1 Memory

Implicit vs. explicit, procedural/semantic vs. declarative, working memory vs. long term memory, etc. or...

Mechanisms: Weights vs Activations.

1. Priming: Basic cortical model. (which we’ve already seen can also handle semantic and procedural memory)

2. Specializations: Hippocampus and PFC.

2 Weights vs Activations

Weights:
- Long-lasting.
- Requires re-activation.

Activations:
- Short-term.
- Already active, can influence processing.

3 Weight-based Memories

Rapid weight changes causes interference:

Two systems needed:
- Slow learning cortex.
- Rapid learning hippocampus (pattern sep avoids interference).

4 Priming

win____
handle
winter
shower...

win____

Spell /rɛd/.

Name a musical instrument that uses a reed.
Spell /rɛd/.

Explanations? Activations or weights: Even slow cortical weight changes yield one-trial learning effects.
5 Weight-based Priming Model

6 Memory

Implicit vs. explicit, procedural/semantic vs. declarative, etc. or...

**Mechanisms:** Weights vs Activations.

1. Cortical Priming: Weights or activations.

2. Specializations: Hippocampus and PFC.

7 AB-AC List Learning

Humans can rapidly learn overlapping associations without too much interference.

Example: learn AB paired associates:

window-reason
bicycle-garbage
...

8 AB-AC List Learning

Humans can rapidly learn overlapping associations without too much interference.

Then AC paired associates:

window-locomotive
bicycle-dishtowel
### AB-AC List Learning

Then test on AB list:
- window-?
- bicycle-?

and on AC list:
- window-?
- bicycle-?

% Correct

<table>
<thead>
<tr>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
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<tr>
<td>AC List</td>
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</table>

Learning Trials on AC List

#### Learning Trials on AC List

a) AB−AC List Learning in Humans

b) AB−AC List Learning in Model

Standard network has **catastrophic interference** (McCloskey & Cohen, 1989).

### AB-AC Exploration

<table>
<thead>
<tr>
<th>Input</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>?</td>
</tr>
<tr>
<td>B</td>
<td>?</td>
</tr>
<tr>
<td>C</td>
<td>?</td>
</tr>
</tbody>
</table>

Input = A, Output = B,C

Context identifies list (random distortions).

### Hippo To the Rescue

Two specialized, complementary systems resolve fundamental tradeoff:

The hippocampus can learn rapidly without interference by using sparse, pattern-separated representations!

Meanwhile, cortex slowly learns overlapping representations of similarity structure & regularities.
13 Complementary Learning Systems

<table>
<thead>
<tr>
<th>Remember Specifics</th>
<th>Extract Generalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example:</td>
<td>Extract Generalities</td>
</tr>
<tr>
<td>Need to:</td>
<td>Best parking strategy?</td>
</tr>
<tr>
<td>avoid interference</td>
<td>Accumulate experience</td>
</tr>
</tbody>
</table>

**Solution:**

1. Separate reps (keep days separate)
   - D1 D2 D3...
   - Overlapping reps (integrate over days)
     - PS (parking strategy)
     - D1 D2 D3...

2. Fast learning (encode immediately)
   - Slow learning (integrate over days)

*These are incompatible, need two different systems:*

- System: Hippocampus
- Neocortex

14 Hippo: On top of Cortex

15 Hippocampal Anatomy

16 Sparse Activity

<table>
<thead>
<tr>
<th>Area</th>
<th>Neurons</th>
<th>Pct Act</th>
<th>Units</th>
<th>Pct Act</th>
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</thead>
<tbody>
<tr>
<td>EC</td>
<td>200,000</td>
<td>7.0</td>
<td>144</td>
<td>25.0</td>
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<tr>
<td>DG</td>
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<td>0.5</td>
<td>625</td>
<td>1.0</td>
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<td>CA3</td>
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<td>2.5</td>
<td>240</td>
<td>5.0</td>
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<tr>
<td>CA1</td>
<td>250,000</td>
<td>2.5</td>
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<td>9.4</td>
</tr>
</tbody>
</table>
17 Sparse Activity

18 Pattern Separation & Conjunctions

19 Pattern Separation & Conjunctions: Space and episodes

20 The Flip Side of Separation: Pattern Completion

College friend example: “This one time, at this one party...”

Pattern completion in CA3 activates corresponding CA1 rep, which reinstates original EC pattern.
21 The Model

22 Memory

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3. Interactions between weight- and activation-based memory.

23 Activation-based Priming

Residual activity affects subsequent processing.

24 Active Maintenance

Maintaining information in active form over longer time periods.

Can be used for *working memory* (e.g., in mental arithmetic).

Attractor = stable activation state:

(don’t want activity to spread)
25 Exploration

26 PFC to the rescue! for robust active memory

- Single-cell recording
- Imaging
- Lesion/Patients

Uses isolated representations?

Dopamine provides dynamic gating mechanism: determines when to hold, when to fold.

27 Memory

Implicit vs. explicit, procedural/semantic vs. declarative, etc. or...

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28 Weight- and Activation-Based Memory Interactions

When active memory must overcome prior experience. A-not-B task

- Perseverative searching at A
- Better performance in gaze/expectation
- Inhibition problem?
- Model demonstrates maintenance problem.
A-not-B Model

Memory

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