Memory for Objects in Nonhuman Primates

Elisabeth A. Murray
NIMH, NIH
in The New Cognitive Neurosciences
M. Gazzaniga (ed.)

Presented by Debbie Taylor
Overview

- Background
- Introduction
- Object recognition memory
- Object association memory
- Is the medial temporal lobe a functionally homogeneous neural network?
- Specializations within the temporal lobe
Background

Fig. 1 Ventral view of a monkey brain showing medial temporal lobe structures and memory system (Squire and Zola-Morgan, 1991)
Background

Fig. 3 Classification of memory (Squire and Zola-Morgan, 1991)
Background

Table 1 Results of large bilateral lesions of the medial temporal lobe (Squire and Zola-Morgan, 1991)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Memory is impaired on several tasks including ones identical to those failed by amnesic patients.</td>
<td>(23, 27, 56)</td>
</tr>
<tr>
<td>2. Memory impairment is exacerbated by increasing the retention delay or the amount of material to be learned.</td>
<td>(11, 25)</td>
</tr>
<tr>
<td>3. Memory impairment is exacerbated by distraction.</td>
<td>(23)</td>
</tr>
<tr>
<td>4. Memory impairment is not limited to one sensory modality.</td>
<td>(32)</td>
</tr>
<tr>
<td>5. Memory impairment can be enduring.</td>
<td>(25)</td>
</tr>
<tr>
<td>6. Memory for events prior to the onset of amnesia can be affected (retrograde amnesia).</td>
<td>(57)</td>
</tr>
<tr>
<td>7. Skill-based memory is spared.</td>
<td>(23, 58)</td>
</tr>
<tr>
<td>8. Immediate memory is spared.</td>
<td>(59)</td>
</tr>
</tbody>
</table>
Introduction

- Commonly held views in memory research:
  - A single functional system subserves object recognition
  - Hippocampus mediates associative memory and consolidation of info. into LTM
- Authors present a different view, based in part on a new experimental method
Introduction

- Aspirations (old method)
  - Produces inadvertent damage to efferent fibers from other brain regions
- Excitotoxin-MRI technique (new method)
  - MRI allows accurate placement of lesions
  - Excitotoxins spare fibers passing nearby or through the site of the lesion
Object recognition memory

- How is object recognition tested in nonhuman primates?
  - Delayed nonmatching-to-sample (DNMS)
  - Delayed matching-to-sample (DMS)
  - This paradigm: novel objects on each trial
- Thus, recognition has occurred when the monkey makes a judgement that it has seen the object in a prior occurrence
Delayed matching-to-sample

From Gazzaniga
Object recognition memory

- Comparison of several data sets (Fig. 52.2A):
  - unoperated controls
  - excitotoxic lesions of amygdala & hippocam.
  - aspiration lesions of the rhinal cortex
- Monkeys with AH excitotoxic lesions performed as well as controls on the DNMS task
Object recognition memory

Fig. 52.2

A.

B.
Object recognition memory

- Effects of the variation of damage to the hippocampus on performance (Fig. 52.2B)
- Whether you lesion 50% or 100% of the hippocampus, the monkeys still perform very well (scores of 90 – 98)
- Thus, the hippocampus plays a very limited role in object recognition
However, monkeys with aspiration lesions of the rhinal cortex perform very poorly on the DNMS task (Fig. 52.2A).

The rhinal cortex has also been found to be important in tactile recognition.
Object recognition memory

- Other important studies involving the rhinal cortex:
  - entorhinal + perirhinal > entorhinal or peri.
  - TE + perirhinal > TE or perirhinal
  - entorhinal + perirhinal < AH aspirations
  - TE + perirhinal < AH aspirations

- So, although the perirhinal cortex plays a central role in object recognition the entorhinal and TE make contributions as well.
Object recognition memory

- The results of AH aspiration lesions show the greatest impairments because they directly or indirectly damage all five areas.
- Other evidence shows that the parahippocampus does not contribute to tactile or visual recognition.
Object association memory

How is object association tested in nonhuman primates?

• Paired-associates task:
  If sample A, choose X but not Y on test
  If sample B, choose Y but not X on test

Thus, association has occurred when the monkey makes a judgement that A -> X or B -> Y will lead to a reward
Effects of lesions in various medial temporal areas on the performance in the paired-associates task (Fig. 52.3)

- A+H+Rh had a profound effect on retention and learning of new associates
- H + sub. Cortex had virtually no effect on retention or learning of new associates
- A + sub. Cortex had a mild effect on retention and learning of new associates
Object association memory

Fig. 52.3
It can be concluded that the hippocampus is not critical for associative memory and for the consolidation of LTM about objects.

Rh lesions caused an impairment in learning associates comparable to A+H+Rh lesions.

Thus, it seems that paired-associates learning depends on the rhinal cortex and not the amygdala and the hippocampus (either separately or together).
Strong implication that the rhinal cortex is involved in associative memory

- pair-coding neurons in inferotemporal cortex

These neurons showed responses of similar magnitude to separate presentations of certain paired associates (A1-> X1 and A2 ->X2) but not others (B-> Y)

Neurons didn’t show pair coding after excitotoxic lesion of Rh for the prepoperatively or postoperatively learned set.
Furthermore, this result, as well as other evidence, leads to a hypothesis that the perirhinal cortex (not the amygdala) associates together the different sensory qualities of individual objects (Fig. 52.4)

- Tactile-visual task (Fig. 52.5)
- Olfactory-gustatory task
- Auditory-visual task
Object association memory

Fig. 52.4
Object association memory

Fig. 52.5
Is the medial temporal lobe a functionally homogeneous neural network?

- Several findings provide evidence that different parts of the medial temporal lobe subserve different functions
  - evidence summarized in Table 52.1
  - similar findings in rodent studies

- Thus, there are multiple functional subdivisions within the medial temporal lobe.

- However, these structures work together in mediating information storage.
Is the medial temporal lobe a functionally homogeneous neural network?
Specializations within the medial temporal lobe

- Rhinal cortex: critical for knowledge about objects
- Amygdala: links object, event, or place information with affective valence
- Hippocampus: knowledge about places and events

Medial temporal lobe may be organized in a hierarchical fashion:

- Rhinal cortex: initial processing involving object recognition
- Hippocampus & Amygdala: later processing involving object info being linked with events/affective valences
Specializations within the medial temporal lobe

Fig. 52.6