KING'S College LONDON

INSTITUTE OF PSYCHIATRY,
PSYCHOLOGY & NEUROSCIENCE

**Module:**
**Biological Foundations of Mental Health**

Week 4:
Biological basis of learning, memory and cognition

Professor
Peter Giese

**Topic 1:**

**Learning, memory and synaptic plasticity**

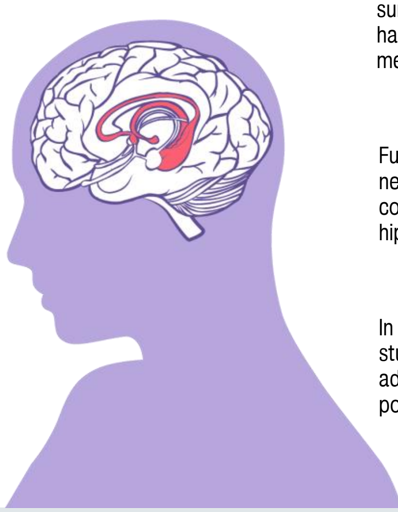
Part 3 of 4

# Part 3

## Part 3: Overview

### Hippocampal memory tasks

The hippocampus is very important for learning memory in humans.



Studies have shown that some of the patients treated for epilepsy with surgical ablation of the hippocampus have reported suffering from severe memory impairment.

Further animal experiments are needed to understand the exact consequences of lesioning the hippocampus.

In this part, we will focus on mice studies that have been used to address the issue of long term potentiation and memory.



## General points about memory

Different **forms of memory** can be distinguished by:

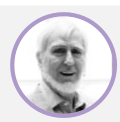
**Time scale:**

- short-term
- long-term
- working memory

**Brain areas:**

- hippocampus
- cerebellum

Long term potentiation is thought to be an important mechanism in long term memory storage.



**John O'Keefe**
American-British neuroscientist, University College London

Discovered the importance of the hippocampus in the process of making a spatial map of the environment, a so called **'cognitive map'**.

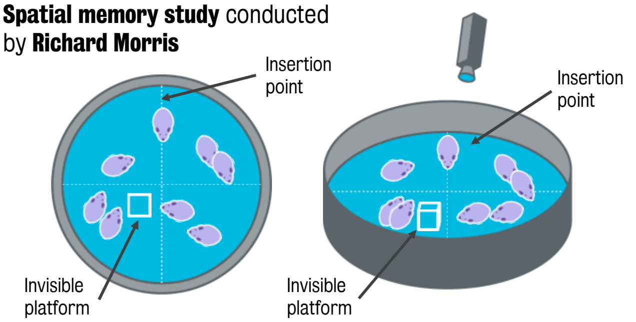
The hippocampus is important for **declarative memories** in humans.

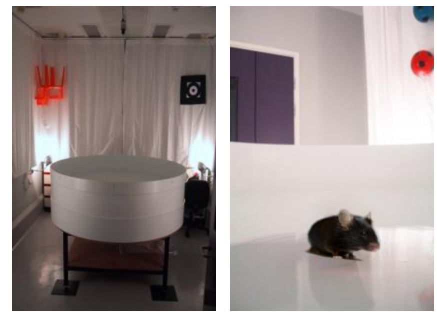
**Declarative memories** are not applicable to mice.

Studies in mice have shown the hippocampus to be of particular importance in spatial and contextual memory.

## Water maze

**Spatial memory study** conducted by **Richard Morris**



**Learning outcome:**
To be able to remember the location of the platform.

**Procedure strategies** ultimately lead to **spatial learning**.

**Learning phases:**

1: Try to climb out of the pool

2: Explore the environment by swimming around randomly

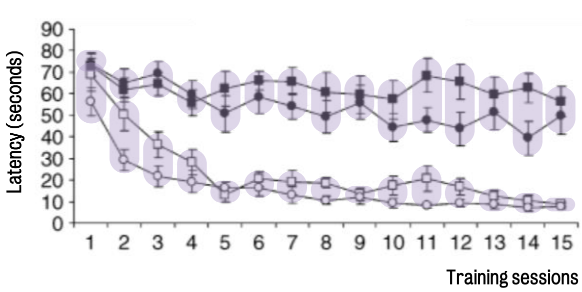
3: Learn to use the platform as a resting spot

4: Develop a strategy ('procedures') to locate the platform

**Testing the learning strategy:**
Remove the platform and observe if the animal searches the area where it used to be located in.



## Example of learning in the water maze




The mutant mice did not show the same improvement

The wild type mice showed an improvement in learning over time

The training curve alone does not suffice as an indicative of impaired spatial learning in the mutant mice or of spatial learning in the wild type mice.

**Latency (seconds):**
The time the animal needs to reach the platform

To get evidence for the performance of the wild type mice, we have to conduct a **memory probe trial** that indicates different strategies, such as:

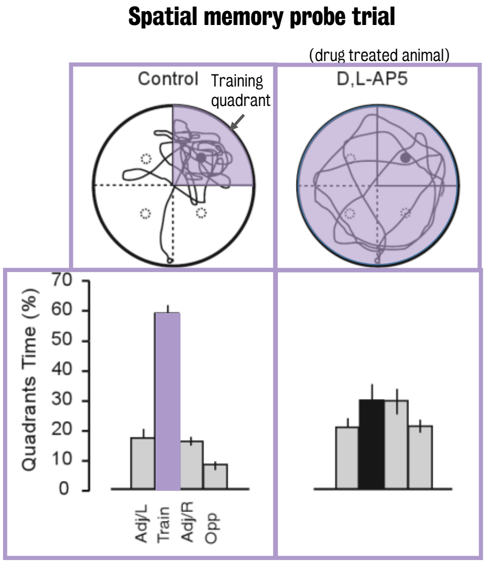
- learning that there is no escape
- use of platform
- strategy learning
- spatial strategy

**Types of mice:**

- T286A mutants, nonenriched (n=9)
- WT (wild type mice), nonenriched (n=9)
- T286A mutants, nonenriched (n=12)
- WT (wild type mice), enriched (n=12)

Need and Giese (2003)

## Assessment of spatial memory in a probe trial




The amount of time spent by the control mice in the training quadrant indicates:

- a clear spatial bias
- evidence for spatial memory

The amount of time spent by the drug treated mice in the training quadrant indicates:

- a lack of spatial memory

Morris et al. (1986)

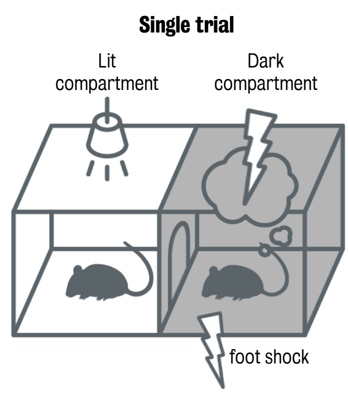


## Passive avoidance (1)

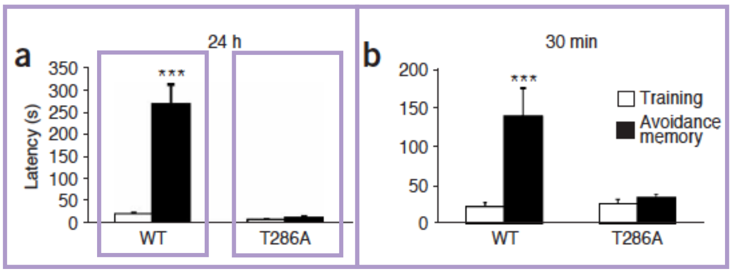
**Passive avoidance task**
Can be learned in a single training trial.

This passive avoidance task requires the hippocampus.

A lesion in the hippocampus would jeopardise the mouse's association between the dark compartment and the foot shock.



## Passive avoidance (2)




**One-trial learning task**

**Advantages:**

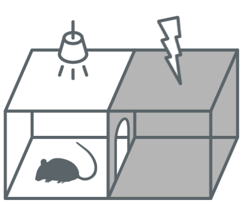
- useful in the study of molecular and cellular processes because due to all animals learning at the same time
- more suitable in the study of learning and memory processes in comparison to the water maze due to the lack of synchronization in animal behavior
- easy to distinguish between short term memory (STM) and long term memory (LTM)

Irvine et al. (2005)

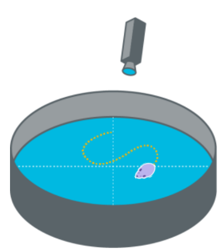


## Part 3: Summary

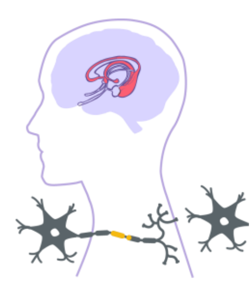
Behavioural testing of protocols for assessing hippocampus dependent memory



Long term potentiation measured in the hippocampus is connected to hippocampus dependent memory tasks



What happens when the induction of LTP is blocked?



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