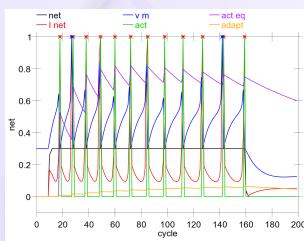


## Learning and Memory

Computational Cognitive Neuroscience  
Randall O'Reilly

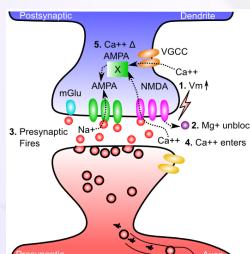
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## Two Neural Forms of Memory: Activation vs. Synaptic Changes



Activation = Neurons continue to fire action potentials, "remembering" what you were just seeing, thinking

But when firing stops.. You forget..



Synapses change strength ("weight") as a result of LTP / LTD (learning): this encodes long-term memories that last even after your activation switches to something new..

## Major Types of Memory

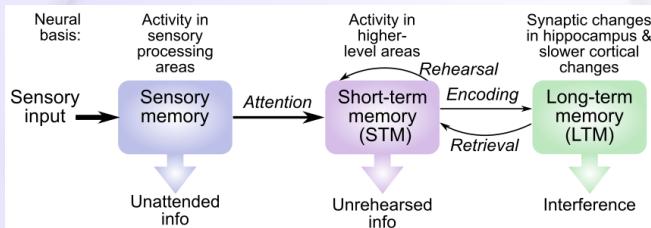
- ?

## Major Types of Memory

- Weight-based (changes in synapses)
  - Long lasting, persist over distraction, etc
  - Very high capacity
- Activation-based (sustained neural firing)
  - Transient, easily lost
  - Very flexible: mental arithmetic, etc.

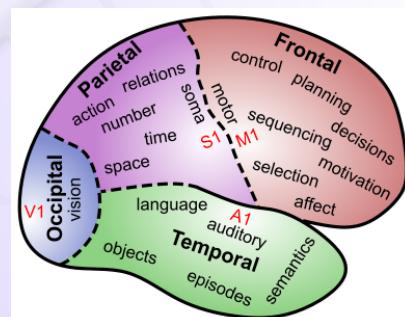
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## STM vs. LTM



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## The Brain IS Memory

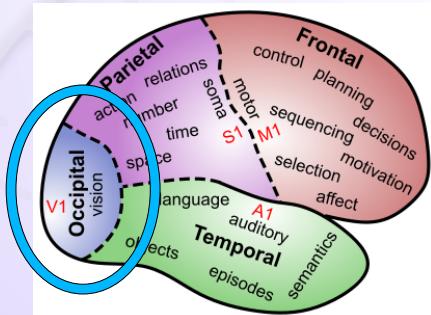


Memory is located in every single synapse in the brain

There are as many different kinds of memory as there are neurons and synapses and brain areas...

6

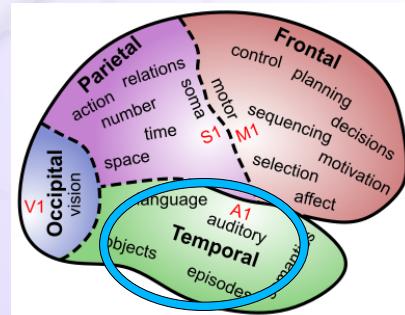
## Where is Sensory Memory?



Surprise! It is just neural firing in **sensory** brain areas  
– those neurons just keep on firing away (briefly..)

7

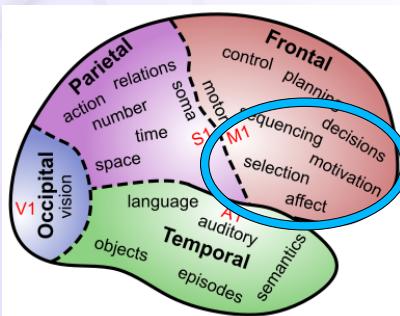
## Where is Short-Term Memory?



Surprise! It is neural firing in higher level brain areas  
that represent specific thing you're remembering – those  
neurons just keep on firing away (briefly..)

8

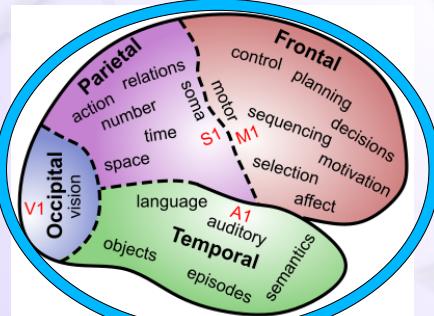
## Where is Short-Term Memory?



Extra surprise! And it usually requires contribution from  
prefrontal cortex – has extra holding power to keep  
those neurons firing longer!

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## Where is Long-Term Memory?



Surprise! It is in the relevant brain area(s) that encode  
the specific information! LTM is the sum total of all  
those synaptic weight changes!

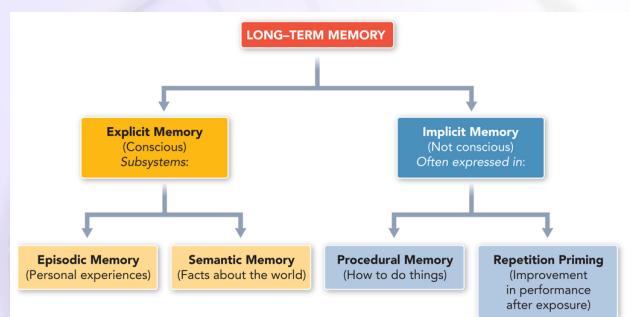
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## Major Types of Memory

- Episodic Memory: events, facts, etc
  - Hippocampus
- Familiarity-based recognition
  - Perirhinal cortex: you look familiar, but...
- Weight-based priming
  - Subconscious, can be very long-lasting
- Activation-based priming
  - Also subconscious, but transient..

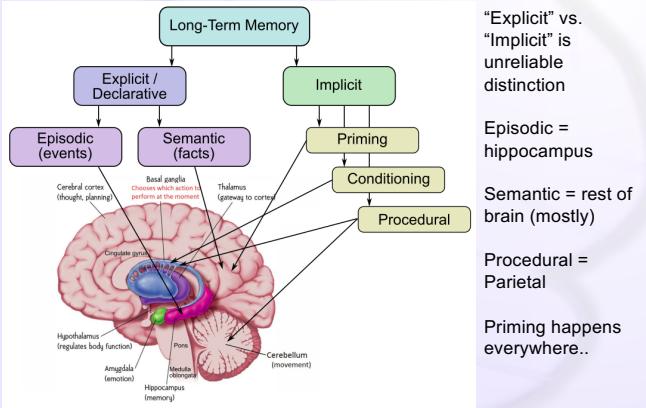
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## Organization of LTM



Is this the best way to organize LTM?  
Can you think of any other ways?

## Where is Long-Term Memory?



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## Episodic Memory

- Autobiographical memory (life events)
- Arbitrary new memories (lab tasks)
- ...

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## Classic Lab Task: AB-AC

- Learn AB paired associates:
  - window-reason
  - bicycle-garbage
  - ...
- Then AC paired associates:
  - window-locomotive
  - bicycle-dishtowel
  - ...

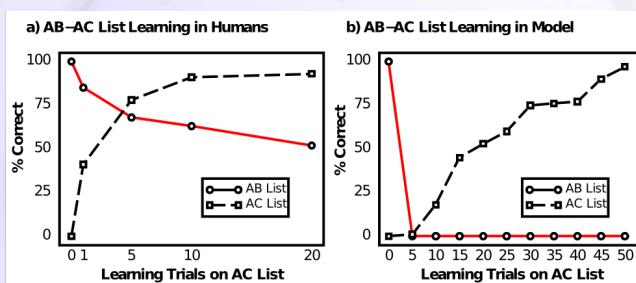
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## AB-AC

- Test on AB list:
  - Window ?
  - Bicycle ?
- And AC list:
  - Window ?
  - Bicycle ?

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## Catastrophic Interference

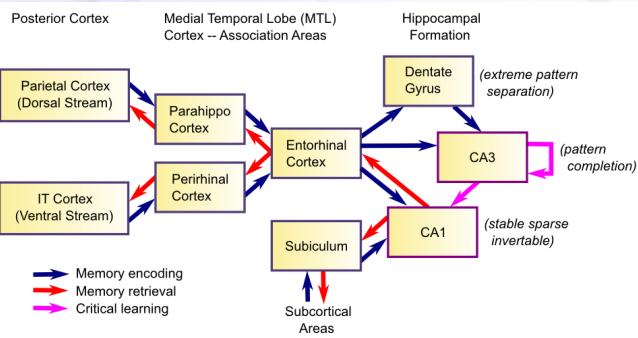


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- Demo AB-AC cortical model

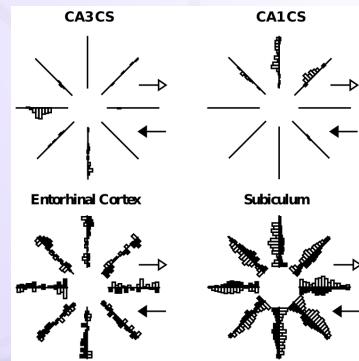
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## Hippocampal System



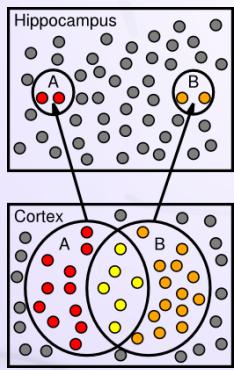
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## Sparse Activity



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## Sparse = Pattern Separation



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## Hippo Project

- Run hip.proj

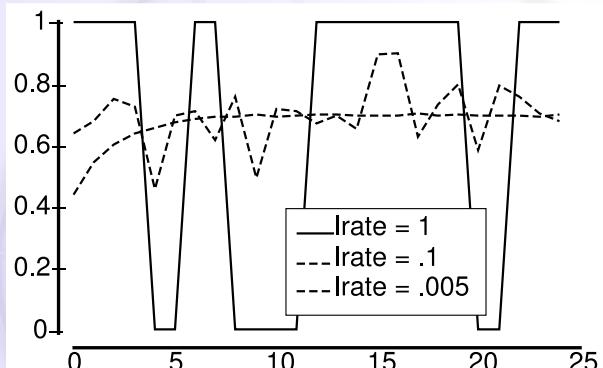
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## Complementary Learning Systems

Goals:	Remember <b>Specifics</b>	Extract <b>Generalities</b>
Example:	Where is car parked?	Best parking strategy?
Need to:	Avoid <b>interference</b>	<b>Accumulate</b> experience
Solution:		
1.	<b>Separate</b> reps (keep days separate) 	<b>Overlapping</b> reps (integrate over days) 
2.	<b>Fast</b> learning (encode immediately)	<b>Slow</b> learning (integrate over days)
3.	Learn <b>automatically</b> (encode everything)	<b>Task-driven</b> learning (extract relevant stuff)
These are <b>incompatible</b> , need two different systems:		
System:	<b>Hippocampus</b>	<b>Neocortex</b>

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## Slow Learning Integration



Event has a .66 probability of occurring: only with a slow learning rate (.005) does it converge on an accurate estimate across discrete events

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## Priming

- Can a brief subliminal message influence your behavior?

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## Two Forms of Memory

- Priming provides good window onto weight vs. activation based memories.
  - Demos: wt, act priming

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## More Robust Activation-Based Memory

- In Executive Function Chapter:
  - PFC robust active maintenance over secs to mins
  - BG provides dynamic gating signal for updt vs. maint
  - Used for “working memory”, cognitive control..

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## More Memory

Recognition: familiarity vs. recall

Using memory for planning: hippocampus is key hub of the “default network” – where you want to be inside your brain..

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