The organization of recent and remote memories
Paul W. Frankland, Bruno Bontempi

Martin Stadler
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Introduction

- The hippocampus and declarative memory
- Models of system consolidation
- Memory reactivation
- Memory reorganisation
- The prefrontal cortex and remote memory
- Future directions
Medial temporal lobe (MTL)

anatomically connected brain region

includes the hippocampus, the entorhinal and perirhinal cortex

seems to have the same function and organization in humans, primates and rodents
Types of memory

declarative memory:

• two types of declarative memory:
  • memories of events (episodic memory)
  • general knowledge or facts (semantic memory)

• requires explicit learning

non-declarative memory:

• skills, "how to" knowledge

• requires implicit learning, practice
Types of memory consolidation

synaptic consolidation:

- a fast process; in the first few hours after learning
- initiated by synaptic activation
- growth and restructuring of synaptic connections
- a manipulation will block memory formation

system consolidation:

- a slow process
- gradual process of reorganization of brain regions which support memory
Anretrograde amnesia

MTL damage produces persistent anretrograde amnesia

no new declarative memory can be formed

but non-declarative memory can be learned

→ memory is not a unitary phenomenon

→ there exist several anatomically distinct memory systems
Retrograde amnesia

a loss of declarative memories which were acquired in a certain time-period

also occurs at MTL lesions

the length of the period depends on the extent of the damage and the type of memories

→ MTL has a time-limited role in the storage

→ over time, declarative memories are stored elsewhere
Modelling retrograde amnesia in animals

on humans only retrospective tests are possible and the extent of the damage varies

several behavioural models tested in animals
  • contextual fear conditioning
  • socially-acquired food preference

→ disrupting hippocampus affects recent rather than remote memories
Standard model of system consolidation

hippocampus stores rapidly events

transfer process to cortical networks

using replay of patterns of neural activity during sleep

leads to gradual enhancement of cortical connections

over time memories become independent from hippocampus
Standard consolidation model

Cortical modules

Hippocampus

Time

The organization of recent and remote memories
Multiple trace theory
an alternative model of system consolidation
based on two observations:

• MTL damage can produce ungraded retrograde amnesia for some types of declarative memories
• the recall of detailed remote episodic memories engages the hippocampus
Cellular correlates of memory reactivation

memory is reactivated
  • in online states (task-relevant situations)
  • in offline states (sleeping, daydreaming)

hippocampal place cells fire the same patterns in spatial exploration and in subsequent sleep states
Molecular correlates of memory reactivation

~ 500 genes are upregulated during sleep

blocking of hippocampus blocks upregulation of several genes

→ hippocampus controls gene expression in the cortex
normal plasticity in the cortex might be crucial for remote memories
Reorganization at regional level

recall of recent memory: hippocampus is active

call of remote memory: cortical regions are active

cortical consolidation involves synaptic rewiring

→ spatial and contextual memories are represented in distributed cortical networks

→ there might be a generation of semantic knowledge
Reorganization at regional level

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Reorganization at sub-regional level

parietal cortex shows similar activation at recent and remote memory recall

at recent recalls the deep layers are activated
at remote recalls the higher layers are activated
Targeted disrupting of system consolidation

damage in a special region of the entorhinal cortex blocks the dialogue between hippocampus and cortex

damage of prefrontal cortex blocks the recall of remote memories

→ the prefrontal cortex might be an essential node of the broad cortical memory networks
The prefrontal cortex (PFC) and remote memory

PFC can process remote memories

like a mirror to the hippocampus and recent memories

hippocampus is inhibited from PFC while recalling remote memories

re-encoding of existing memories is prevented

in mutant mice with defect cortex plasticity hippocampus gets re-engaged
The prefrontal cortex (PFC) and remote memory

a Recent memory
Prefrontal cortex
Cortical modules

b Remote memory
Prefrontal cortex
Cortical modules

Hippocampus

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Future directions

• Why learns hippocampus fast and cortex learns slow? Where is the biological difference?
• How are memories erased, especially in the hippocampus?
• Are recalled memories qualitatively the same or different at recent and remote time points? Is there a difference on different memory types?
Thank you.