



Mind wandering

Mental time travel, theory of mind, and language

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We're going through!" The Commander's voice was like thin ice breaking. He wore his full-dress uniform, with the heavily braided white cap pulled down rakishly over one cold gray eye. "We can't make it, sir. It's spoiling for a hurricane, if you ask me." "I'm not asking you, Lieutenant Berg," said the Commander. "Throw on the power lights! Rev her up to 8,500! We're going through!" The pounding of the cylinders increased: ta-pocketa-pocketa-pocketa-*pocketa-pocketa*. The Commander stared at the ice forming on the pilot window. He walked over and twisted a row of complicated dials. "Switch on No. 8 auxiliary!" he shouted. "Switch on No. 8 auxiliary!" repeated Lieutenant Berg. "Full strength in No. 3 turret!" shouted the Commander. "Full strength in No. 3 turret!" The crew, bending to their various tasks in the huge, hurtling eight-engined Navy hydroplane, looked at each other and grinned. "The old man will get us through" they said to one another. "The Old Man ain't afraid of Hell!" . . .

"Not so fast! You're driving too fast!" said Mrs. Mitty. "What are you driving so fast for?"

—from *The Secret Life of Walter Mitty*, by James Thurber

The Secret Life of Walter Mitty

The 1947 movie,
starring Danny Kaye
and Ann Rutherford

Walter Mitty /wol or wol' ter mit' i/

Noun

1. An ordinary person who indulges in escapist day-dreams of fame, power, etc
2. An intrepid daydreamer

—Chambers Dictionary





2013 version with Ben Stiller and Kirsten Wiig

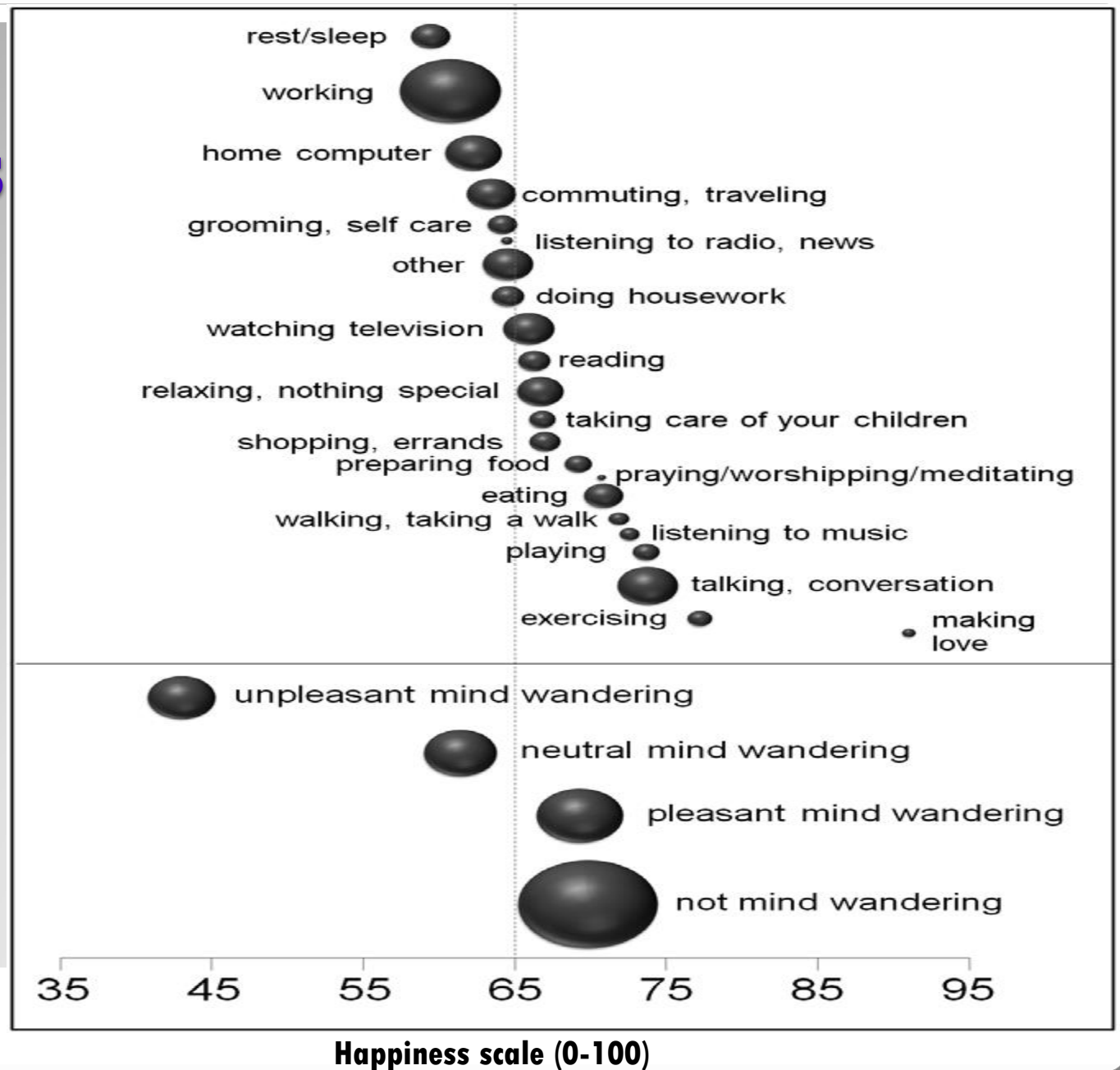
The Harvard experiment

- 2250 people in 83 countries randomly contacted during waking hours
- 46.9% were not focused on what they were doing



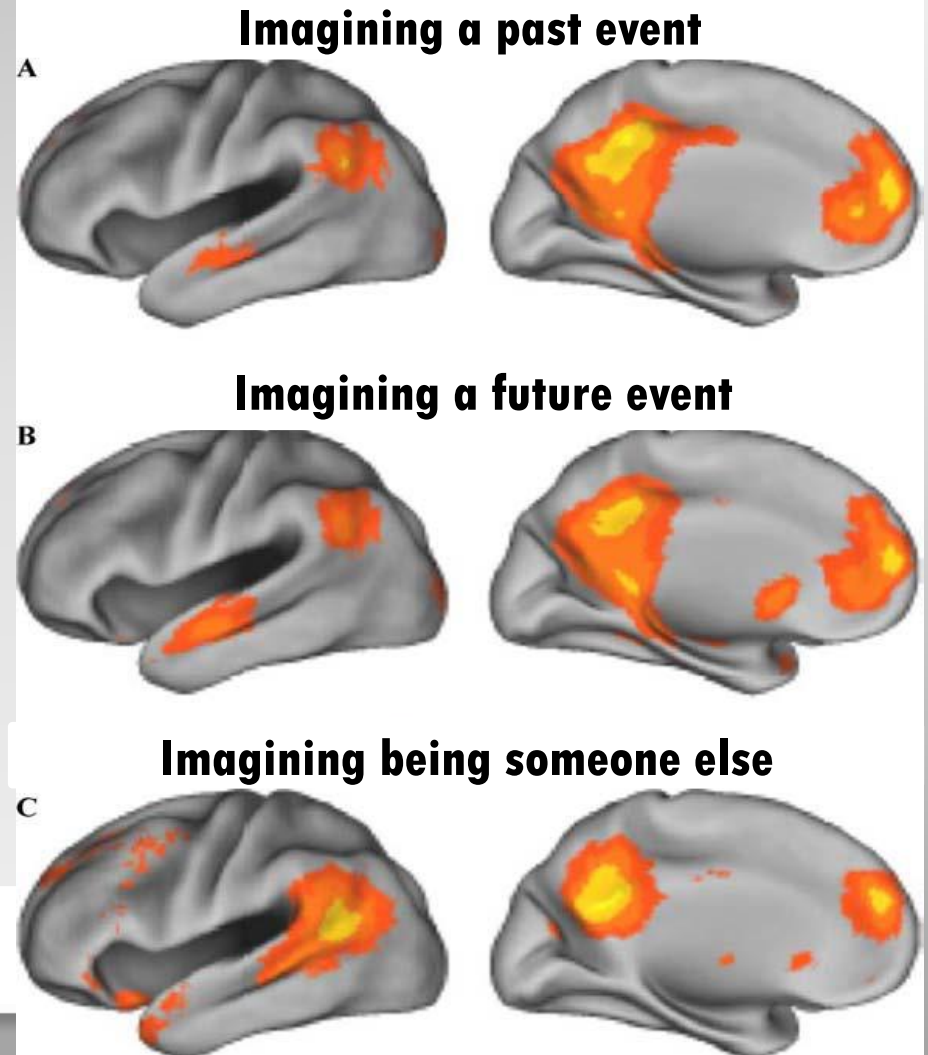
Killingsworth & Gilbert, *Science*, 2010, 330, 932

Results



Brain activity in mind wandering

- Examples show common patterns of activation
- Known as the *default-mode network*



Autobiographical memory

- We relive past events
- But we also create them
 - Hillary Clinton
 - Elizabeth Loftus
 - False memories, implanted memories
- Memory is story telling, based to varying degrees on fact

Imagining the future

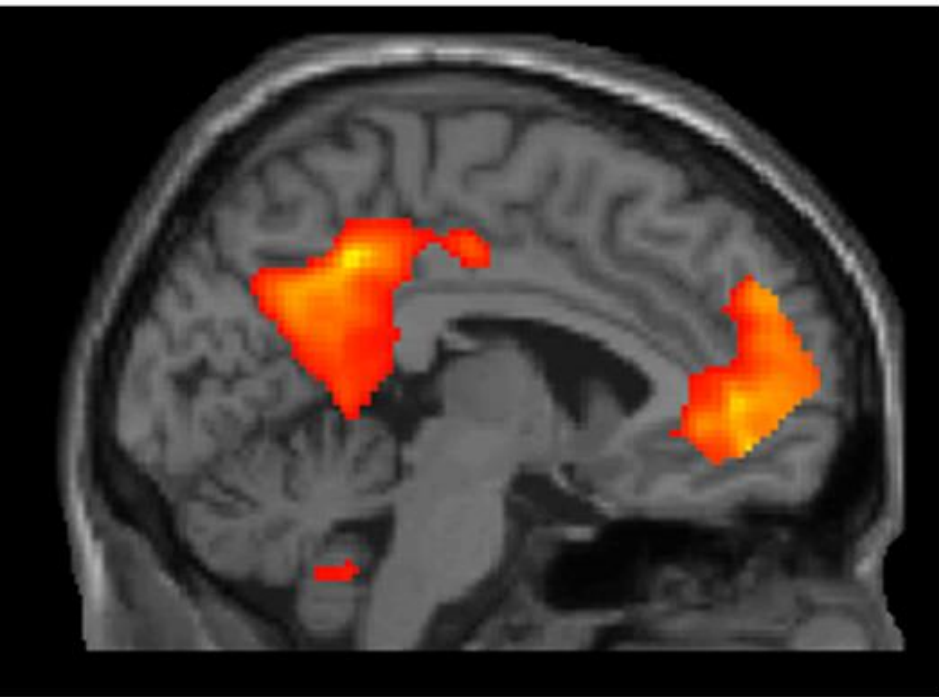
**“It’s a poor sort of memory that only works backwards,”
The Queen remarked.**

Lewis Carroll, *Through the Looking Glass*

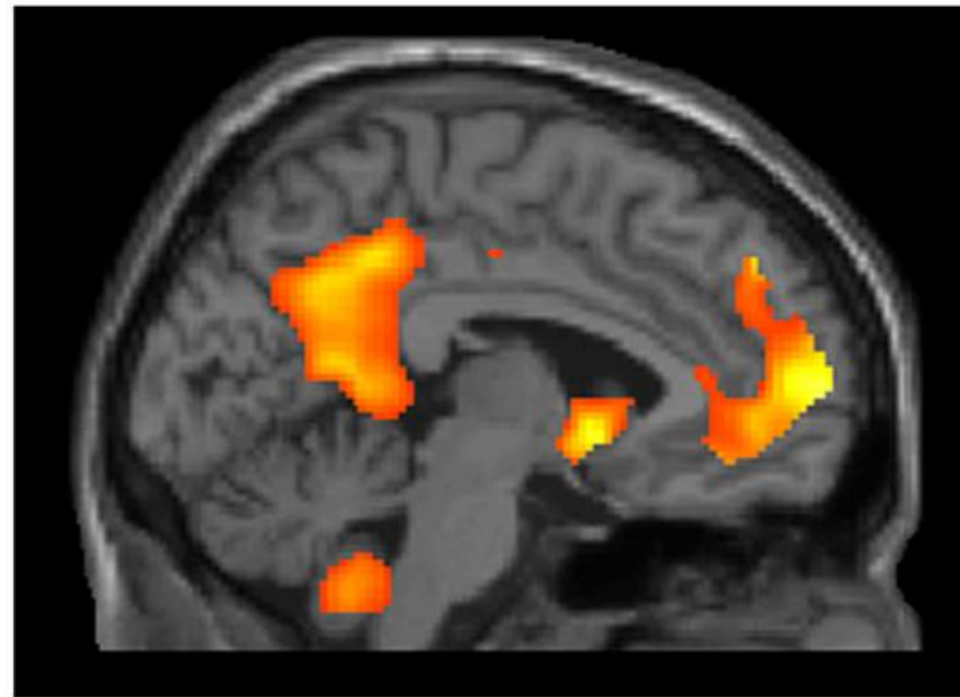
- We construct possible future events
 - Dinner party
 - Job interview
 - Wedding
 - The big game on Saturday
- Based on memory, but located in the future, and have much more of a fictional component

Mental Time Travel

PAST AND FUTURE EVENT ELABORATION



PAST EVENT > CONTROL



FUTURE EVENT > CONTROL

Time

- **Mental time travel links future and past**
- **This underlies the mental concept of time itself**
- **We humans are obsessed with time**
 - **Clocks, watches, calendars, appointments, anniversaries, festivals**
 - **Nanoseconds, microseconds, seconds, hours, days, weeks, months, years, decades, centuries, aeons**
 - **Life, death—and beyond**
- **But time is what creates the self**

We also wander into the minds of others

- Pretending to be someone else
- Mind reading
- Empathy
- Fiction
- TV soaps



“Be yourself; everyone else is already taken.”
—Oscar Wilde

Understanding false beliefs in others

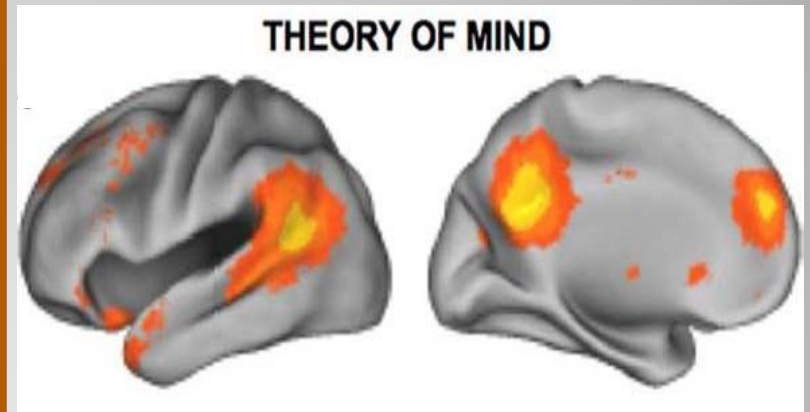
False belief (FB) sample story

John told Emily that he had a Porsche. Actually, his car is a Ford. Emily doesn't know anything about cars though, so she believed John.

When Emily sees John's car she thinks it is a:

Porsche?

Ford?

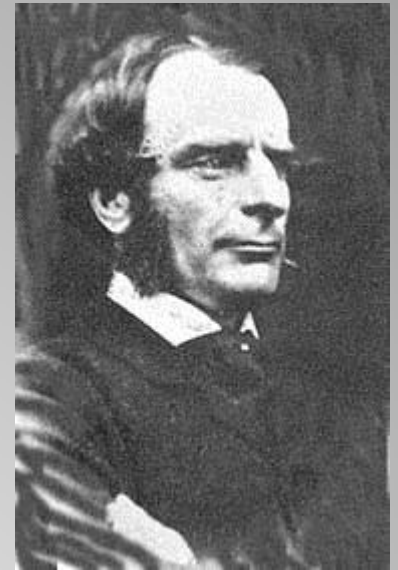


Default mode network
again lights up

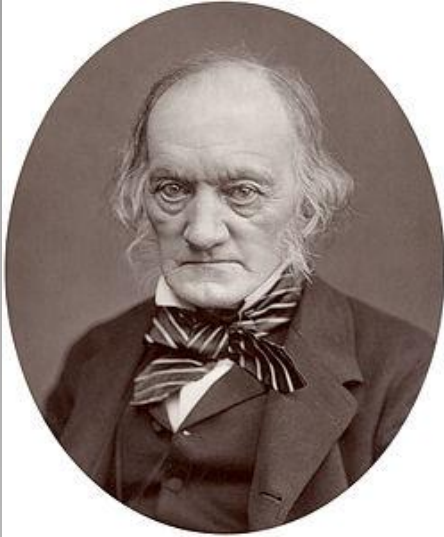
The hippo in the brain

“You may think that there are other more important differences between you and an ape, such as being able to speak, and make machines, and know right from wrong, and say your prayers, and other little matters of that kind; but that is a child’s fancy, my dear. Nothing is to be depended on but the great hippopotamus test.”

—from *The Water Babies*, by Charles Kingsley



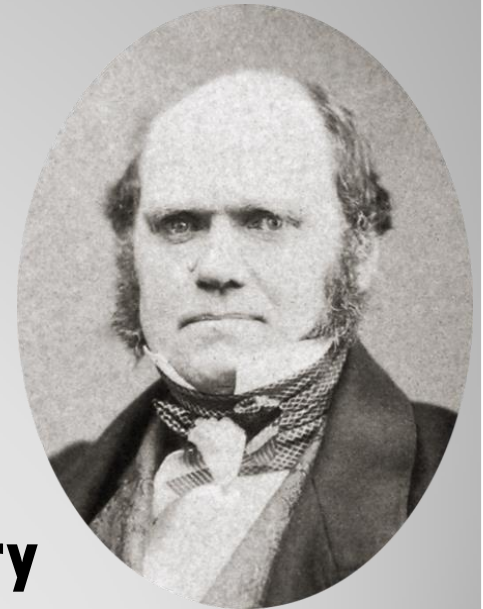
**Rev. Charles Kingsley
(1819-1875)**



Sir Richard Owen
(1804-1892)

The great hippopotamus test

- Owen believed that only humans possess a hippocampus minor
- This disproved Darwin's theory of evolution



Charles Darwin
(1809-1882)

Darwin once described Owen as “spiteful, unfair, ungenerous, extremely malignant, false, rude, unjust, illiberal and disingenuous.”



**Thomas Henry Huxley
(1825-1895)**

But Owen was wrong

- **Huxley (“Darwin’s bulldog”)
showed great apes also possess a
hippocampus minor**
- **Humans evolved from great apes**

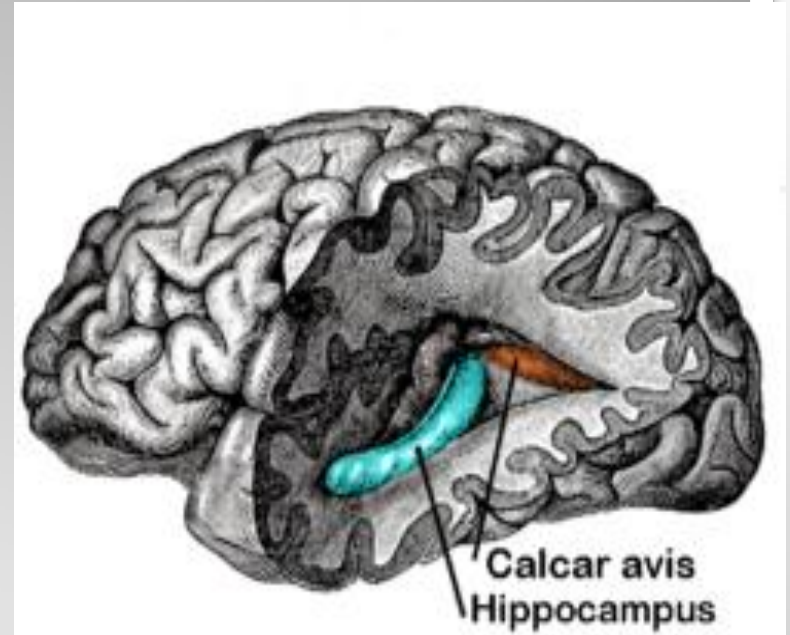
But Kingsley got it wrong too

“... if a hippopotamus major is ever discovered in one single ape’s brain, nothing will save your great- great- great- great- great- great- great- greater- greatest- grandmother from having been an ape too.”

It was actually the hippocampus minor, not the hippocampus major, that Owen referred to.

Banishment

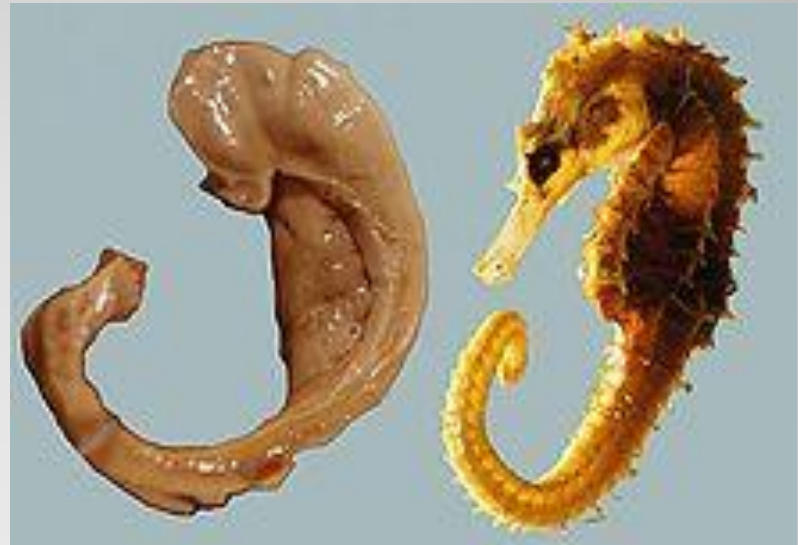
- The hippocampus minor doesn't do much for us at all
- It is now called the *calcar avis* ("cock's spur") and is banished to remote corners of medical texts
- Of much greater interest is the hippocampus major, now known simply as the **hippocampus**



Charles Kingsley was
unwittingly prophetic

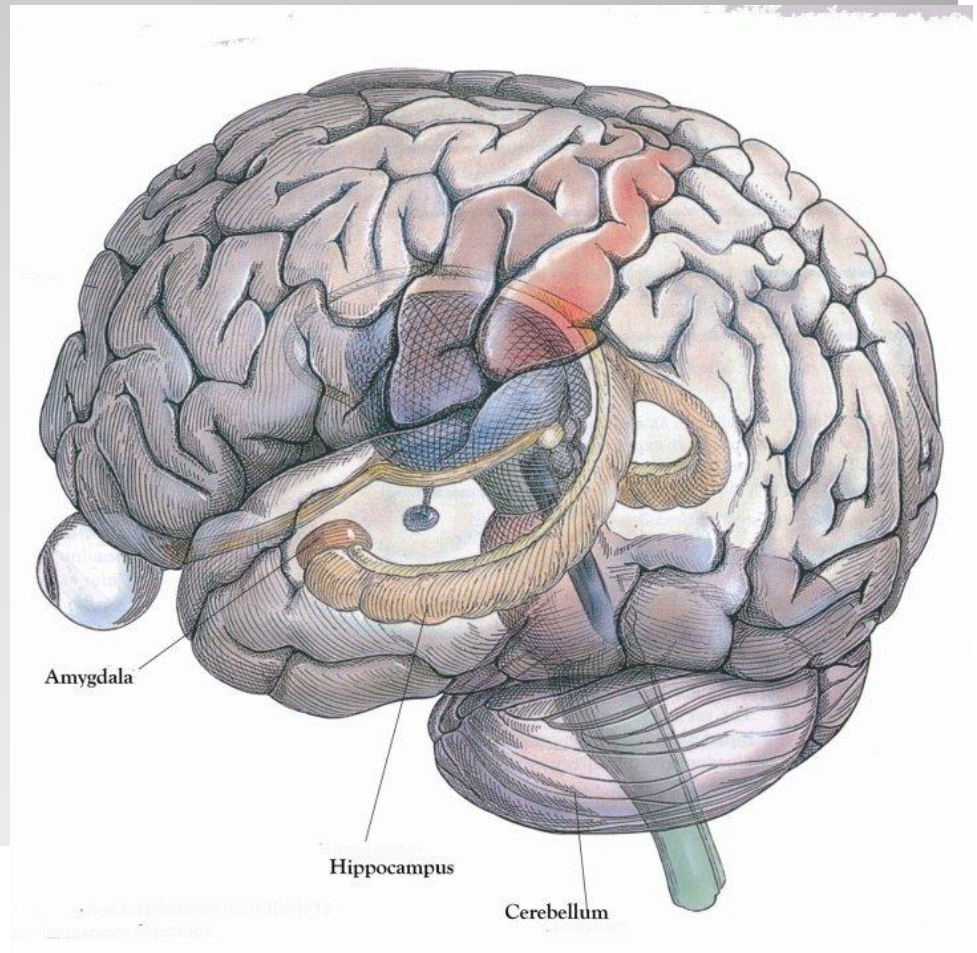
The hippocampus is critical to mind wandering

- It is shaped like a seahorse

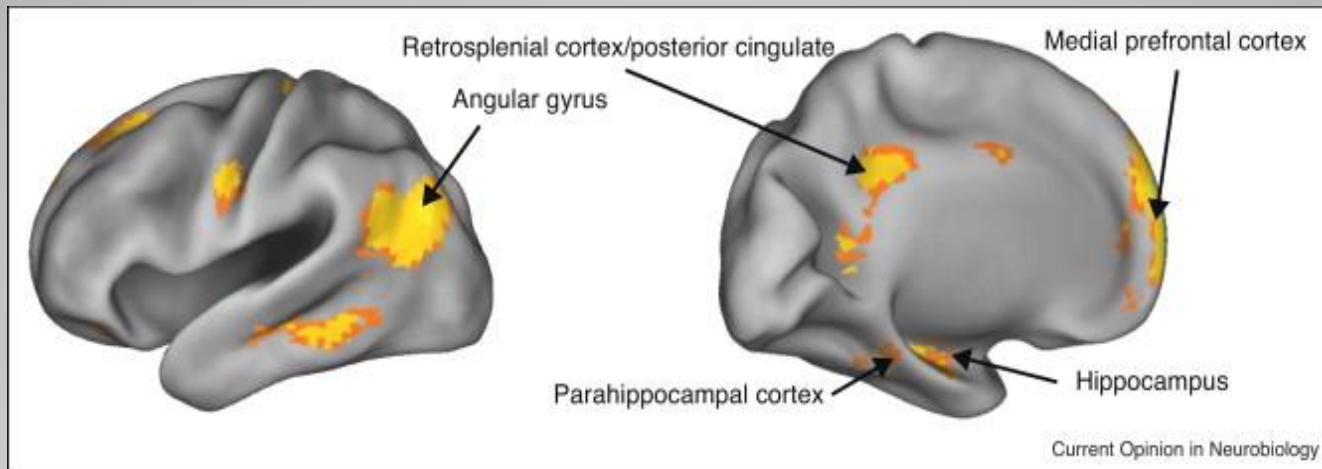


(“hippocampus” is Greek for seahorse)

How the hippocampus sits in the brain



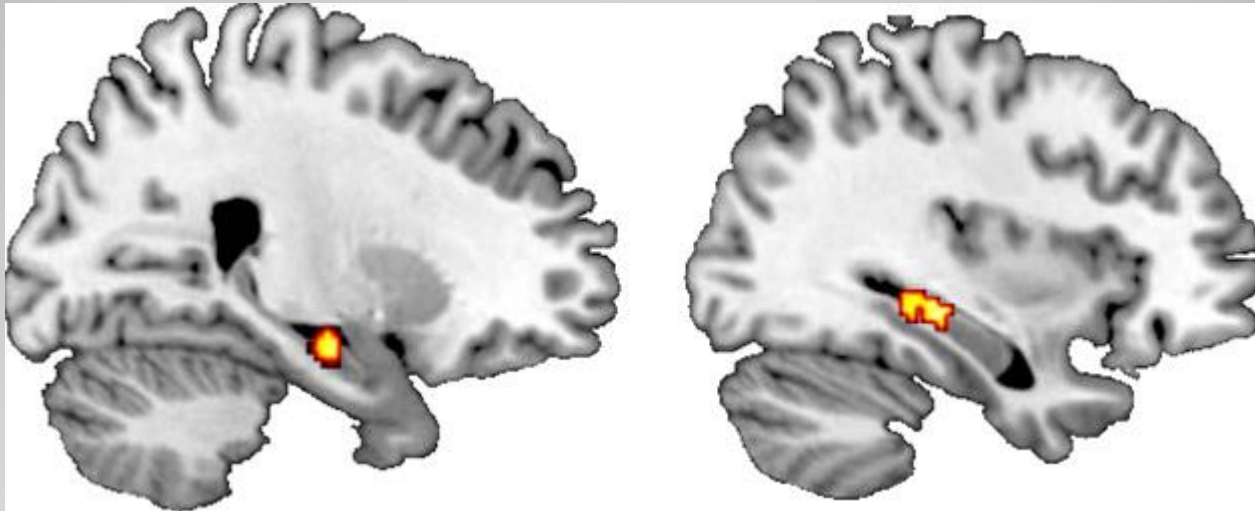
The episodic memory circuit



The hippocampus is the hub of the larger episodic memory circuit

Rugg, M.D. & Vilberg, K.L. (2013). Brain networks underlying episodic memory retrieval. *Curr. Opinion Neurobiol.*, 23, 255-260

Activation of hippocampus



**Anterior hippocampus
(future oriented)**

**Posterior hippocampus
(memory oriented)**

—from Martin, V. et al. (2011). *PNAS*, 108, 13858-13863

If your hippocampus is destroyed

- You lose memory of your past
- You can't imagine your future
- Your mind can't wander

Clive Wearing

- **British musician**
- **Hippocampus was destroyed after brain infection from *Herpes simplex* virus**
- **Lives in a 7-second window of time**



“... by the time they had figured out what was wrong with Clive and started pumping the anti-viral drugs into him all he had left were seahorse-shaped-scars where his memory used to be.”

—Deborah Wearing

Henry Molaison (HM)

- Hippocampus removed at age 27 for intractable epilepsy
- Loss of autobiographical memory (except for a few childhood episodes)
- Also unable to imagine future
- But implicit learning intact (e.g., mirror drawing)



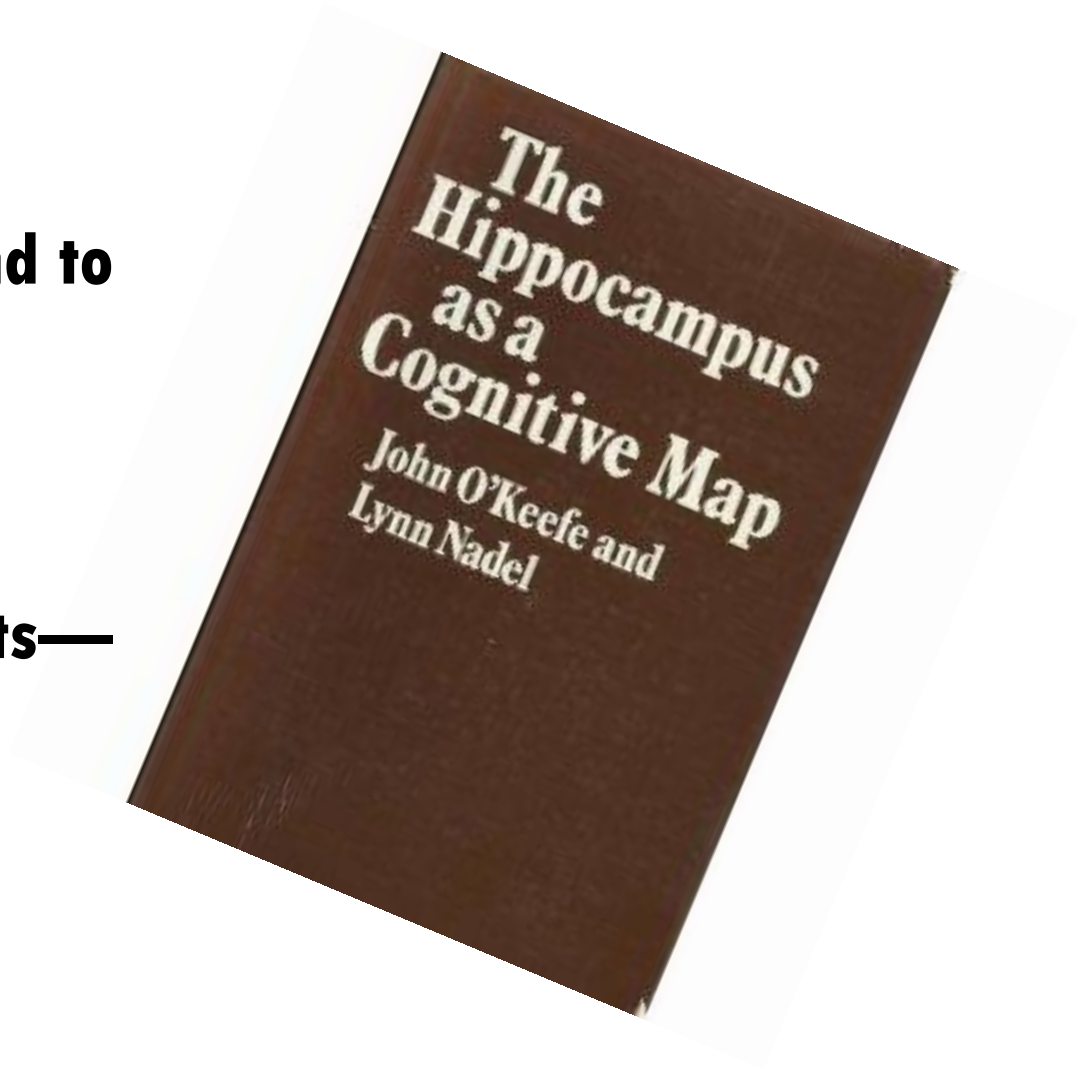
Henry Molaison (1926-2008)

Q: “What do you think you’ll do tomorrow?”

Henry: “Whatever is beneficial”

Hippocampus records space as well as time

- Cells in the rat hippocampus respond to particular locations
- These are known as “place cells”
- A GPS system for rats—and humans

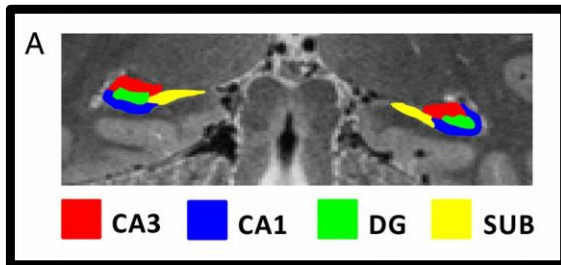


London taxis drivers

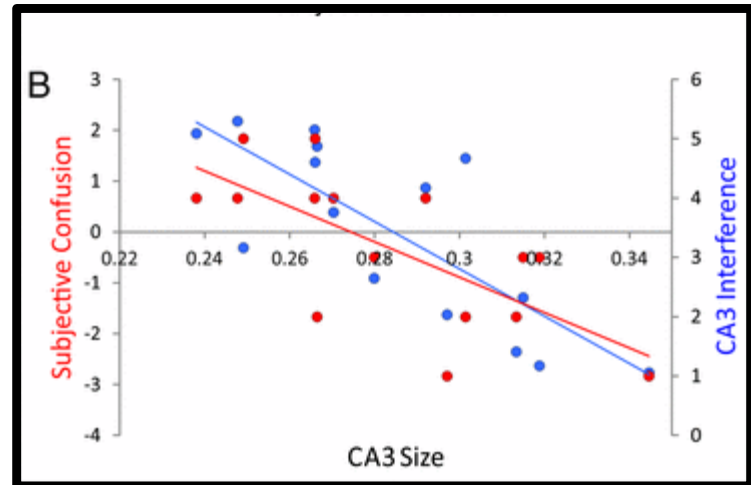
- **Must know any route without a map, GPS, cellphone**
- **This is called “The Knowledge” (est. 1865)**
- **Hippocampus is enlarged**



Confusion in recognizing pictures related to size of CA3



Precision with which we differentiate past experiences depends on size of CA3 subfield, but not on other hippocampal subregions



**Chadwick, M.J. et al. (2014).
PNAS, 111, 10720-10725**

Is mental time travel uniquely human?

“The lives of apes are lived entirely in the present.”

—Merlin Donald (1991), *Origins of the Modern Mind*

“He said “What’s time? Now is for dogs and apes! Man has forever!” —Robert Browning : *A Grammarian’s Funeral*

“Humans, unlike animals, have the ability to travel mentally in time.”

—Suddendorf, T., Corballis, M.C. (1997)
Genet. Soc. Gen. Psych Monogr. 123, 133-167

“The time in which the chimpanzee lives is limited

In past and future”

--Wolfgang Kohler (1927)
The Mentality of Apes

“There is no evidence that any nonhuman animals—including what we might call higher animals—ever think about what we could call subjective time ... They have minds, they are conscious of their world, and they rely as much

on learning and memory in acquiring the skills needed for survival as we do, but they do not seem to have the same kind of ability humans

do to travel back in time in their own minds, probably because they do not need to.”

—Endel Tulving (1972). *Ann Rev Psychol*, 53, 1-25.

Is mental time travel uniquely human?

“What’s the one obvious thing we humans do that they don’t do? Chimps can learn sign language, but in the wild, so far as we know, they are unable to communicate about things that aren’t present. They can’t teach what happened 100 years ago, except by showing fear in certain places. They certainly can’t plan for five years ahead. If they could, they could communicate with each other about what compels them to indulge in their dramatic displays. To me, it is a sense of wonder and awe that we share with them. When we had those feelings, and evolved the ability to talk about them, we were able to create the early religions.”

—Jane Goodall, interview with Freddy Gray in *The Spectator* of 10 April, 2010.

Why do people think MTT is uniquely human?

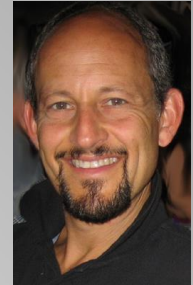
Because nonhuman animals have no language?

- **Chomsky: Symbolic thought emerged in a sudden event within the past 100,000 years: “the great leap forward”**
- **This uniquely endowed humans with grammatical language**

Language is uniquely human?

“Most current commentators agree that, although bees dance, birds sing, and chimpanzees grunt, these systems of communication differ qualitatively from human language. In particular, animal communication systems lack the rich expressive and open-ended power of human language (based on humans’ capacity for recursion).”

—Hauser, M.D., Chomsky, N., Fitch, T. (2002). *Science*, 298, 1569-1579



Declarative memory

- **Episodic and semantic memory combine as declarative memory**
- **Memory that can be “declared”**
- **This implies a special role for language**

Animals fight back



- **How to test episodic memory in animals?**
- **Suggested criteria:**
Memory for what, where, and when (the WWW test)

Scrub jays

- Evidence that scrub jays can pass a waw test
- Allowed to cache perishable worms and peanuts in different locations
- Tested for retrieval after 4 hours or 124 hours
- At 4 hours, chose the worms (they like them better)
- At 124 hours, chose the peanuts (worms decayed by then)



CONCLUSION: Birds remembered **what** had been cached (worms and nuts), **where** they were cached, and **when** (so they could figure whether worms were fresh or not)

—Clayton, N.S. et al. (2003) *TICS*, 4, 685-691

Great apes



- **Chimpanzees, orangutans, bonobos shown frozen juice (preferred) and grapes being hidden**
- **After 5 min or one hour given the choice**
- **5-min choice more commonly for juice, 1-hour choice for grapes**
- **Again suggests WWW memory**

Martin-Ordas, G. et al. (2010). *Anim. Cognit.* 13, 331-340

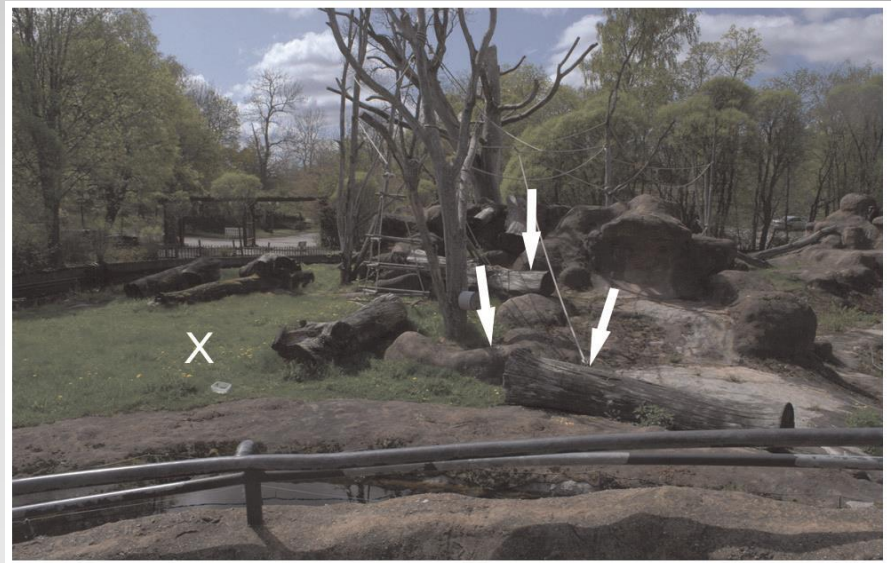
Future-thinking birds: Thieving jays

- **Jays recache their food if another jay watched them cache in the first place.**
- **But only if they have themselves stolen food (“It takes a thief to know a thief”)**
- **Is this future time travel?**
- **Or just associative learning?**

—Clayton, N.S. *et al.* (2003), *Nature Reviews Neuroscience*, 4, 685-691

Chimpanzee: future plans?

- **Chimpanzee Santino in Furuvik Zoo in Sweden**
- **Hides projectiles well before visitors appear**
- **Later affects nonchalance, then suddenly picks up hidden projectiles to throw at visitors.**



**X is a hay heap made to conceal projectile.
Arrows show rocks used for concealment**

What do behavioural studies show?

- **Reasonable demonstrations of time-bound memory and planning for future events**
- **But do the animals mentally replay past events, or pre-play future ones?**
- **... little indication of autonoetic consciousness (Tulving)?**
- **Hence memory in nonhuman animals often described as “episodic-like.”**

But can we access consciousness in nonhuman species?

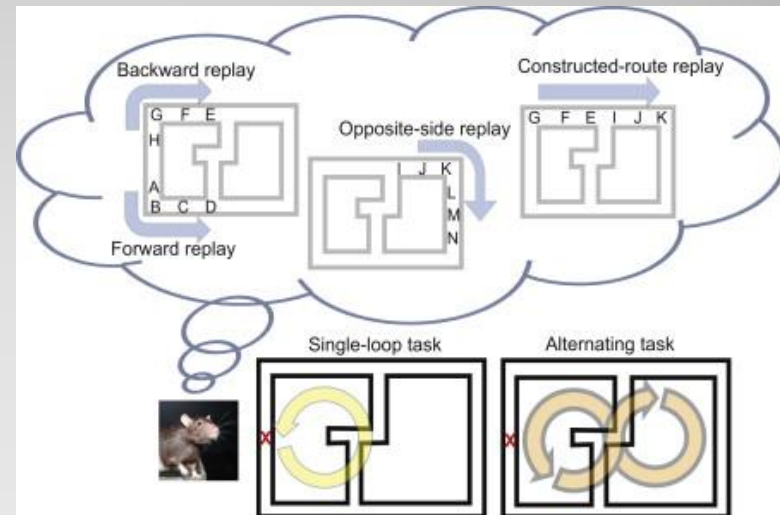
The Secret Life of Walter Ratty

- **Recordings from hippocampal place cells map out past trajectories in a maze**
- **And maybe future ones too**
- **Even fictitious ones?**
- **This occurs when rat is asleep, or awake but motionless (day-dreaming?)**



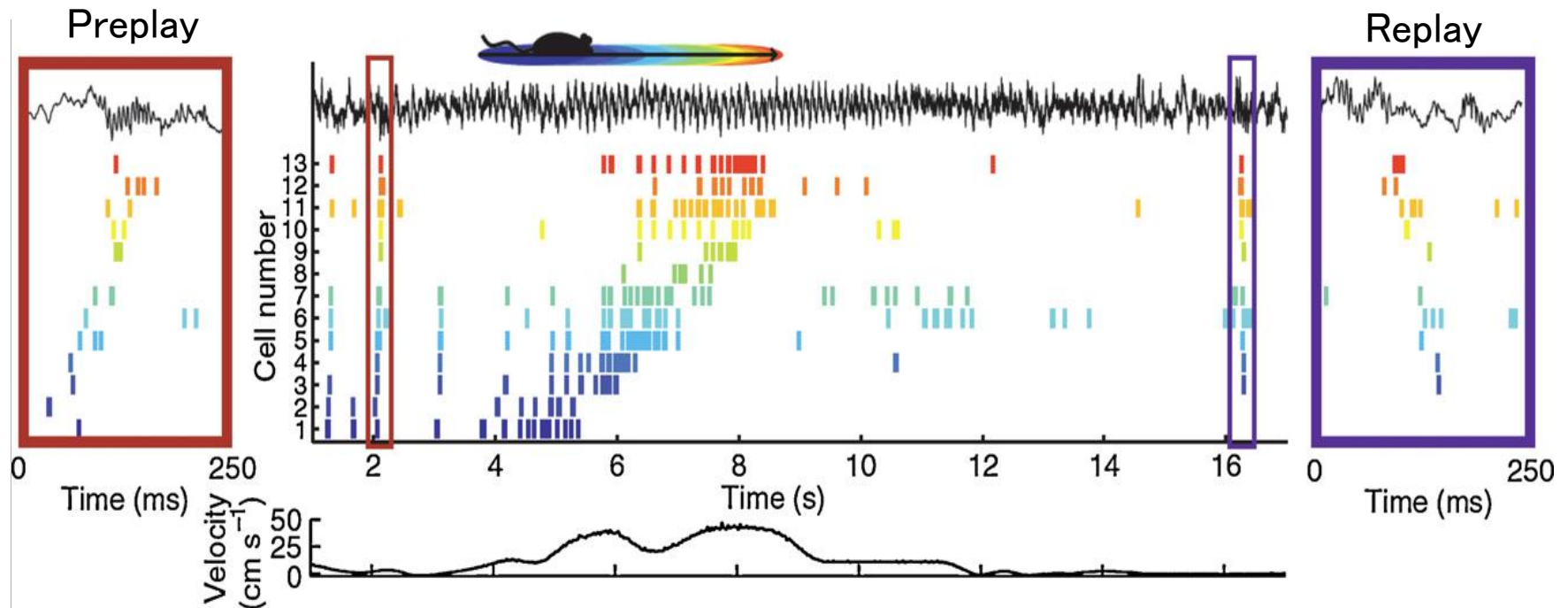
Hippocampal replay of maze trajectories

- “Sharp-wave ripples” (SWRs) in hippocampal place cells trace out trajectories following experience in maze running
- Occur in slow-wave sleep or when animal is awake but immobile
- Replays up to 10 min after experience



Derdikman, D., Moser, M-B. (2010). *Neuron*, 65, 582-584

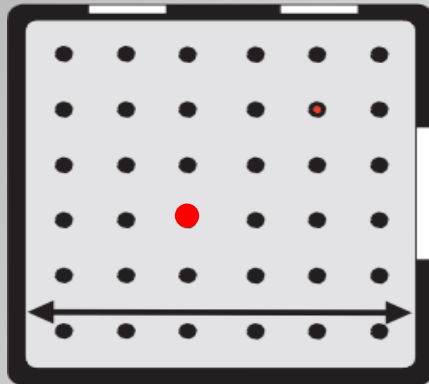
The hippocampus plans a trip



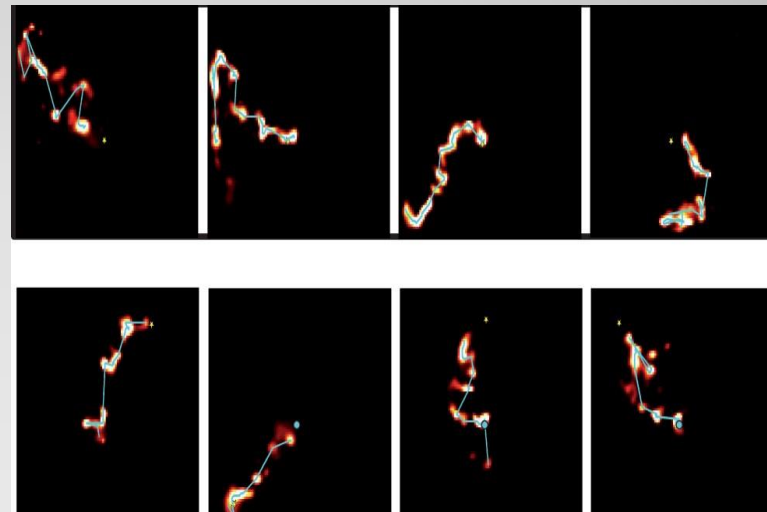
Place cells map progress along track from purple to red

—Buzsaki & Lopes da Silva (2012) *Progress in Neurobiology*, **98**, 241-249

Rat hippocampus shows the way home



**Food wells in open
environment (red dot
is "home")**



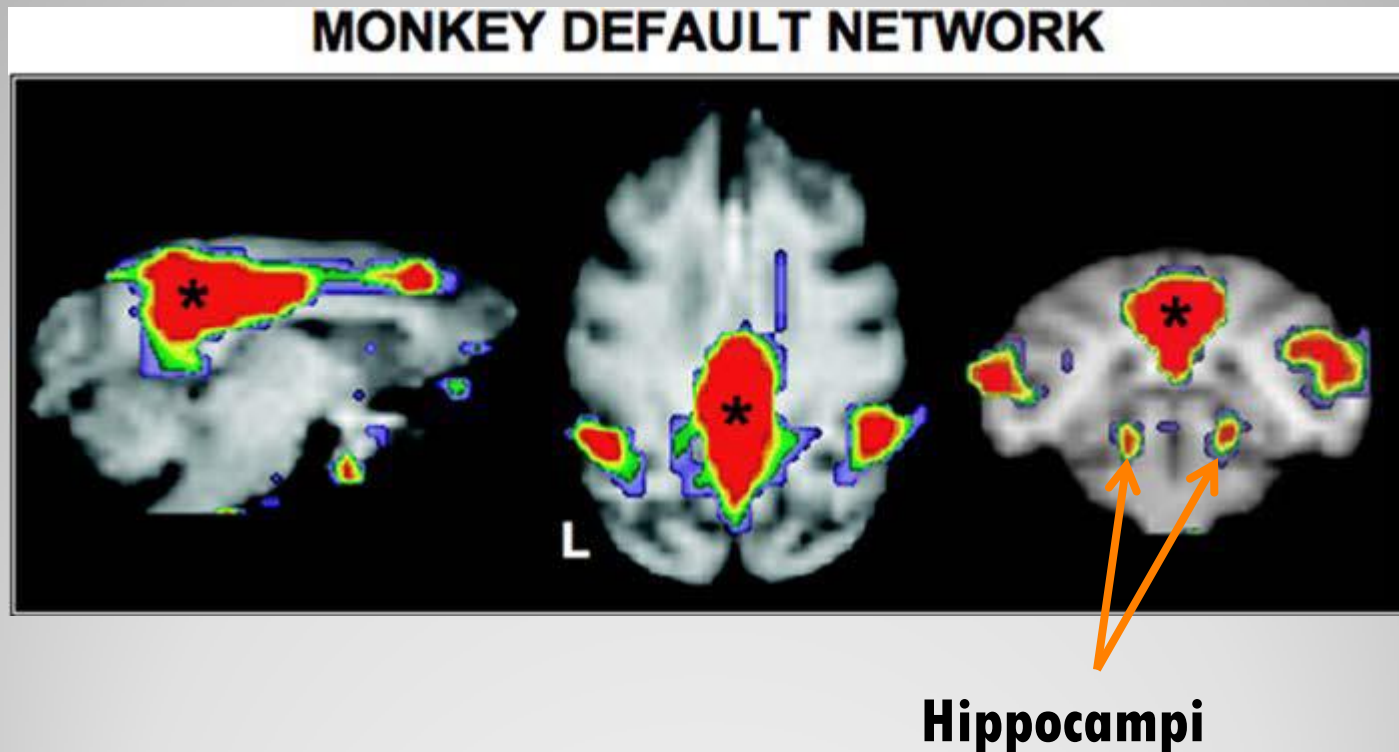
**Hippocampal pre-play marks
the route home**

Do SWRs imply conscious mind wandering?

Maybe depends on the null hypothesis

- **Lloyd Morgan's canon: "In no case may we interpret an action as the outcome of a higher mental faculty, if it can be interpreted as the exercise of one which stands lower in the psychological scale" (Morgan, 1903, p. 59).**
- **Darwin (1871): "The difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind." (Darwin, 1871, p. 126)**

And the default-mode network is also present in monkeys



Vincent, J.L., et al. (2007). *Nature*, 447, 83–86.

So what of language?

- **Driven by the imperative to share, rather than by the structure of thought?**
- **Or does mind wandering in humans achieve a narrative structure to which language adapted?**
- **Strong human imperative to share narratives, whether memories, plans, or fiction**

**“My voice goes after what my eyes cannot reach,
With a twirl of my tongue I encompass worlds,
And volumes of worlds ... ”**

—Walt Whitman, *Song of Myself*

What is language?

- **Language is a device for sharing our mind wandering (stories, arguments, theories)**
- **One of its design features is *displacement* :**
 - **“Linguistic messages may refer to things remote in time and space, or both, from the site of communication” (Hockett, 1966).**

Stories

- **Perhaps originated in our hunter-gatherer past**
- **Emergence of the social mind in the Pleistocene**
- **Advantages gained from sharing experiences, knowledge**
- **And creation of shared myths**

Gossip

- **“Who did what to whom, when, where and why”
(Pinker, 2003)**
- **Establishes social knowledge, social hierarchies**
- **Dunbar—gossip evolved from grooming**

Fiction

Epic tales, plays, novels, TV soaps

- **Made-up stories**
- **Derived from play**
- **Fiction stretches the bounds of the possible, creates hypothetical scenarios adaptive for future survival**
- **Fiction increases the ability to understand others, show empathy** (Kidd & Castano, *Science*, 2013, 342, 377-380).

Crime fiction

“A detective is the perfect character, the perfect means, of looking at society as a whole. I can’t think of any other character you could use that allows you access to any area of society.... [The detective] allows access to the banks, the politicians, the CEOs, the people who run business, but also the dispossessed, the disenfranchised, the unemployed, the drug addicts, the prostitutes. “

—Ian Rankin, author of crime fiction

Summary

- **Mind wandering occupies about half of our waking lives—and our nightly dreams**
- **It takes us away from the present, into past, future, and the minds and lives of others**
- **It is the basis of fiction, and of language itself**
- **It is the source of creativity**

Acknowledgements

- Thanks to many, and especially to
 - Donna Rose Addis
 - Brian Boyd
 - Nicola Clayton
 - David Redish
 - Thomas Suddendorf

Now read the book

