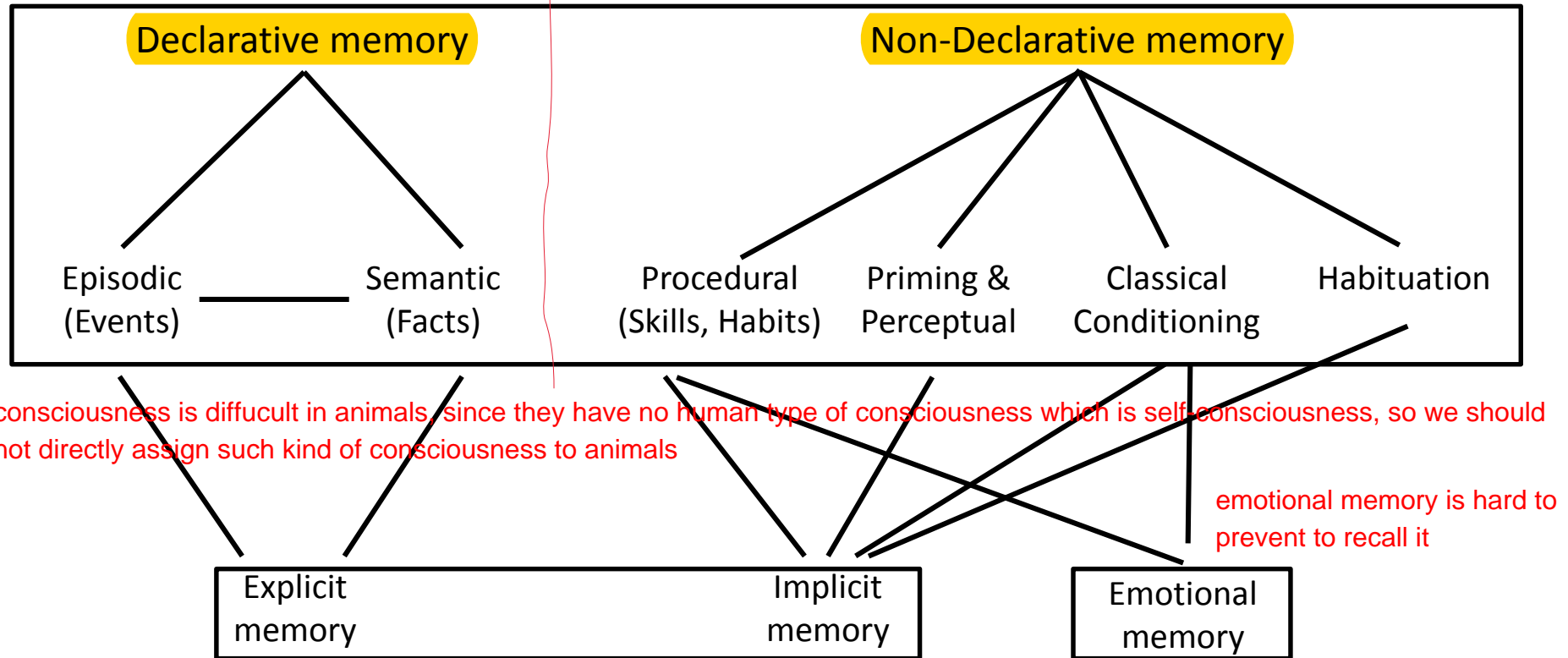


Learning and Memory: Memory

- Memory systems
- Learning
- Information consolidation
- Retention
- Recall
- Recognition
- Short-term, Long-term
- Emotional memory
- Post-traumatic stress disorder (PTSD)
- Episodic memory, where-what-when
- Medial temporal lobe

A taxonomy of mammalian memory systems (after L.R. Squire)



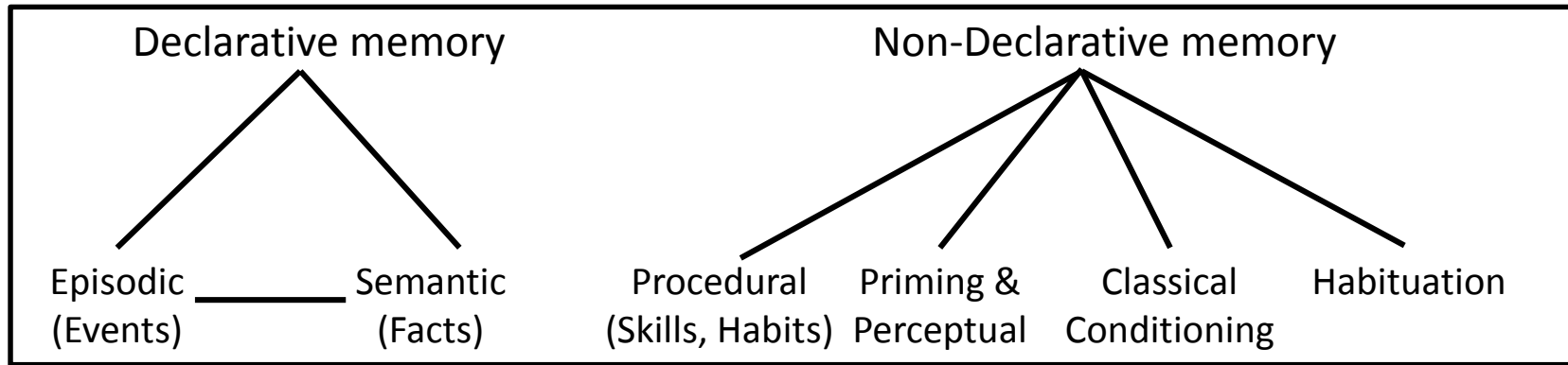
Declarative memory: Everyday memory for facts and events that are subject to conscious recollection and can be explicitly expressed in many ways outside the conditions of original learning. The combination of episodic and semantic memory.

Explicit memory: Memory expression based on conscious recollection involving direct efforts to access memories

Implicit memory: Unconscious changes in behaviour as influenced by some previous experience

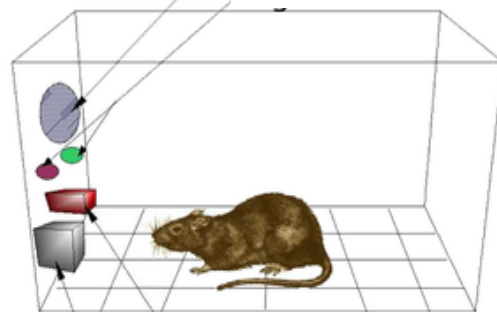
Emotional memory: Representation of a positive or negative affect associated with specific stimuli. Typically not subject to conscious recollection but reflected in emotional behaviour and/or physiology

A taxonomy of mammalian memory systems (after L.R. Squire)



if behaviour is performed frequently enough, then the goal won't be in mind anymore and it will simply become a habit (important for overtraining, because else goal directed behaviour cannot be demonstrated anymore)

*** R-UCS Goal**



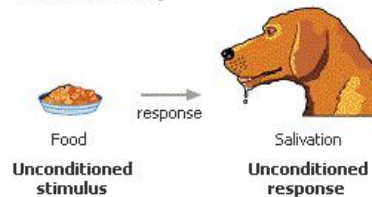
Response lever

Food dispenser

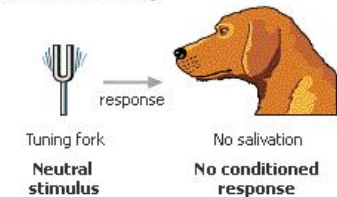
*** Operant S-R**

*** CS-UCS**

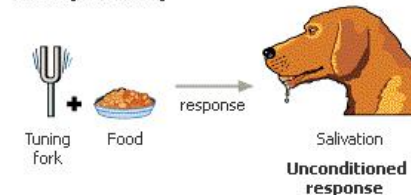
1. Before conditioning



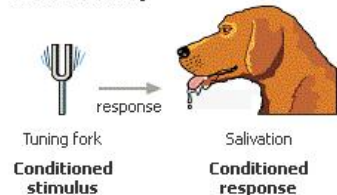
2. Before conditioning



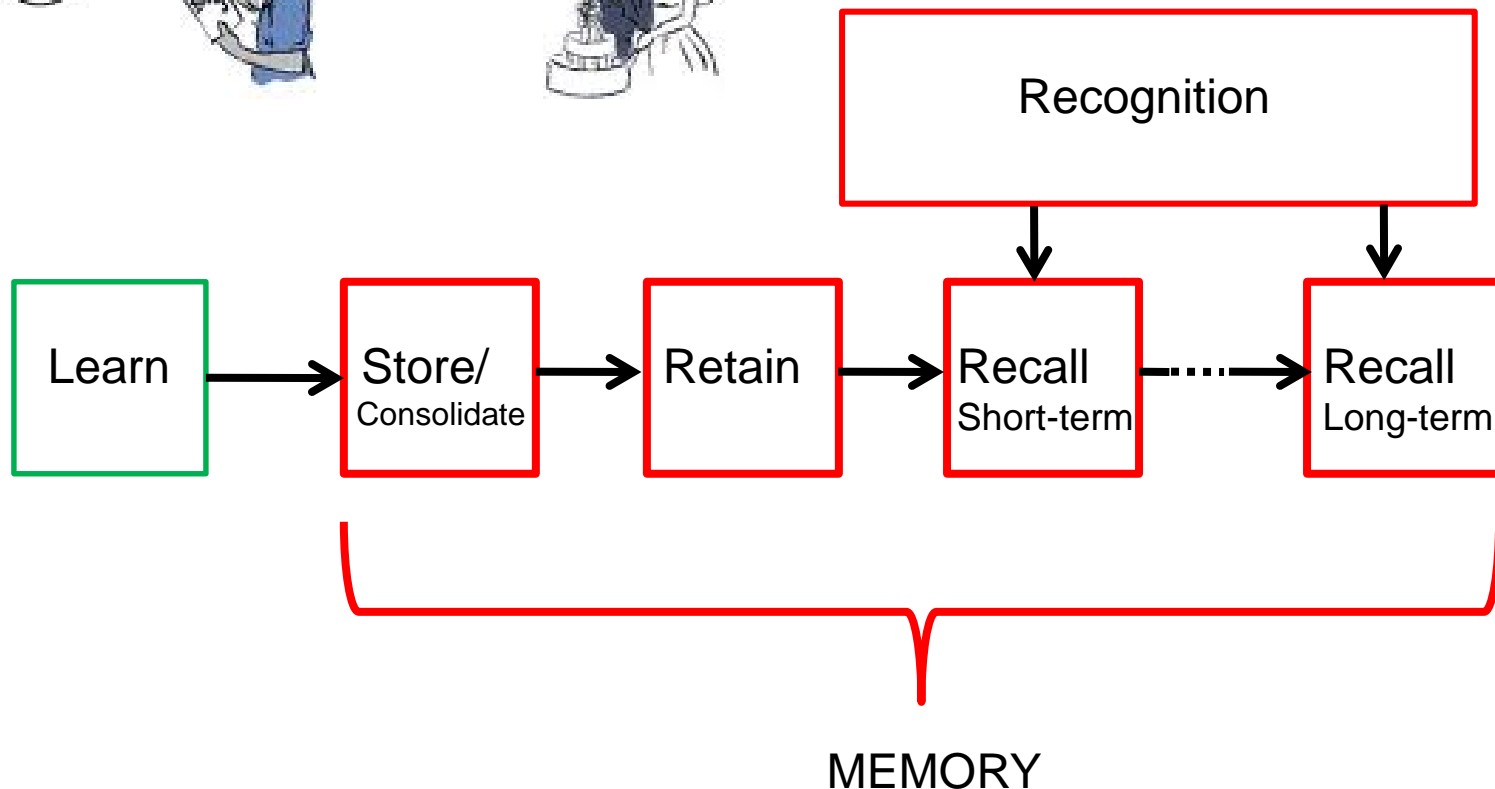
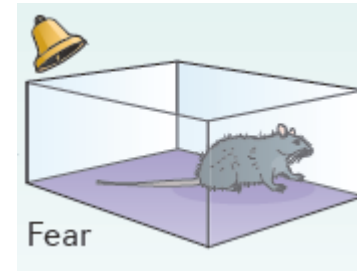
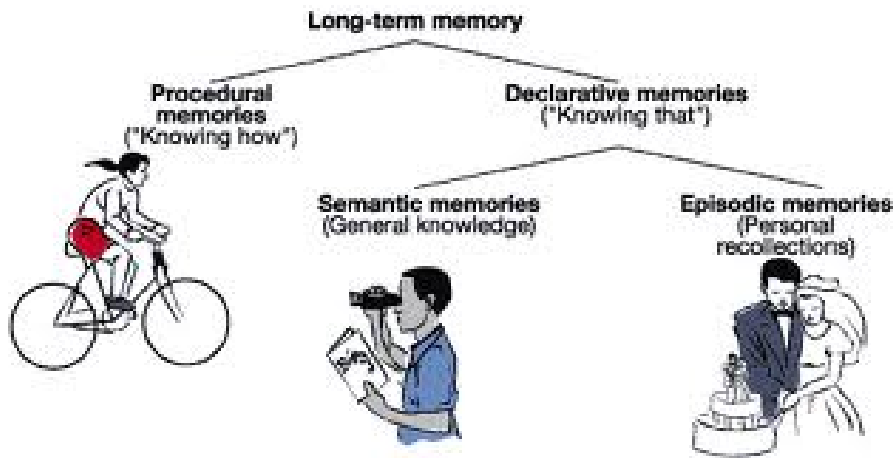
3. During conditioning



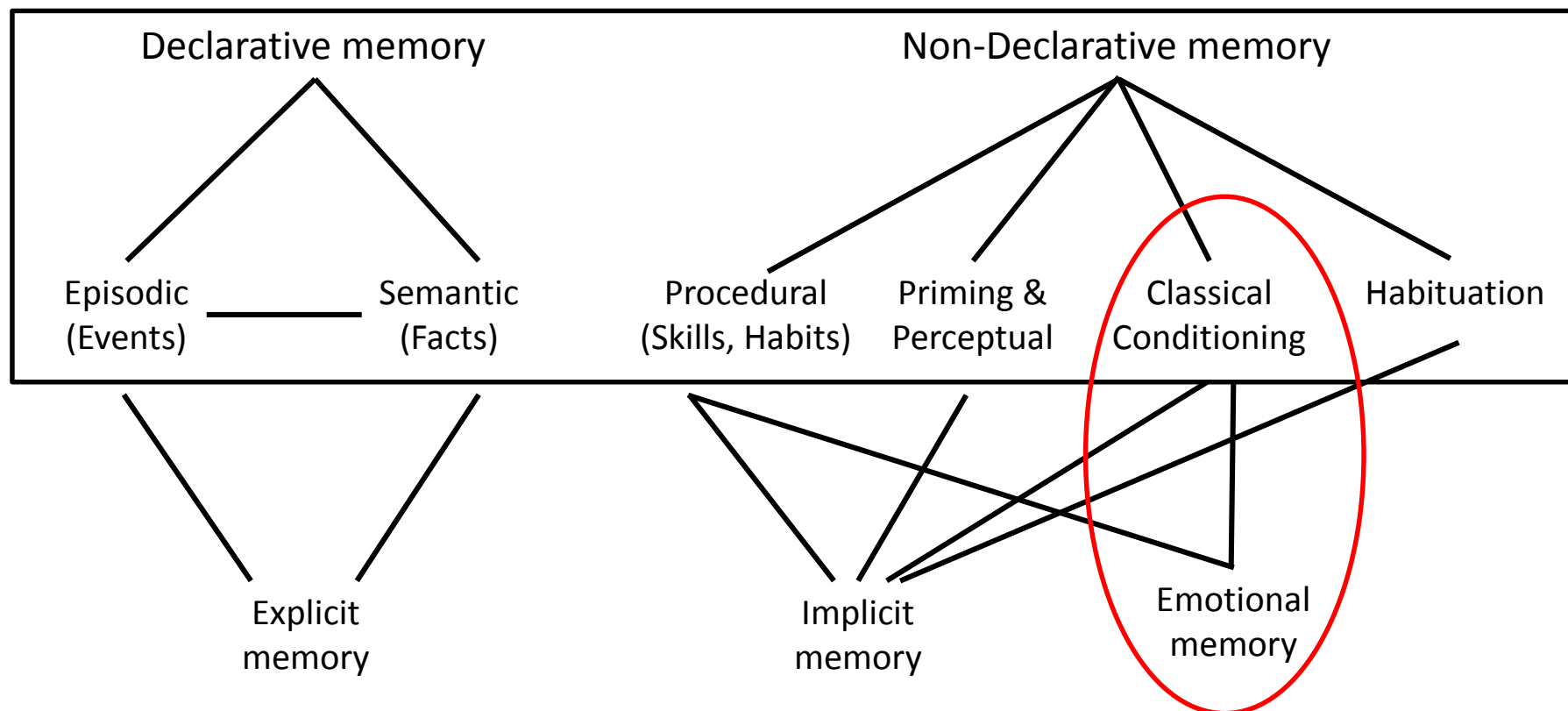
4. After conditioning



Sequence of processes that together make up (most) memory types



A taxonomy of mammalian memory systems (after L.R. Squire)



Declarative memory: Everyday memory for facts and events that are subject to conscious recollection and can be explicitly expressed in many ways outside the conditions of original learning. The combination of episodic and semantic memory.

Explicit memory: Memory expression based on conscious recollection involving direct efforts to access memories

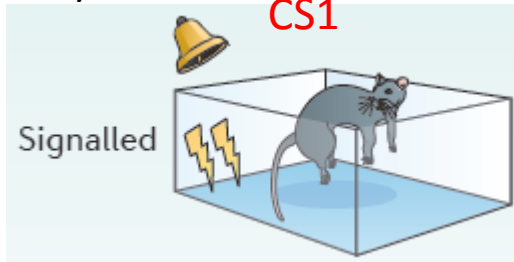
Implicit memory: Unconscious changes in behaviour as influenced by some previous experience

Emotional memory: Representation of a positive or negative affect associated with specific stimuli. Typically not subject to conscious recollection but reflected in emotional behaviour and/or physiology

Importance of Amygdala in CS Fear Memory in Rat

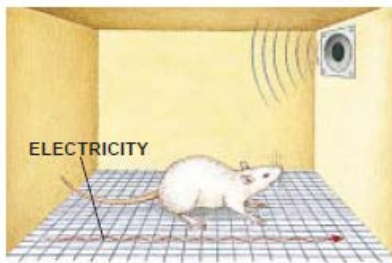
Day 0

CS1



480 Days

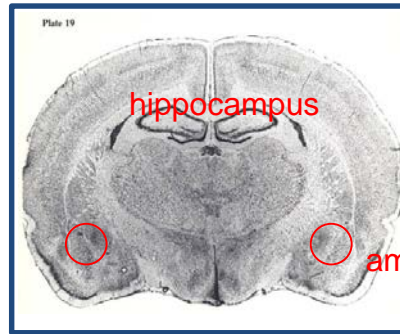
CS2



Day 481
Amygdala or Control
Lesion

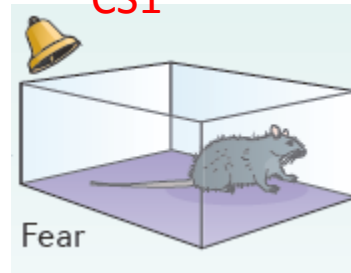
14 Day Recovery
Remote CS Test
Recent CS Test

only in amygdala lesion group, there was a removal of amygdala
control group, they simply went through same surgery, but not removal
in order to have a control group

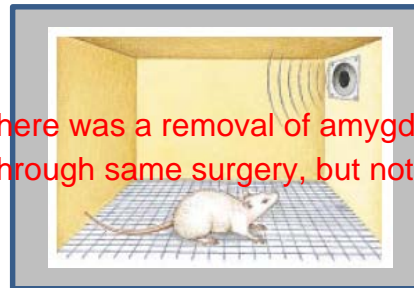


amygdala right next to temporal lobe (similar situation in humans too)

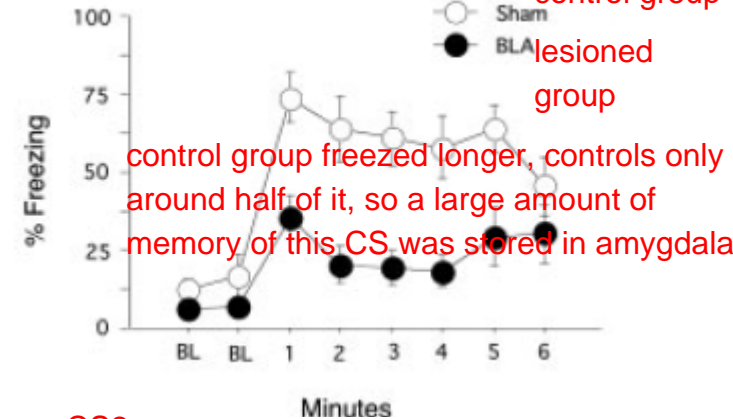
CS1



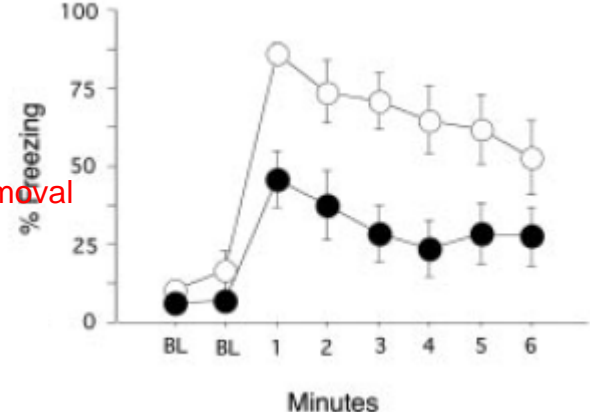
CS2



CS1

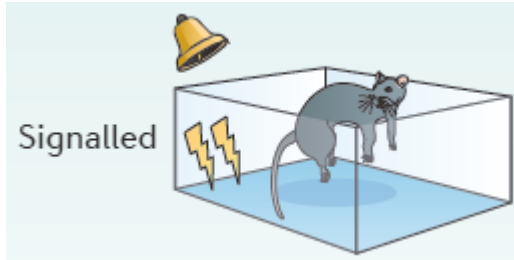


CS2



Importance of Hippocampus in Contextual Fear Memory in Rat

Day 0

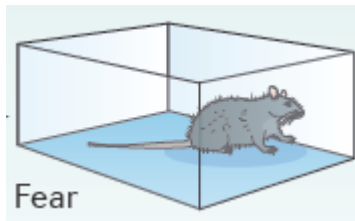


hippocampal tissue can be destroyed with injection of chemicals to make a lesion. animals are under anaesthesia

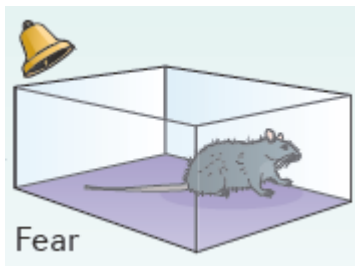


Day 1, 7, 14, 28
Hippocampal or Control
Lesion

Day 7 Post-surgery: Context Test

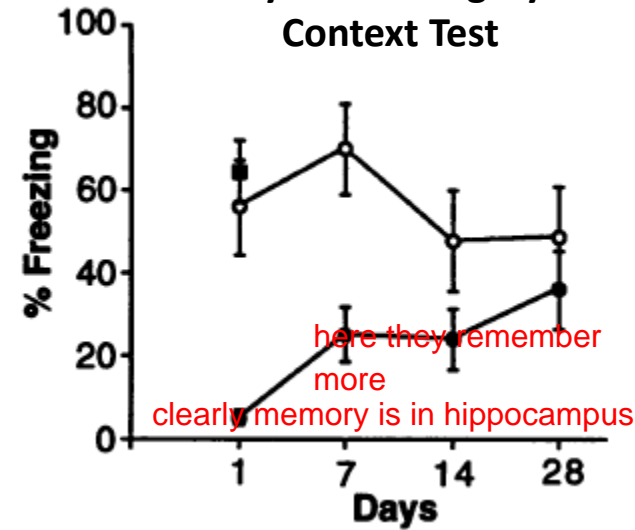


Day 8 Post-surgery : CS Test in Novel Context

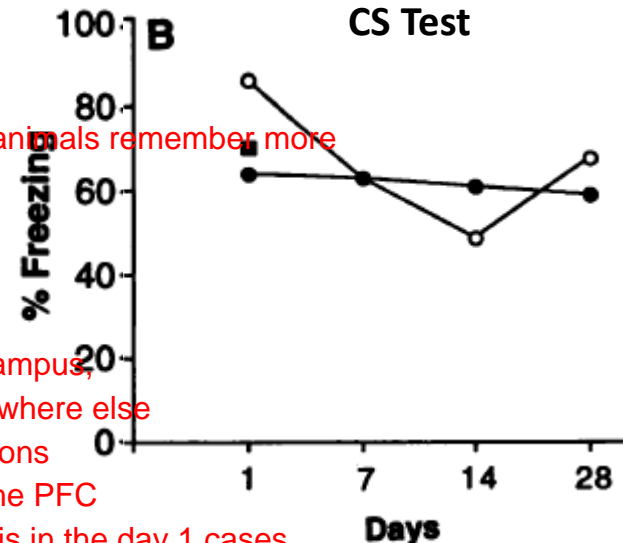


(○), Control
(●), hippocampus lesion
(■), cortex lesion.

Day 7 Post-surgery:
Context Test



Day 8 Post-surgery:
CS Test



the longer you wait btw learning and lesions the animals remember more

memory movement occurs: formation in hippocampus, but after some time, memory will be stored somewhere else and this memory is immune to hippocampal lesions the brain region where memory is migrating is the PFC if PFC and HPC are lesioned, then same result is in the day 1 cases

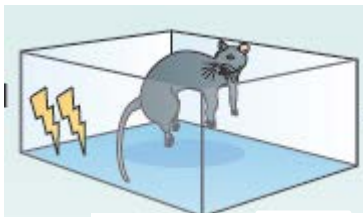
Kim & Fanslow (1992) Science 256: 675

Persistent memory of trauma and emotional over-reactivity to neutral stimuli in rat:

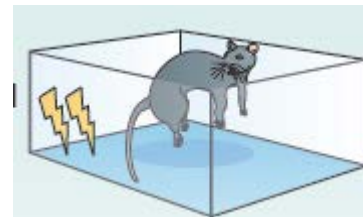
Model for post-traumatic stress disorder

- Psychological distress at exposure to stimuli associated with the traumatic event
- Hyper-reactivity to neutral stimuli

Day 0

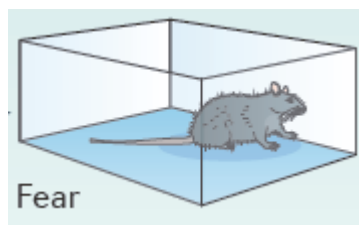


Day 0

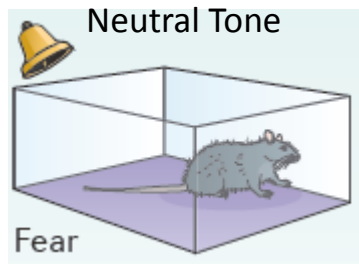


1.5 mA

0, 0.7 or 1.5 mA

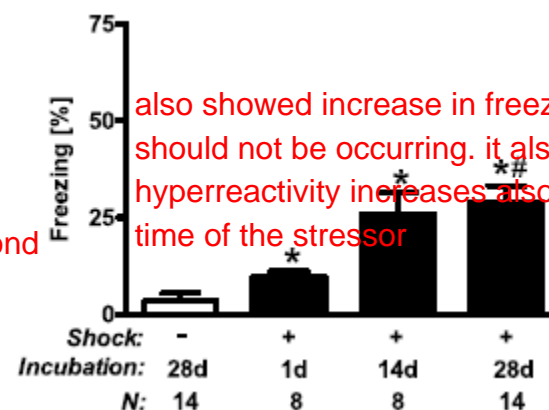
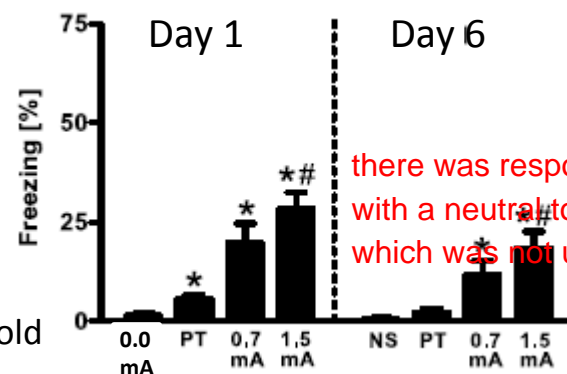
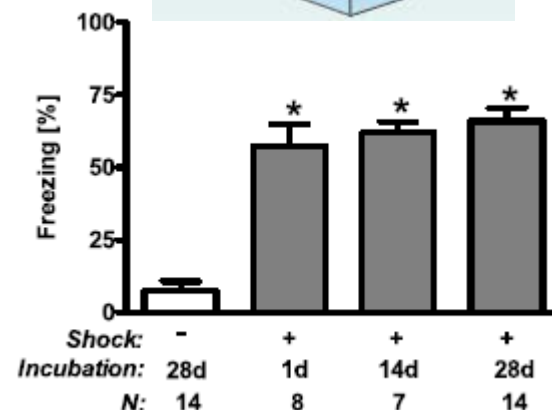
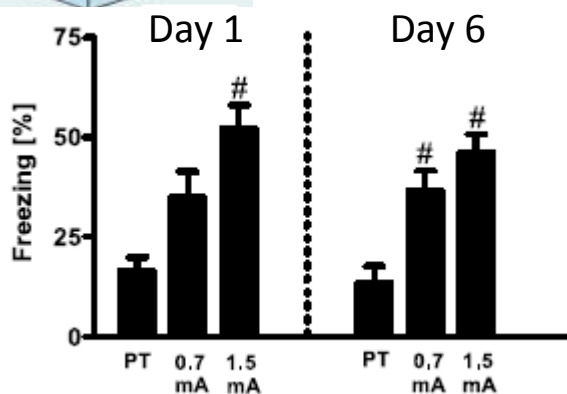


Fear



Neutral Tone

Fear

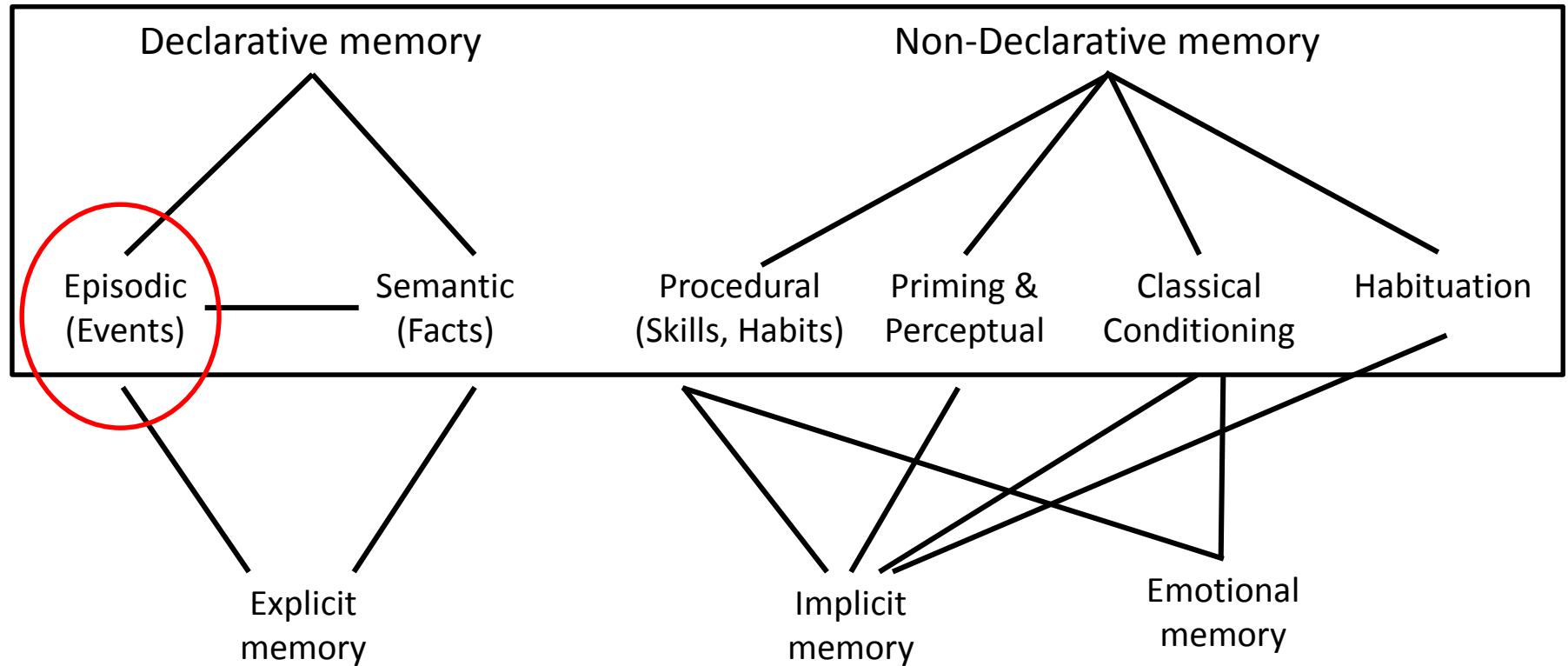


there was response with a neutral tone, which was not used for cond

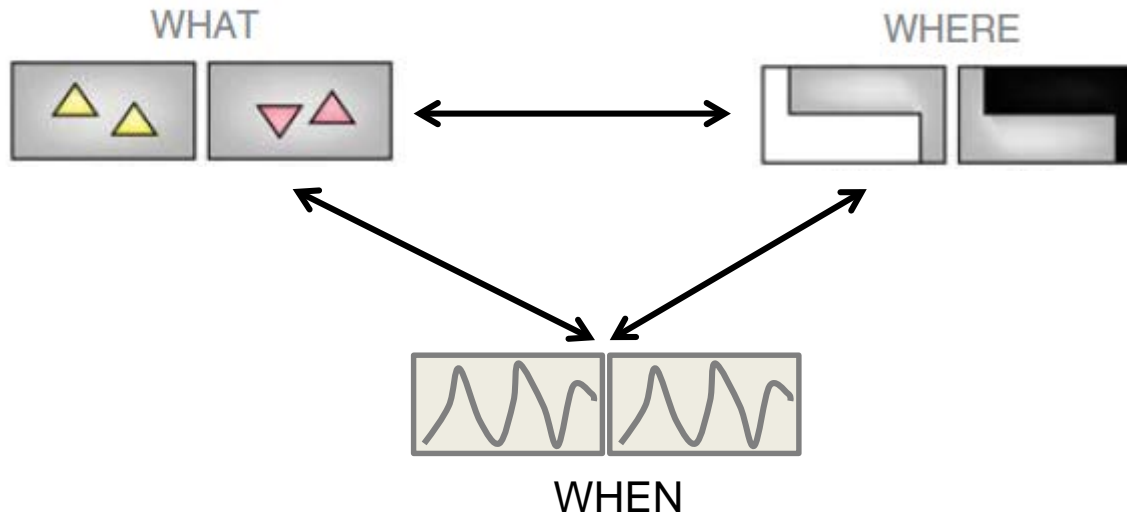
also showed increase in freezing which should not be occurring. it also seems that hyperreactivity increases also, the longer the time of the stressor

PT=E-shock at pain threshold
if val < PT, then no response
if val > PT, then response

A taxonomy of mammalian memory systems (after L.R. Squire)



Episodic memories can be described as where-what-when memories



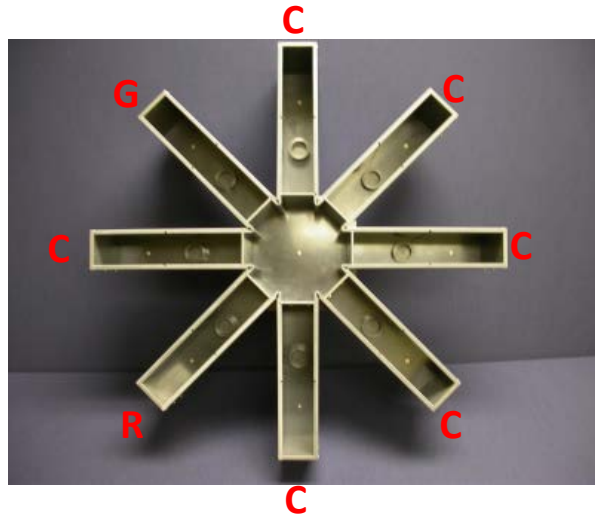
Box 2 | Behavioural criteria for **episodic-like memory** in animals

Content: recollecting what happened, where and when on the basis of a specific past experience.

Structure: forming an integrated 'what–where–when' representation.

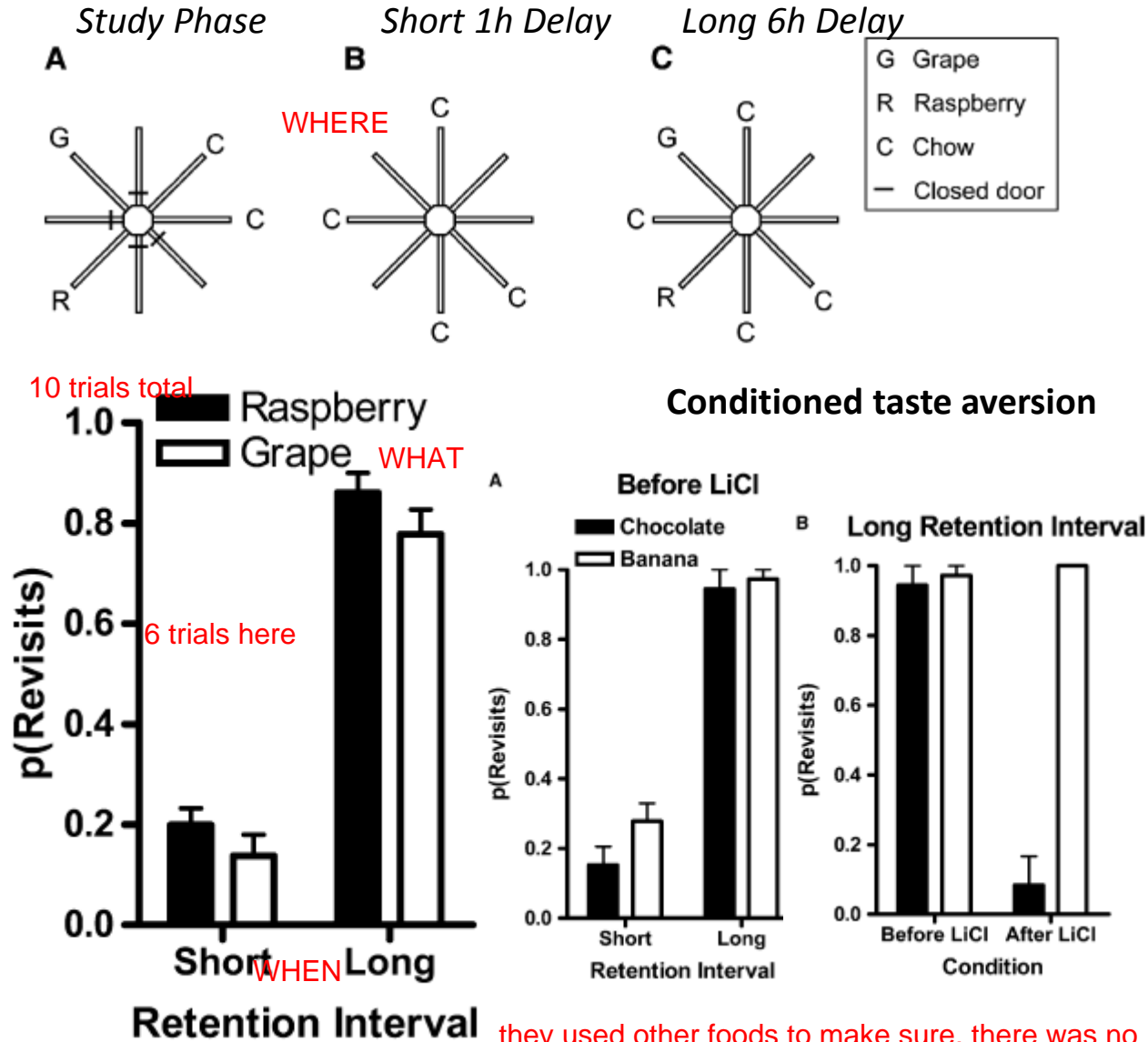
Flexibility: episodic memory is set within a declarative framework and so involves the flexible deployment of information.

Evidence for episodic-like where-what-when memory in rats



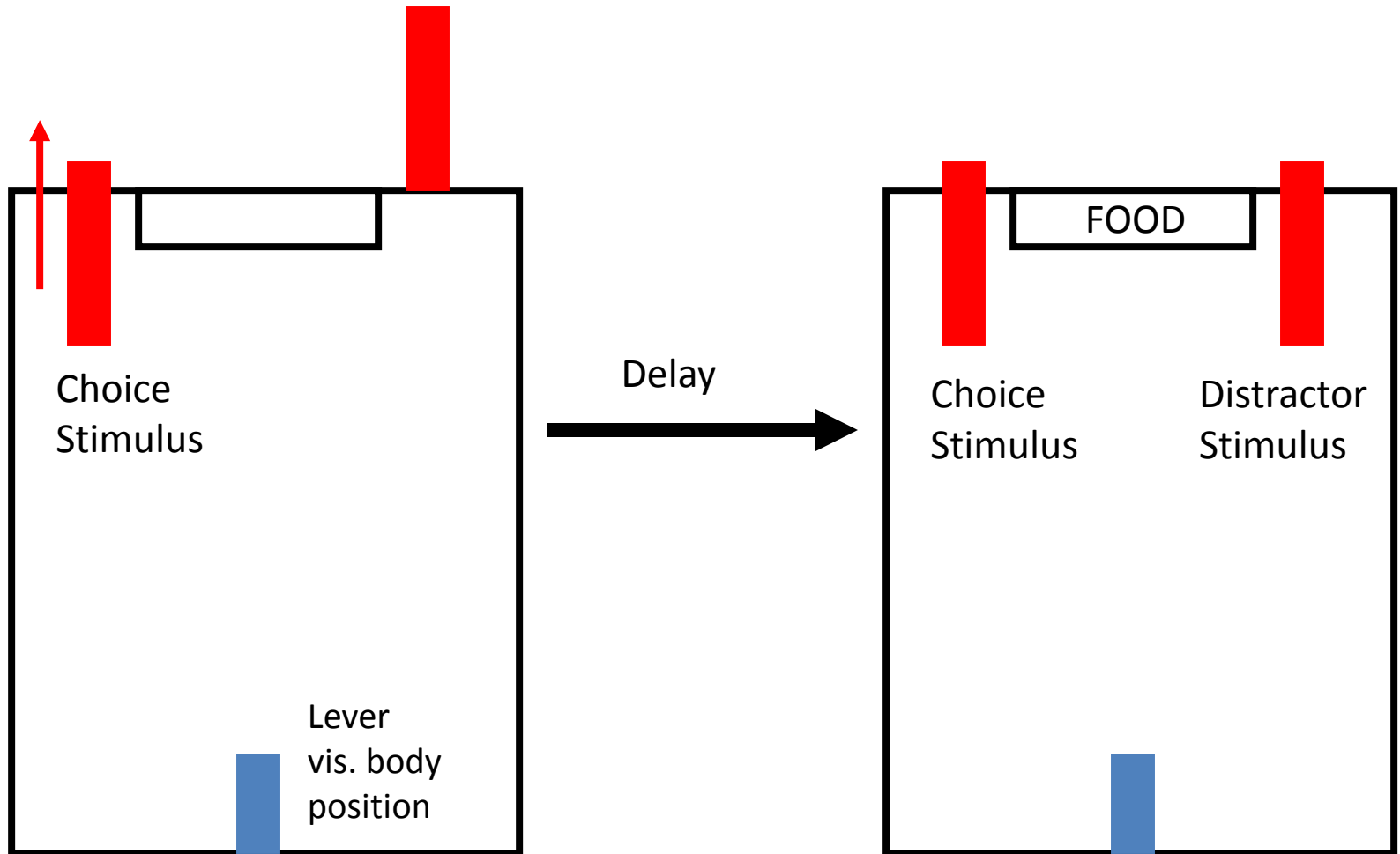
8-Arm Radial Maze

$P(\text{Revisits}) =$
Probability of a
revisit in the
first 4 arm visits



Rodent Delayed Matching to Position Task

Short-term memory or Working memory of «Where»



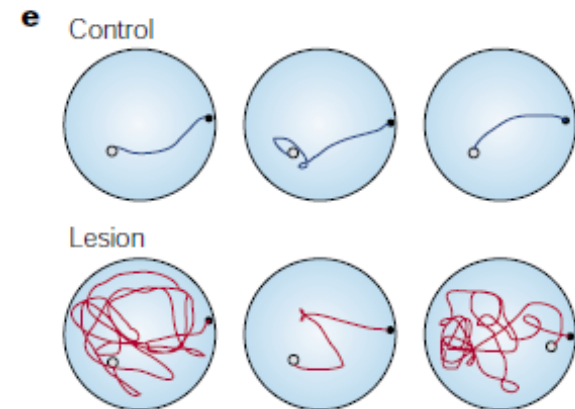
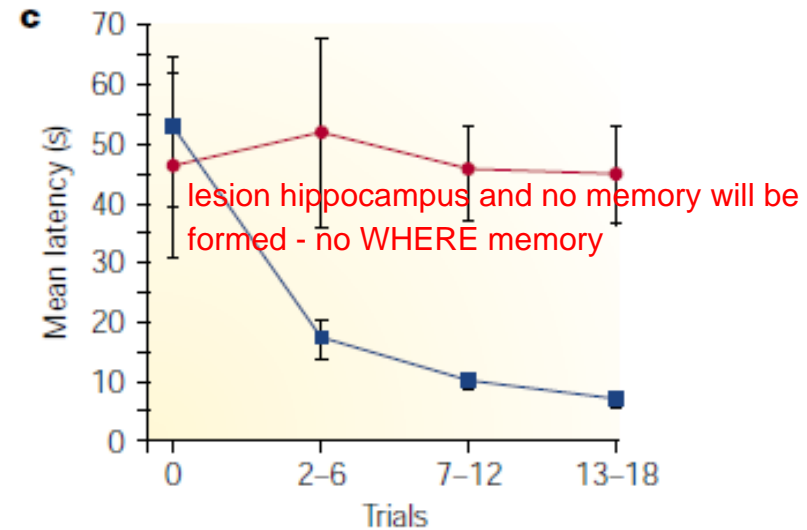
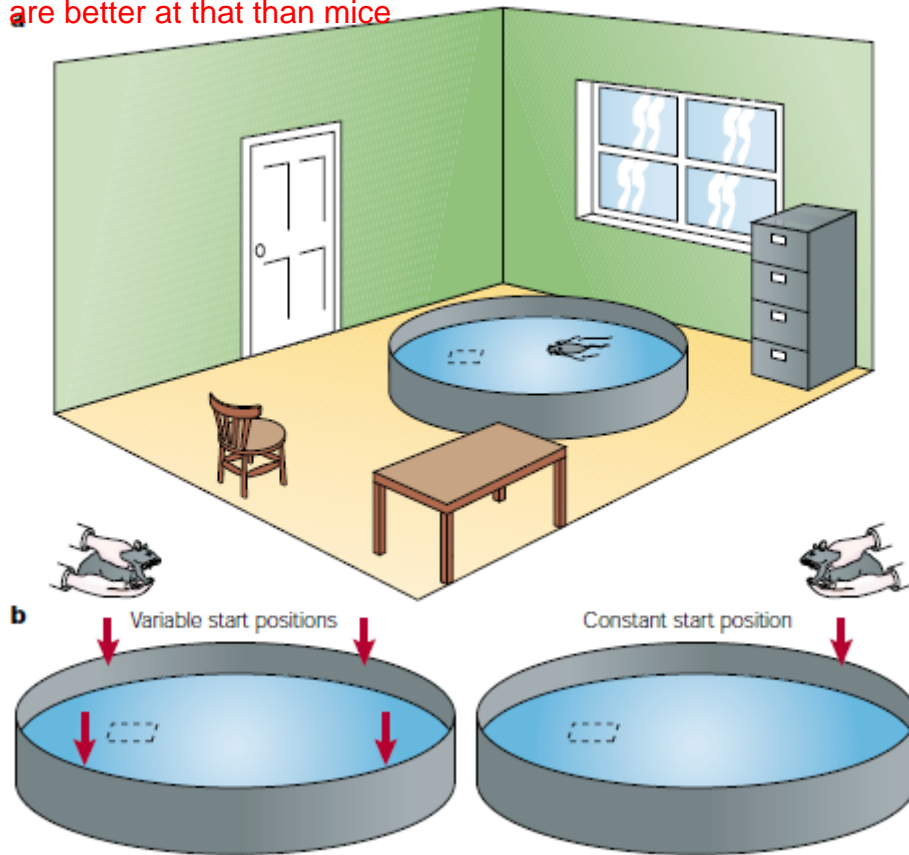
Rat water maze spatial memory (navigation) task

let them sit on platform so they can build up a spatial memory.

on subsequent days, one can put them back in water at different positions or at the same place and one can measure the time it takes them to get to that place

rats are better at that than mice

Long-term memory of «Where»



Monkey Delayed non-matching to sample Task

Short-term memory or Working memory of «What»

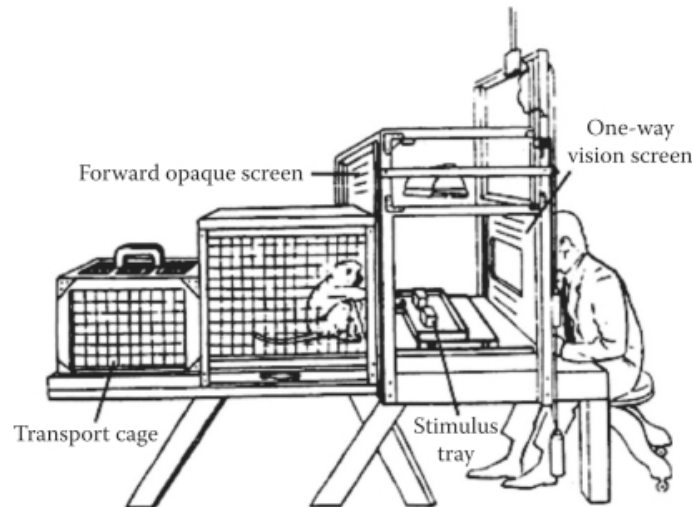
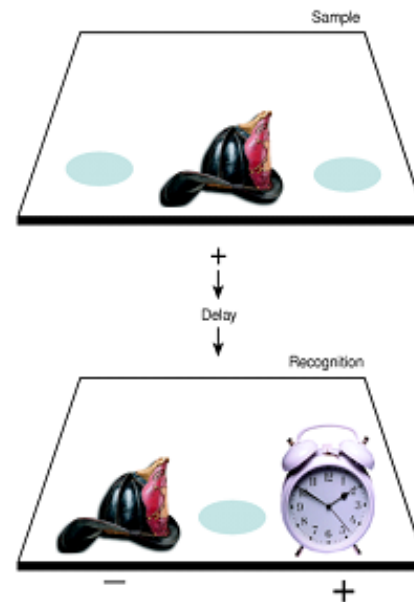
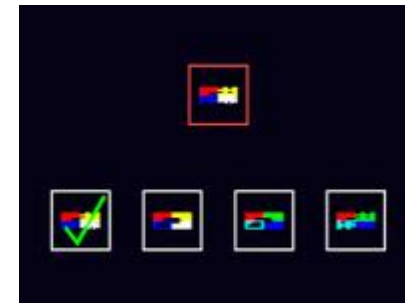
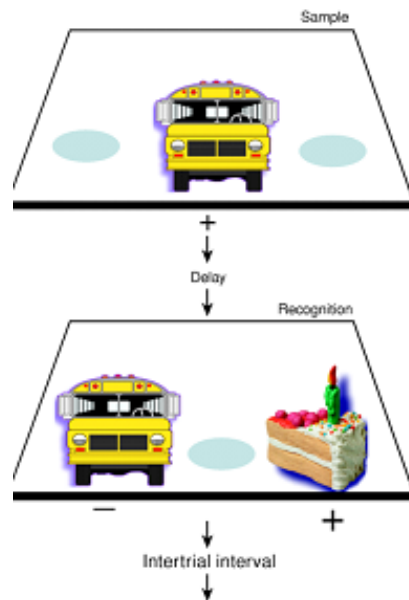
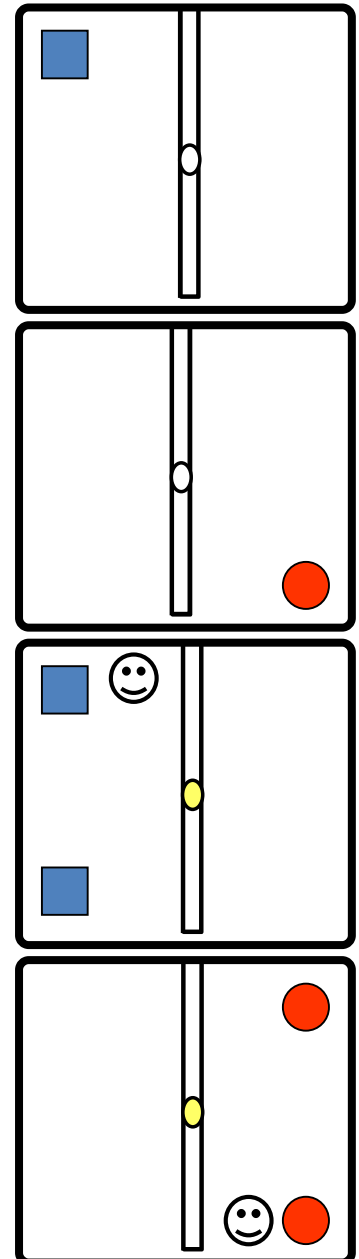


FIG 56.3

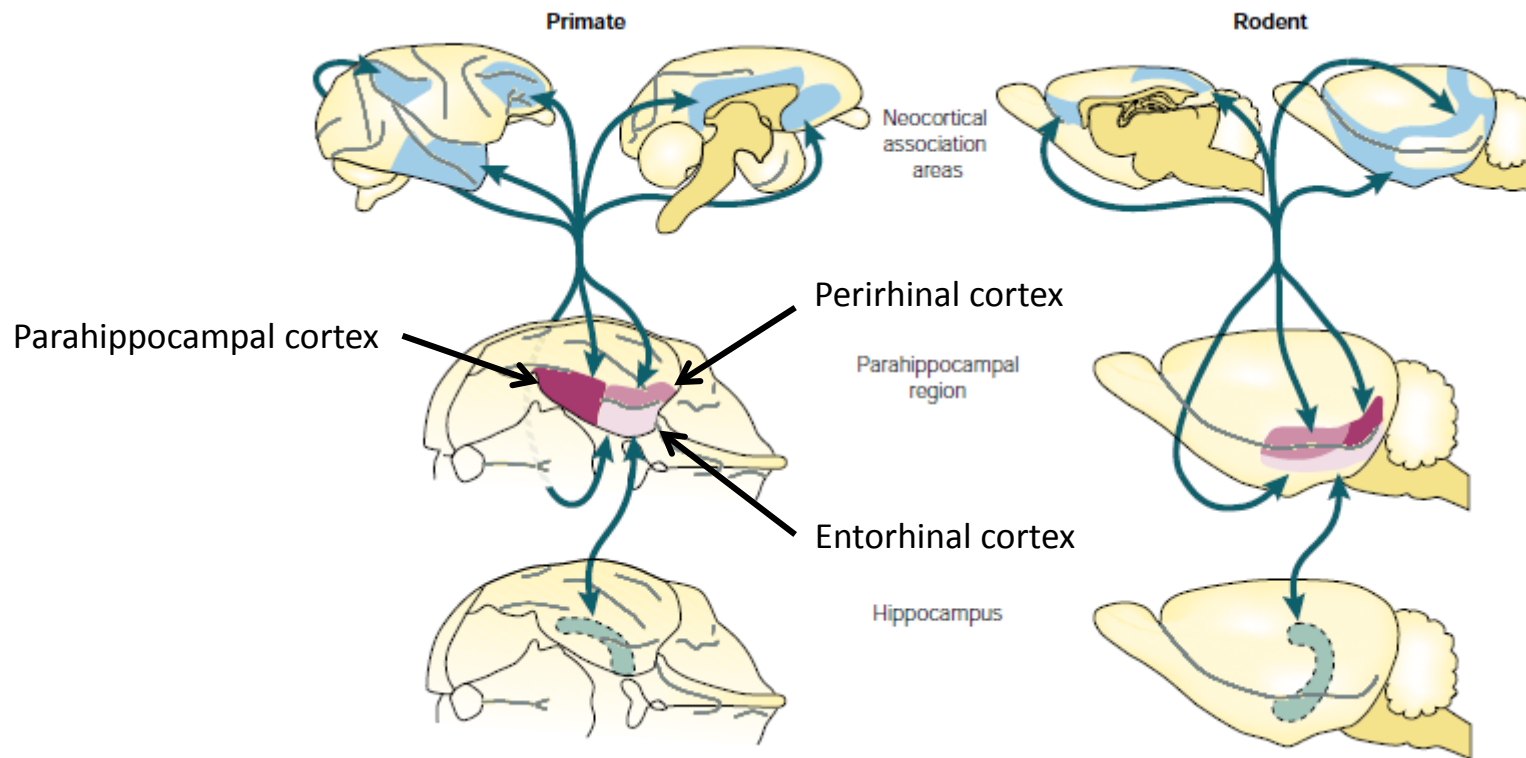


representation of two objects, in this experiment, they need to take the nonmatching, which is the clock resp cake each trial requires new stimuli

Visuo-spatial Paired Associates Learning Task: Version for marmoset monkey



Anatomy of the medial temporal lobe (MTL) memory system

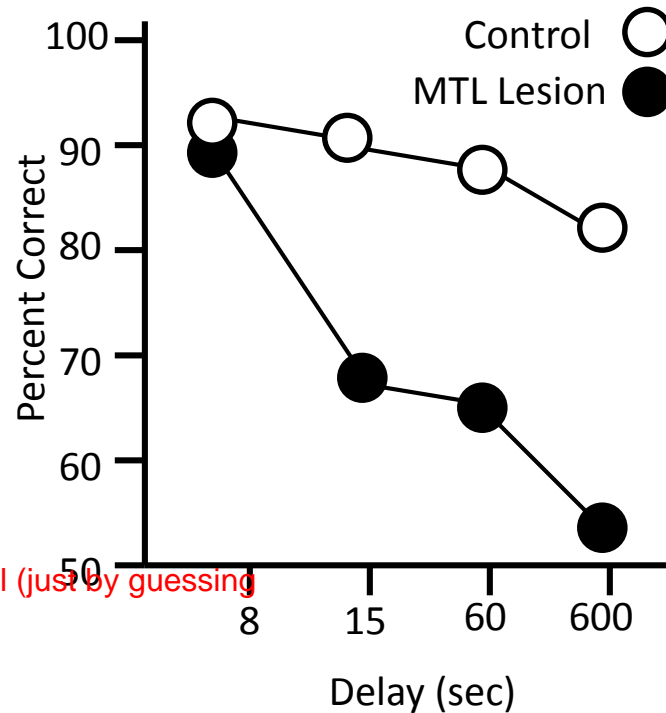
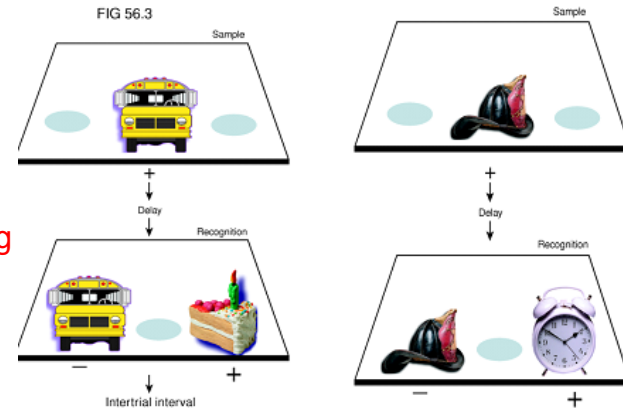
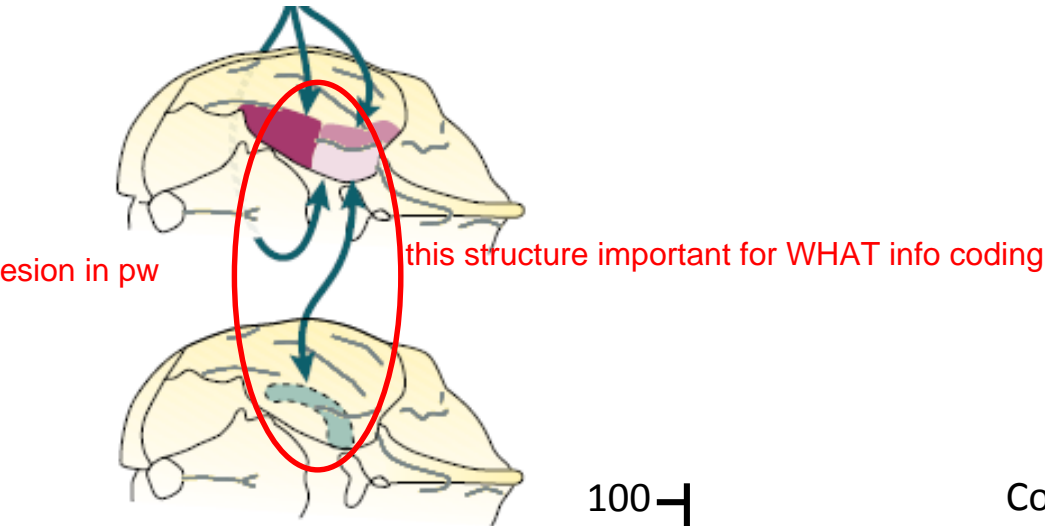


Dickerson and Eichenbaum (2010) Neuropsychopharmacol 35: 86

Eichenbaum (2000) Nature Reviews Neuroscience 1: 41

lesion in pw

Combining surgical lesion and behavioural test to demonstrate functional neuroanatomy of object («What») memory in monkey



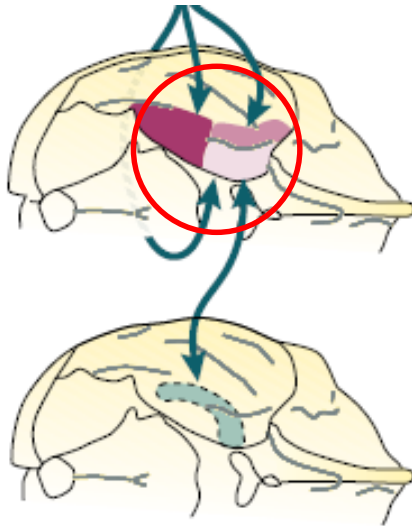
50% is the chance level (just by guessing you get 50% correct)

lesion monkey get progressively worse with increasing delay (delay=waiting time) after 10mins delay, they work on chance level, they simply cant remember

squire is the mr memory man
Squire (1992) Psychol Rev 99: 195

Combining surgical lesion and behavioural test to demonstrate functional neuroanatomy of object («What») memory in monkey

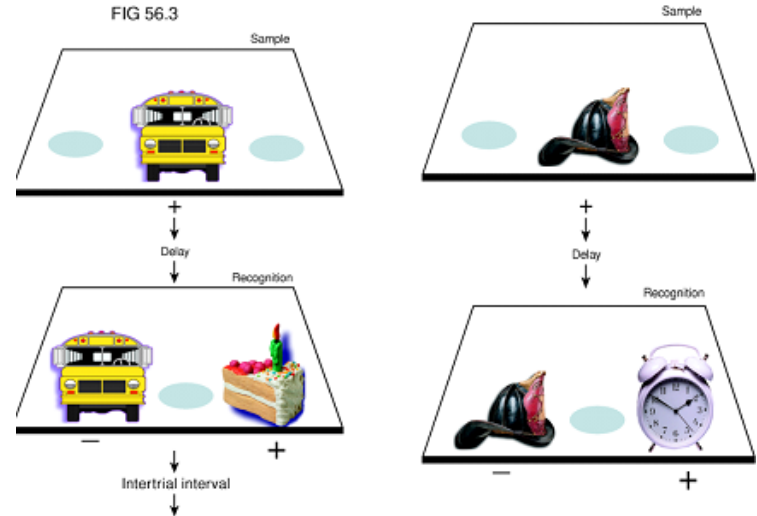
lesion in region



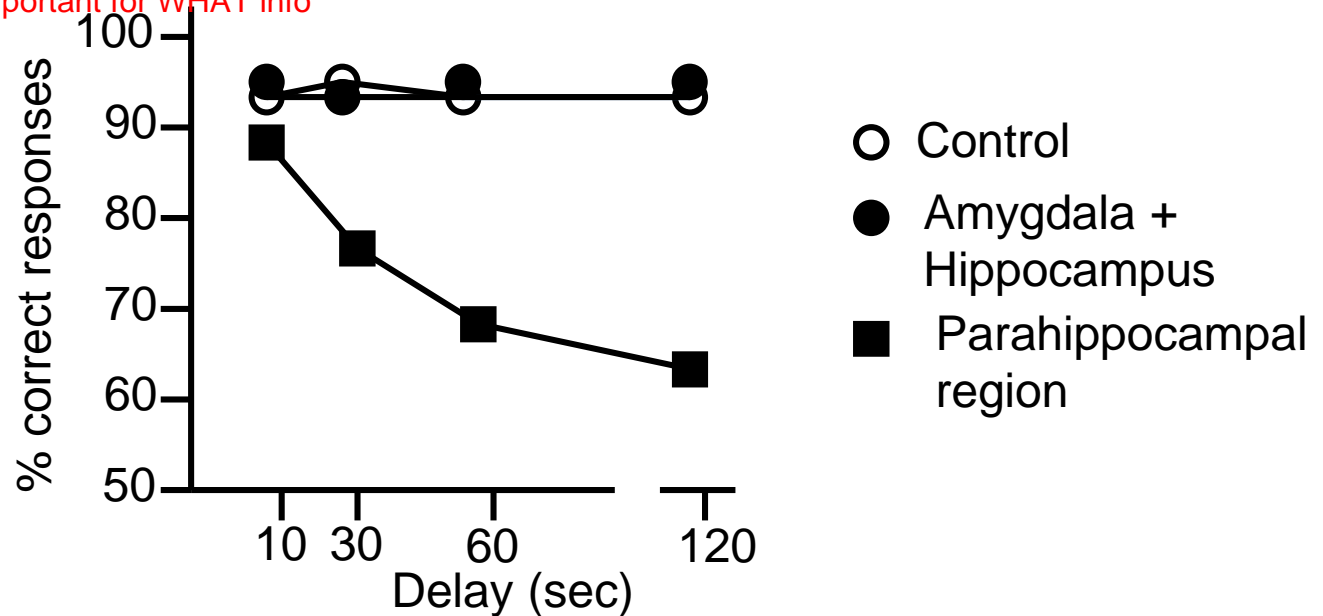
removed regions:

Parahippocampal region

Hippocampus

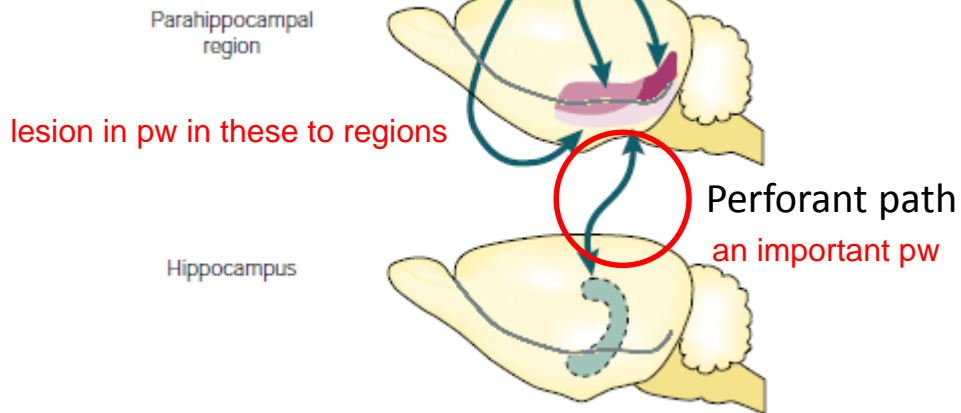


parahippocampal region very important for WHAT info



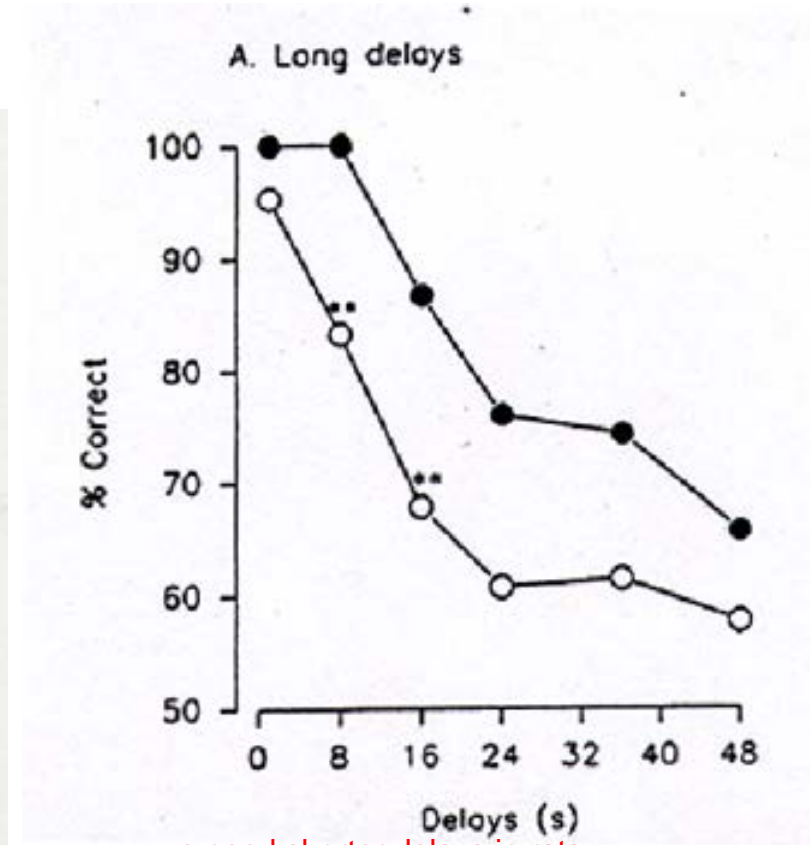
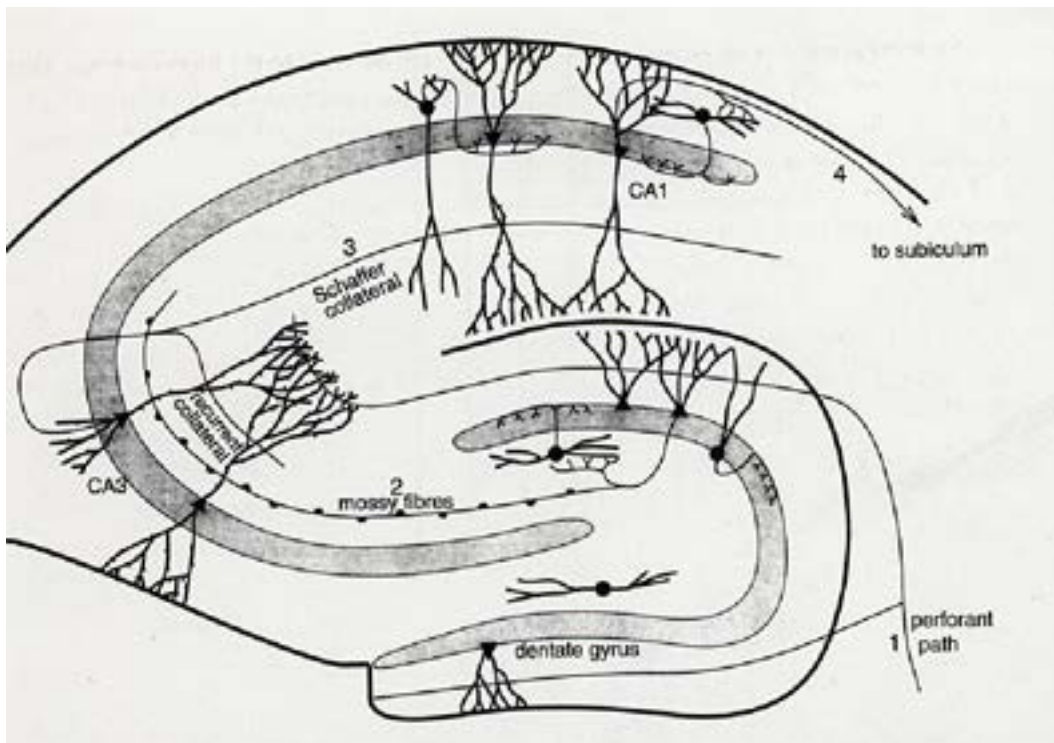
Combining surgical lesion and behavioural test to demonstrate functional neuroanatomy of spatial («Where») memory in rat

this is in rats



DMTP: Working memory

○ Lesioned
● Controls

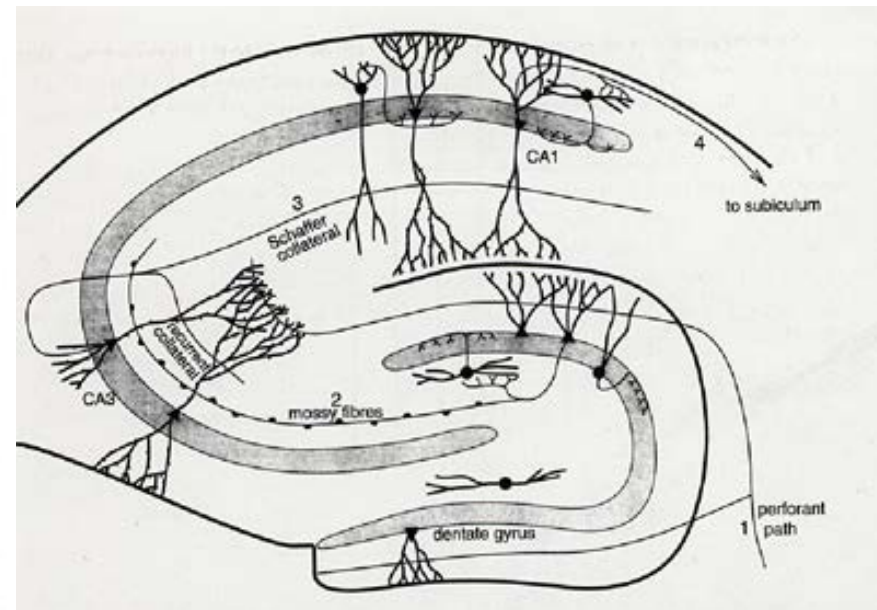
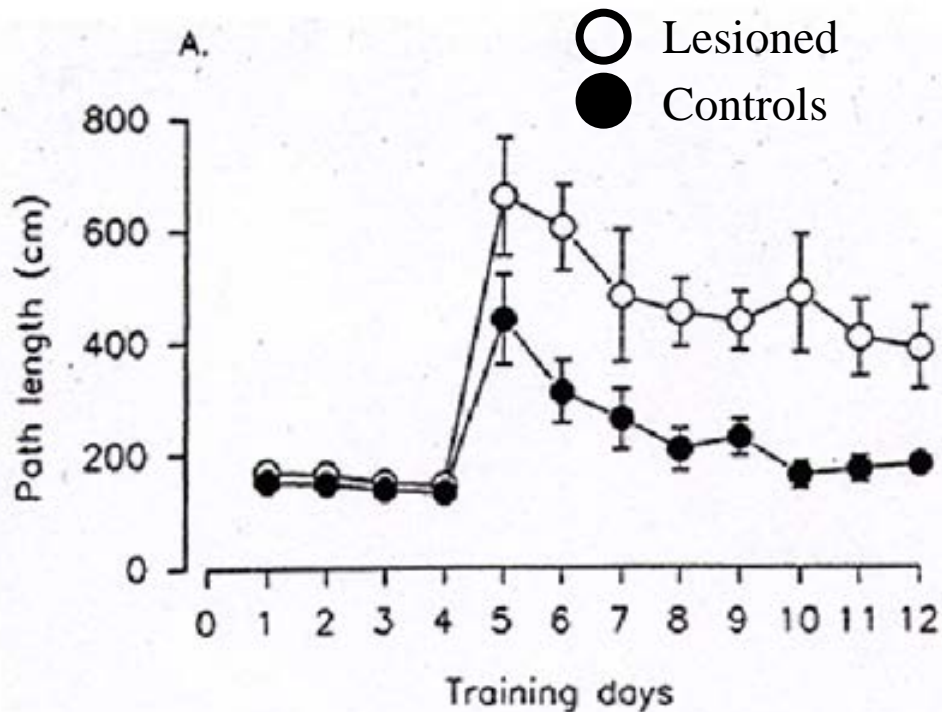
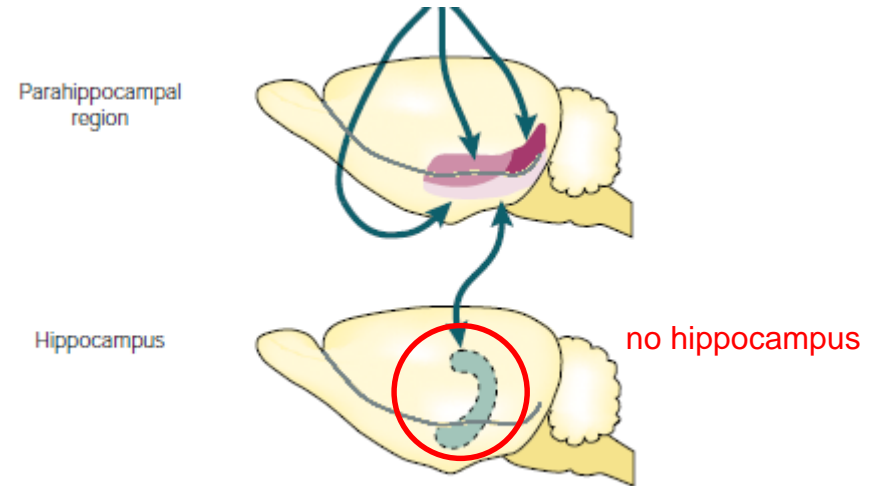


we need shorter delays in rats

Combining surgical lesion and behavioural test to demonstrate functional neuroanatomy of spatial («Where») memory in rat

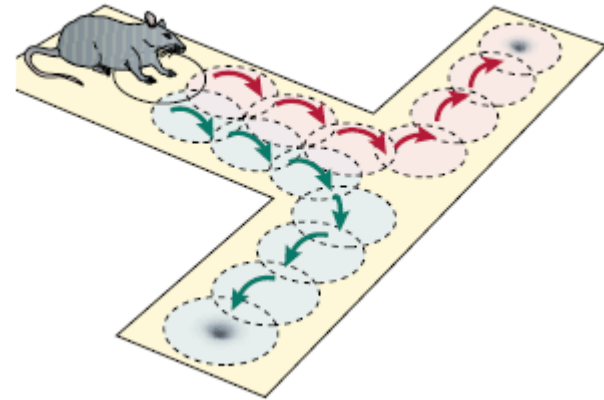
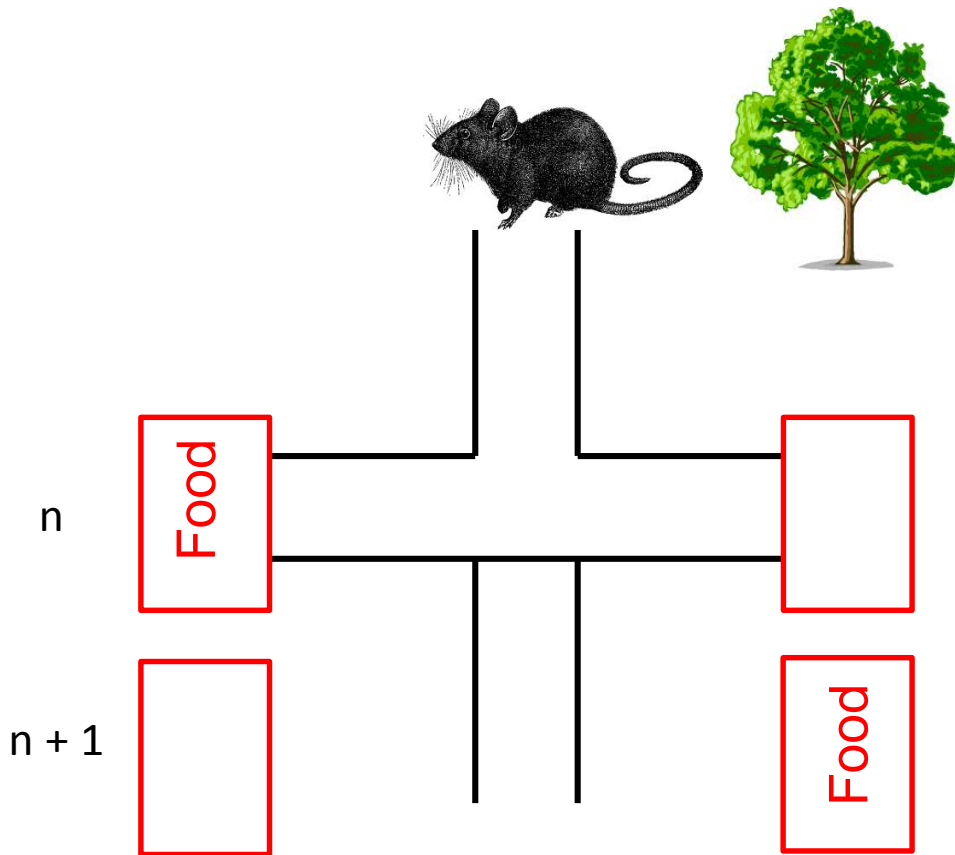
water maze example

- Aversive water
- Hidden platform
- Extra-maze cues
- Repeated trials
- Variable start position
- Path length



Activity (firing) of hippocampal neurons during a Spatial memory task on T-maze

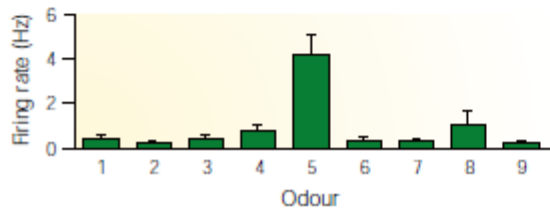
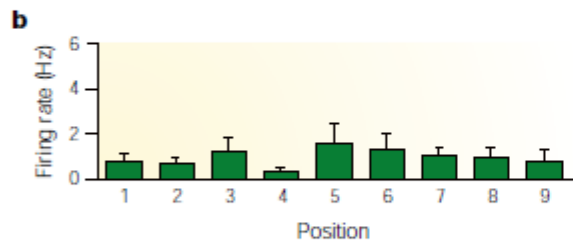
Food position alternates across trials so that current goal-directed behaviour depends on memory



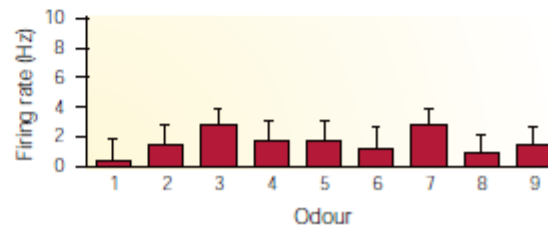
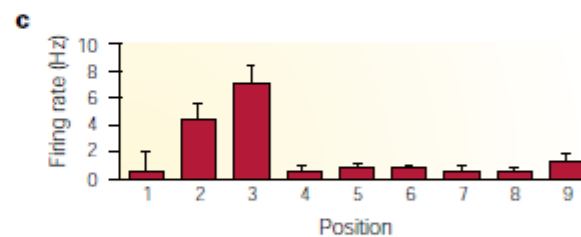
Cell firing was dependent on food location and direction of turning even when rat was on the I of the T (cells signal R-O and not S-R)

Activity (firing) of hippocampal neurons during a What-Where-When task in Rat

Is the odour on this trial ($n+1$, $n+2$) the same as on the previous trial (n , $n+1$) ?

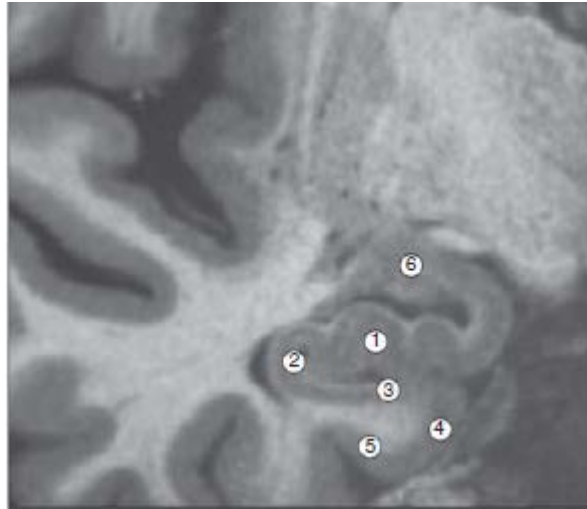


- Neuron is a What neuron and only fires if the Odour is 5 and only if Odour 5 was used on previous trial i.e. also a When neuron

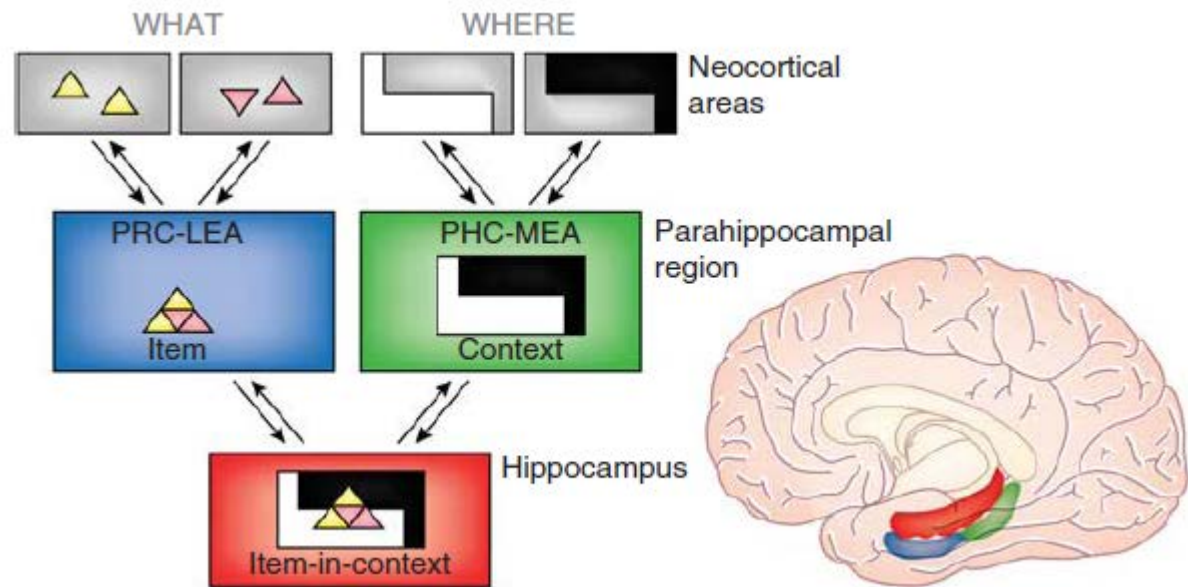


- Neuron is a Where neuron
- Other Neurons fire only if specific combination of an Odour (What), at a location it was already experienced (Where) and if this experience was on the previous trial (When)

Detailed functional organisation of the medial temporal lobe (MTL) memory system



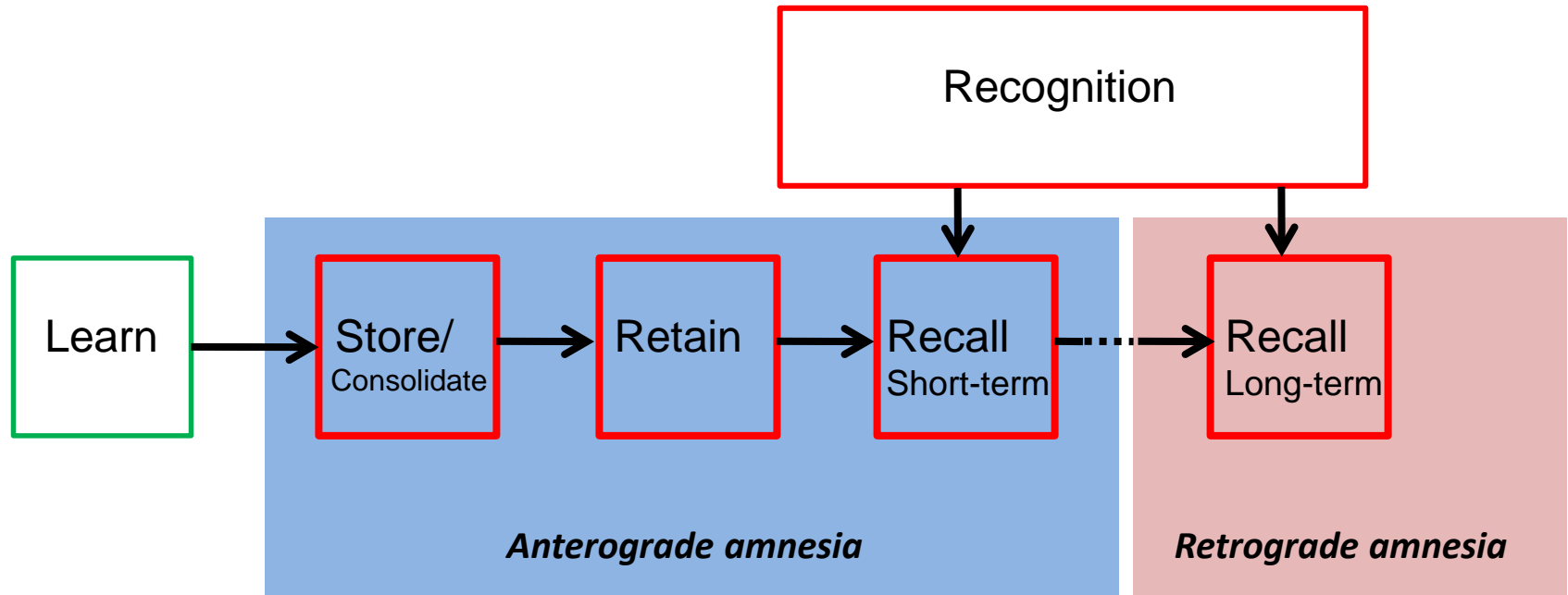
- (1) Dentate gyrus/Cornu ammonis 3
- (2) Cornu ammonis 1
- (3) Subiculum
- (4) Entorhinal cortex
- (5) Perirhinal cortex
- (6) Amygdala



PRC-LEA: Perirhinal cortex – lateral entorhinal area
(Entorhinal cortex)

PHC-MEA: Parahippocampal cortex-medial entorhinal area
(Entorhinal cortex)

Amnesia and animal models



Memory

- The Squire taxonomy of mammalian memory systems is the most widely accepted
- Classical conditioning memories are non-declarative memories
- Operant conditioning memories are a combination of declarative memories for events (what, where) and non-declarative memories for procedures (stimulus-response)
- The amygdala is required for classical conditioning memory of CS and the hippocampus is required for classical conditioning memory of context
- Truly episodic-like memories comprise what, where and when information and have been demonstrated in animals
- What and where components of episodic-like memories can be studied in specific memory tasks
- The perirhinal cortex-lateral entorhinal area processes “what” and transmits to hippocampus
- The parahippocampal cortex-medial entorhinal area processes “where” and transmits to hippocampus
- The hippocampus integrates “what”, “where” and “when” information