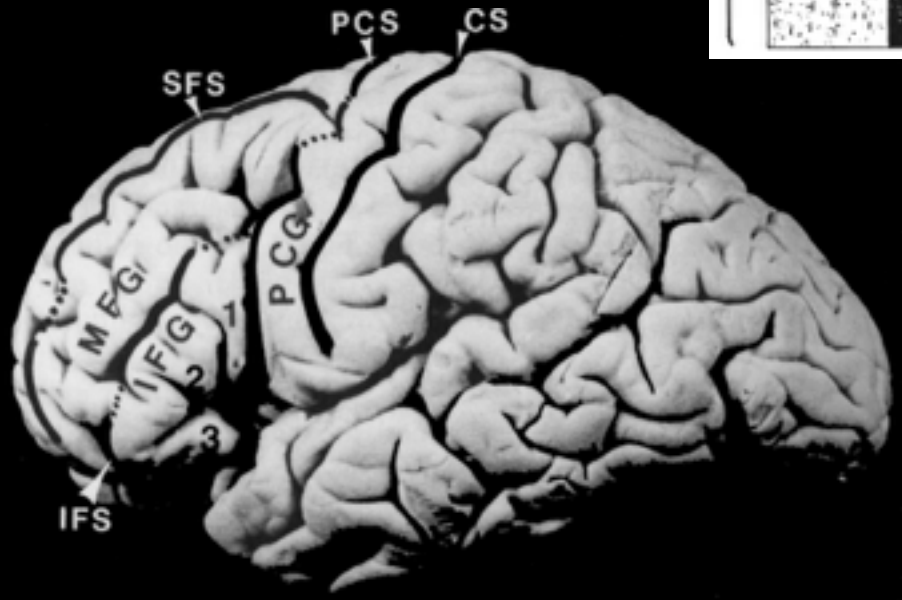
Area

A B



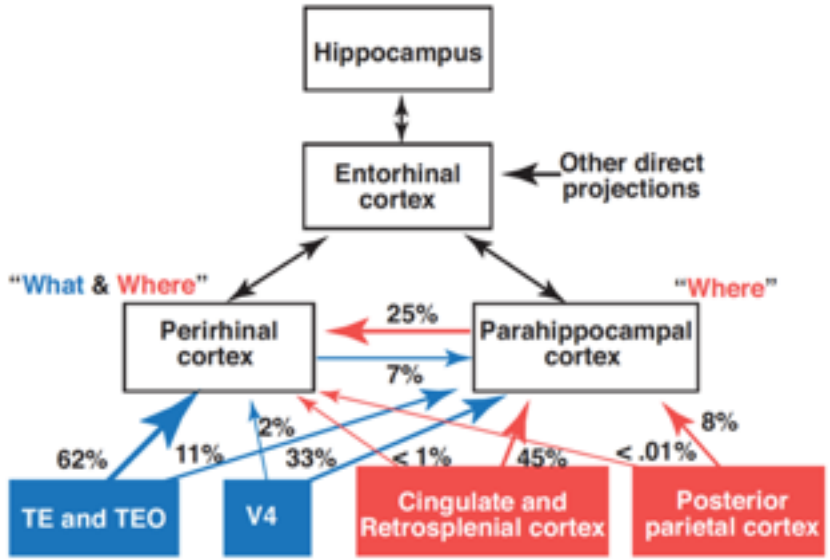
Cortical layers

Brodmann Areas



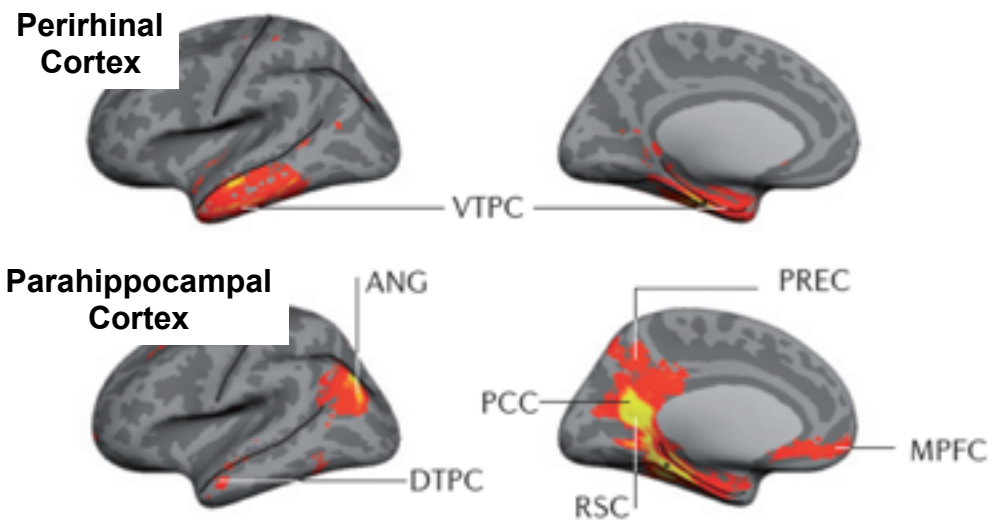
Anatomical Areas and Connectivity

Structural Connectivity



[Wixted & Squire, 2011; adapted from Buffalo et al., 2006]

Functional Connectivity

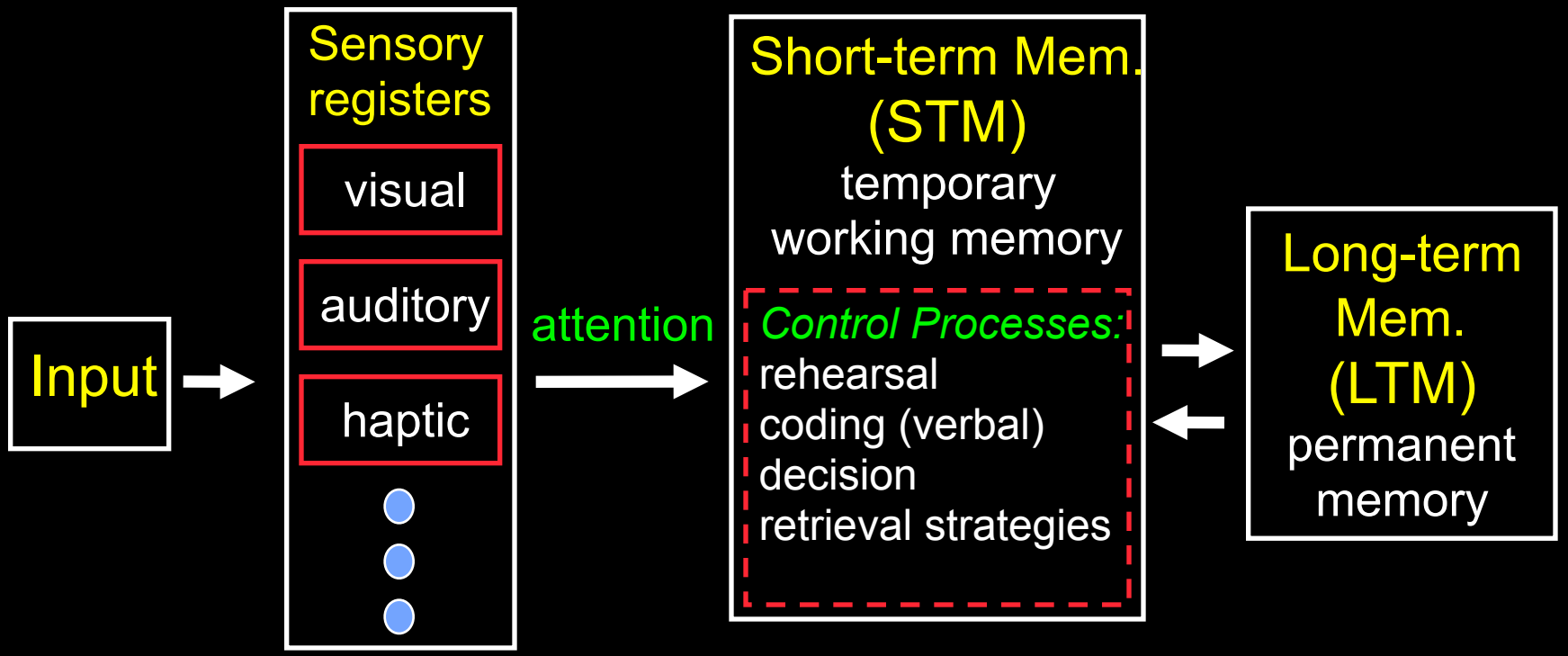


[Ranganath & Ritchey, 2012]

Outline – Working Memory

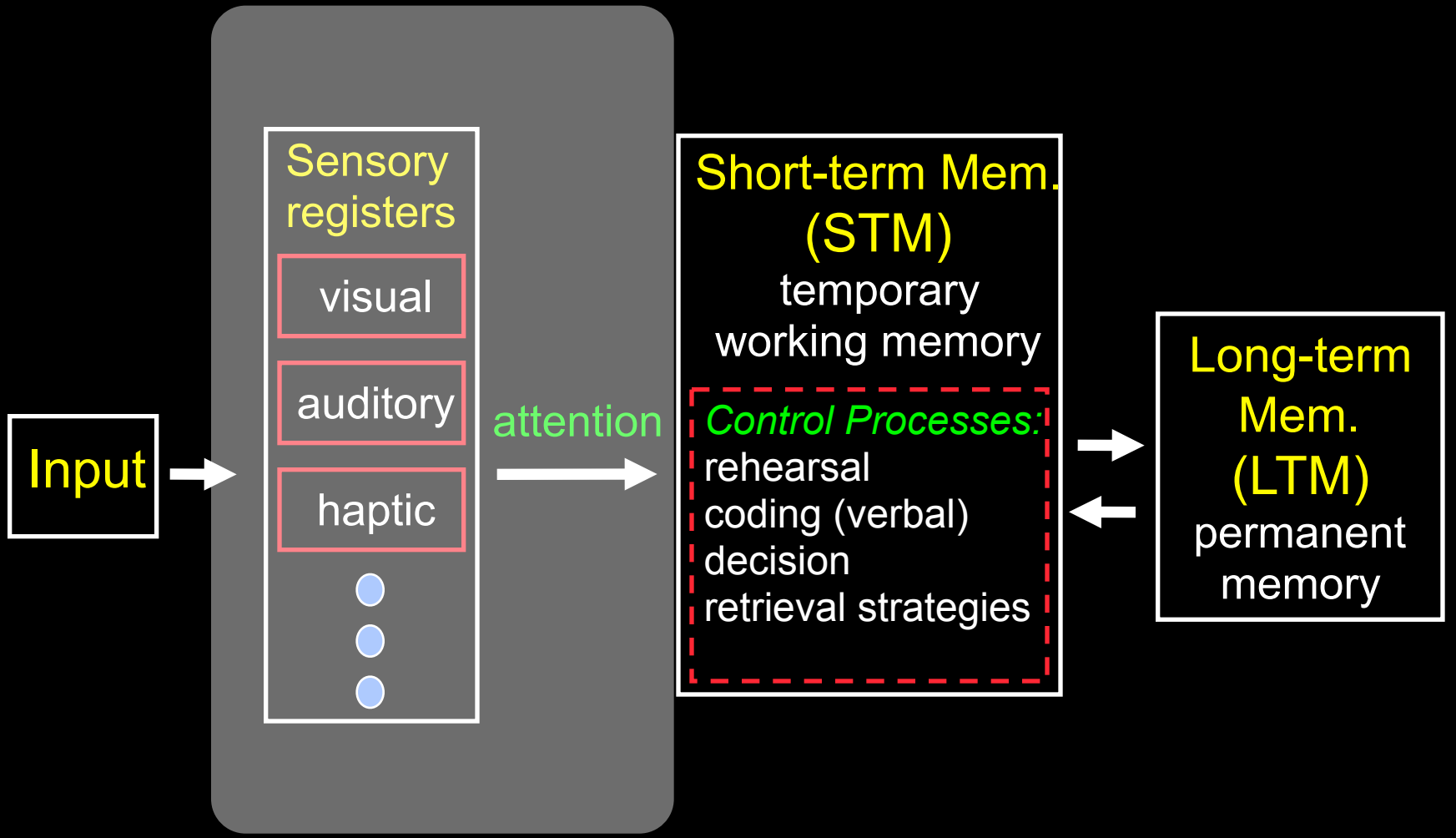
- What is Working Memory (WM)?
- Why is WM important?
- Capacity limits of WM
- Contrasting WM and LTM
- Forms of WM
- Neurobiology of WM

“Modal Model” of Memory



Atkinson & Shiffrin (1968)

“Modal Model” of Memory



Atkinson & Shiffrin (1968)

Sensory Memory

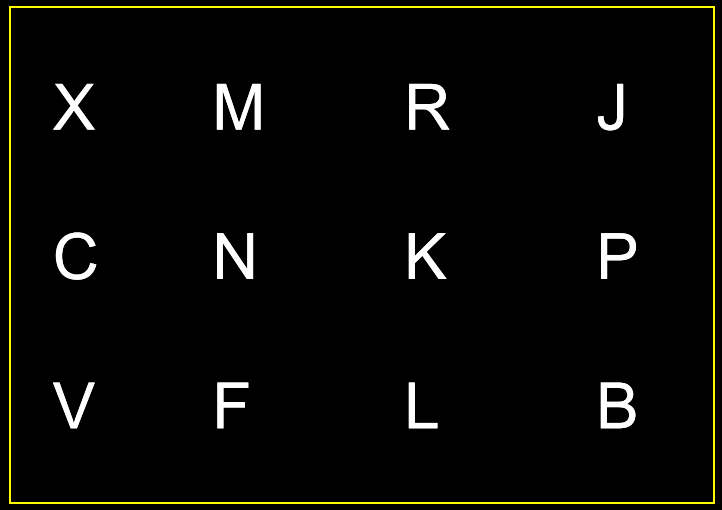
How does information from the outside world get registered in memory?

- sensory systems convert sensory energy (photons, sound waves, etc) into neural representations

- information must be represented in sensory systems long enough so that we can identify (perceive) what is being sensed and create a more stable internal representation

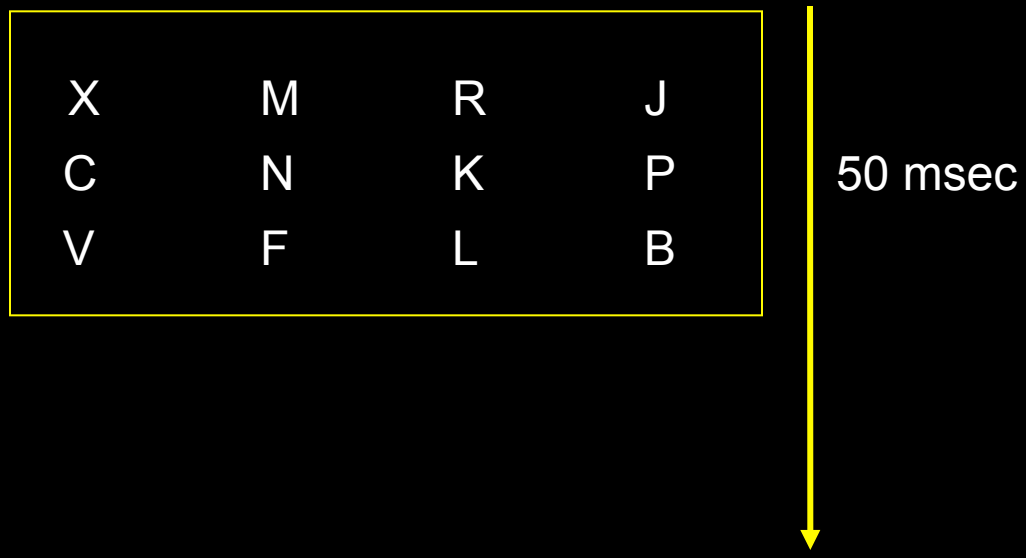
  – sensory systems support brief 'sensory memories'
  – fleeting representations of stimuli just experienced

Visual Sensory Memory: 'Iconic Memory'



- after brief presentation (e.g., 50 msec), participants immediately report what they saw
- typically can report ~4 items
- subjective perception of visual after-effect
- subjective perception that after-effect fades before it can be reported
- capacity does not depend on # of items in display or their spatial arrangement

How Much Information is in Iconic Memory? Sperling's (1960) Partial Report Procedure



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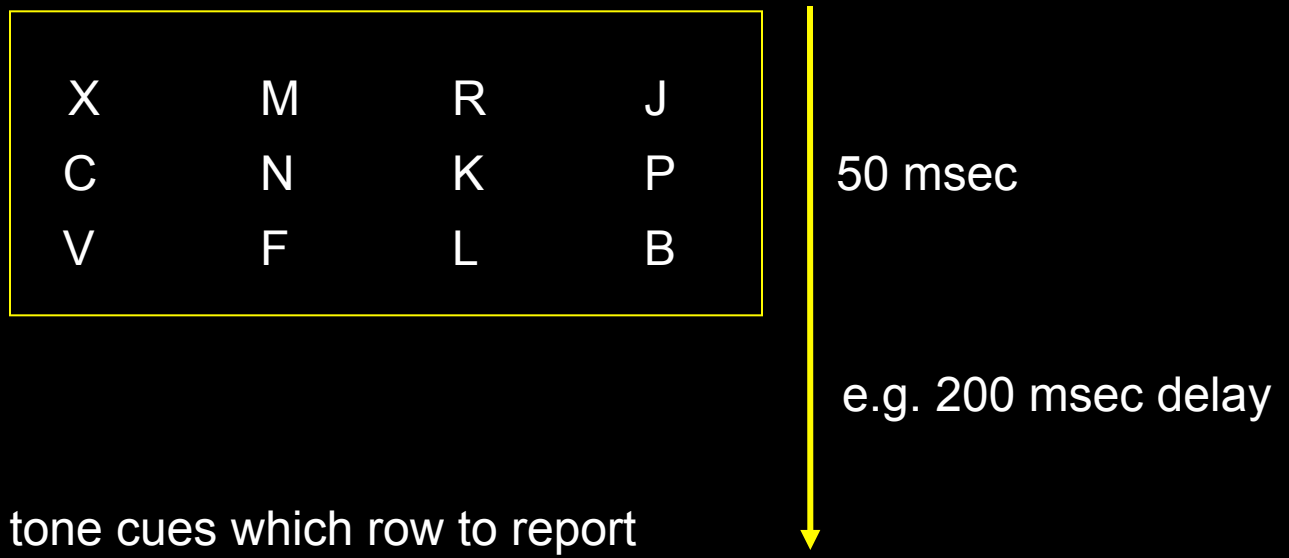

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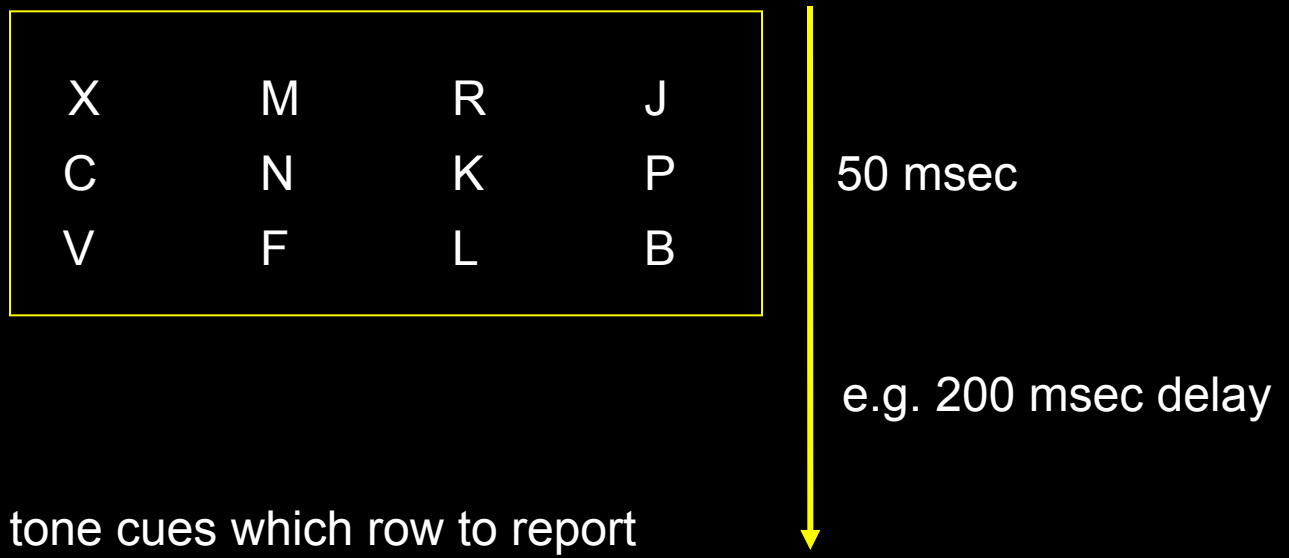
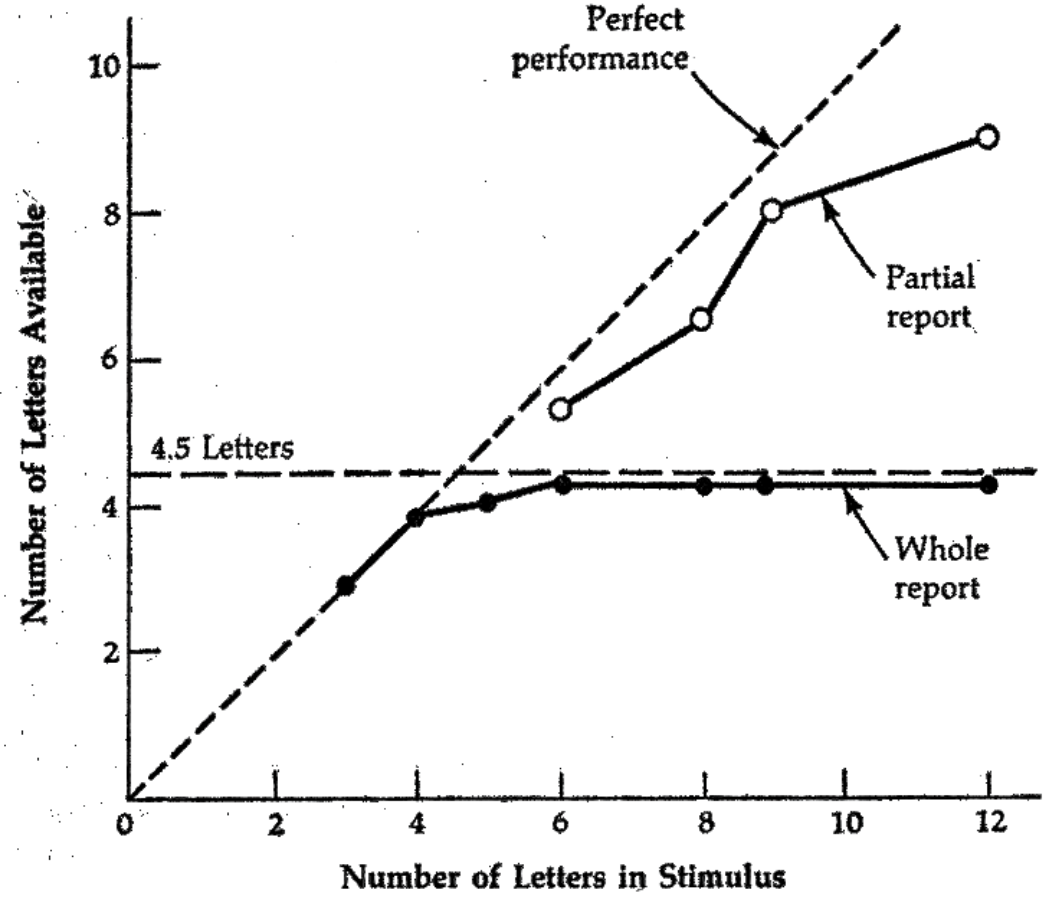


tone cues which row to report

– allows subject to shift attention to the cued sensory information

How Much Information is in Iconic Memory? Sperling's (1960) Partial Report Procedure



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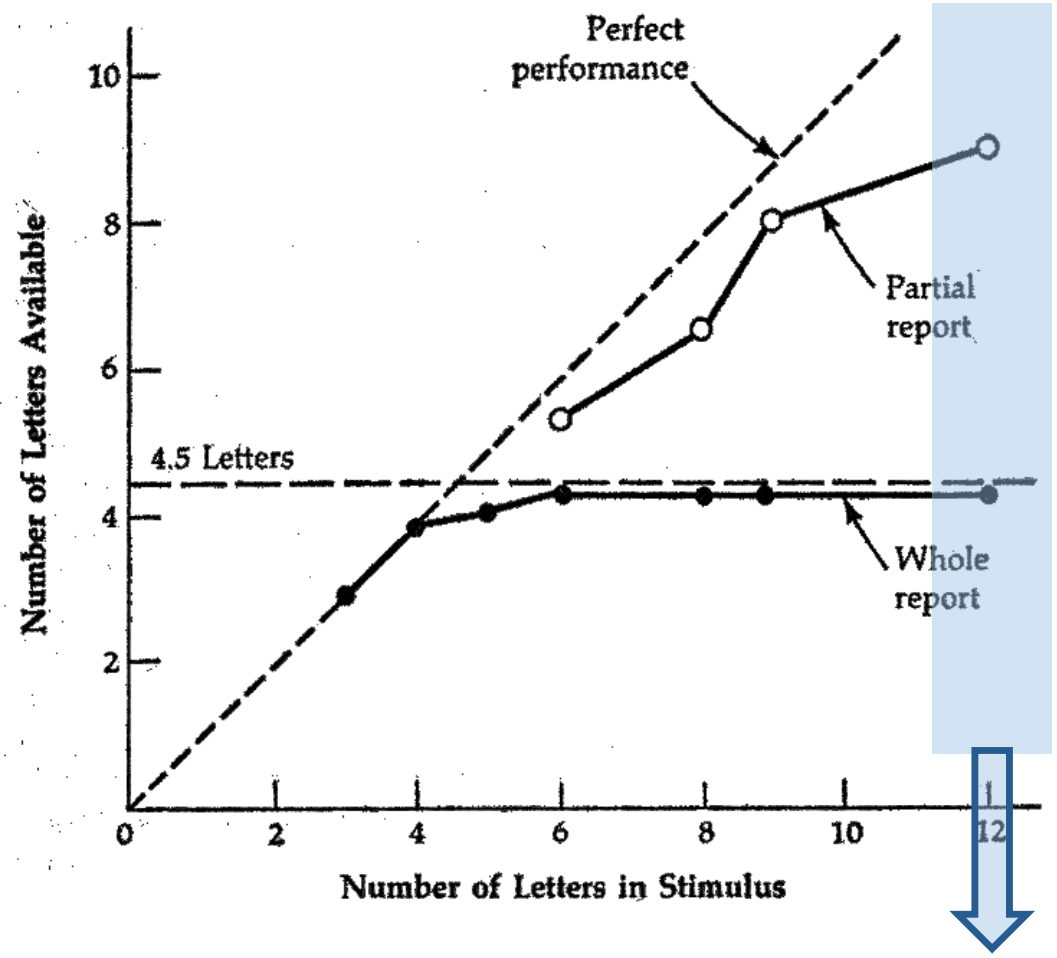

(recalling ~3 letters per row suggests that ~9 letters actually remembered)

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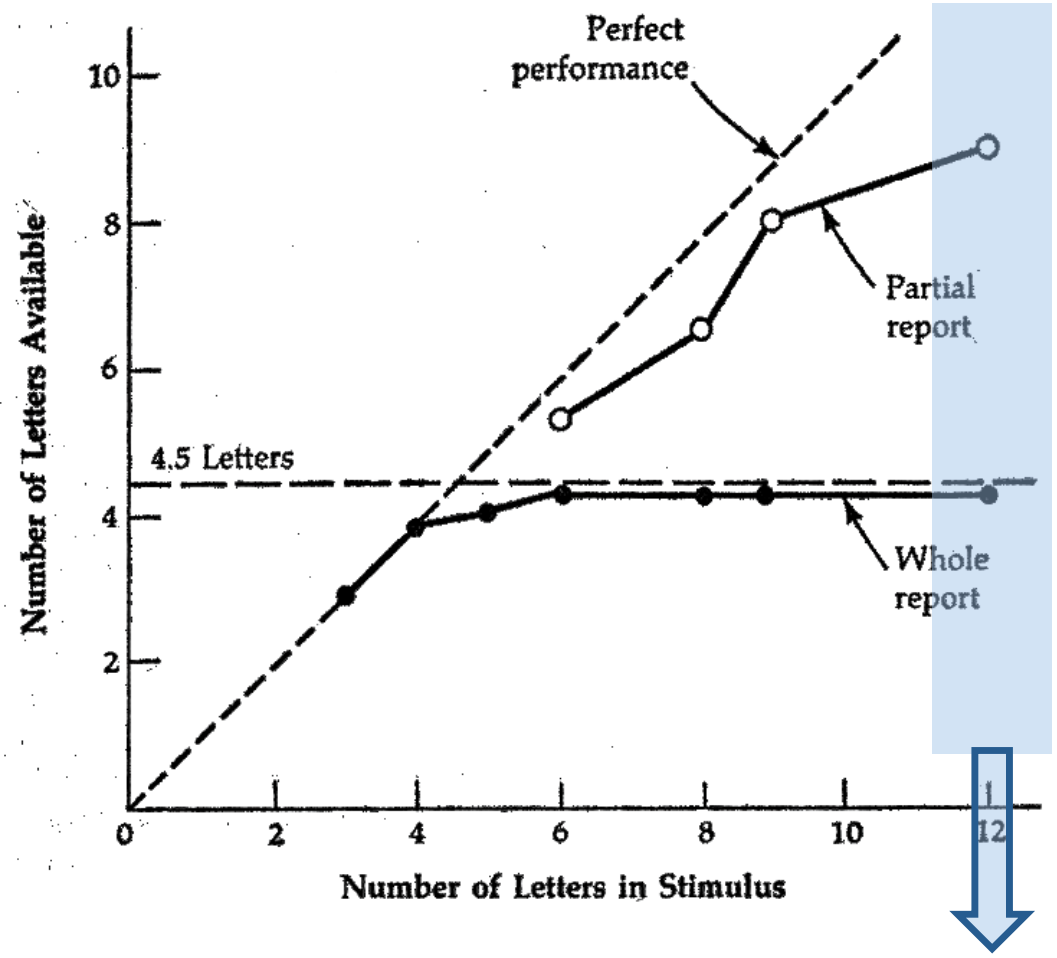
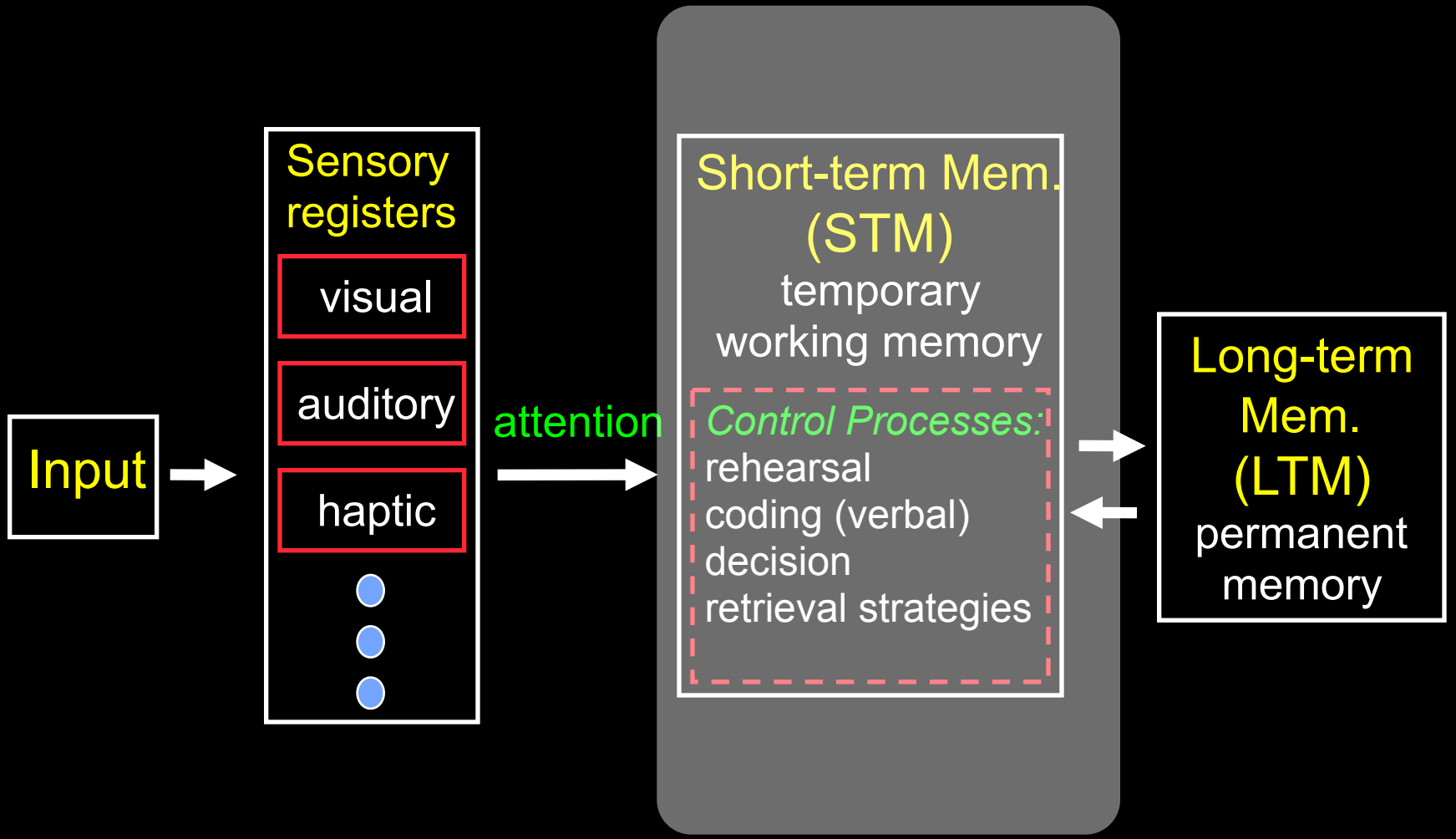


(recalling ~3 letters per row suggests that ~9 letters actually remembered)

- capacity: visual sensory memory seemingly contains all presented visual input
- can report attended items that are converted to a more stable internal representation
- information-processing / attentional capacity is limited
- attentional cue needs to appear within 500-1000 msec to have an effect; sensory memory is fleeting

“Modal Model” of Memory



Atkinson & Shiffrin (1968)

Short-term vs. Long-term Memory

William James
(1890/1905)

- ***primary memory:*** **"the specious present", refers to this moment in time**

  "never lost, its date was never cut off in consciousness from that of the immediately present moment. In fact, it comes to us as belonging to the rearward portion of the present space of time, and not to the genuine past."

- ***secondary memory:*** **"memory proper"; long-term memories**

James and Hebb

James (1890): postulated two forms of memory

- Primary memory
  - The immediate contents of consciousness / information about which you are currently aware
  - Effortlessly available but fleeting
  - Limited capacity
- Secondary memory
  - Memories of the past
  - Permanent but available with effort
  - Unlimited capacity

Hebb (1949): proposed distinction between STM & LTM mechanisms

- STM: relies upon temporary neural activation
- LTM: relies upon structural changes in neurons / connections

Working Memory

Atkinson & Shiffrin (1971)

"…we tend to equate the short-term *store* with 'consciousness,' that is, the thoughts and information of which we are currently aware can be considered part of the contents of the short-term store…Because consciousness is equated with the short-term store and because *control processes* are centered in and act through it, the short-term store is considered a working memory: a system in which decisions are made, problems are solved and information flow is directed."

Working Memory = a system for **maintaining** and **manipulating** active representations