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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.

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Weights vs Activations

Weights:

- Long-lasting.
- Requires re-activation.

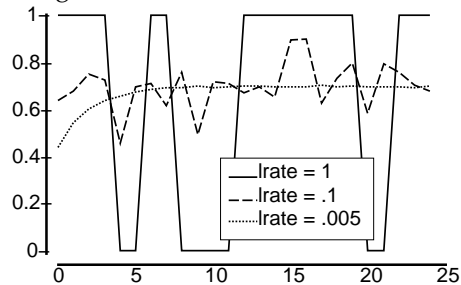
Activations:

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

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Weight-based Memories

Rapid weight changes causes interference:



Two systems needed:

- Slow learning cortex.
- Rapid learning hippocampus (pattern sep avoids interference).

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Priming

win----

handle

winter

shower...

win----

Spell /rēd/.

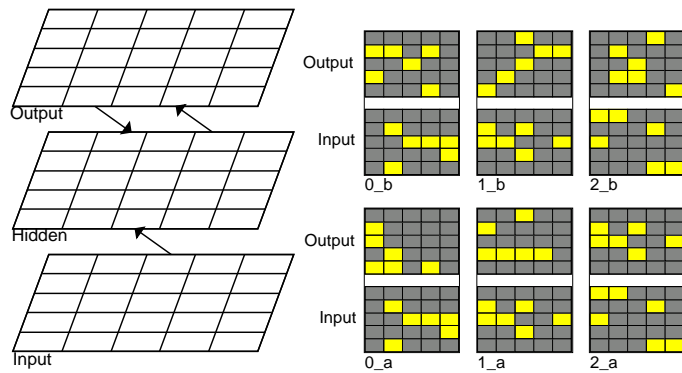
Name a musical instrument that uses a reed.

Spell /rēd/.

Explanations? Activations or weights: Even slow cortical weight changes yield one-trial learning effects.

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Weight-based Priming Model



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AB-AC List Learning

Humans can rapidly learn overlapping associations without too much interference.

Example: learn AB paired associates:

window-reason

bicycle-garbage

...

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AB-AC List Learning

Humans can rapidly learn overlapping associations without too much interference.

Then AC paired associates:

window-locomotive

bicycle-dishtowel

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AB-AC List Learning

Then test on AB list:

window- ?

bicycle- ?

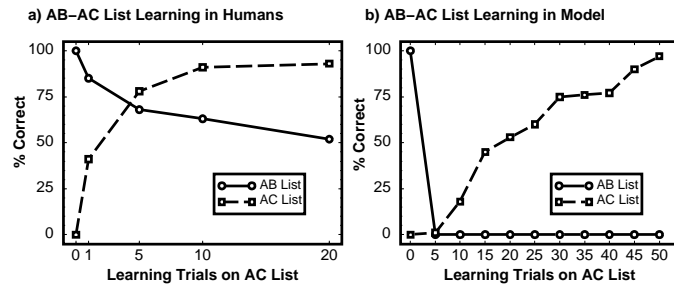
and on AC list:

window- ?

bicycle- ?

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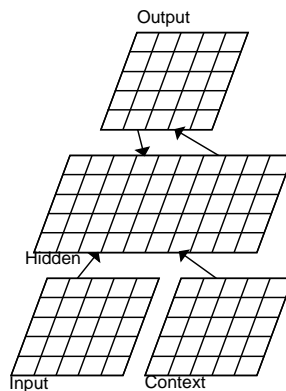
AB-AC List Learning



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

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AB-AC Exploration



Input = A, Output = B,C

Context identifies list (random distortions).

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Hippo To the Rescue

Two specialized, complementary systems resolve fundamental tradeoff:

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

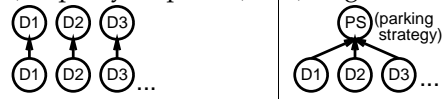
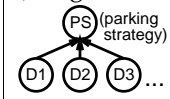
Meanwhile, cortex slowly learns overlapping representations of similarity structure & regularities.

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Complementary Learning Systems

	Remember Specifics	Extract Generalities
Example:	Where is car parked?	Best parking strategy?
Need to:	Avoid interference	Accumulate experience

Solution:

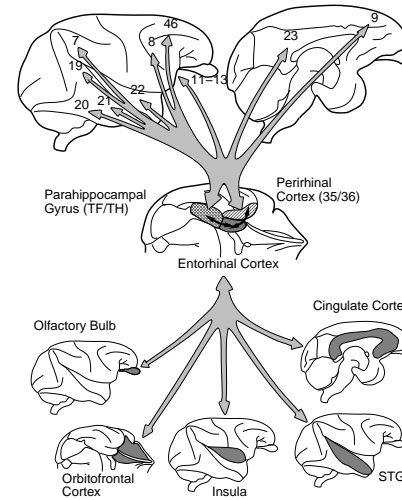
1.	Separate reps (keep days separate) 	Overlapping reps (integrate over days) 
2.	Fast learning (encode immediately)	Slow learning (integrate over days)

These are incompatible, need two different systems:

System:	Hippocampus	Neocortex
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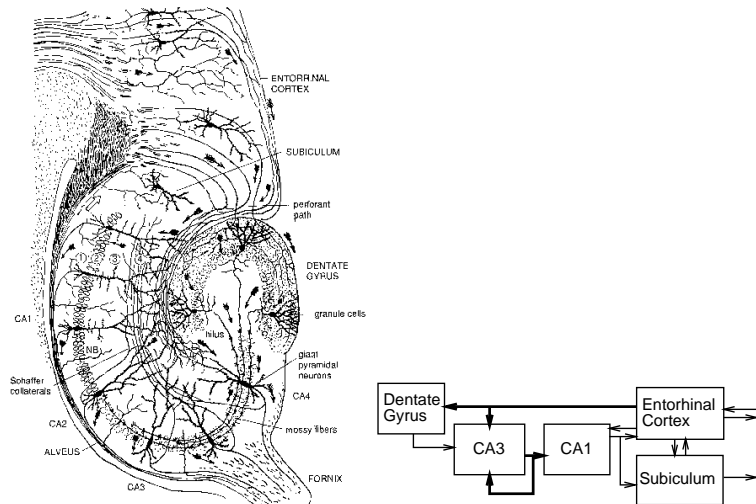
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Hippo: On top of Cortex



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Hippocampal Anatomy



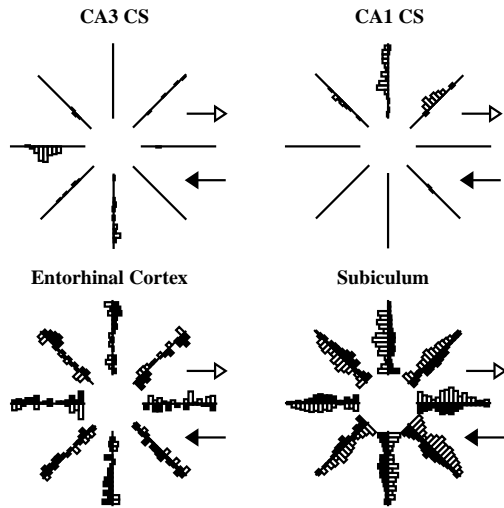
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Sparse Activity

Area	Rat		Model	
	Neurons	Pct Act	Units	Pct Act
EC	200,000	7.0	144	25.0
DG	1,000,00	0.5	625	1.0
CA3	160,000	2.5	240	5.0
CA1	250,000	2.5	384	9.4

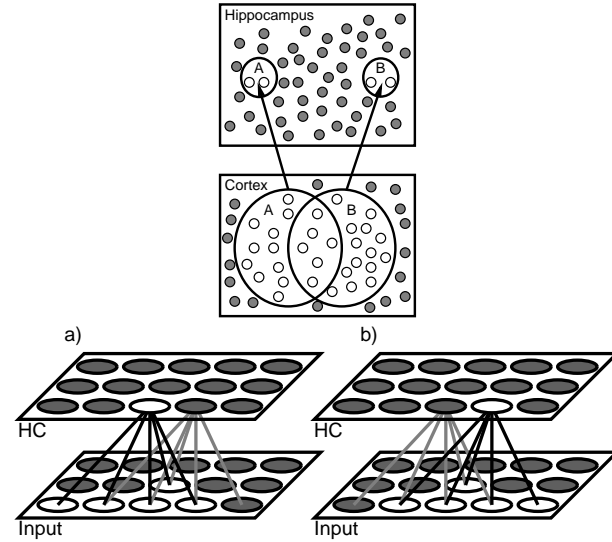
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Sparse Activity

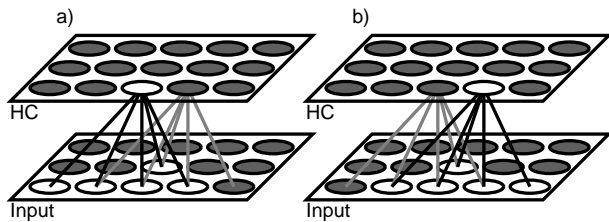


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Pattern Separation & Conjunctions



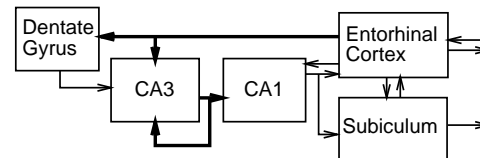
19 Pattern Separation & Conjunctions: Space and episodes



20 The Flip Side of Separation: Pattern Completion

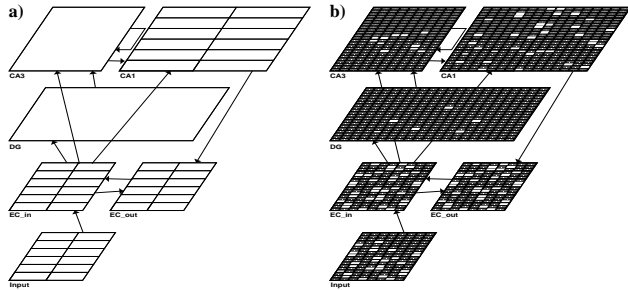
College friend example: "This one time, at this one party..."

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



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The Model



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Activation-based Priming

Residual activity affects subsequent processing.

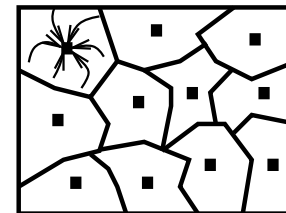
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Active Maintenance

Maintaining information in active form over longer time periods.

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

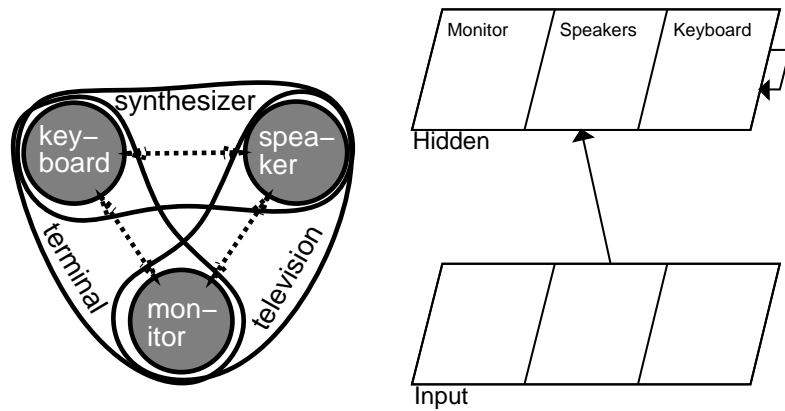
Attractor = stable activation state:



(don't want activity to spread)

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Exploration



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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.

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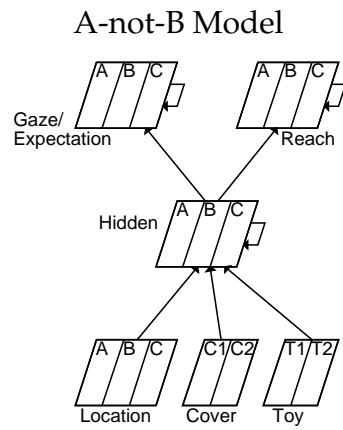
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Weight- and Activation-Based Memory Interactions

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.

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