Hot Science Cool Talks

UT Environmental Science Institute

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Building Memories for Tomorrow: How Our Brains Predict Our Futures

Dr. Alison Preston

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Hot Science - Cool Talks

OUTREACH LECTURE SERIES

Building memories for tomorrow: How our brains predict our futures

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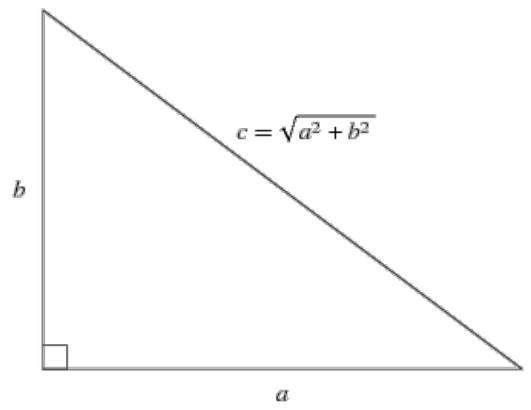
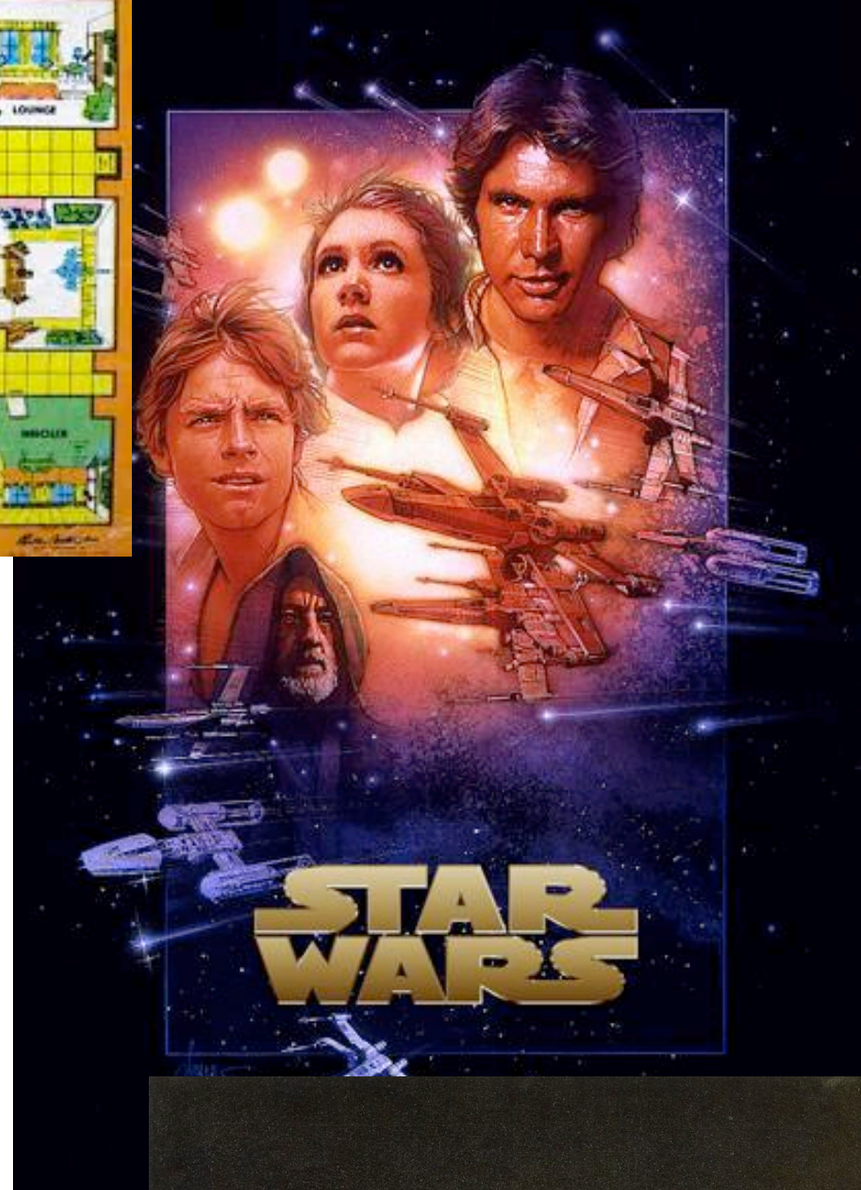
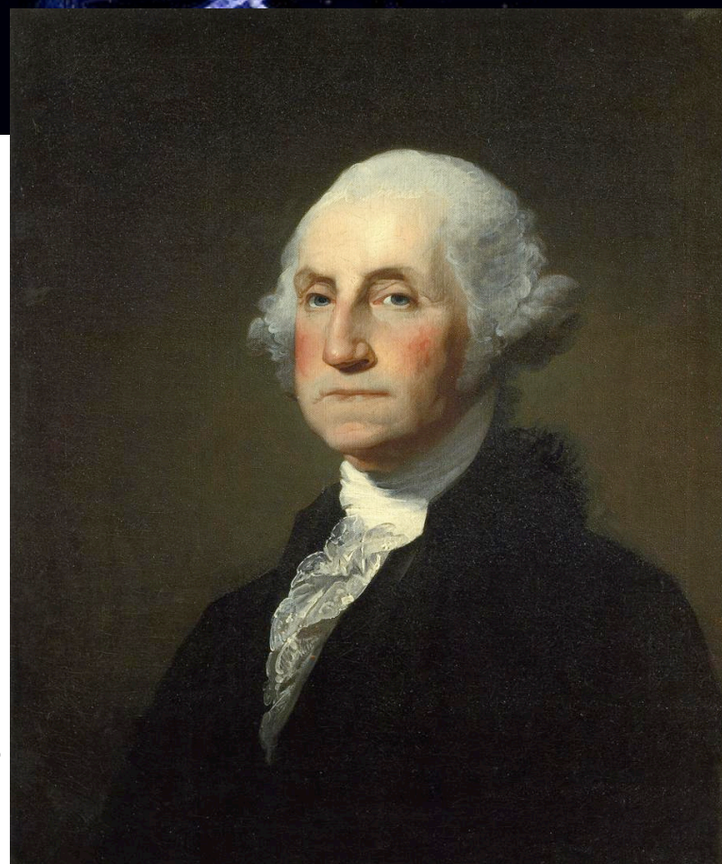
What is memory?

Facts you know







What is memory?

Facts you know

Skills you learn

What is memory?

Facts you know

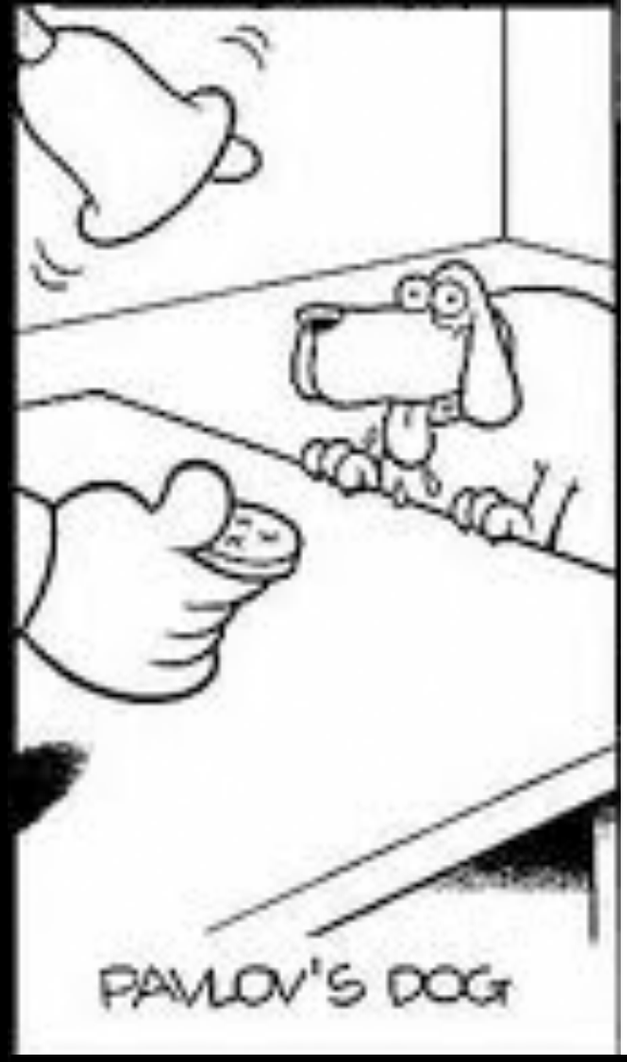
Skills you learn

Habits or fears
you have

What is memory?

So, memory is many things

supported by
different parts of the brain



What is memory?

Facts you know

Skills you learn

Habits or fears you have

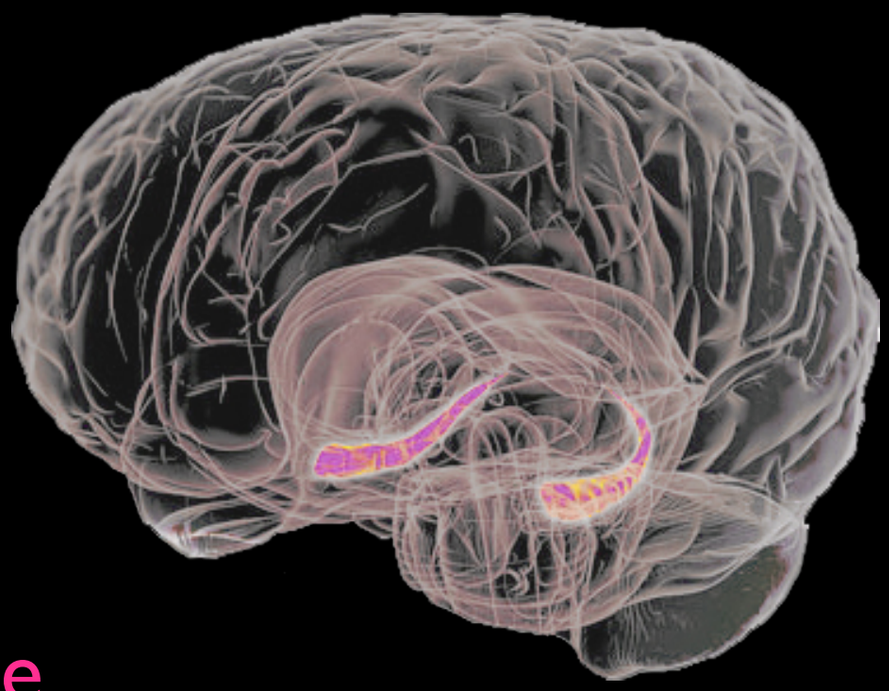
Events you experience

Remembering events is mental time travel

Travel through time and space

Remembering events is mental time travel

Our time machine....



The Hippocampus

Supplementary Movie S1a
viewing session

accompanying
demonstration for Fig. 1

Firing of a single entorhinal cortex neuron while watching short video episodes

(Original audiovisual movie clips are replaced by a textual description of the clip content)

Beeps represent single spikes

H. Gelbard-Sagiv, R. Mukamel, M. Harel, R. Malach, I. Fried, *Science* (2008)

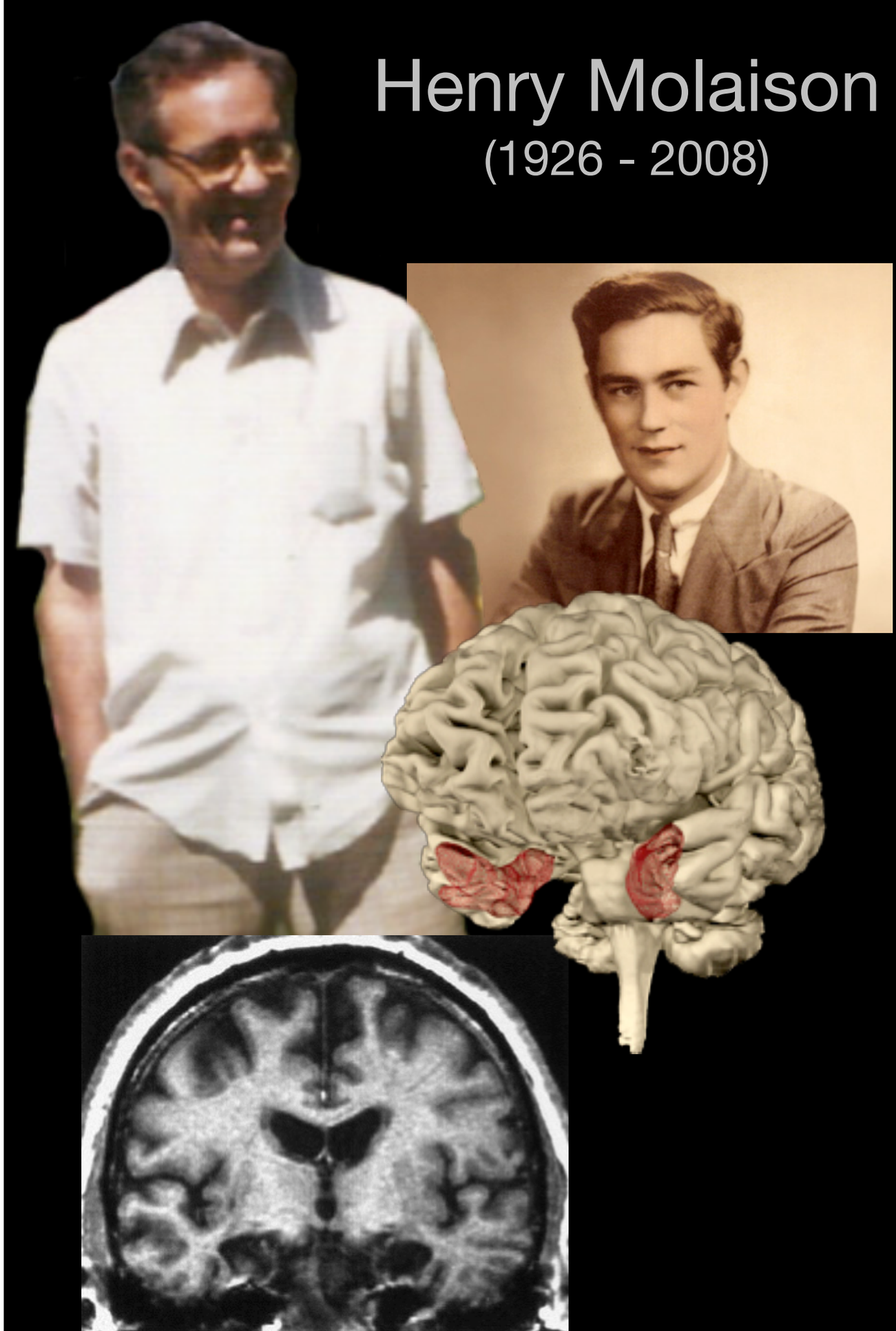
What would life be like without your hippocampus?

Every day is alone in itself, whatever joy I've had and whatever sorrow I've had.

- H.M. (Milner et al., 1968)

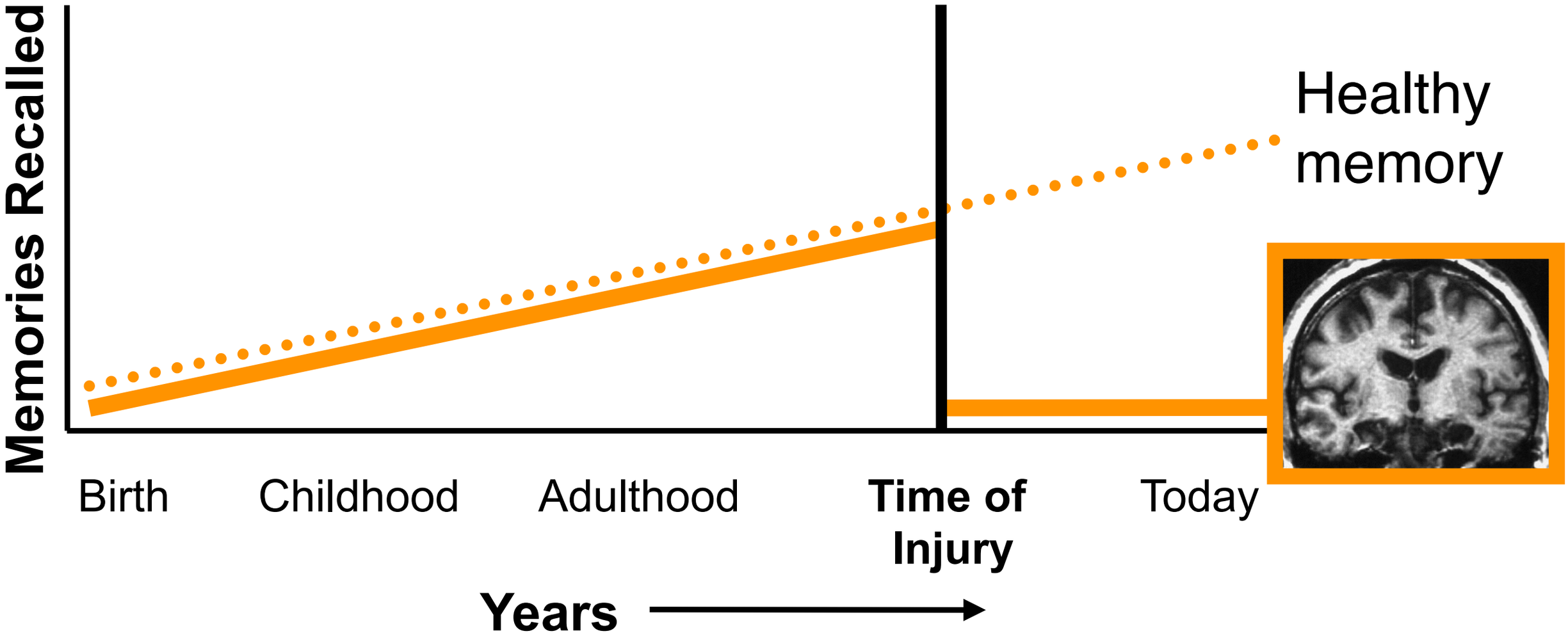
Right now I'm wondering. Have I done or said anything amiss? You see, at this moment everything looks clear to me, but what happened just before? That's what worries me. It's like waking from a dream; I just don't remember.

- H.M. (Milner, 1970)



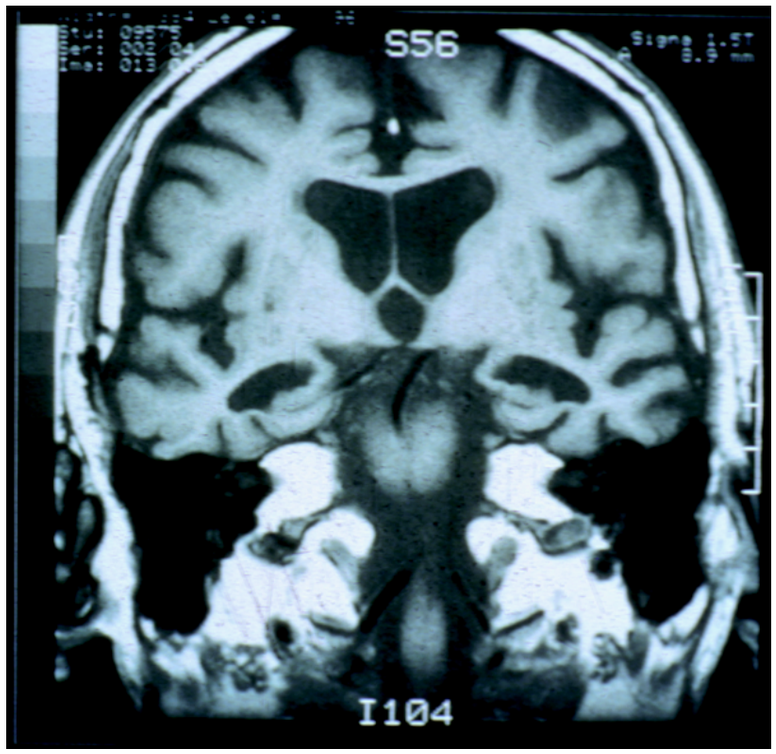
What would life be like without your hippocampus?

Anterograde amnesia



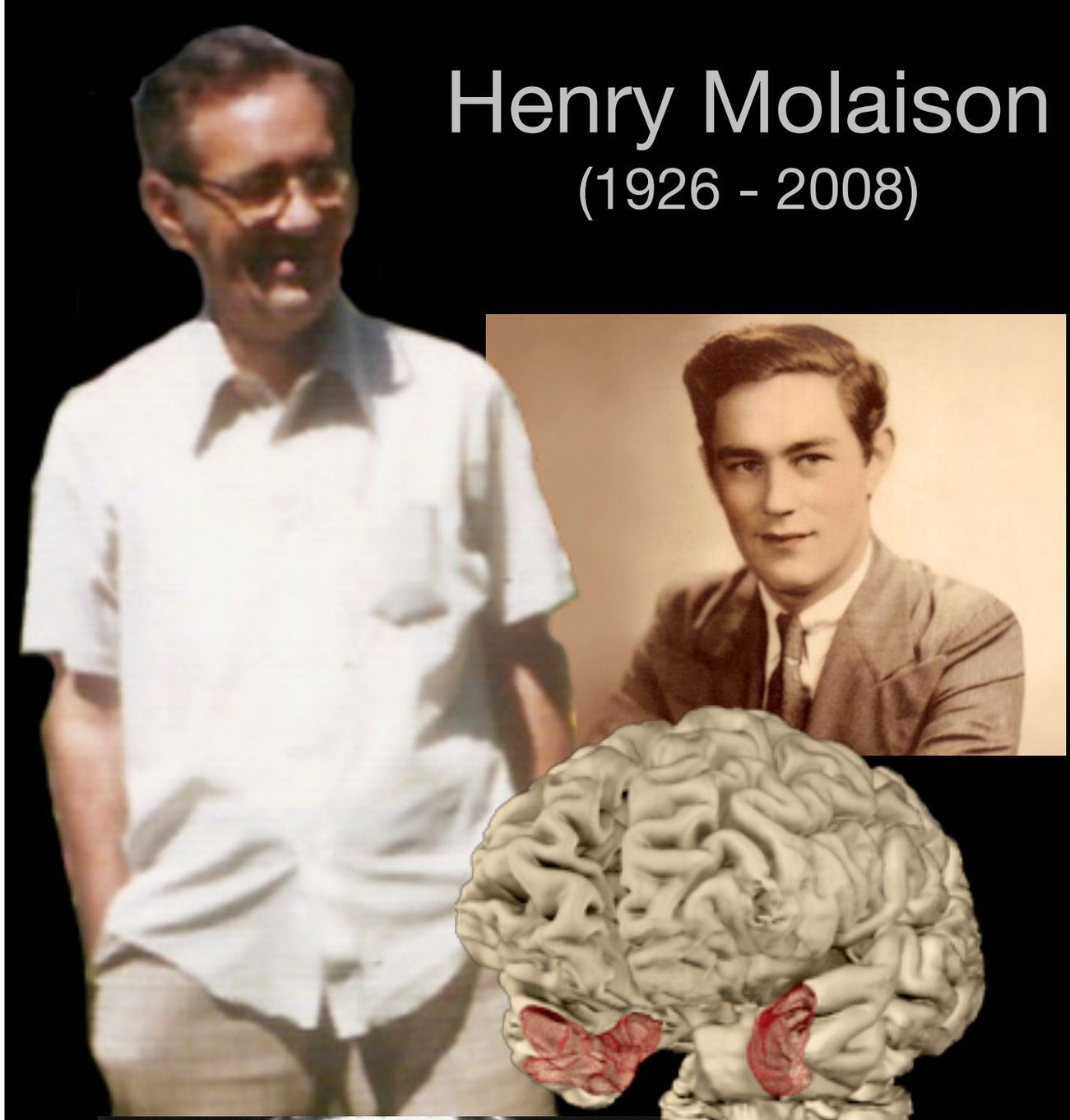
Only **memory for events** (and to some extent factual knowledge) is affected

Alzheimer's Disease

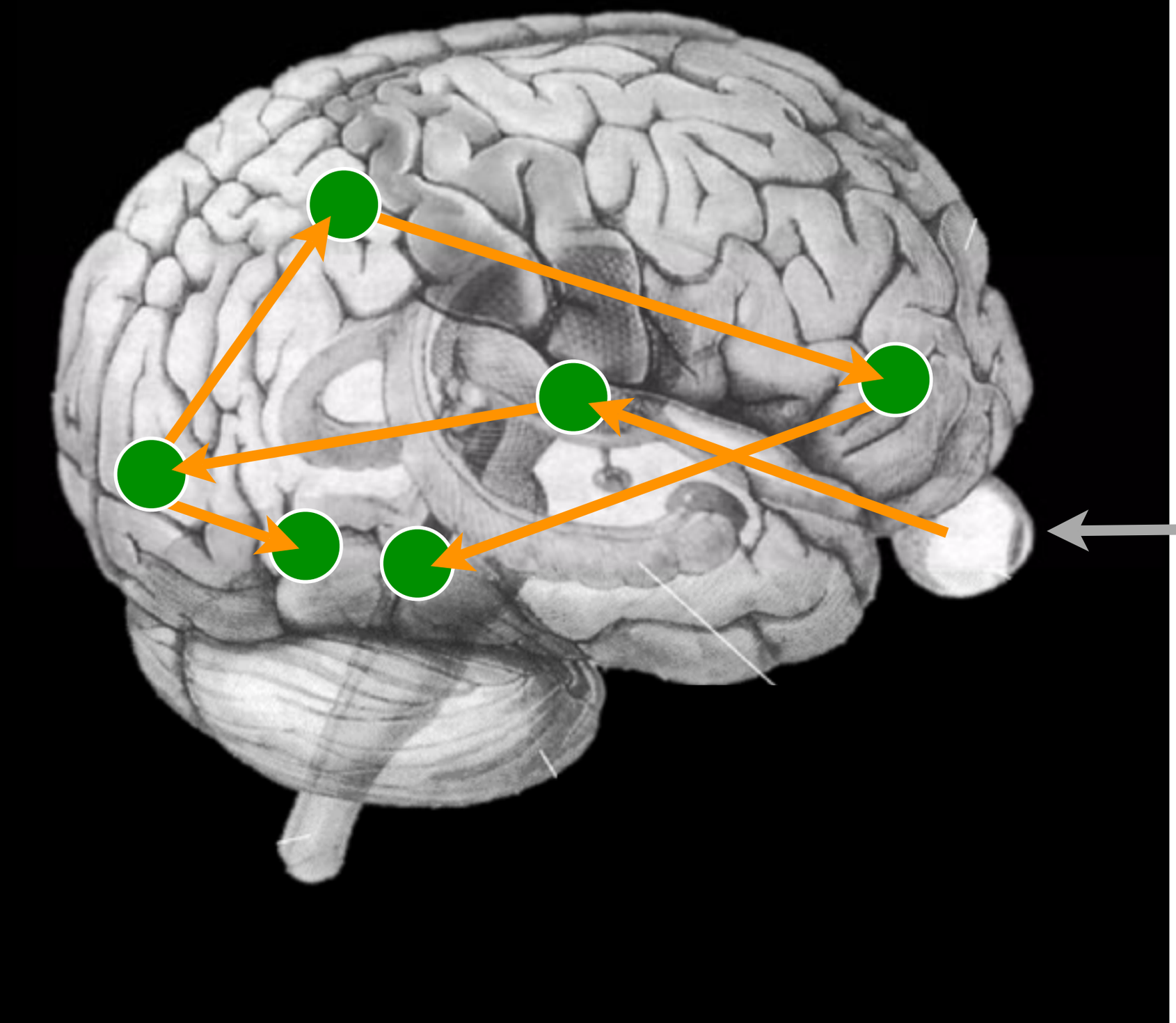


Henry Molaison

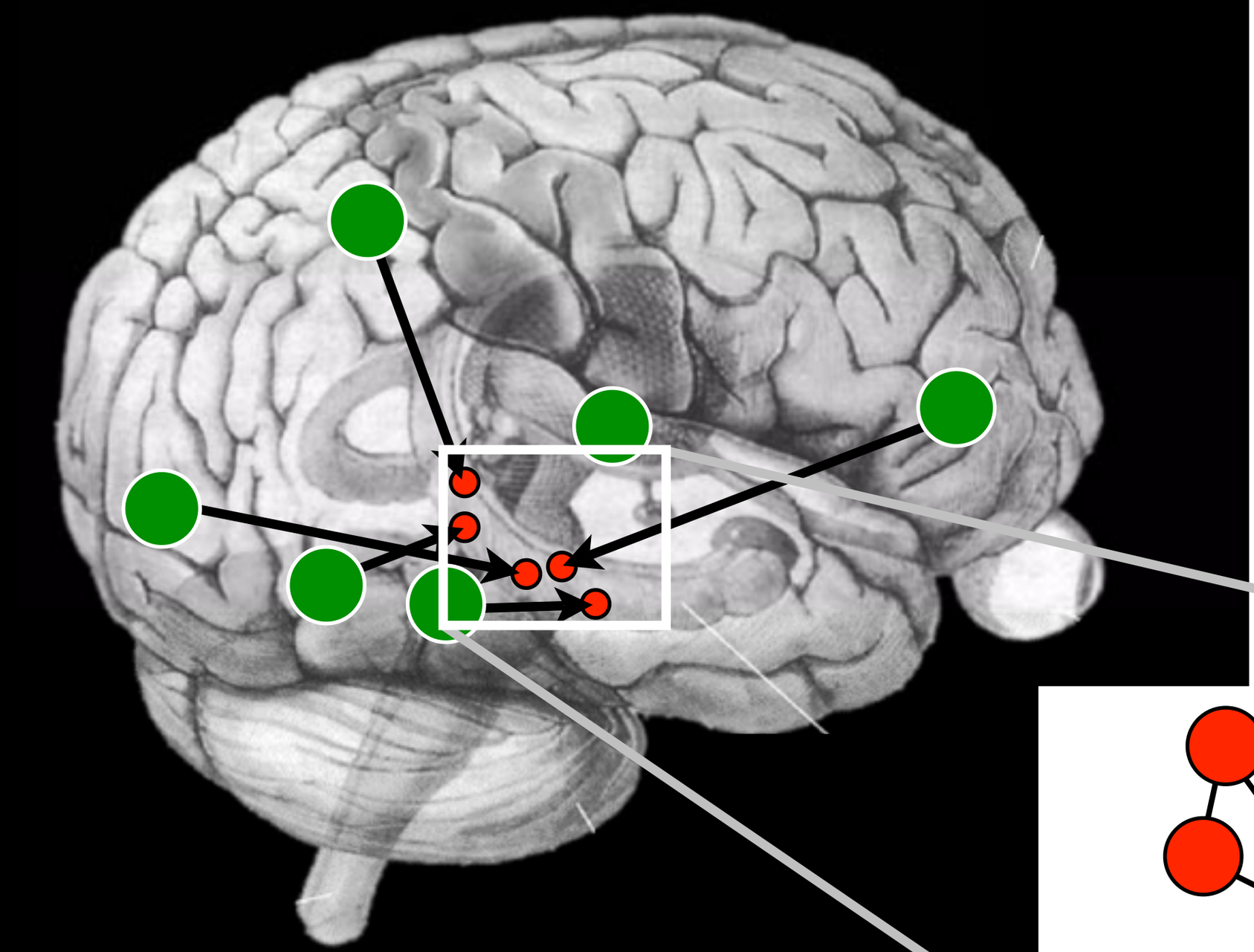
(1926 - 2008)



What does the hippocampus do exactly?

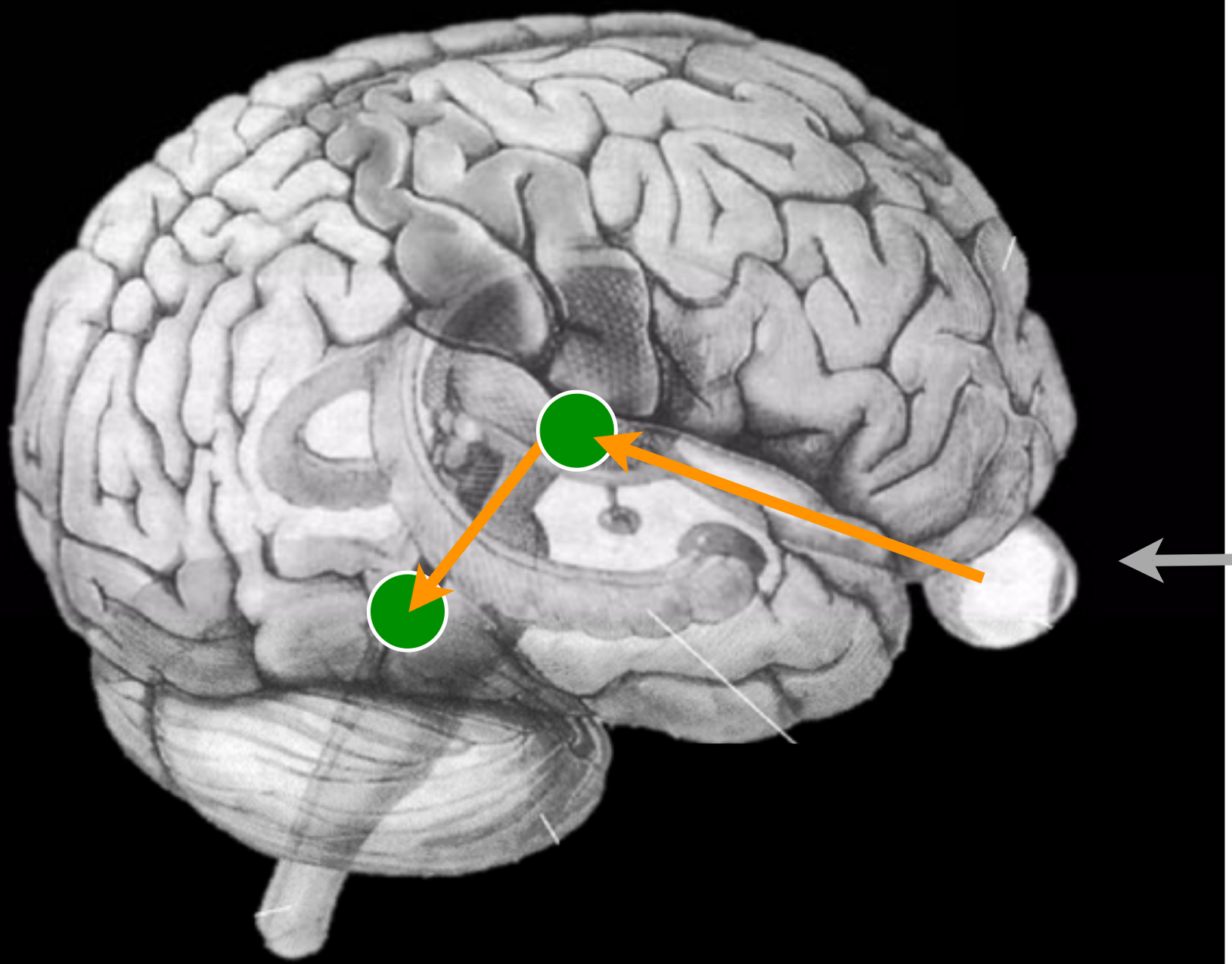


What does the hippocampus do exactly?



"Glues" together all the things that happen during an event

What does the hippocampus do exactly?



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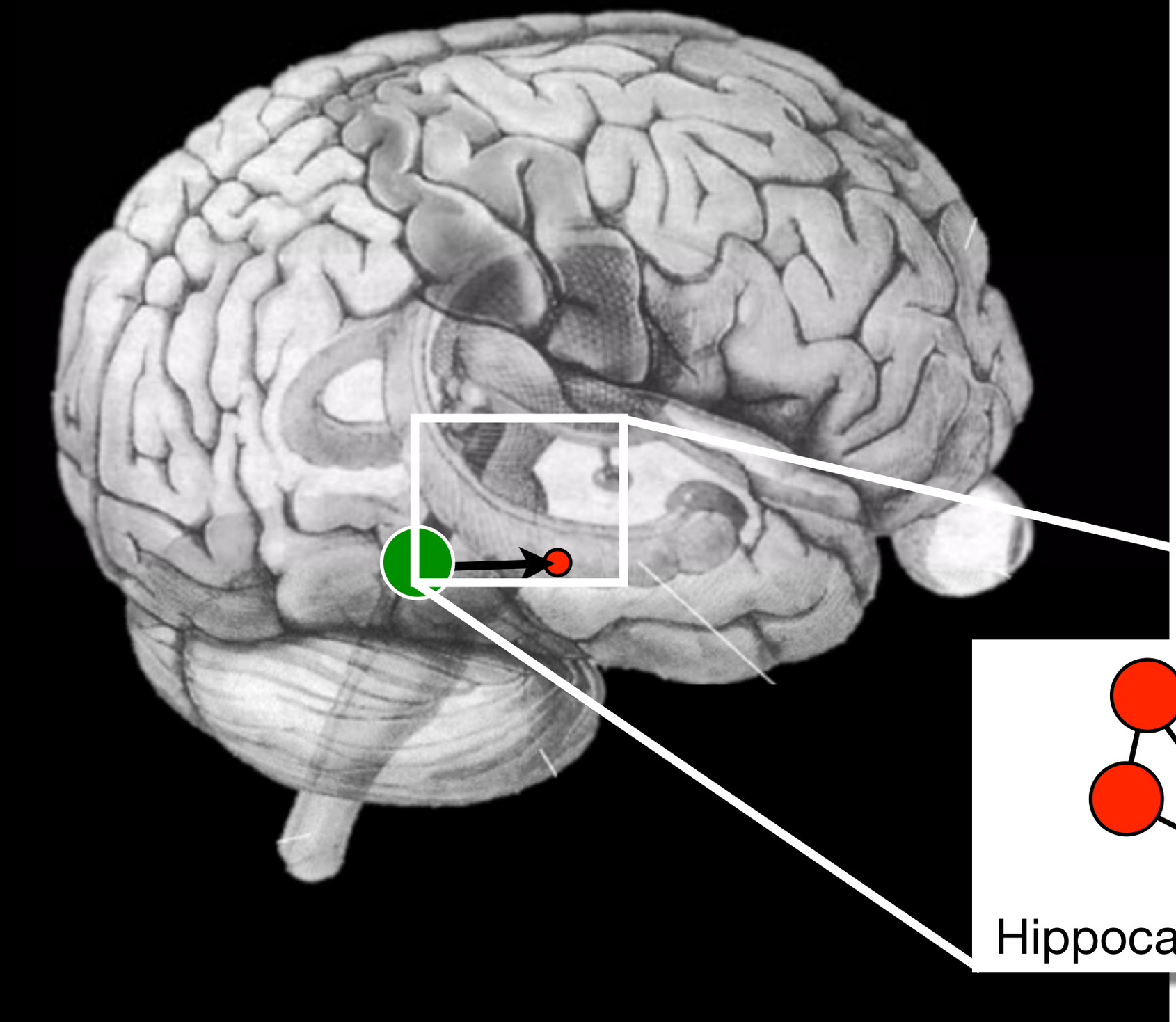
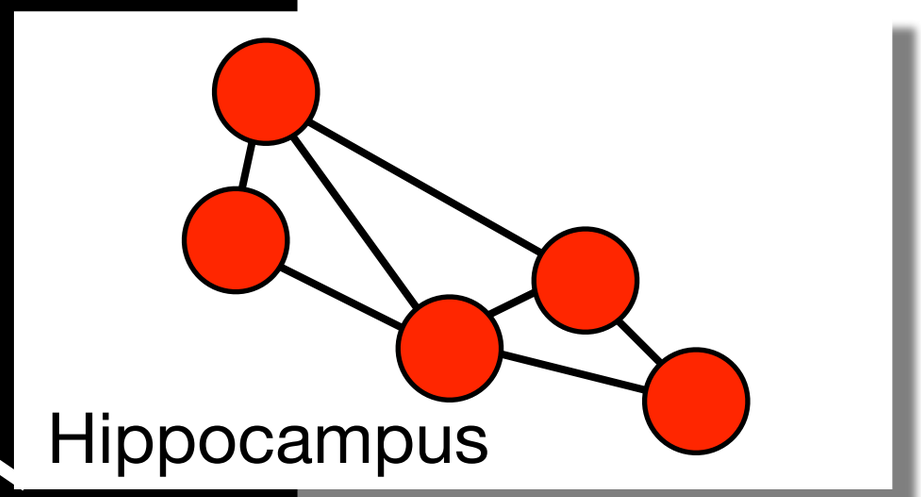
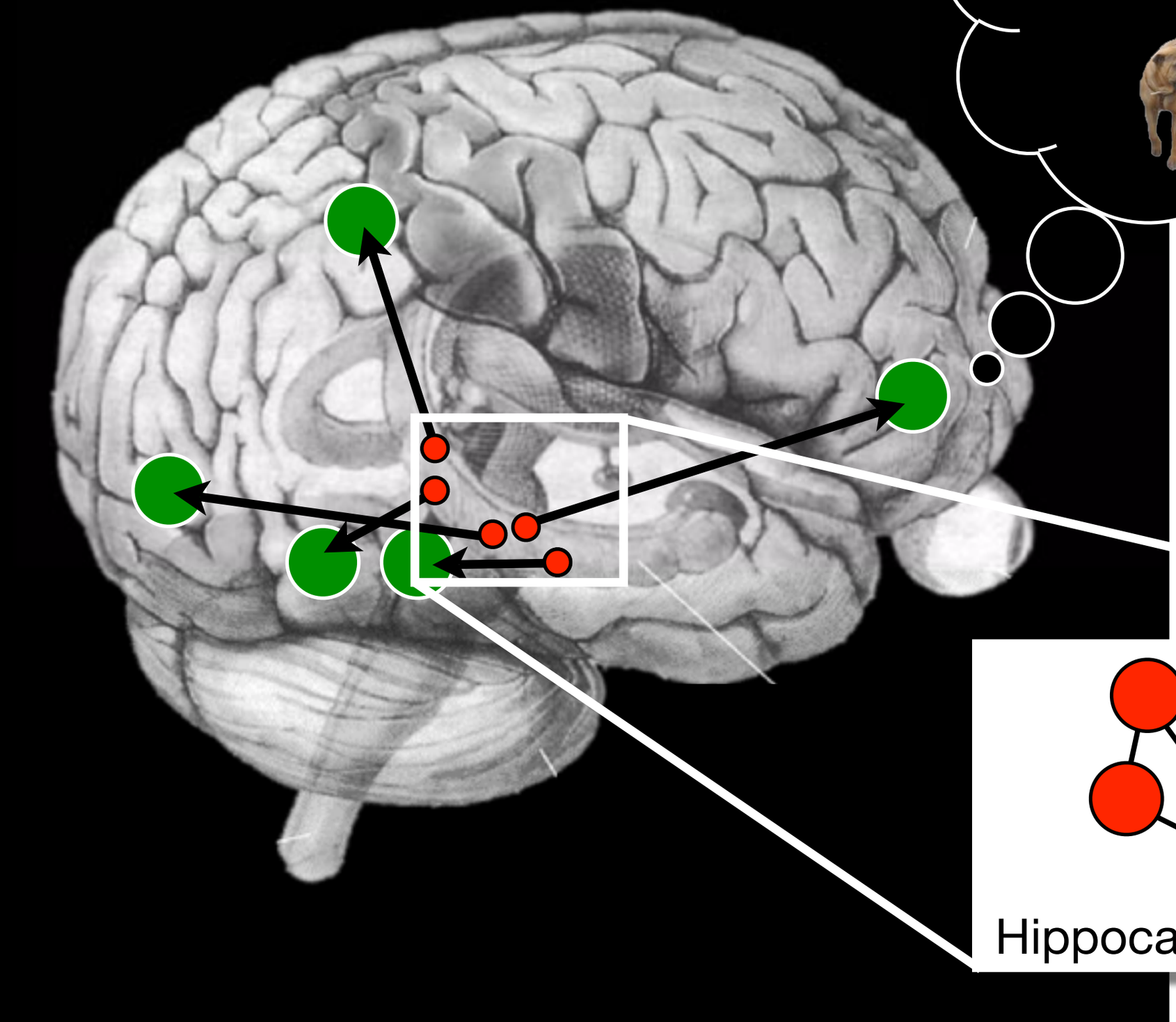
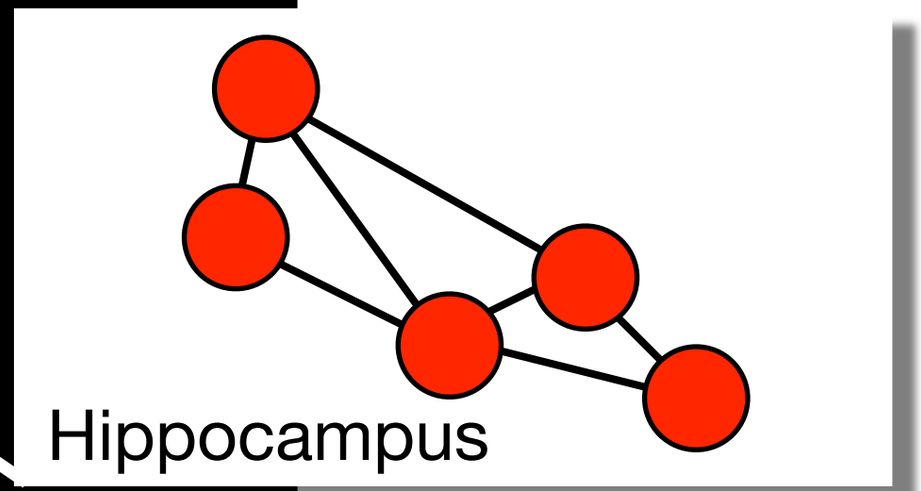




What does the hippocampus do exac



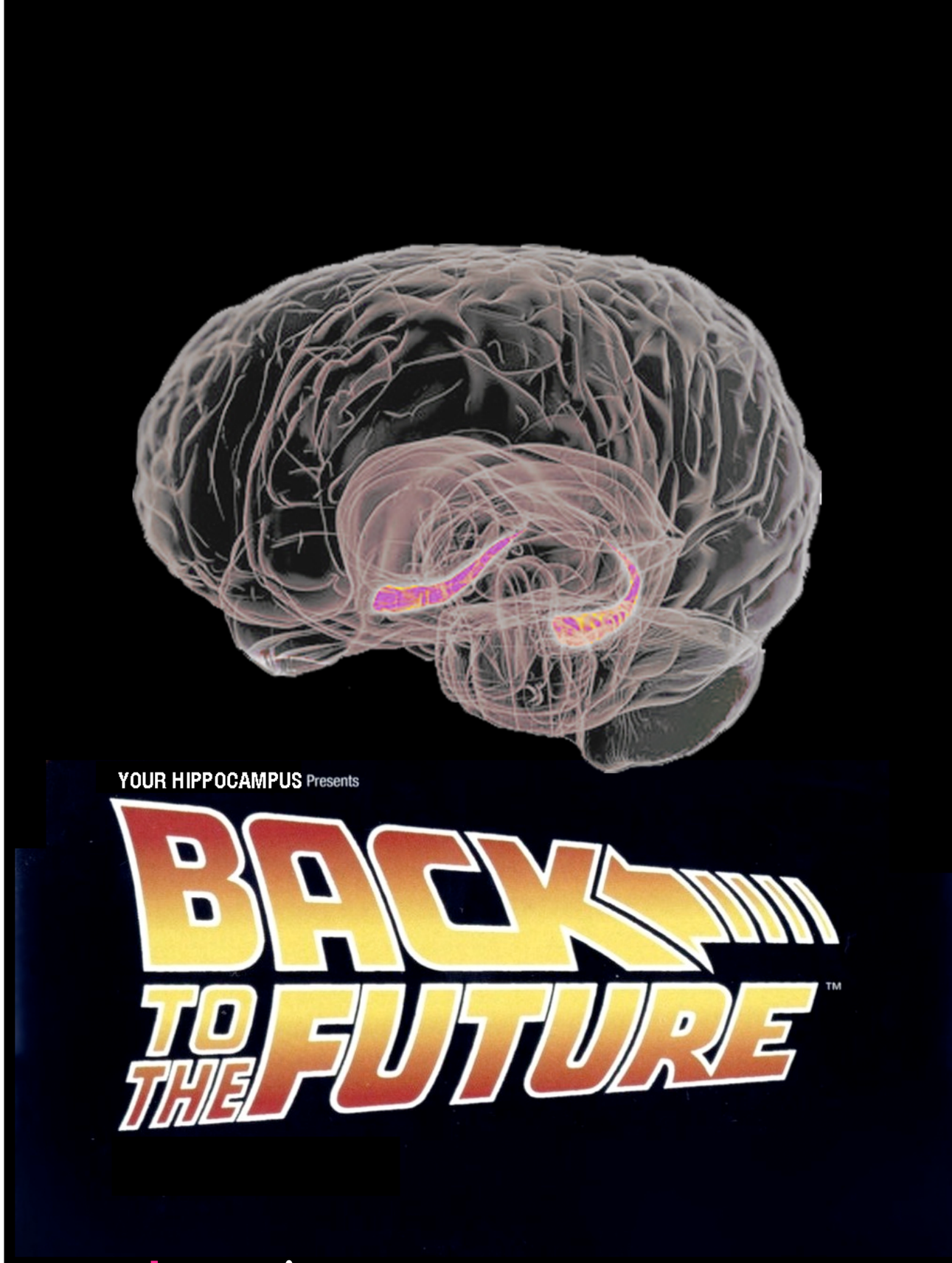
Reactivates memories



How do we use memory?

It's a poor sort of memory that works only backwards.

- The White Queen (Lewis Carroll)



Your brain is a prediction machine!

The hippocampus is predictive

Listen for left turns

Imagining requires remembering

Cue: ***Imagine you are lying on a white sandy beach in a beautiful tropical bay***

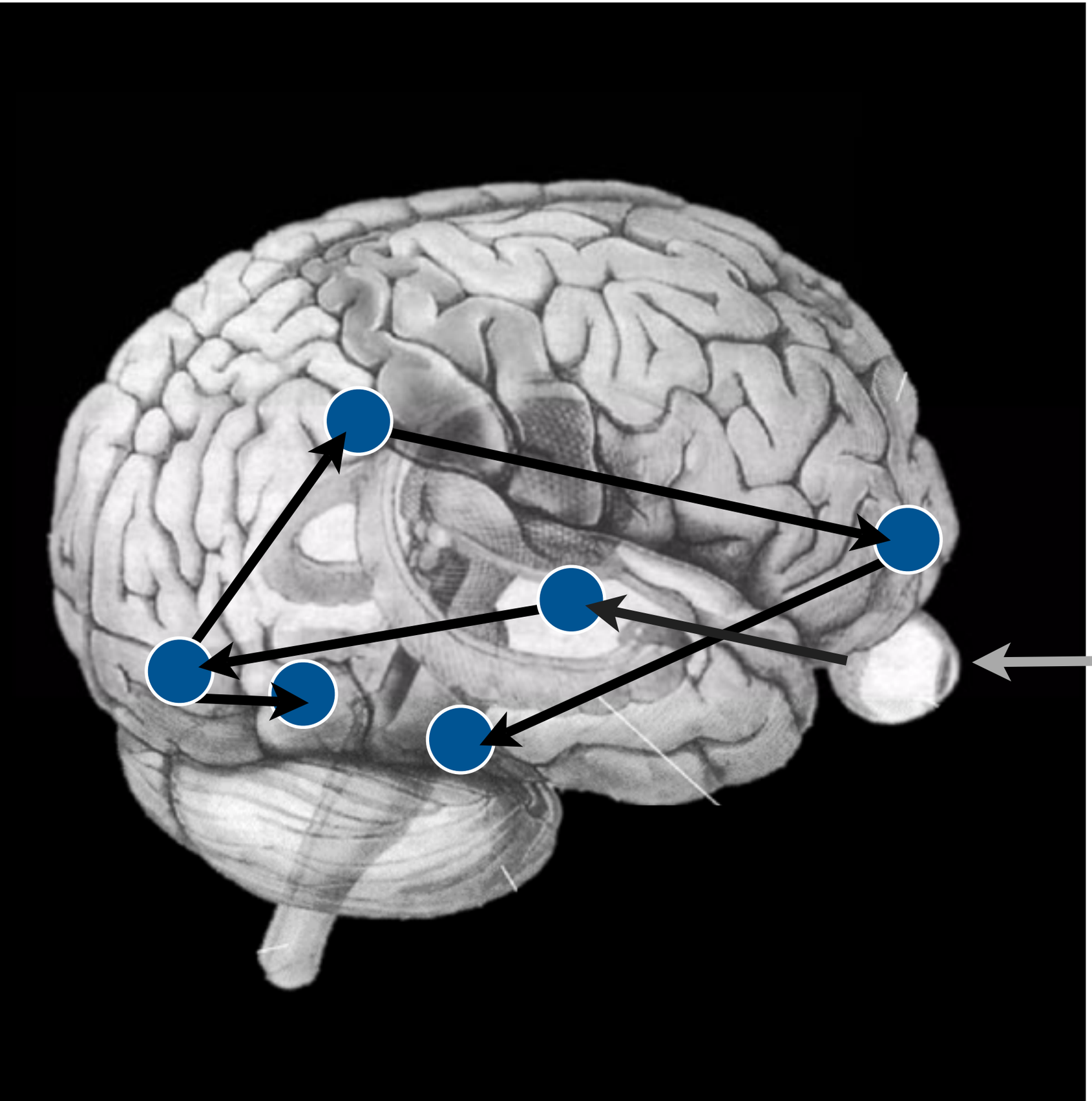
But what if you had no hippocampus?

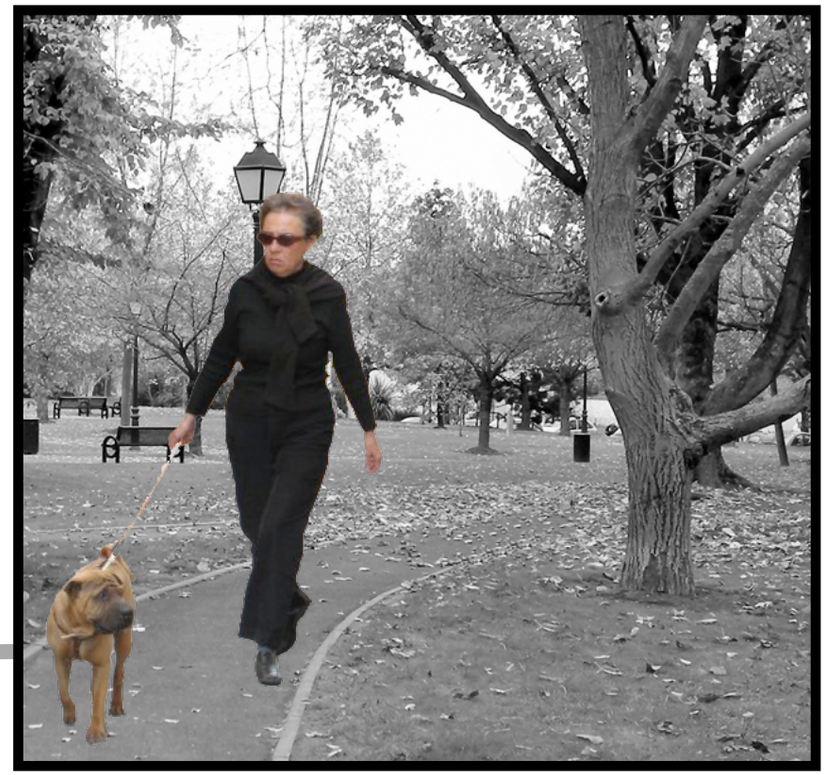
CON: It's very hot and the sun is beating down on me. The sand underneath me is almost unbearably hot. I can hear the sounds of small wavelets lapping on the beach. The sea is a gorgeous aquamarine colour. Behind me is a row of palm trees and I can hear rustling every so often in the slight breeze. To my left the beach curves round and becomes a point. And on the point there are a couple of buildings, wooden buildings, maybe someone's hut or a bar of some sort. The other end of the beach, looking the other way, ends in big brown rocks. There's no one else around. Out to sea is a fishing boat. It's quite an old creaking looking boat, chugging past on its small engine. It has a cabin in the middle and pile of nets in the back of the boat. There's a guy in the front and I wave at him and he waves back...[continues]...

Memories can't be recalled...

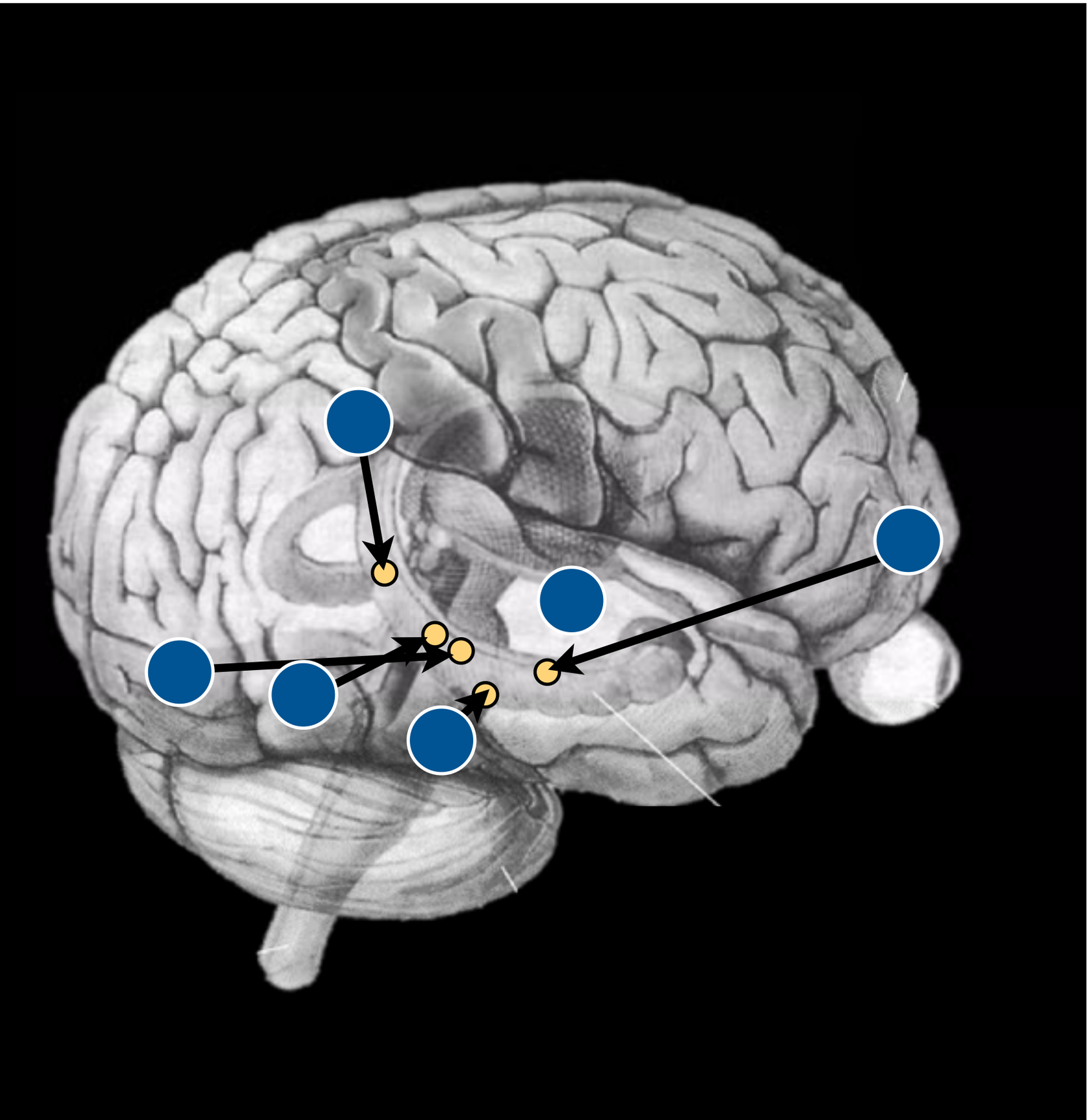
No way to construct an imagined scene

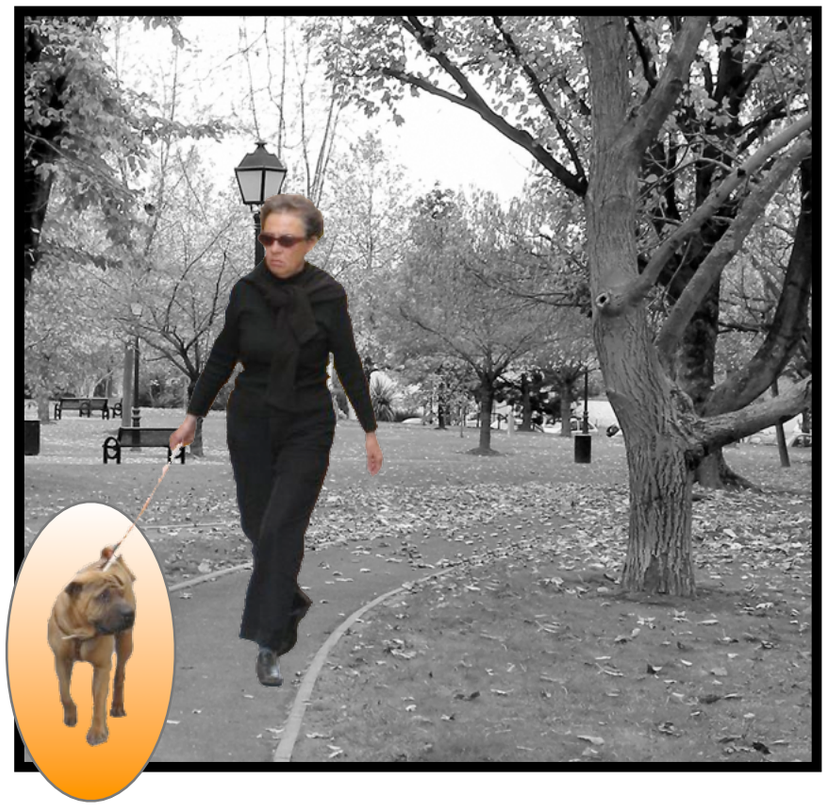
MEMORIES are building blocks





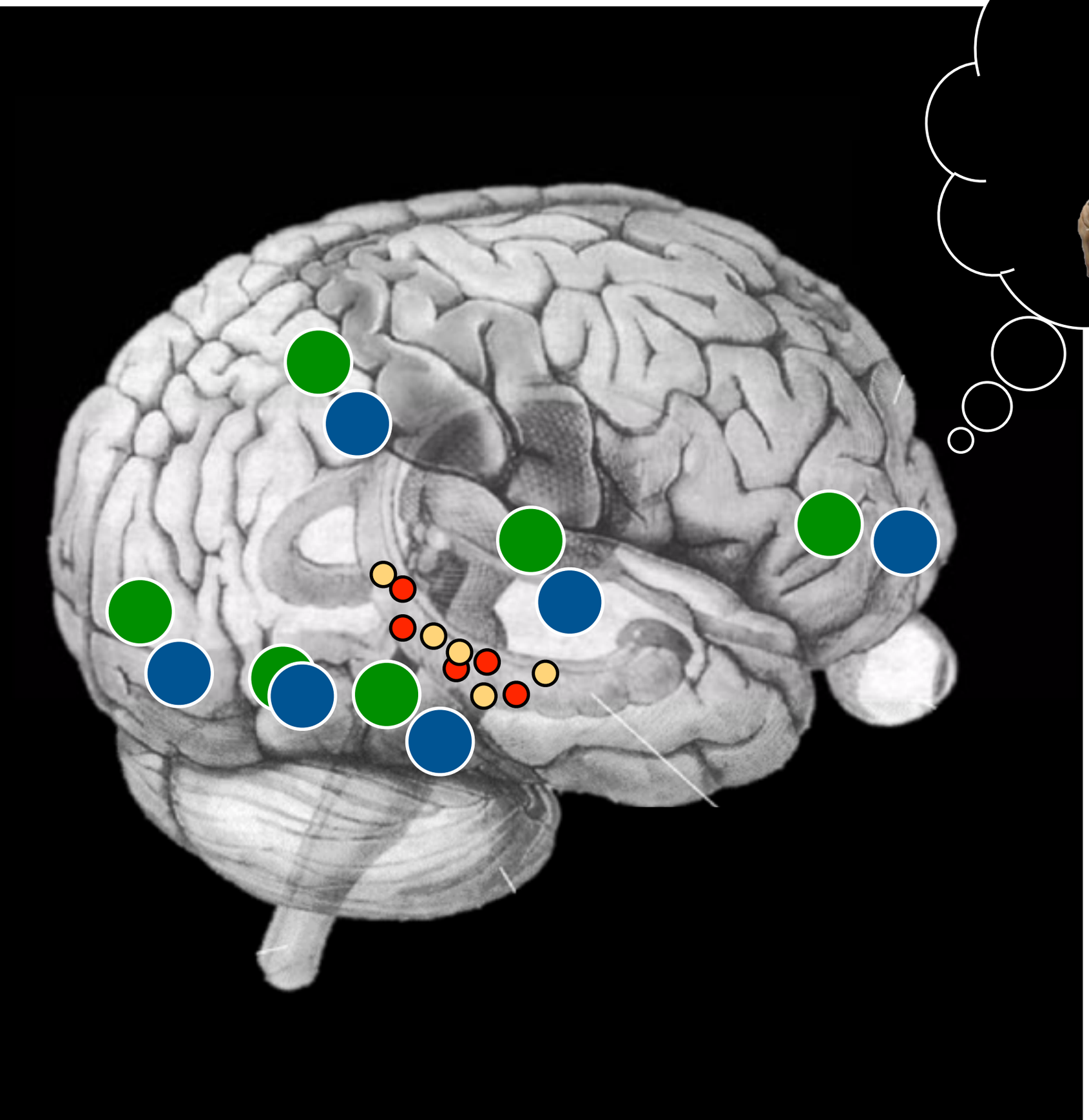
MEMORIES are building blocks

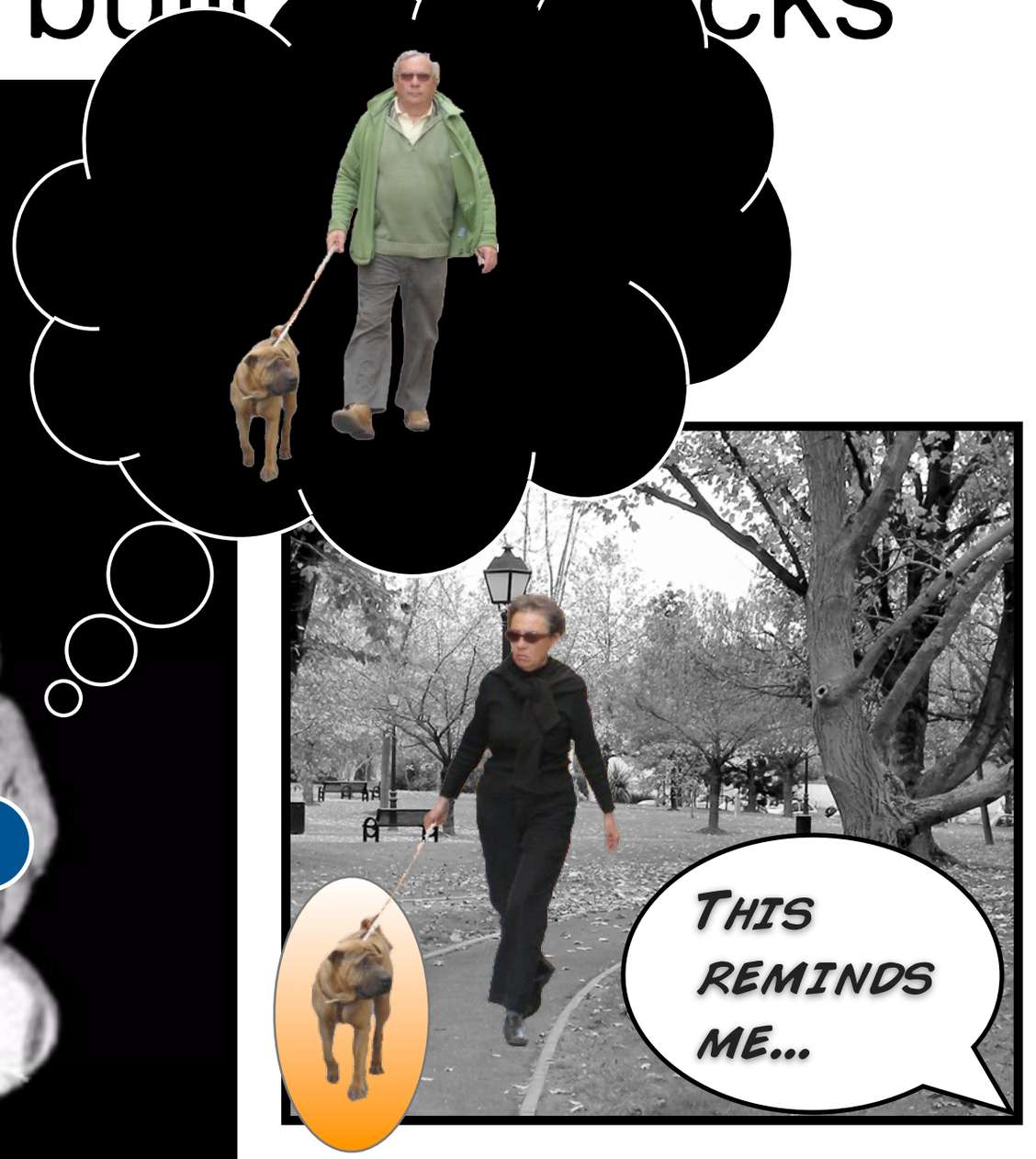




New experiences **share content** with past events

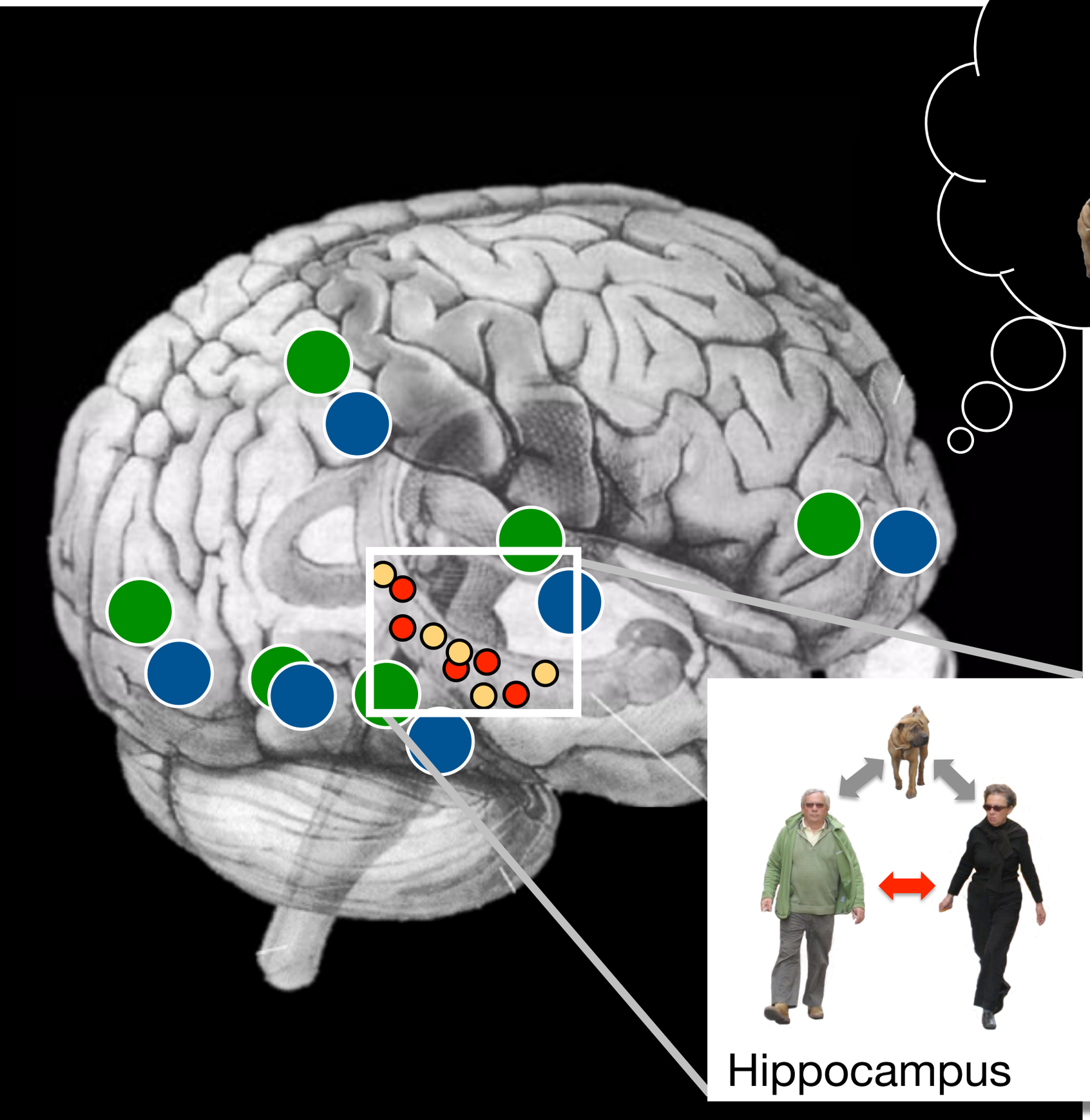
MEMORIES are building blocks

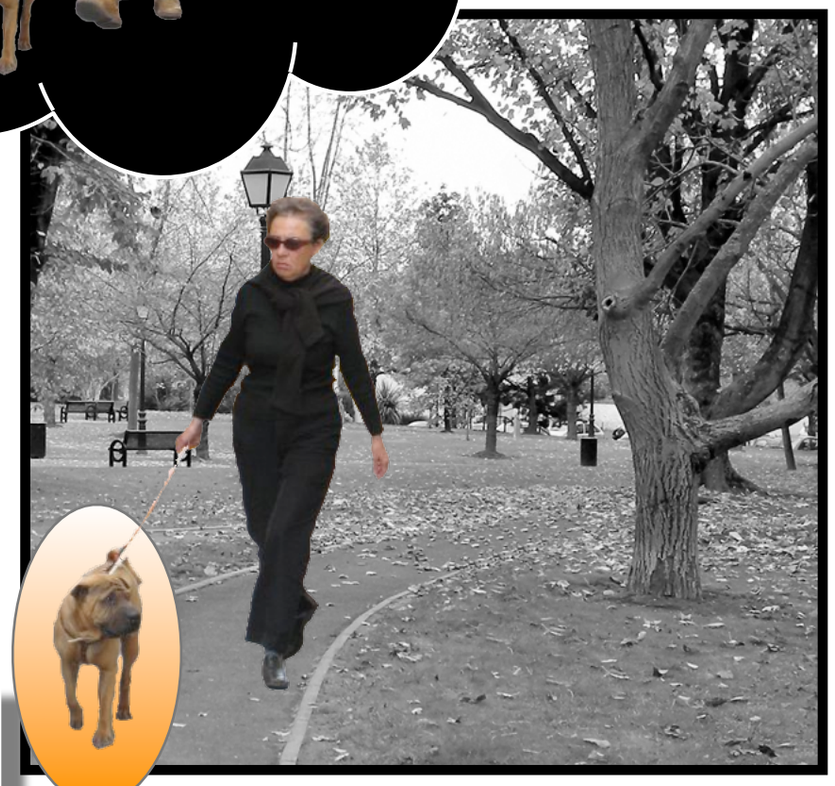




Shared content
triggers reactivation
of related memories

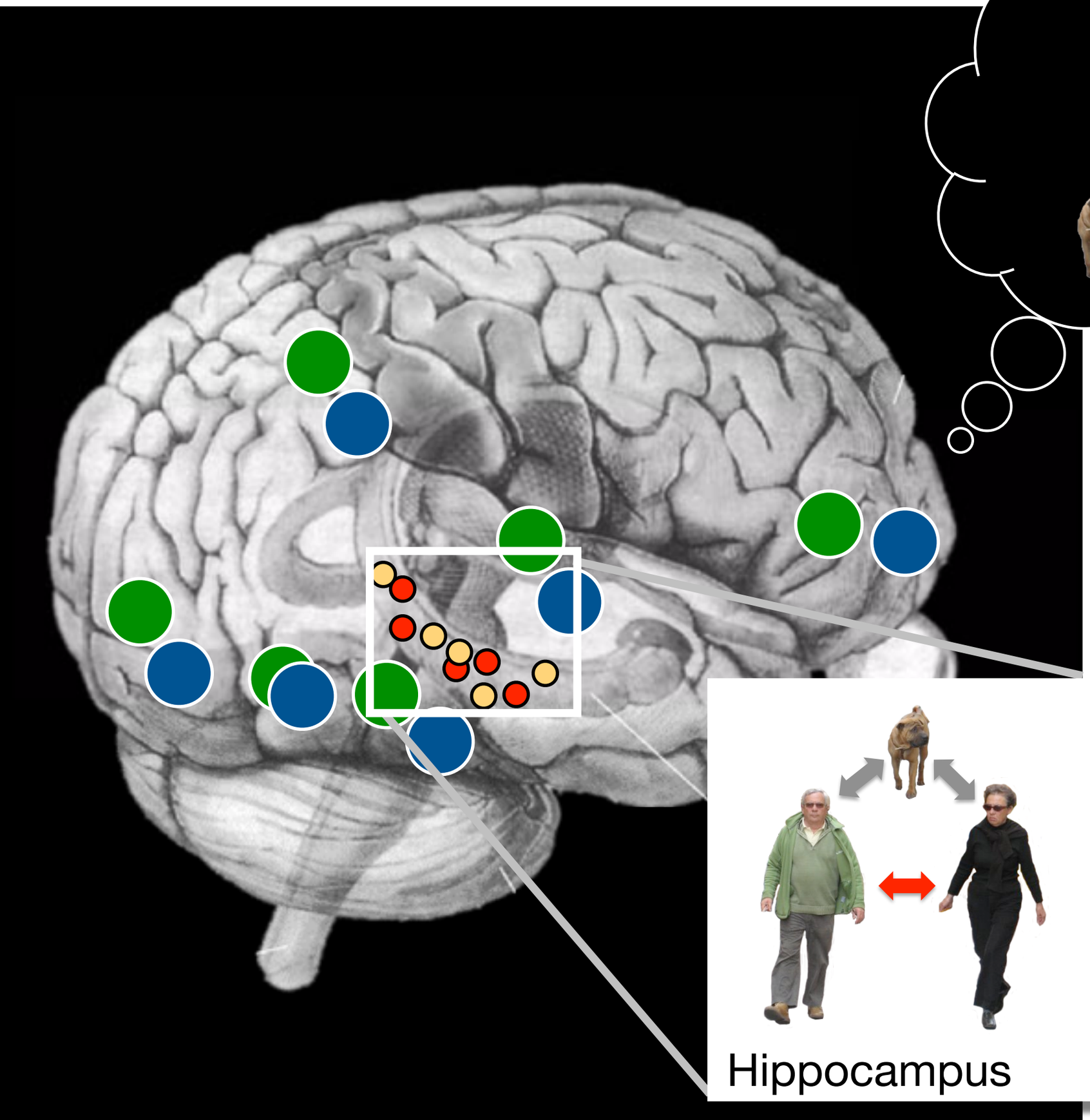
MEMORIES are building blocks

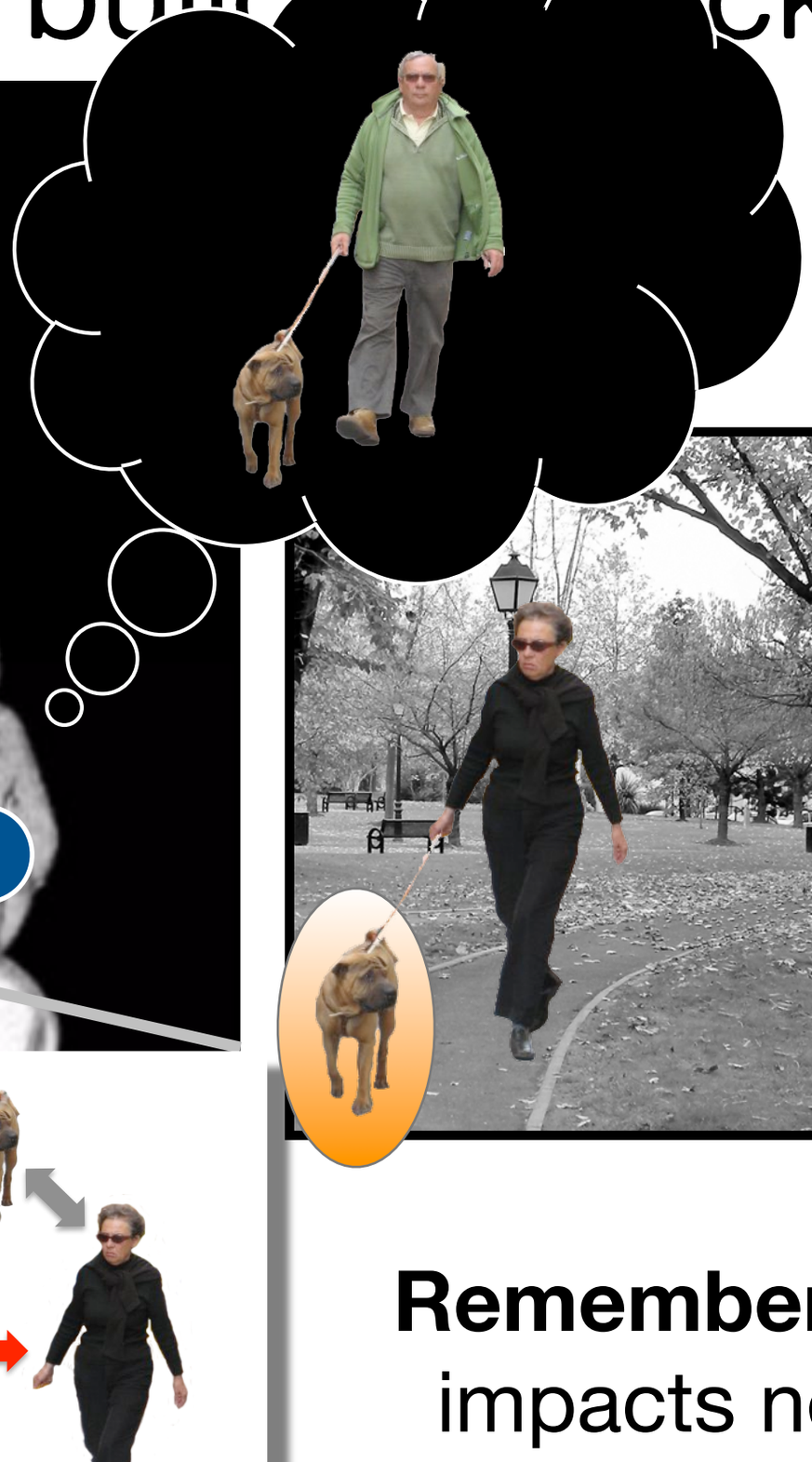




Form **links** between memories

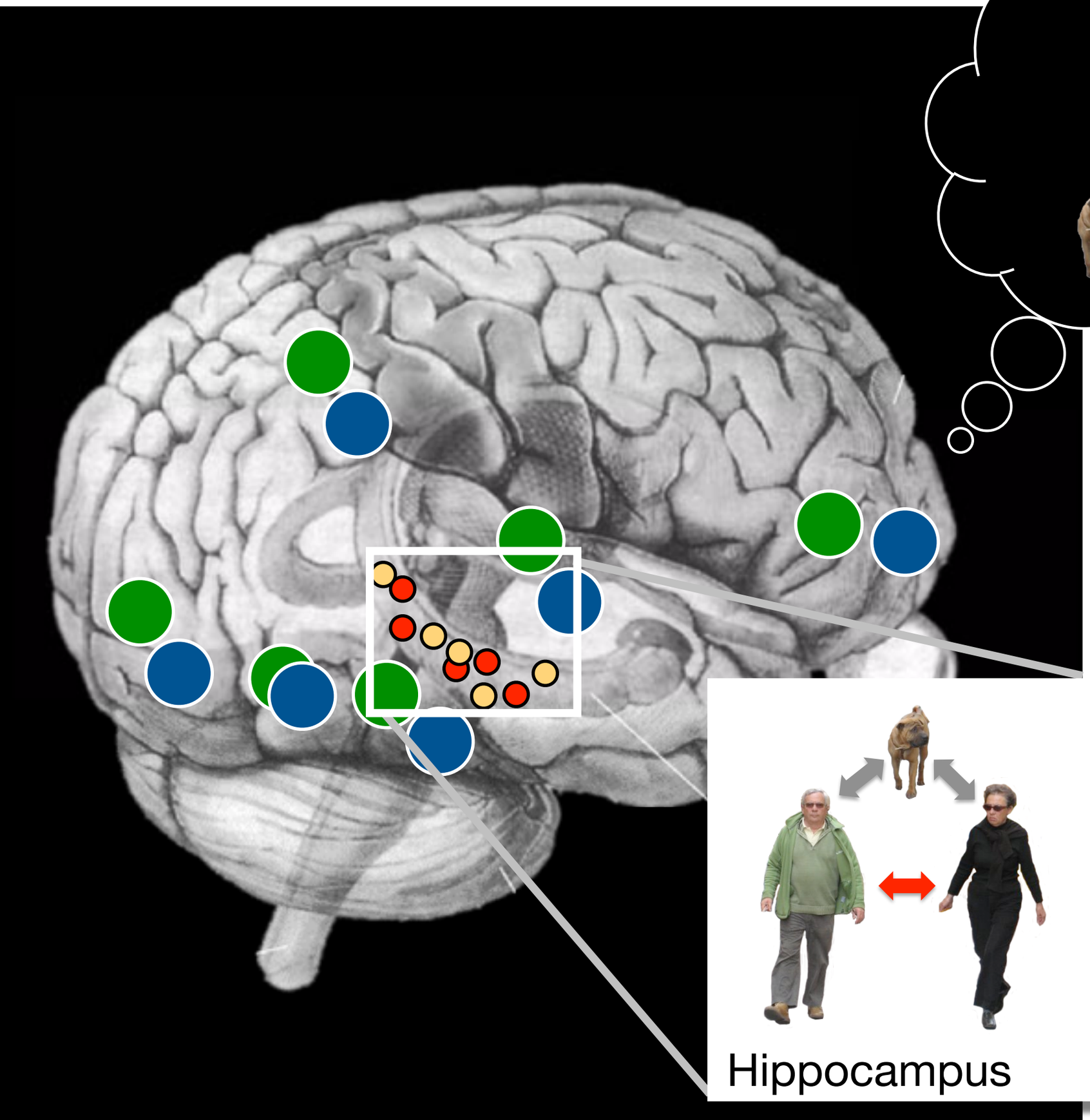
MEMORIES are building blocks

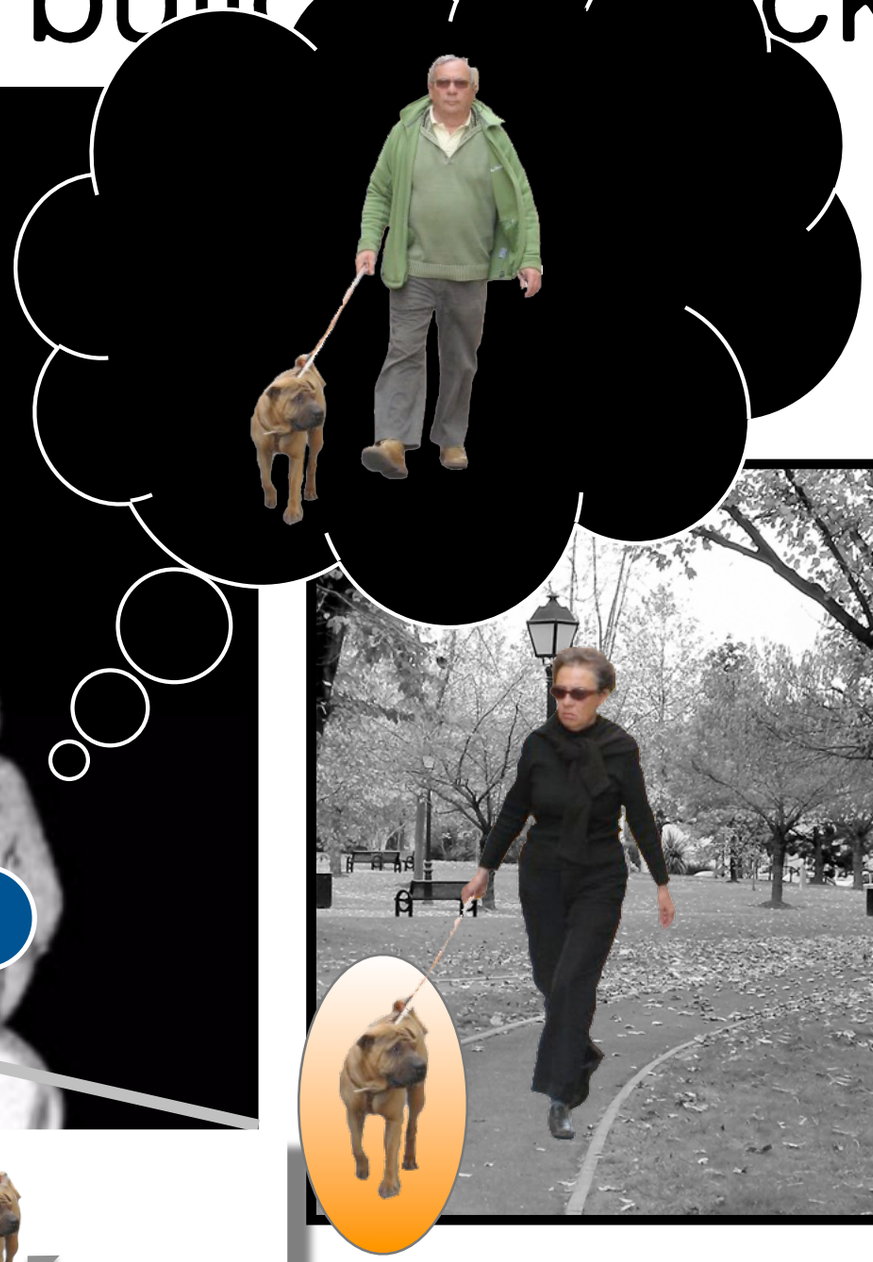




Remembering impacts new learning

MEMORIES are building blocks





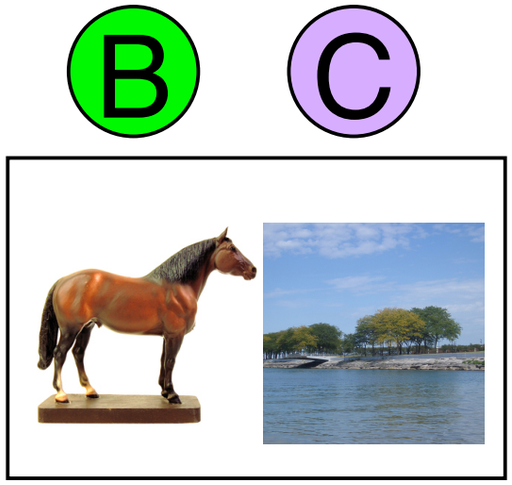
Memories **go beyond** direct experience

Measuring how memories are made

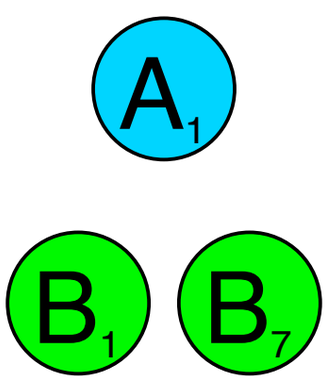
Learning

Initial Association

Overlapping Association

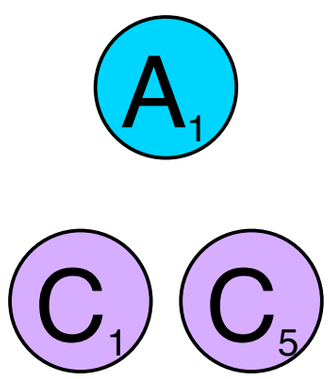


Memory Test



Learned Association

Inferential Association



Examine how brain activation during learning supports later performance on memory tests

functional Magnetic Resonance Imaging (aka fMRI)

Mental process

↓

Brain cell “fires”

↓

Increased bloodflow

↓

More oxygen to brain

↓

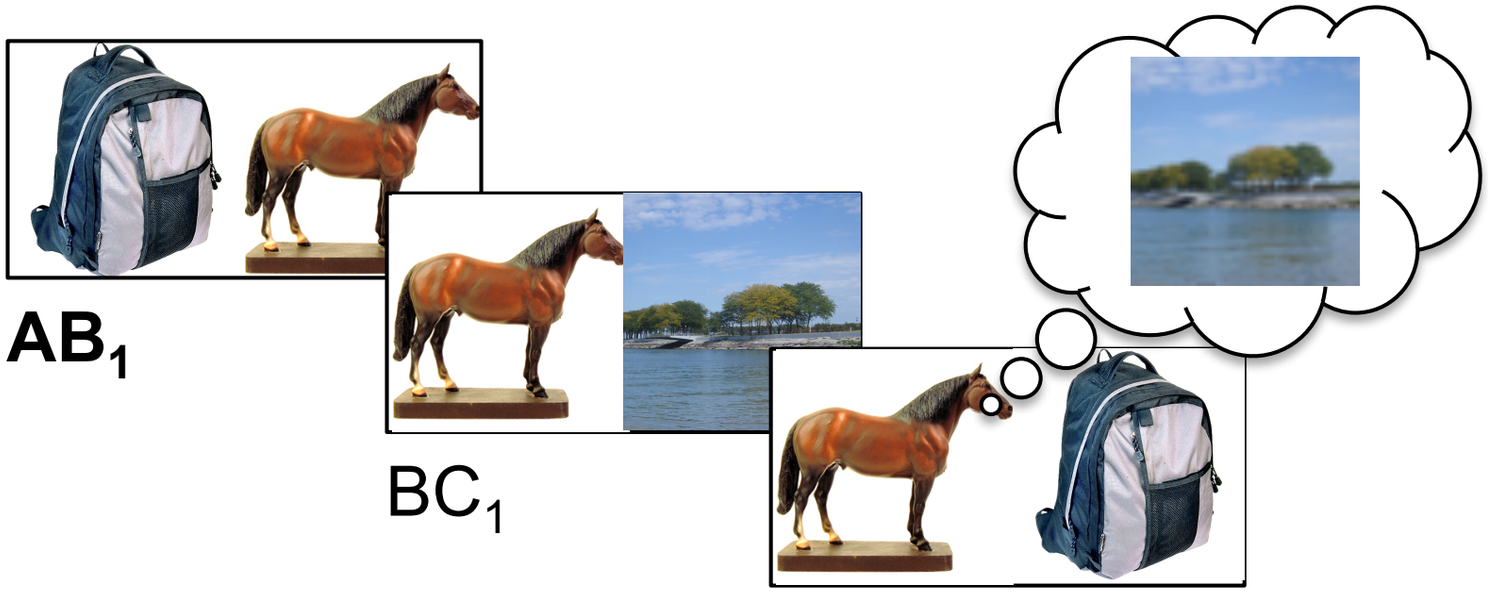
Increased fMRI signal

Remembering influences learning

- **Remember** the first time
  you saw it

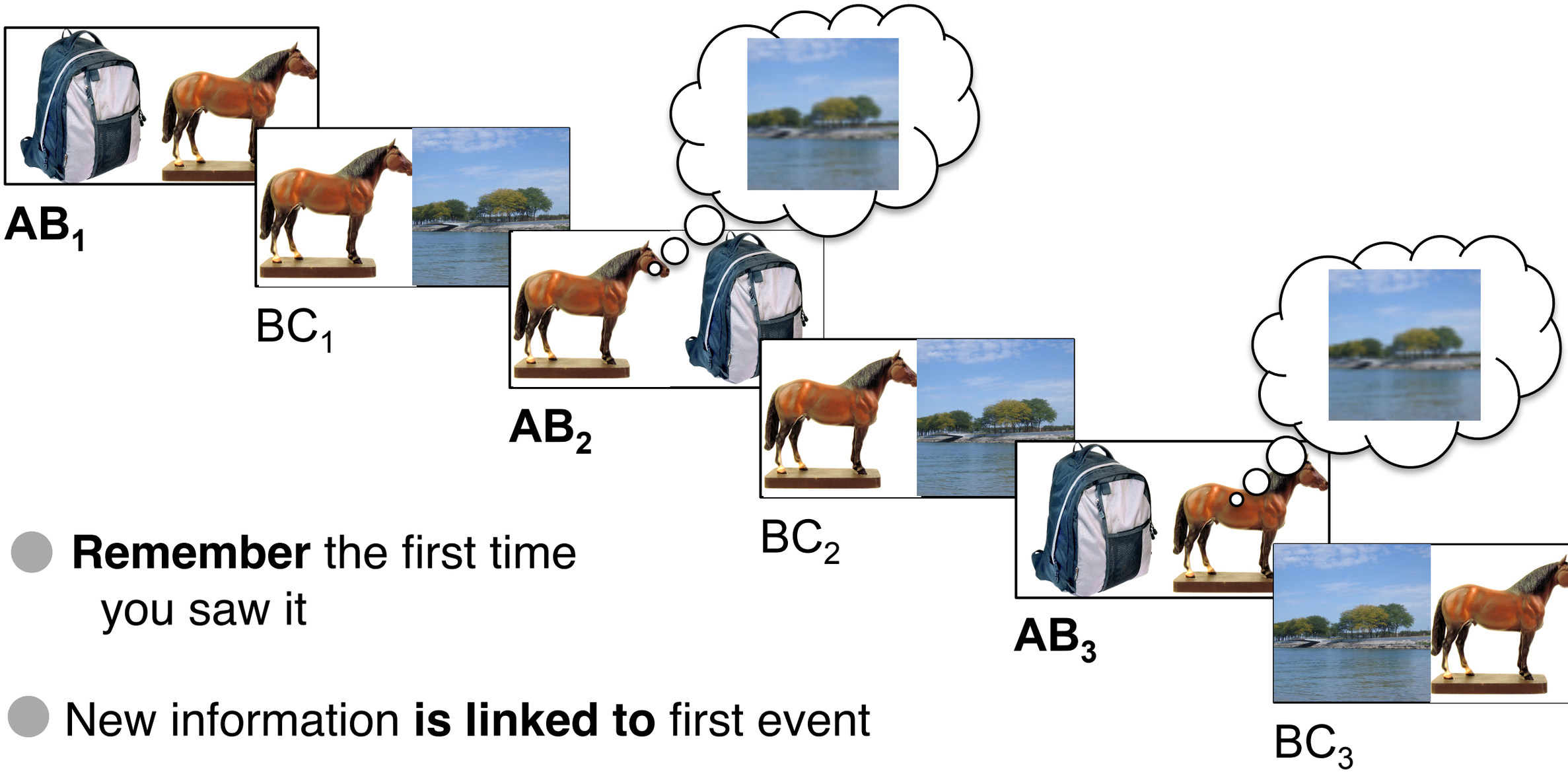
- New information **is linked to** first event

Remembering influences learning



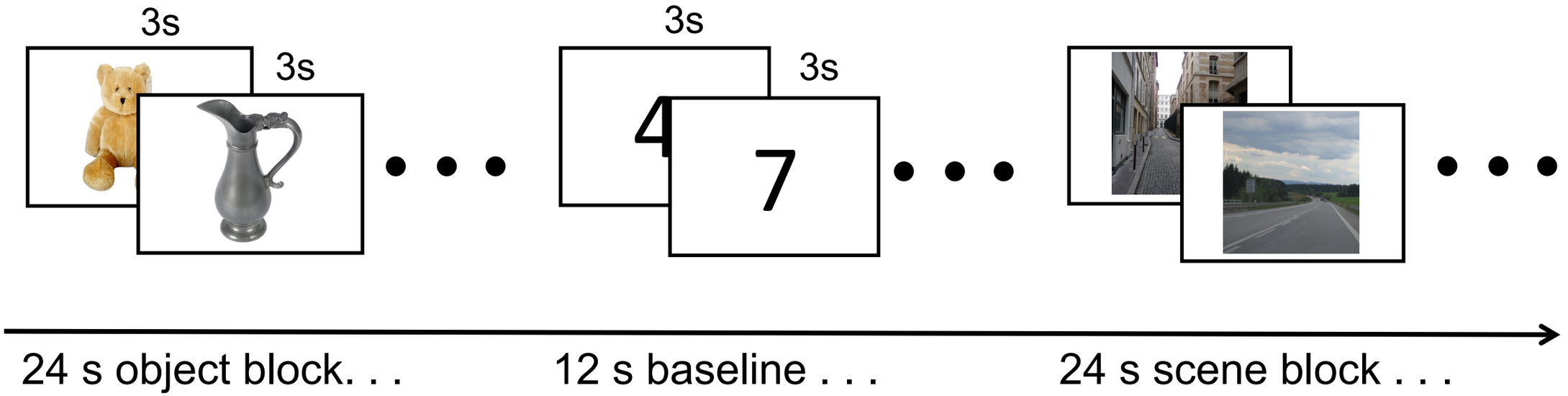
- **Remember** the first time you saw it
- New information **is linked to** first event

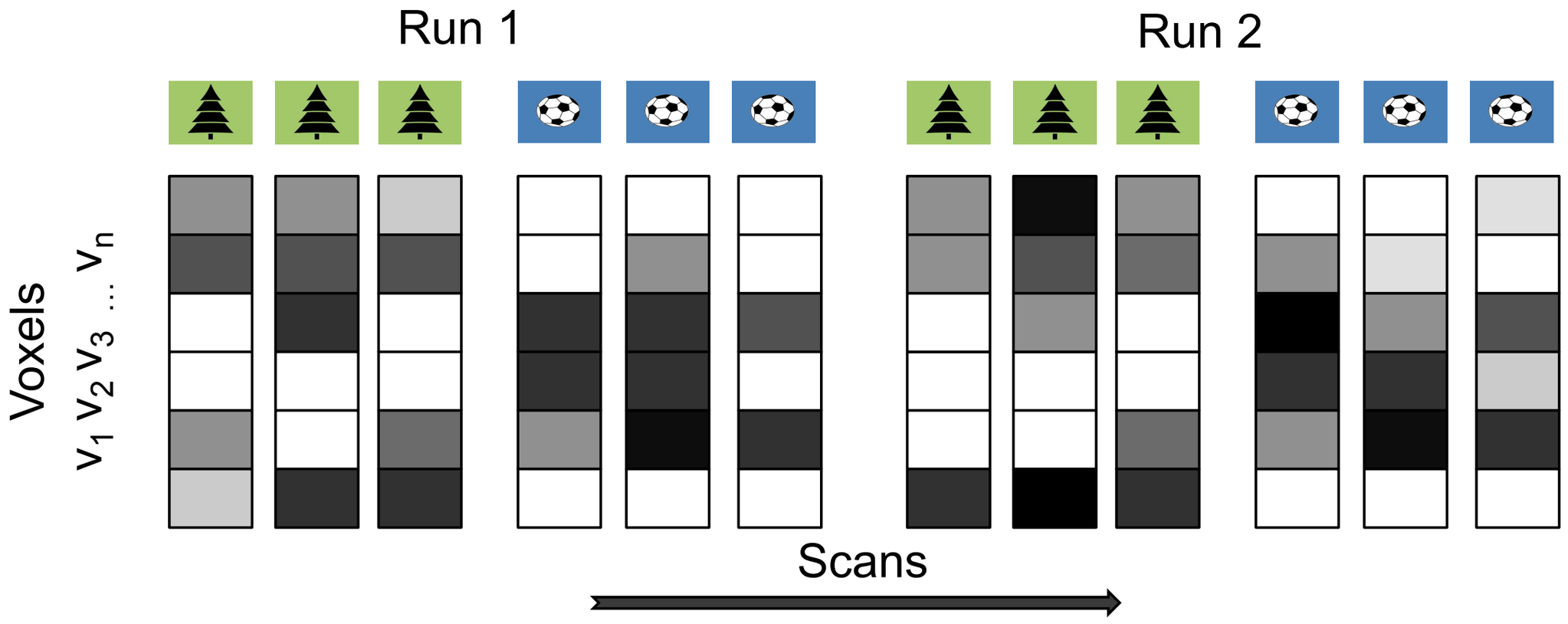
Remembering influences learning



- **Remember** the first time you saw it
- New information **is linked to** first event
- Anticipate that backpack and lake **go together**
- Makes it **easier** to answer inferences at test

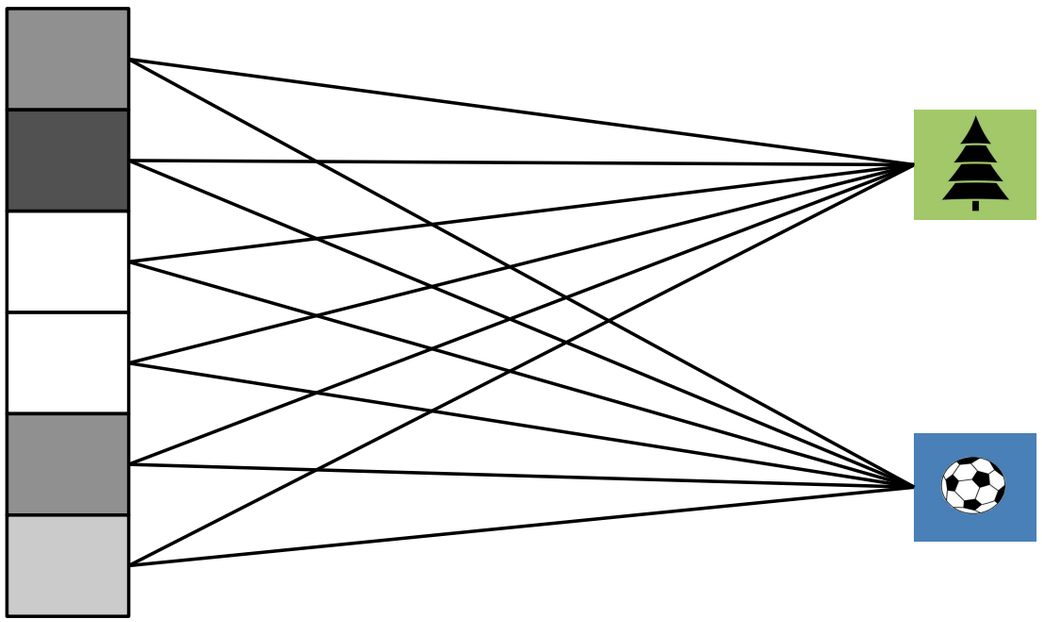
Measuring reactivation during overlapping events





Measuring reactivation during overlapping events

Classify reactivation
across repetitions



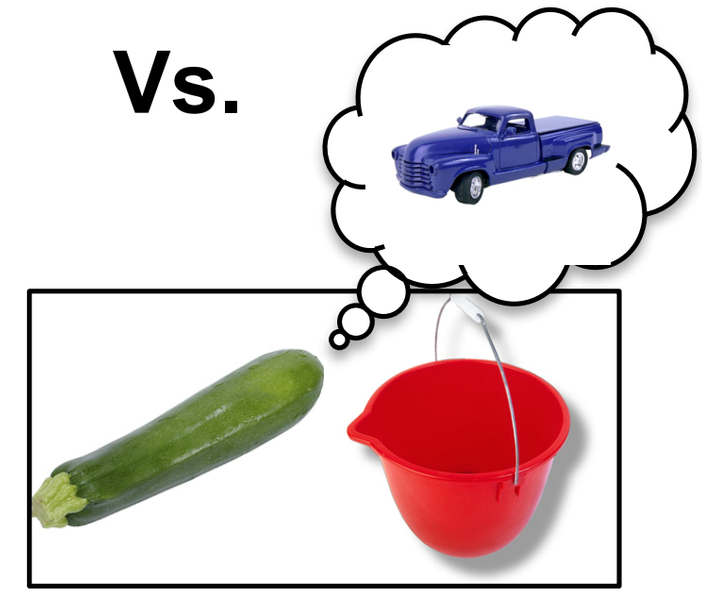
Input
Scan

Classifier
Learned
Weights

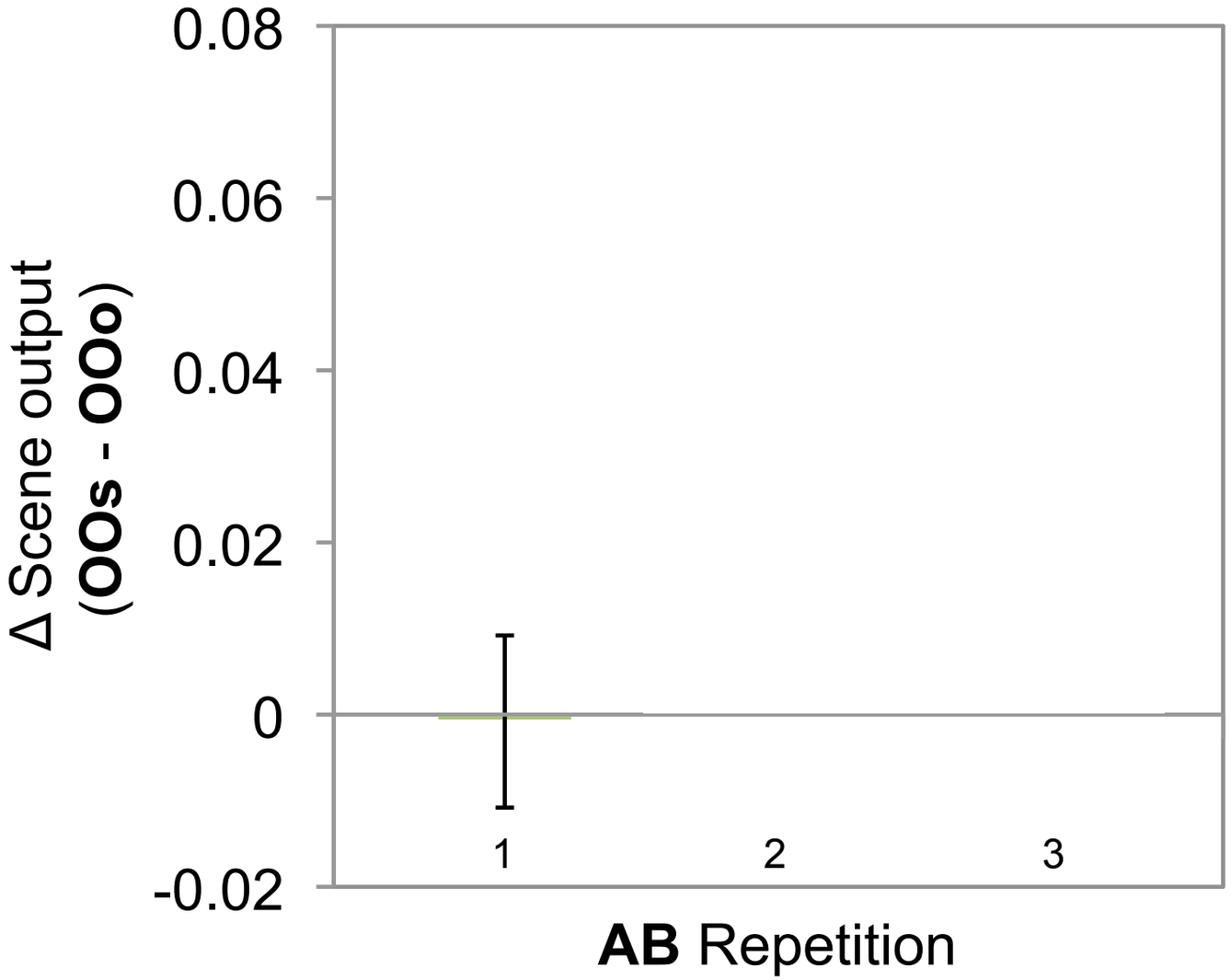
Output =
f(I)

Scene Reactivation

Vs.



Measuring reactivation during overlapping events



Scene Reactivation

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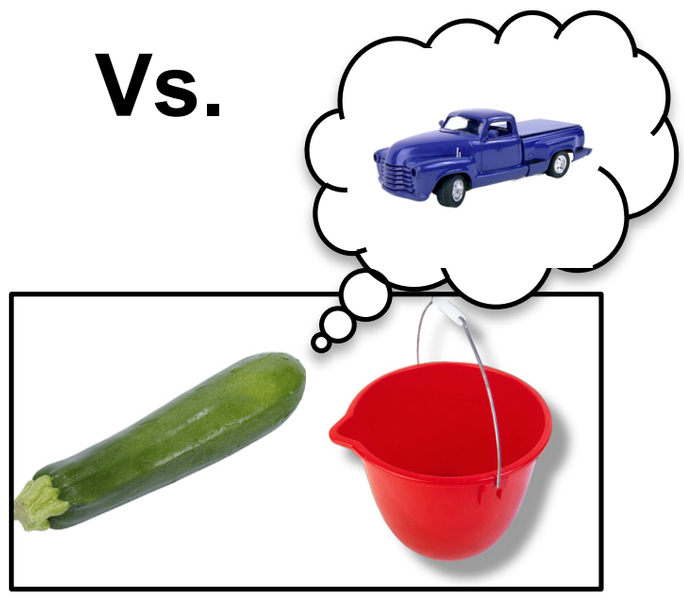

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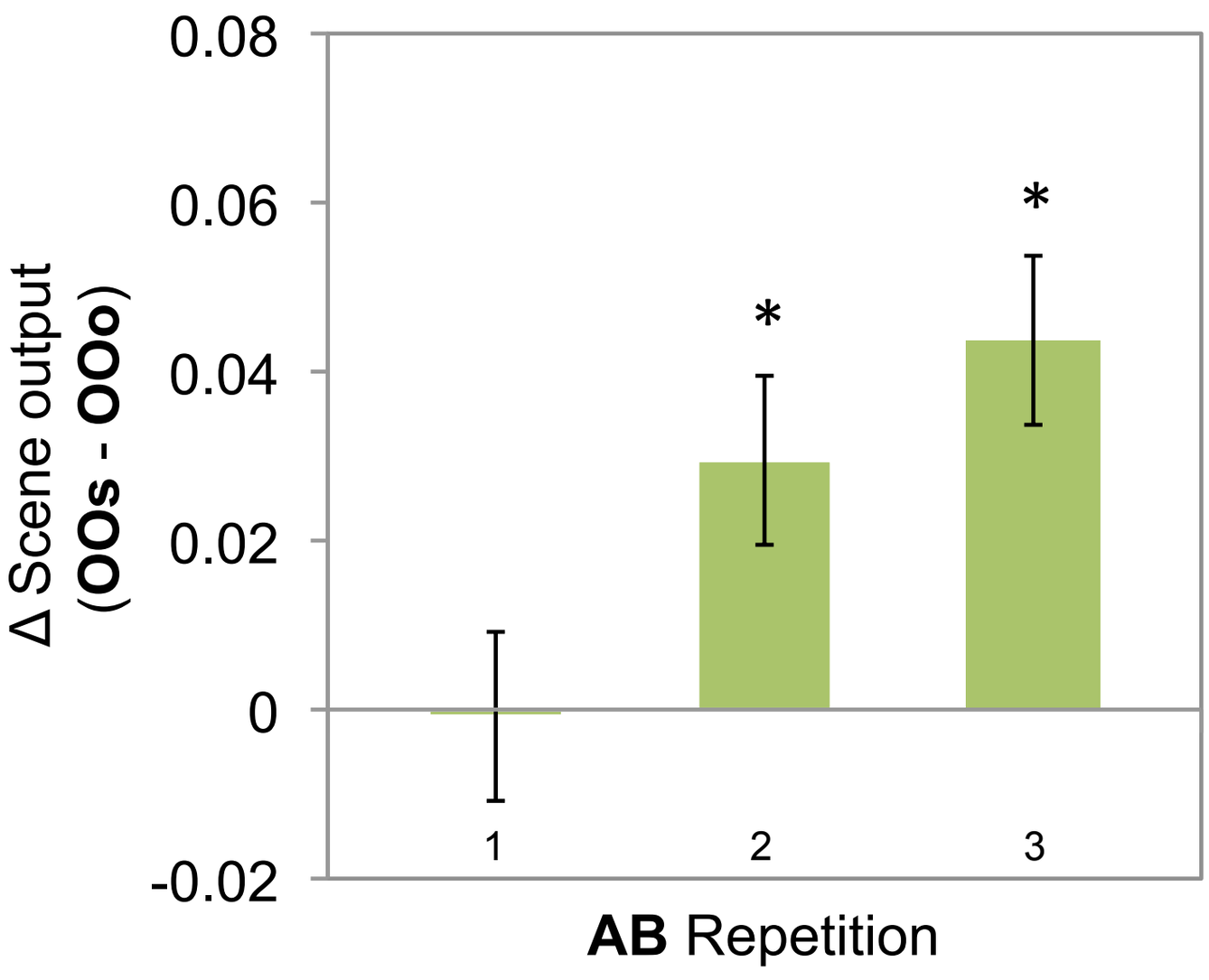
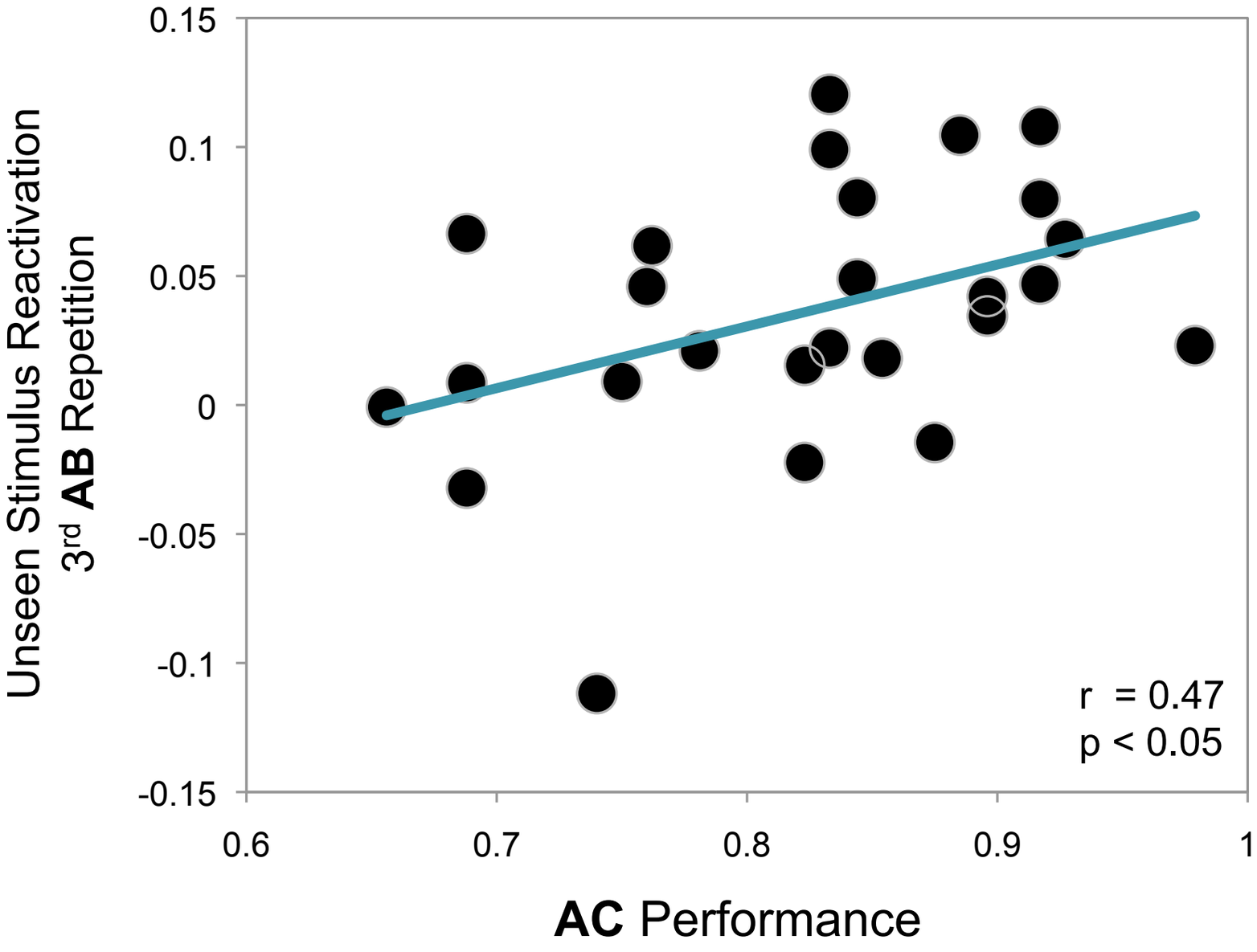


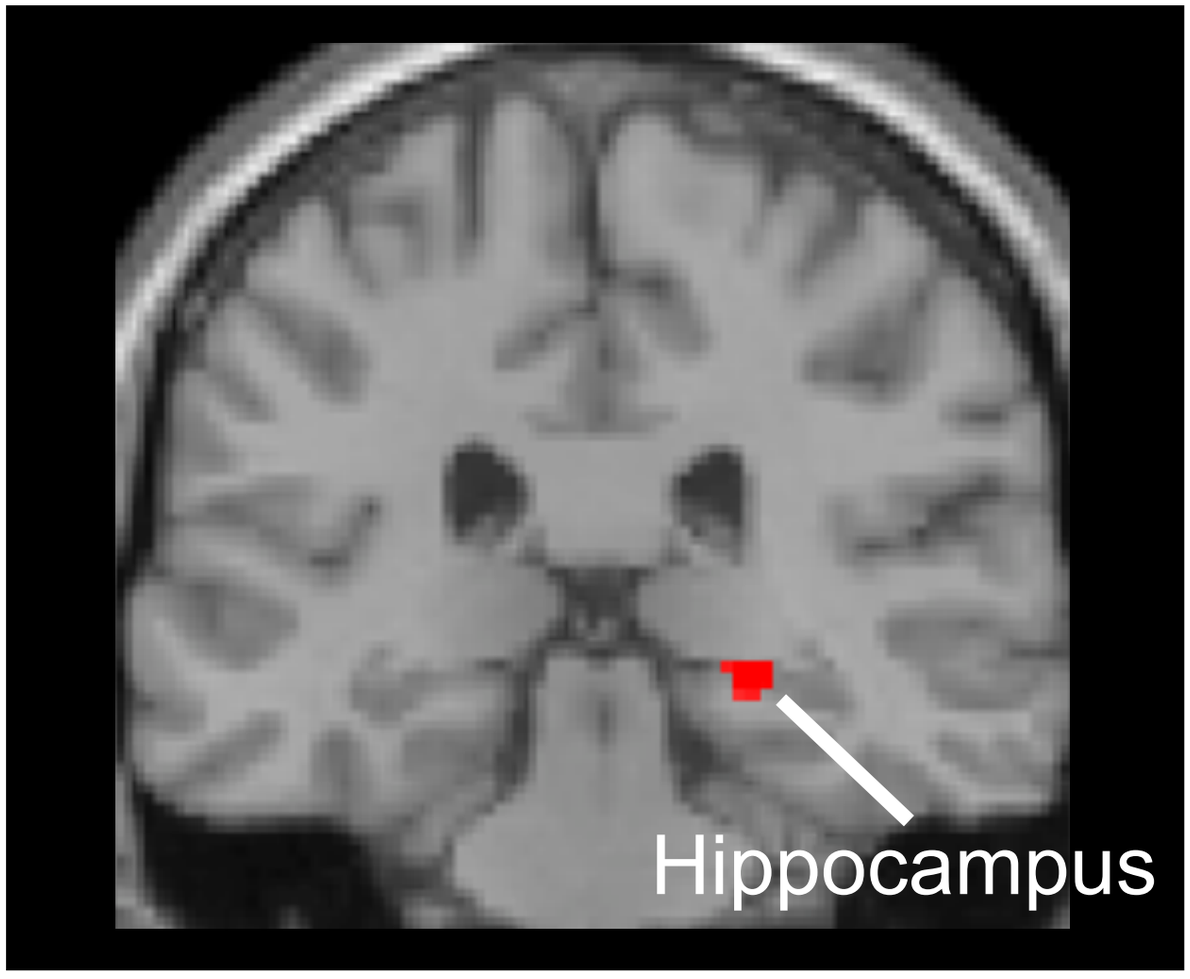
? Does reactivation predict **flexible inference**

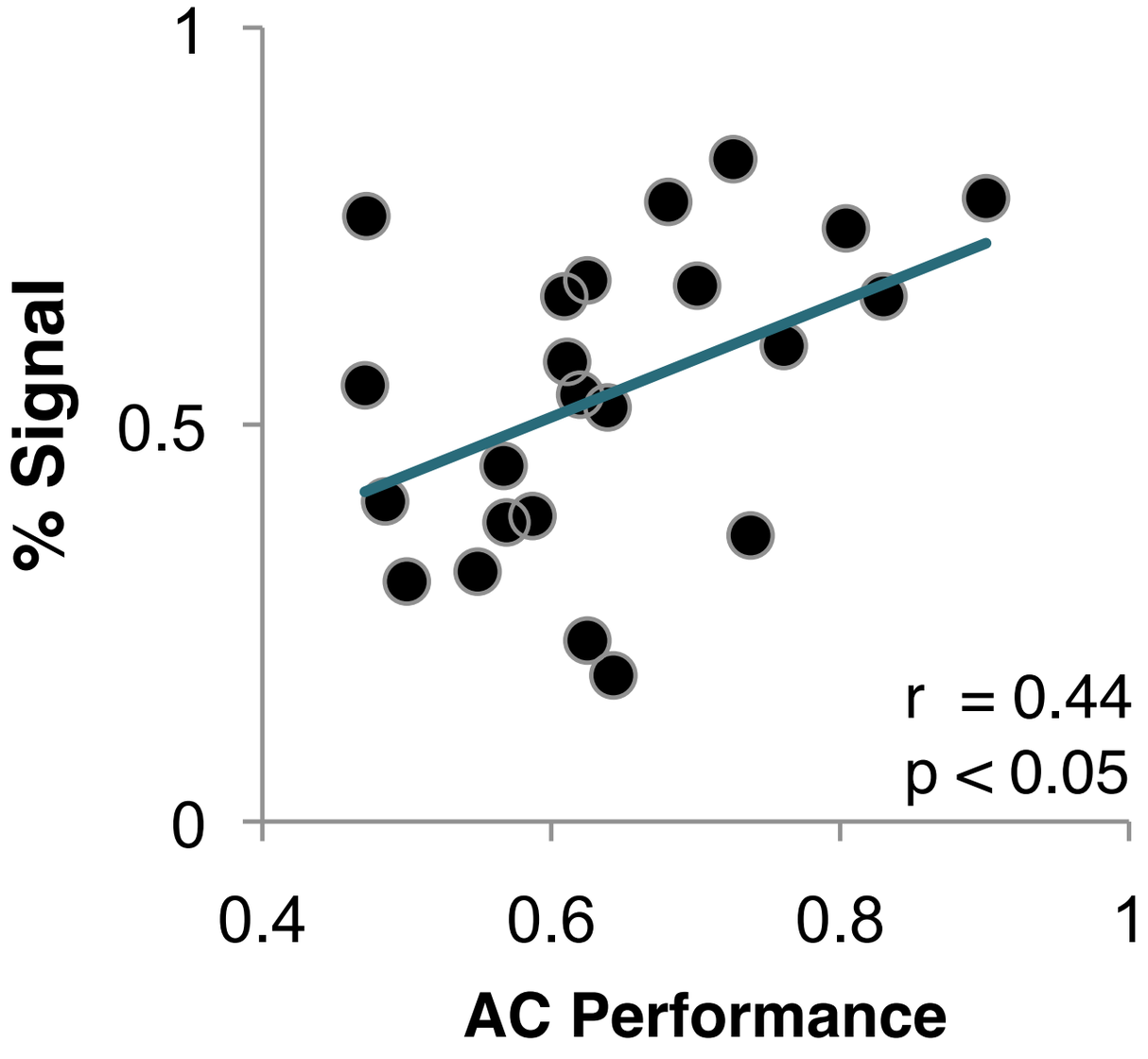
Measuring reactivation during overlapping events



? Does reactivation predict **flexible inference**

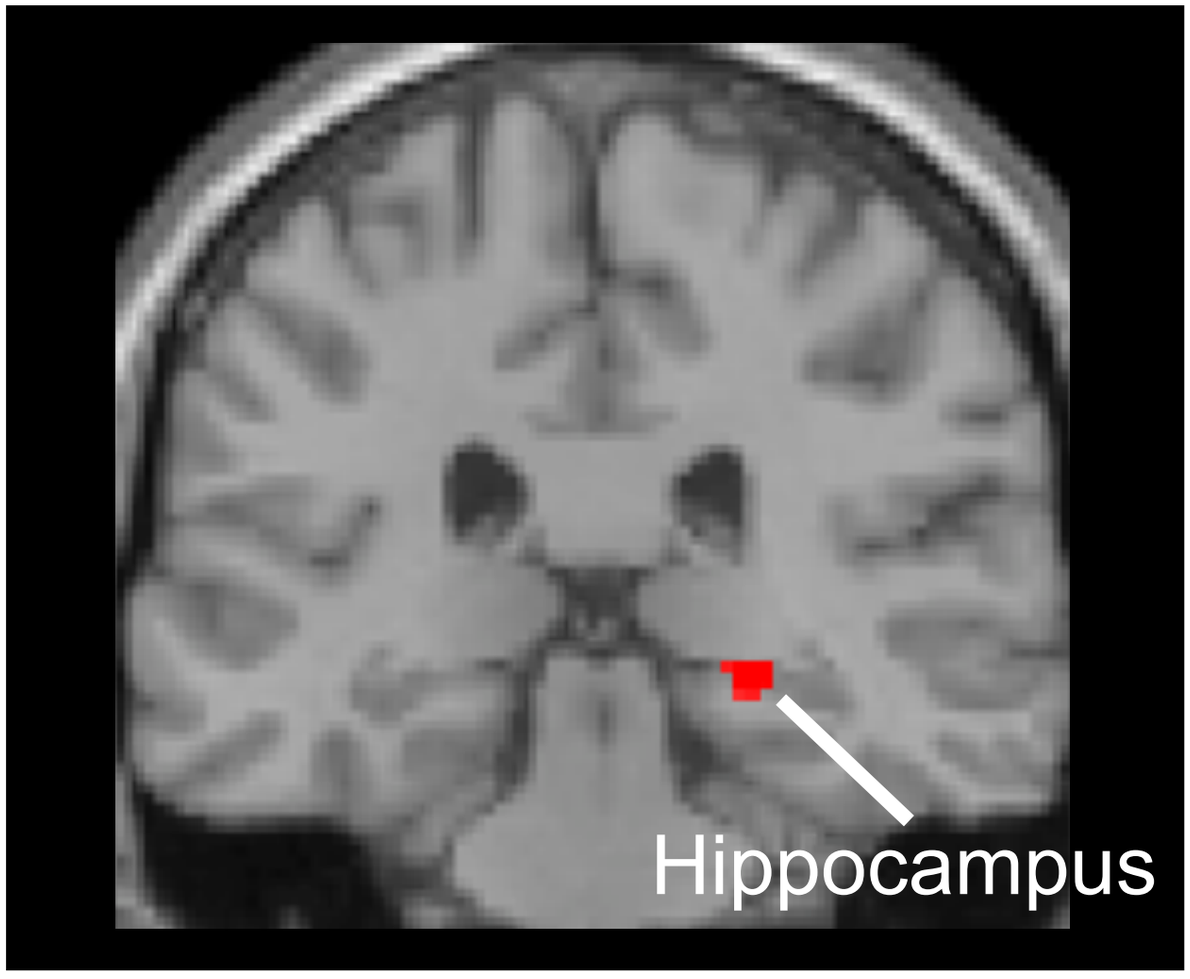
How does hippocampus relate to flexible expression of memory?

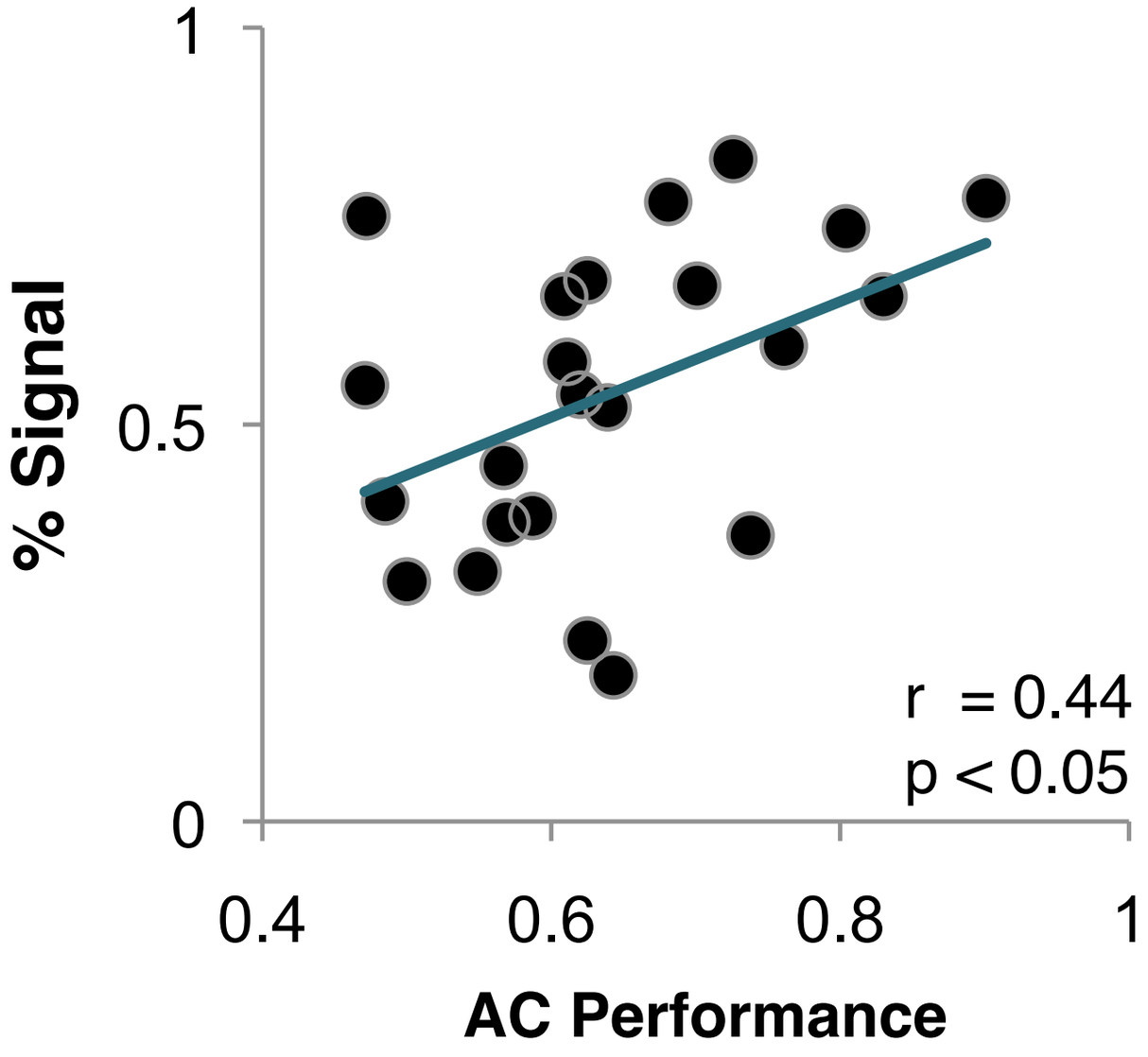




Greater **hippocampal** engagement
leads to better flexible memory performance

How does hippocampus relate to flexible expression of memory?



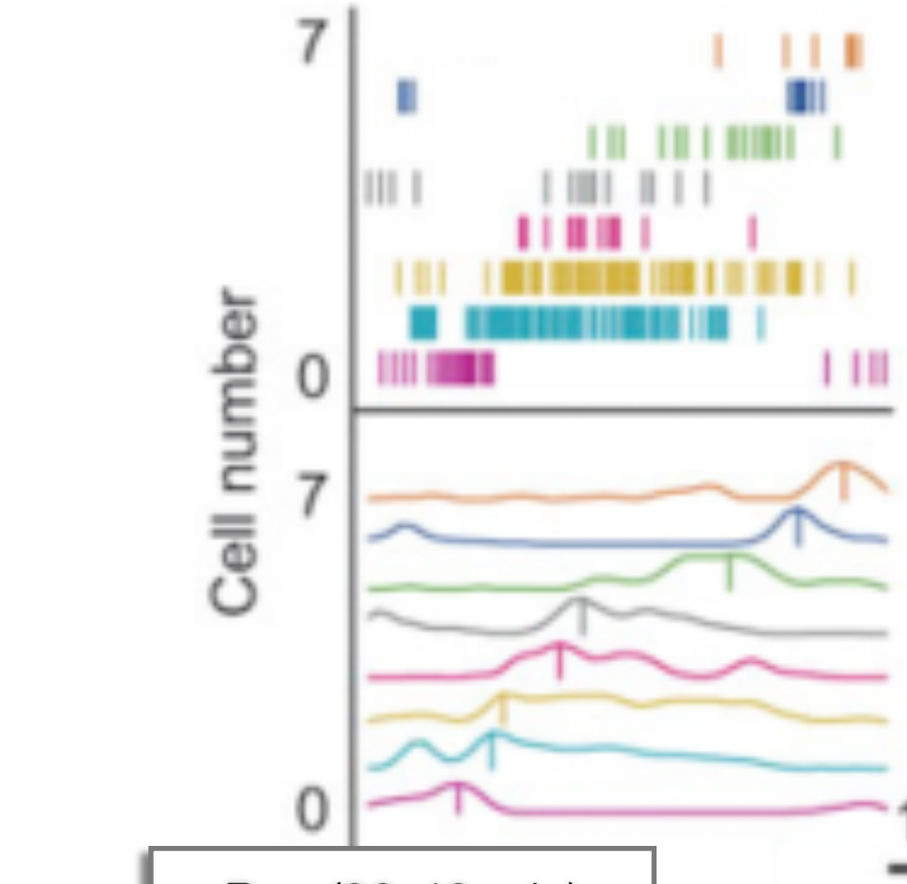


Links current experience **together with** reactivated memories

Of practical importance....

Sleep plays an important role in making memories stronger

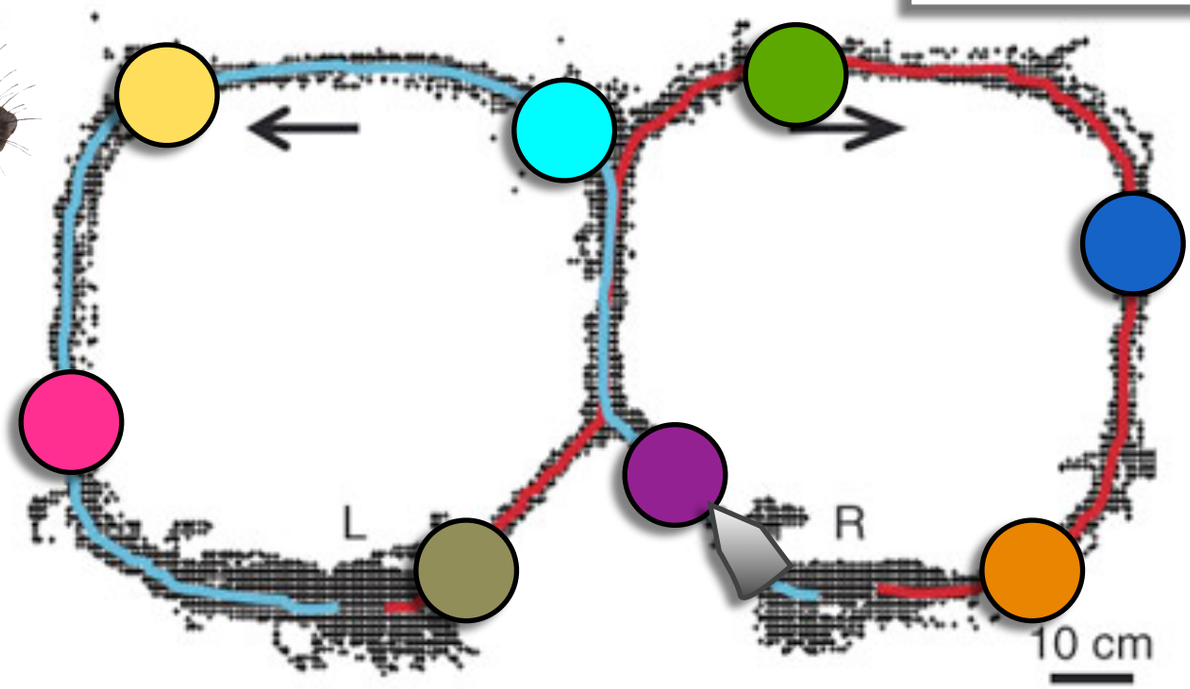
To sleep perchance to remember?



Run (20-40 min)

Experiences
are **replayed**
during sleep

Slow Wave Sleep (1-2 h)



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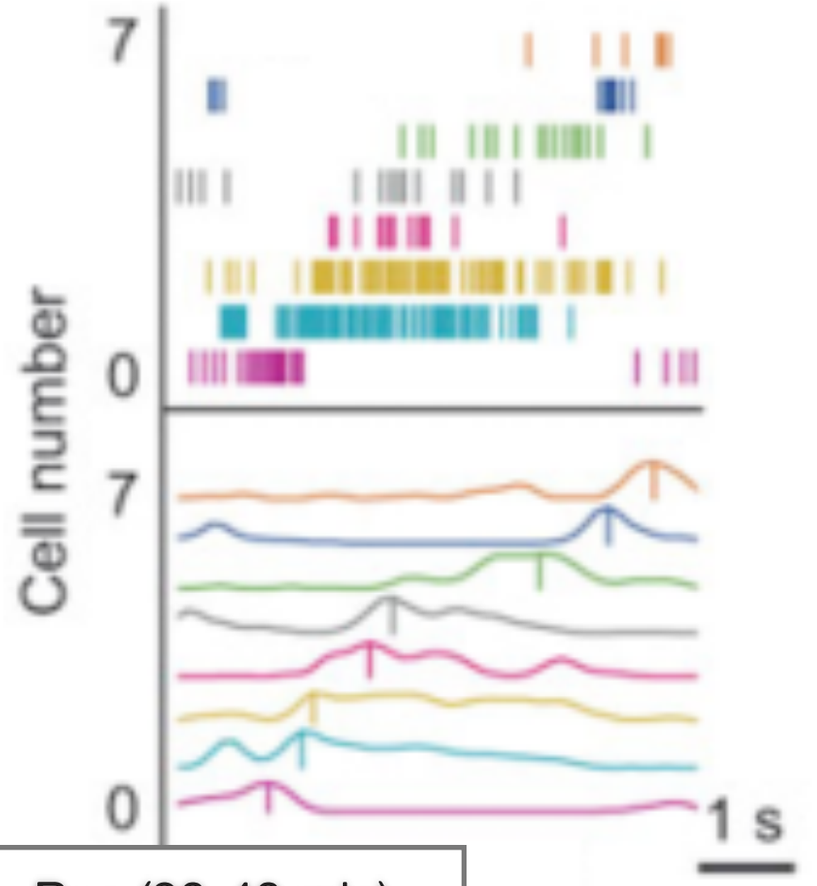
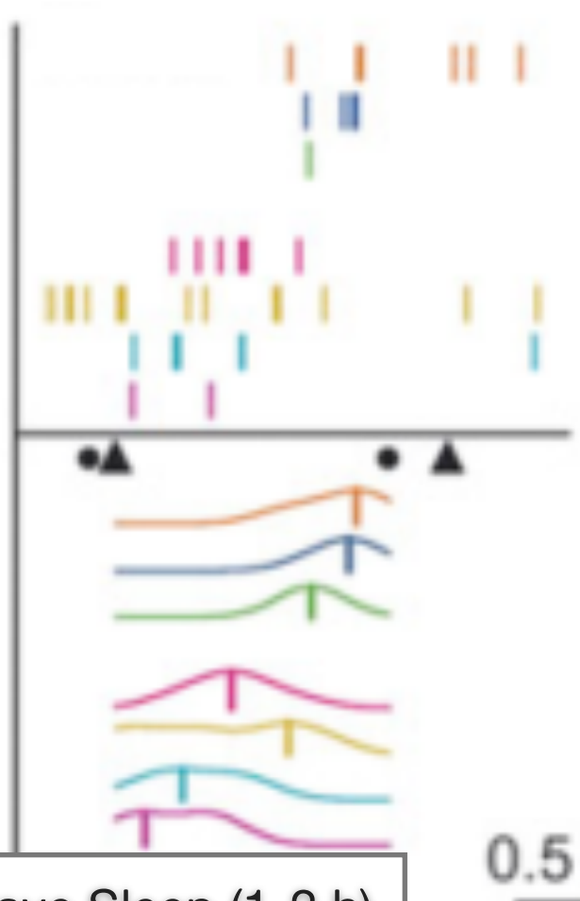
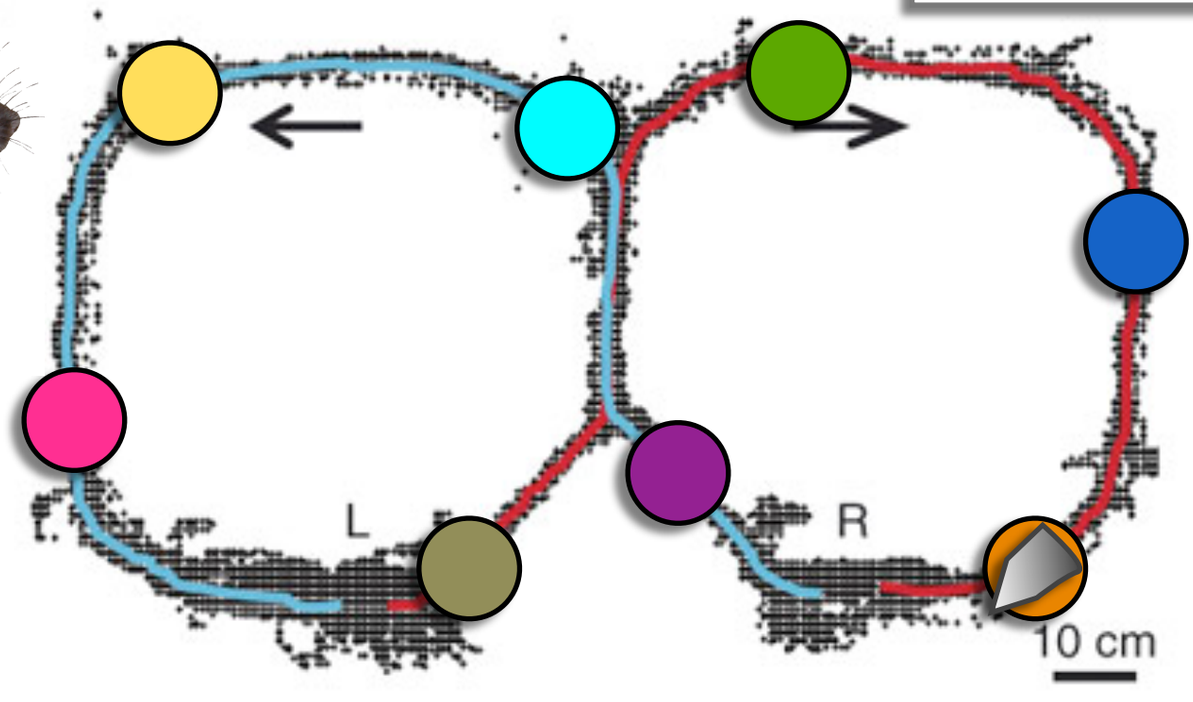


Run (20-40 min)

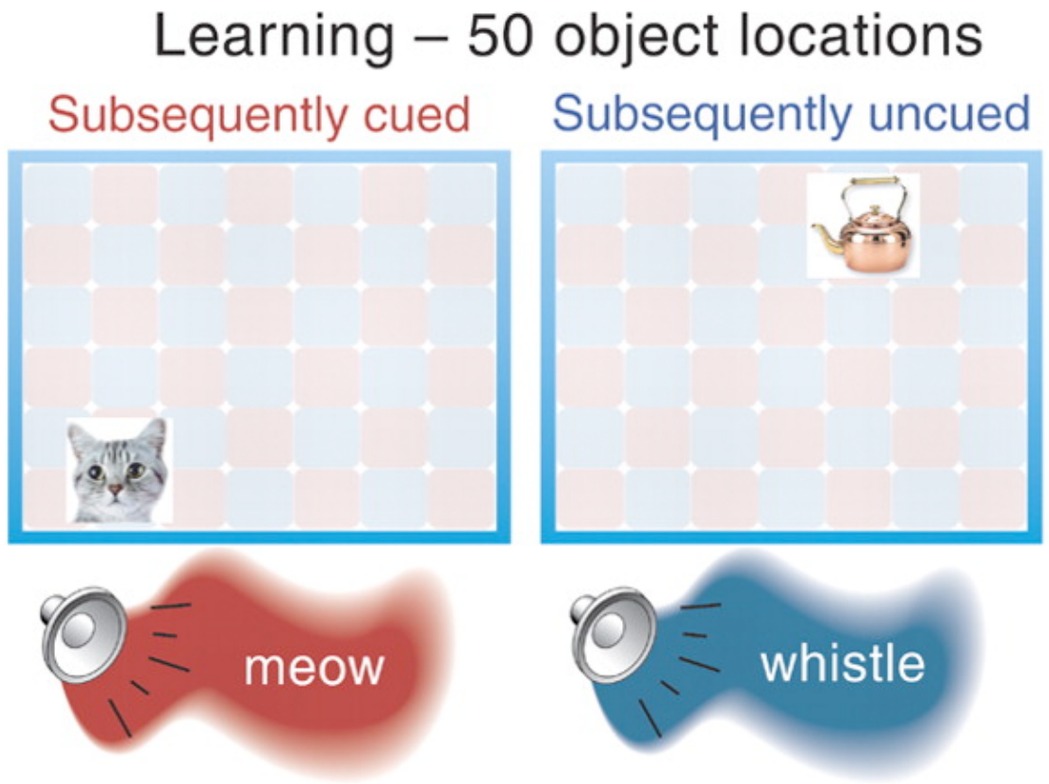
But does it really make memories **stronger**?

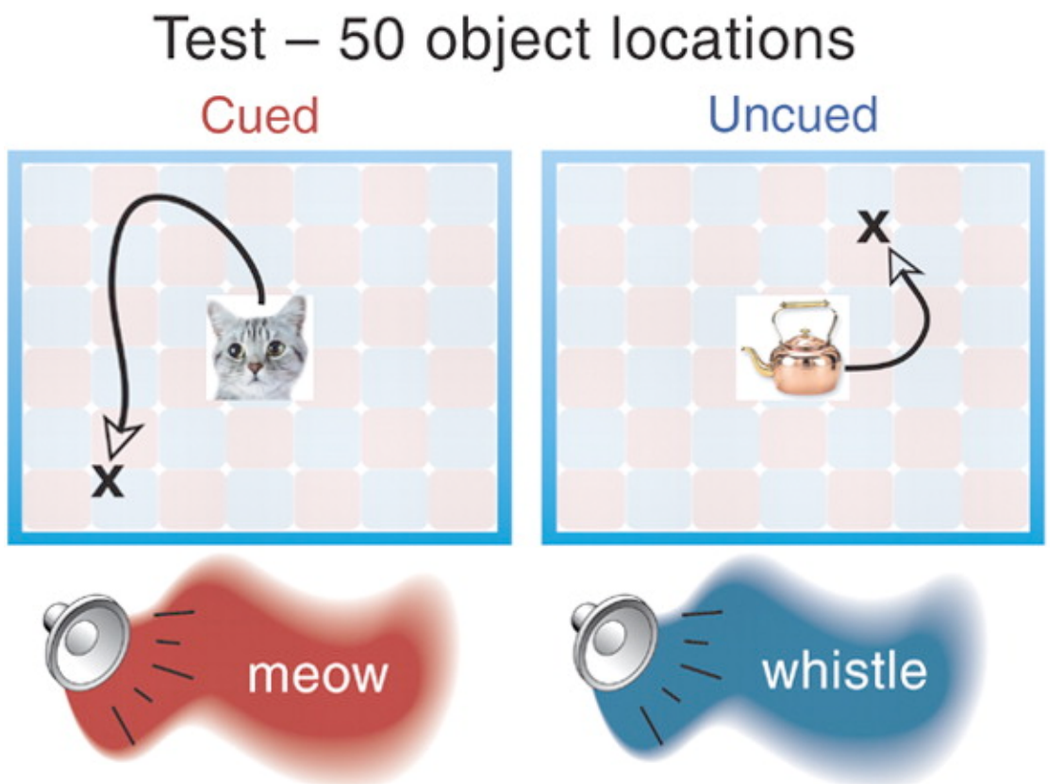


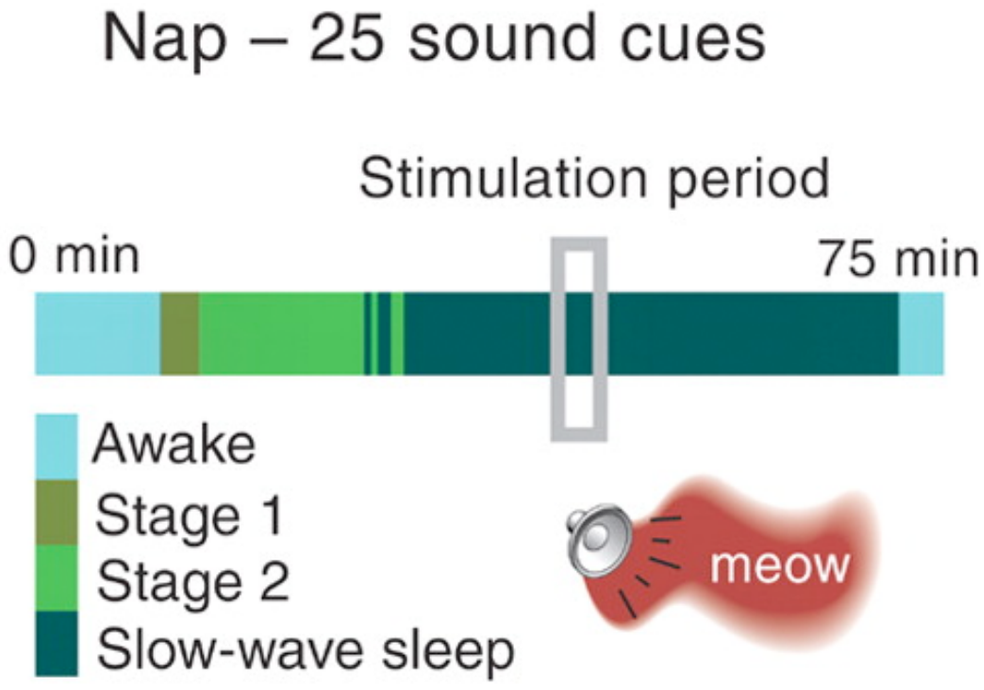
Slow Wave Sleep (1-2 h)



To sleep perchance to remember?

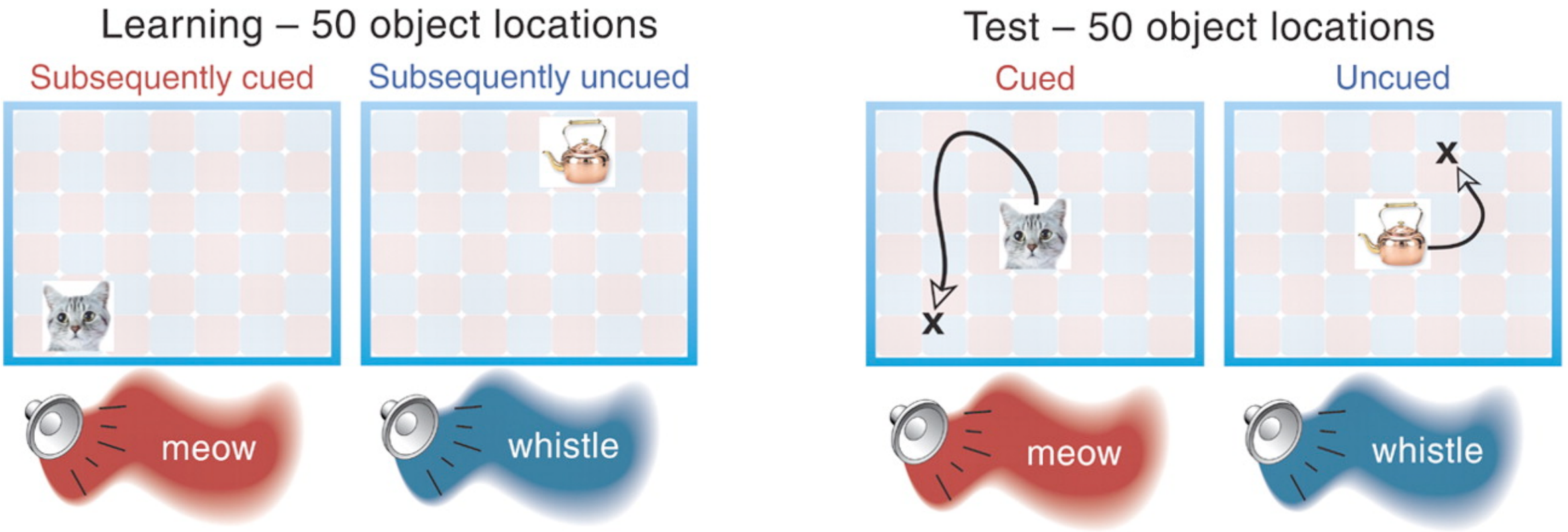


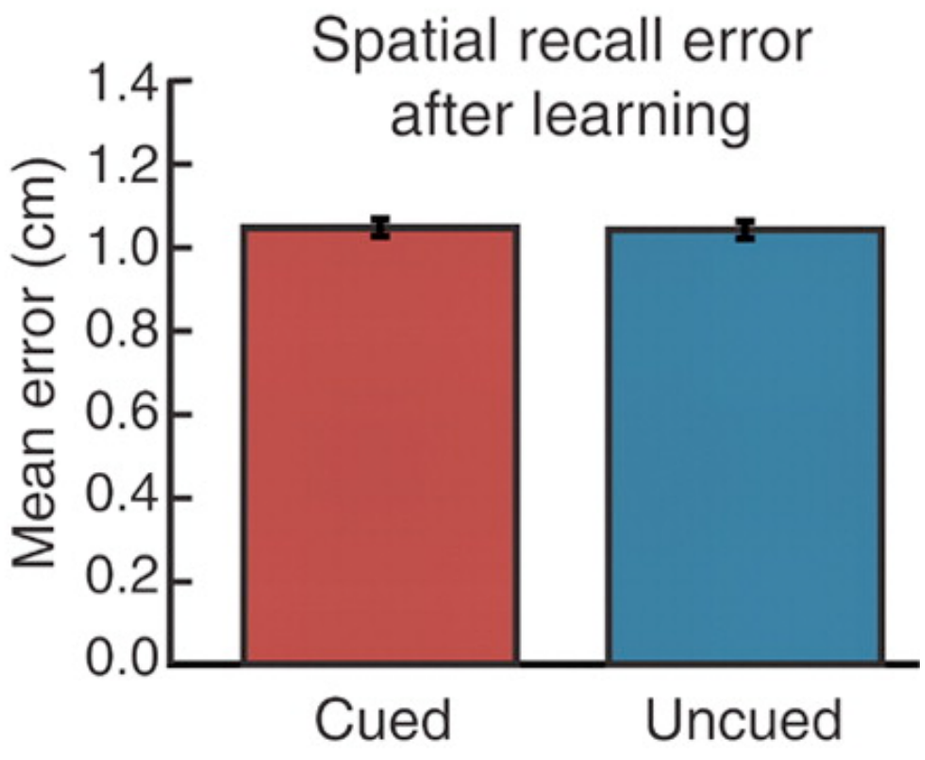




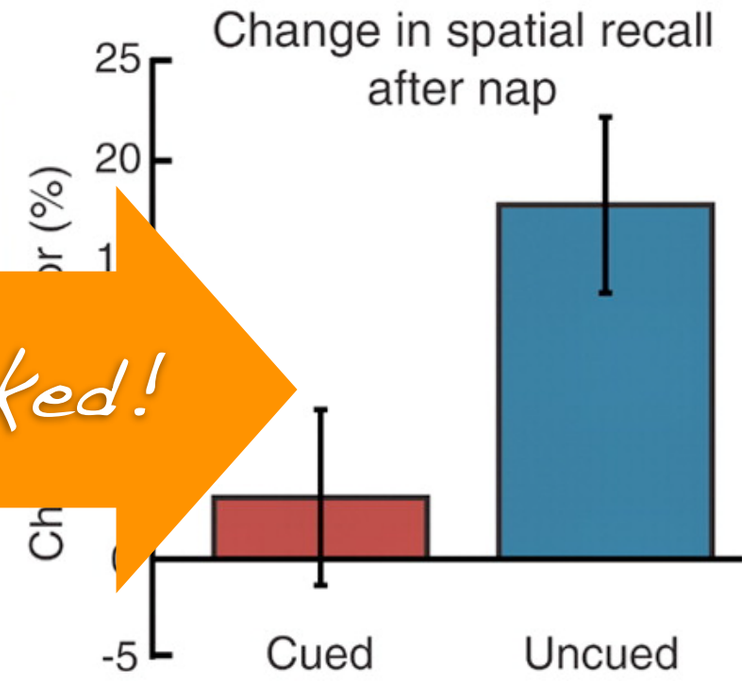
Does playing the sounds during sleep **facilitate** memory?

To sleep perchance to remember?





It worked!



Replay during sleep as an active process of memory construction

- Sleep facilitates extraction of **gist**, novel **insights**, and **inferences**

Training

Premise pairs:

A > B

B > C

C > D

D > E

E > F

Hierarchical relationship:

A > B > C > D > E > F

Replay during sleep as an active process of memory construction

- Sleep facilitates extraction of **gist**, novel **insights**, and **inferences**

Training

Premise pairs:

A > B

B > C

C > D

D > E

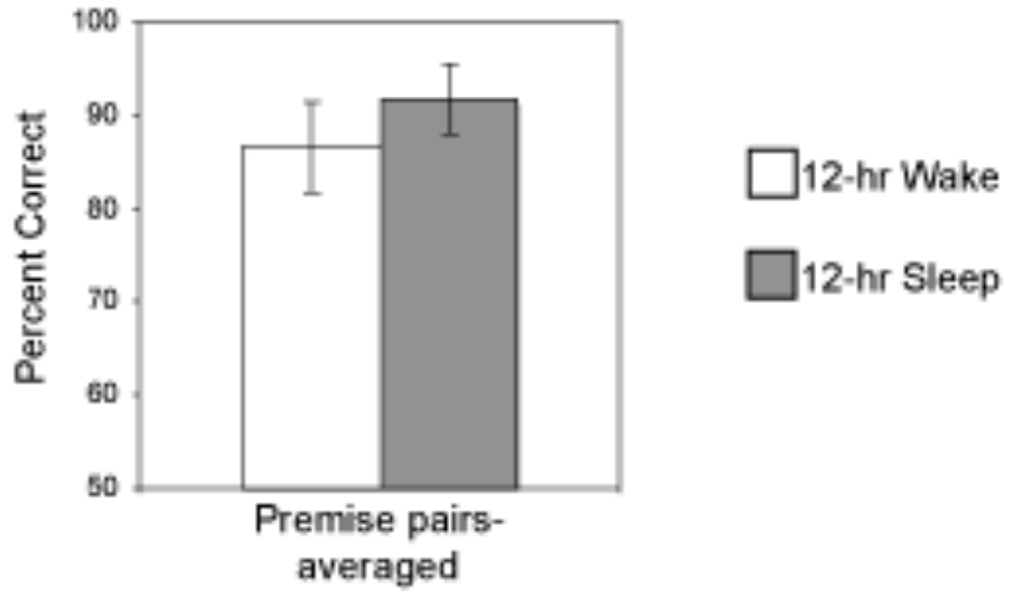
E > F

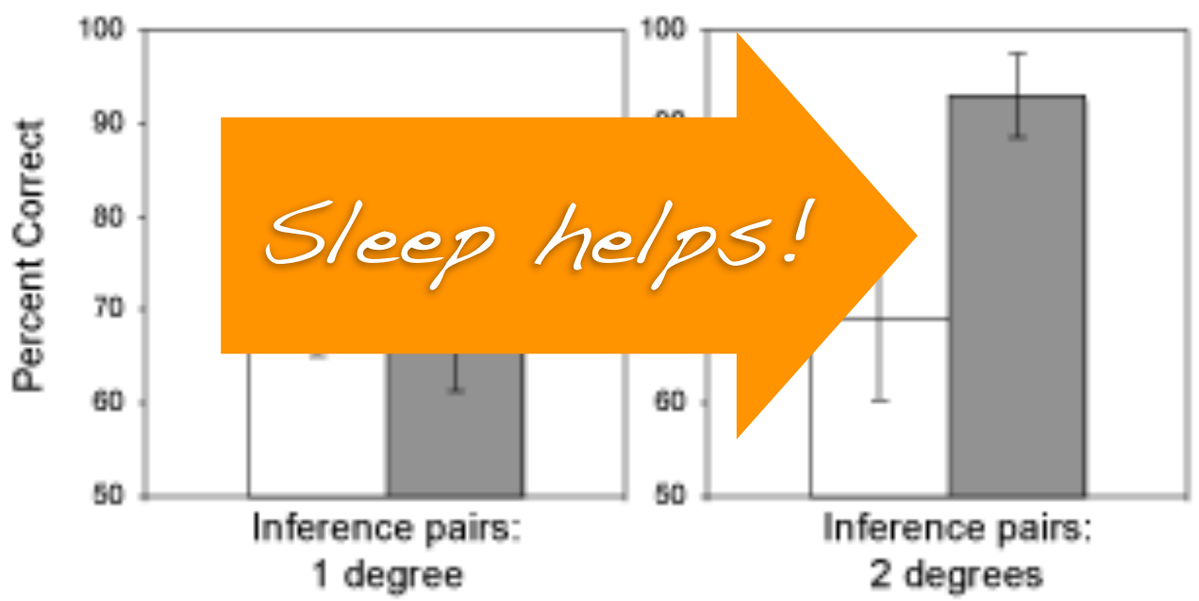
Relational Memory Test

Inference pairs:

B > D
C > E
} 1° separation

B > E
} 2° separation





Great!... But what about?...

Sleep is good, but is

lack of sleep

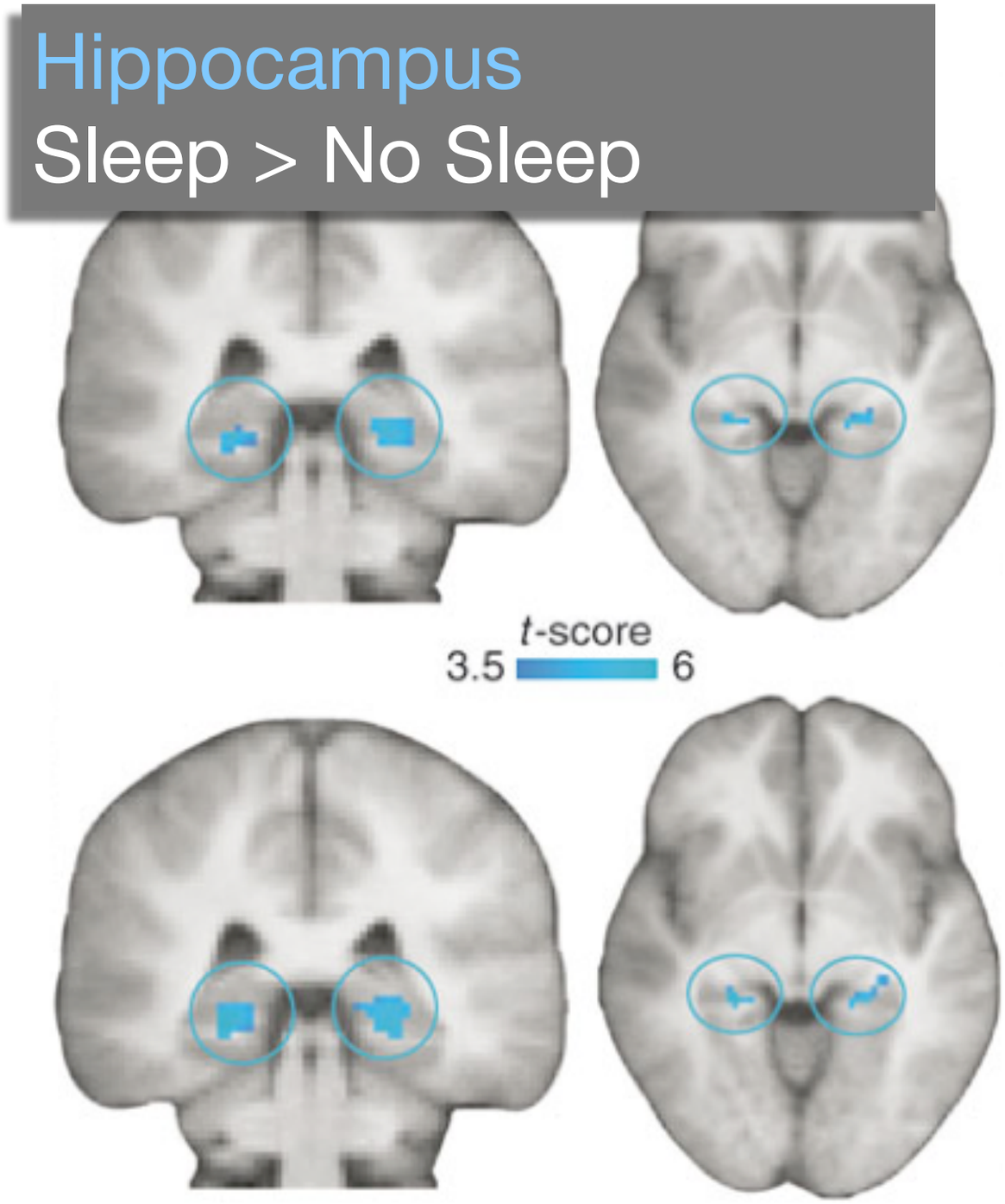
bad?

75% of Americans sleep less than 8h a night

20% of Americans have clinic sleep disorders

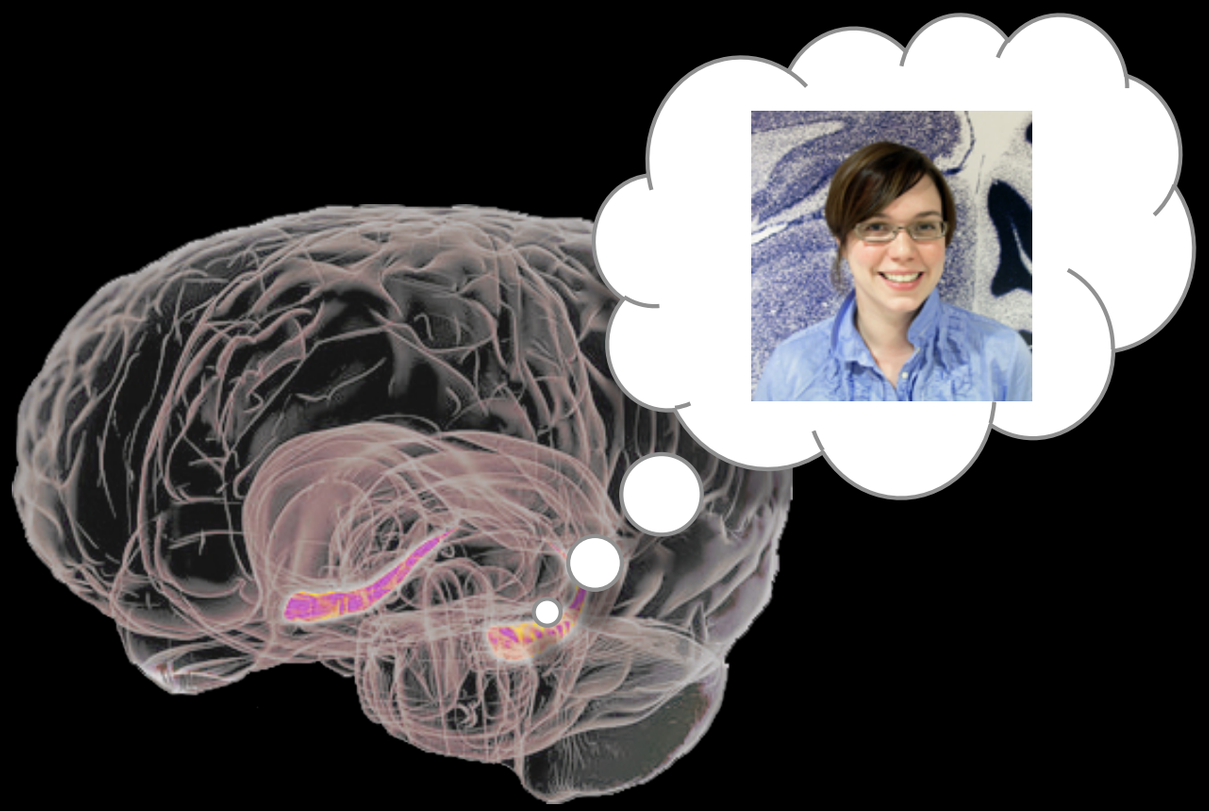
Your brain on *no sleep*

Hippocampus
Sleep > No Sleep



➡ Fewer memories formed

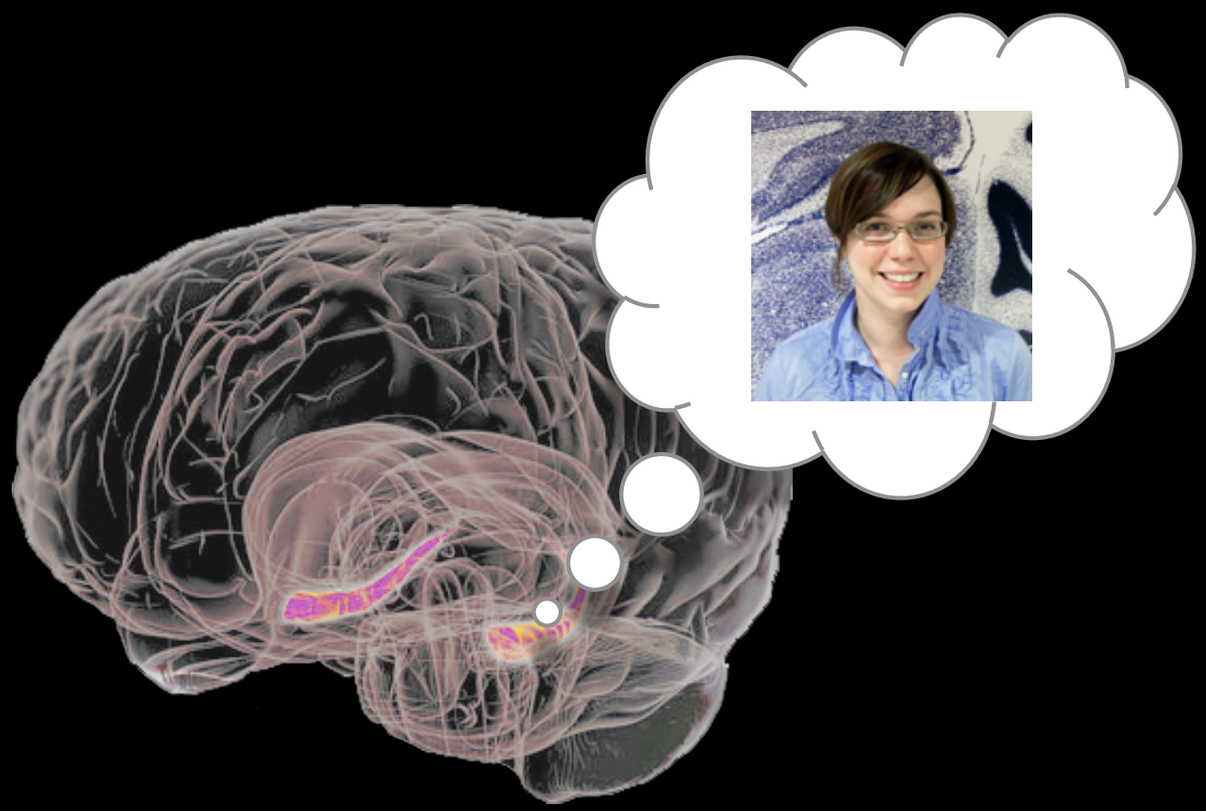
What does
all of this mean?



Memory…

1. is many things
2. anticipates the future
3. goes beyond actual experience
4. is ever changing
5. likes to sleep

What does all of this mean?

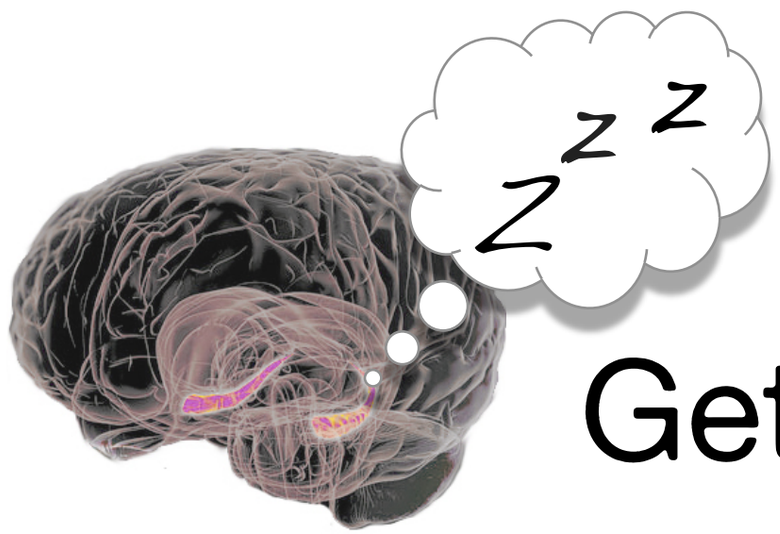


Implications...

- basic understanding of the mind
- educational practice
- enhance memory in aging & clinical populations

PRESTON LAB

http://clm.utexas.edu/~preston



Get some rest!

Dr. Alison Preston

Dr. Alison Preston is an Assistant Professor in the Department of Psychology and Section of Neurobiology at the University of Texas and a member of the UT Center for Learning and Memory. Dr. Preston's research focuses on understanding how memory is implemented in the human brain using functional brain imaging techniques, and she has published several articles in peer review medical journals describing her research efforts. She also teaches courses on the growing field of cognitive neuroscience and its impact in the media and society.

Dr. Preston is a recipient of Young Investigator Awards from the National Alliance for Research on Schizophrenia and Depression (NARSAD) and the Department of Defense as well as a recipient of the National Science Foundation's CAREER Award, recognizing her as one of the leading young teacher-scholars in the country.