Memory Systems

Introduction

Learning appears to be a lifelong adaptation to the environment. Several similarities are apparent between learning and brain development that is dependent on experience. Memory varies widely from recall of facts to habitual motor behaviors, and seems to involve distinct memory systems.

Types of Memory and Amnesia

Learning may be defined as acquisition of new information. Memory may be defined as retention of learned information.

Declarative Memory

- Also called explicit memory
- Is memory for facts and events
- Involves the medial temporal lobe and diencephalon

Non-Declarative Memory

- Also called implicit memory
- Includes procedural memory and classical conditioning

Procedural Memory

- Is memory for skills and habits
- Involves the striatum (caudate nucleus + putamen)

Classical Conditioning

- Is stimulus-response memory
- Skeletal muscle responses
    - Involves the cerebellum
- Emotional responses
    - Involves the amygdala

Long-term, short-term, and working memory

Long-Term Memory

- Memory that is recalled days, months, and years after they are originally stored

Short-Term Memory

- Memory that lasts for seconds to hours and are vulnerable to disruption
- May be consolidated into long-term memory

Working Memory

- Memory that is limited in capacity dependent on sensory modality
- Requires rehearsal (kept alive by repetition)
- May be consolidated into long-term memory

Amnesia

Serious loss of memory or ability to learn that is caused by trauma, chronic alcoholism, encephalitis, brain tumor, and stroke.

Retrograde Amnesia

- Memory loss for events that occurred before trauma
- Forget things already learned

Anterograde Amnesia

- Memory loss for events that occurred after trauma
- Inability to form new memories

Transient Global Amnesia

- Short period of memory loss – minutes to hours
- Associated with permanent memory gap

The Search for the Engram

Lashley and Maze learning

In early studies of maze learning in rats, Karl Lashley (1929) found that destruction of the cerebral cortex increased errors proportional to the amount of cortex removed. Lashley hypothesized that memories were distributed throughout the cerebral cortex.

Hebb and Cell Assemblies

Donald Hebb (1949) developed the idea that the internal representation of sensory information in the brain consists of the neurons that are activated in the brain.

- The neurons that are activated were referred to as cell assemblies
- Hebb proposed that neurons "that fire together, wire together"

Hebb and the Engram

- Memory engrams were viewed as distributed among linked neurons in the cell assemblies

Localization of Declarative Memories in the Neocortex

The inferotemporal cortex is a prime candidate for declarative memory, because:

- Lesions impair discrimination tasks despite intact visual system
- Cells become selective for different faces
- Electrical stimulation elicits recall of past experiences

Temporal Lobe and Declarative Memory

The Effects of Temporal Lobectomy

- In H.M.8cm of medial temporal lobe was excised bilaterally to prevent seizures – included cortex, amygdala and anterior 2/3 of hippocampus
- H.M. remembers childhood and events before surgery
- Unable to form new declarative memories
- Working memory for 6 digits is normal
- Able to learn new procedural tasks (mirror drawing)

The Medial Temporal Lobes and Declarative Memory

The medial temporal lobes include

- Hippocampus
- Rhinal Cortex
    - Entorhinal Cortex – medial and inferior to hippocampus
    - Perirhinal Cortex – lateral and inferior to entorhinal cortex
- Parahippocampal Cortex - lateral and inferior to perirhinal cortex

Interconnections include

- Cortical association areas → Parahippocampal and Rhinal cortex → Hippocampus → Thalamus and Hypothalamus

The Medial Temporal Lobes and Memory processing

Although general lesions Medial Temporal Lobes prevent new declarative memory,

- Selective lesions of Amygdala have no effect on recognition memory
- Selective lesions of Hippocampus produce mild amnesia
- Selective lesions of Perirhinal cortex produce severe memory deficits

The Diencephalon and Memory processing

- Lesions of midline thalamus produce severe amnesia of recognition memory
- Lesions of Mammillary bodies produce mild amnesia

The Striatum and Procedural Memory

- Lesions of Striatum (Caudate nucleus + Putamen) disrupt procedural memory
- Parkinson's patients show that human striatum plays a role in procedural memory

The Neocortex and Working Memory

- Medial temporal lobe structures → Fornix → Hypothalamus → Anterior nucleus of the thalamus → Cingulate cortex
- Medial temporal lobe structures → Dorsomedial nucleus of the thalamus → Frontal cortex
- During a working memory task (card sorting), activity of neurons in prefrontal cortex increases