consciousness and free will in animals

- what do consciousness and free will have to do with one another?
- what are they?

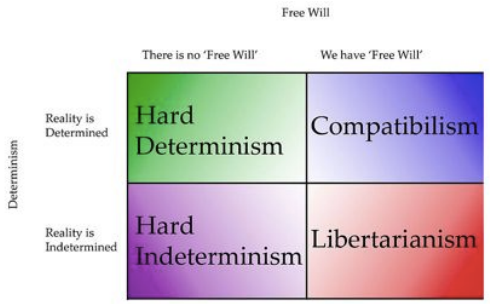
consciousness

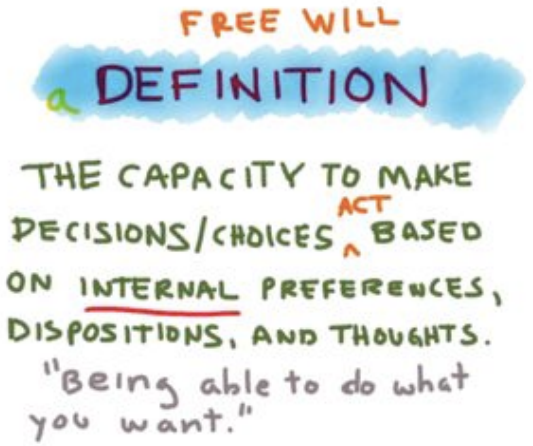
- a sense that 'i' am feeling, thinking, seeing, experiencing something.
- Dennett sometimes refers to this as the serial experience of a parallel mind.

- do we need a serial experience?

the variety of philosophical positions on free will

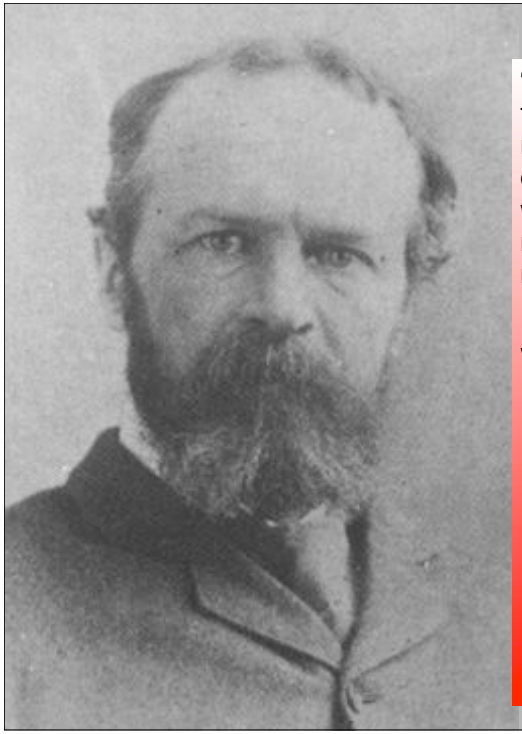
- Determinism -- the past fully determines the future.
- Indeterminism -- the past does not fully determine the future. Possibly there is something undetermined, or random (quantum?)
- Compatibilism -- free will is compatible with a fully determined universe
- Incompatibilism -- free will is not compatible with a fully determined universe.
- Libertarianism -- free will does exist, therefore the future is not fully determined by the past.
- Hard determinism -- everything is strictly determined, so there is no free will.
- Hard incompatibilists -- free will is not compatible with determinism or indeterminism, therefore free will does not exist.
- which do you choose?





- whatever we mean by free will, we mean constrained freedom.
- you can't walk through walls, not see optical illusions, or break certain laws without paying the consequences.

where does choice begin and where does it end?



"We make search in our memory for a forgotten idea, just as we rummage our house for a lost object. In both cases we visit what seems to us the probable neighborhood of that which we miss."

William James, *Principles of Psychology*

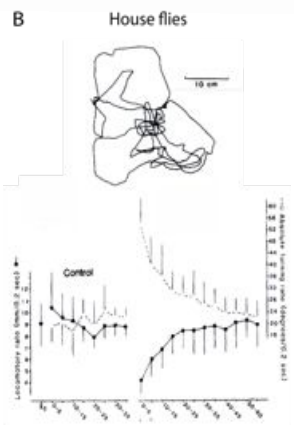
Search in space and mind both have to make adaptive trade-offs between exploration and exploitation.

Analogy or Homology?

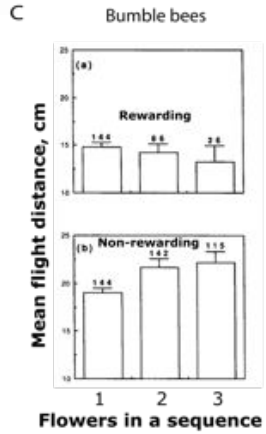
OVERVIEW

- Spatial foraging across metazoans and cognitive control in humans may be homologous, with the shared functional dimension being behavioral perseveration, in particular, the ability to modulate perseveration in such a way that animals can flexibly persist or abandon specific courses of action--initially associated with exploiting and exploring for resources in space.

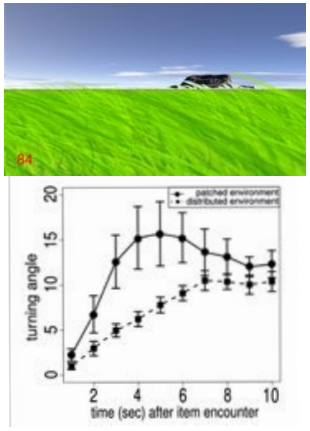
Area-restricted search is the modulation between exploitative and exploratory search behaviors



White et al., 1984



Dukas & Real, 1993



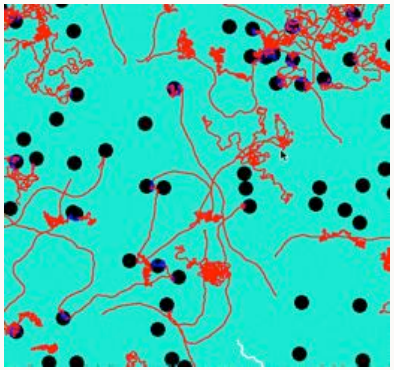
Hills, Kalff, Wiener, 2013

ADAPTIVE VALUE OF AREA-RESTRICTED SEARCH IN CLUSTERED RESOURCE ENVIRONMENTS

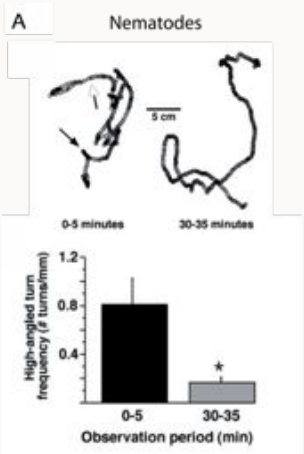
When resources are **clustered**, then area-restricted search is an optimal foraging strategy (Kareiva & Odell, 1987; Grunbaum, 1988).

Better than Lévy flights (Plank & James, 2008; Ferriera et al., 2012).

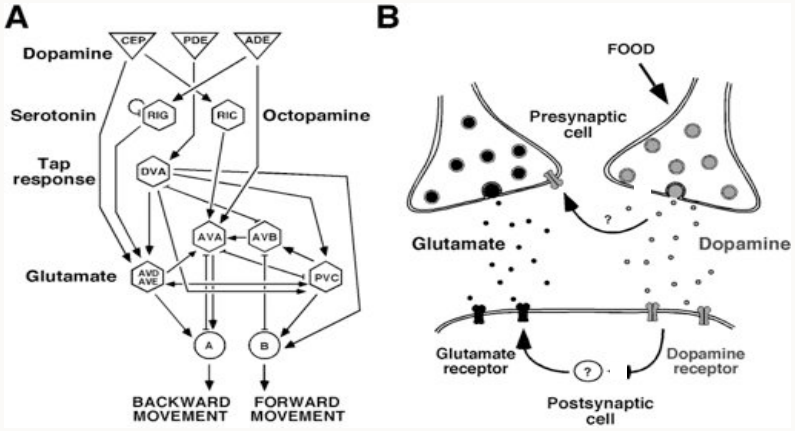
This behavior also evolves rapidly with a **minimal neural architecture** (Hills, 2006).



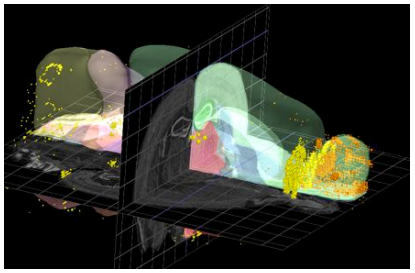
CAENORHABDITIS ELEGANS MODULATES ITS TURNING BEHAVIOR IN THE ABSENCE OF RESOURCES TO MOVE FROM LOCAL TO GLOBAL SEARCH



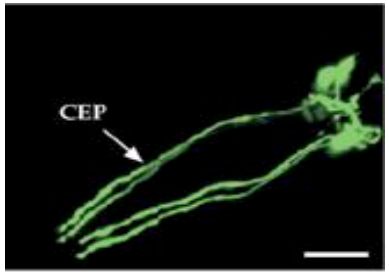
AREA-RESTRICTED SEARCH CIRCUIT IN *C. ELEGANS*



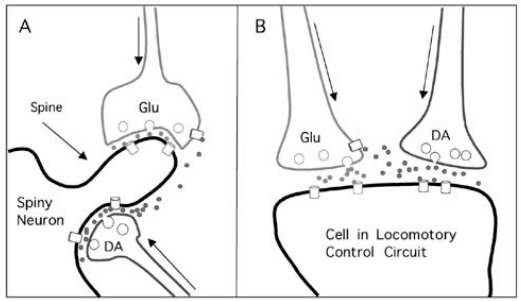
Similar microcircuitry is conserved across species



Allen brain atlas



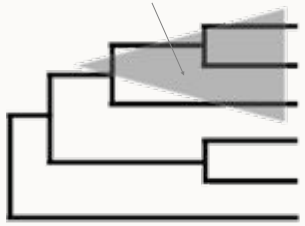
Nass and Blakely, 2002



Dani & Zhou, 2004

Hills et al, 2004

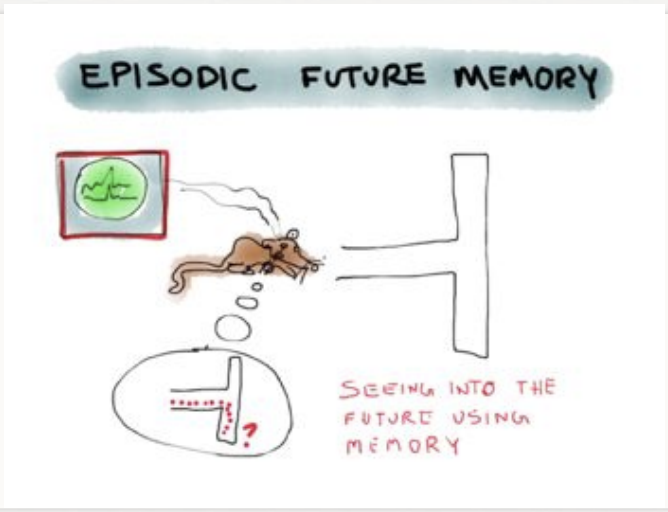
DOPAMINE CONTRIBUTES TO EXPLORATION AND EXPLOITATION ACROSS EUMETAZOANS

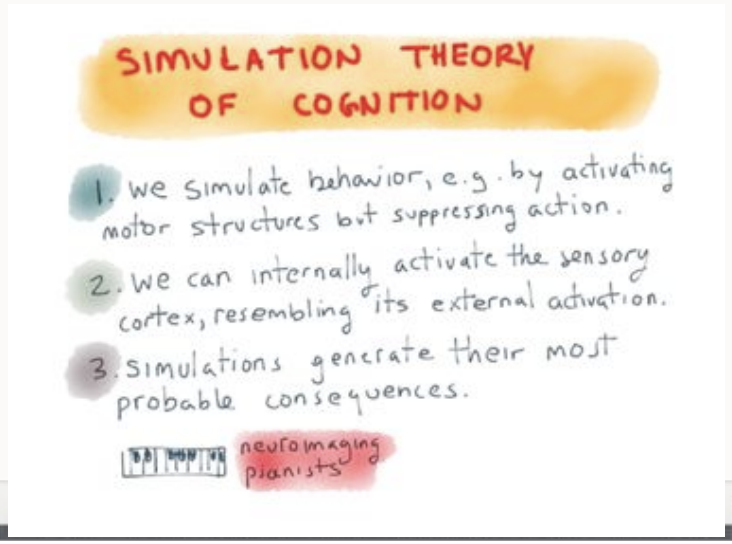


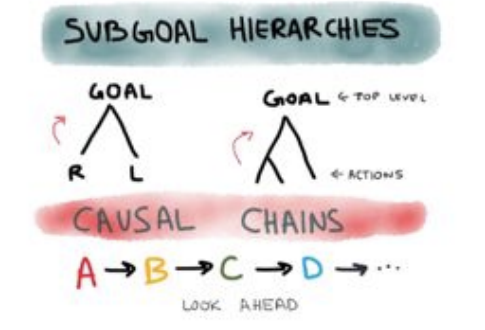
Species	Dopamine modulates...
Homo	goal-directed cognition/pathologies,motor movements
Mus	movement, feeding, exploration
Bufo, Rana	visual orientation, feeding, turning
Drosophila	turning, learning
Aplysia	feeding response
Caenorhabditis	turning

You have made your way from worm to man, and much in you is still worm, Nietzsche

Hills & Dukas, 2012







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PFC-STRIATUM FRONTO-STRIATAL

maintains + updates goals

You can only see as far into the future as you can maintain a particular simulation/goal hierarchy/causal chain.

AND... IT'S ONLY AS GOOD AS YOUR MEMORY/KNOWLEDGE.

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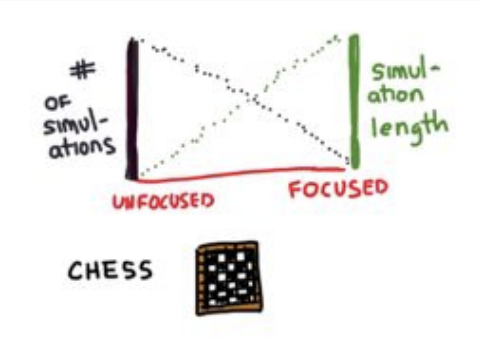

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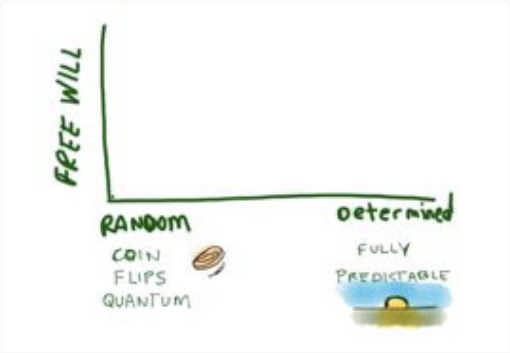

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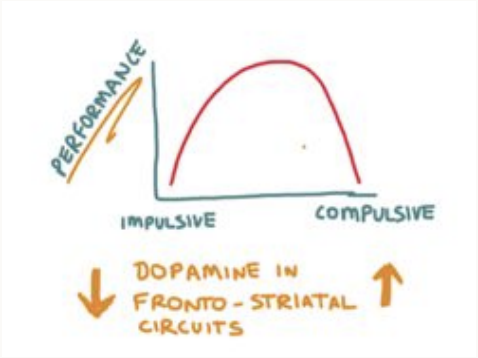

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where does the capacity for choice come from?

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EVOLUTION?

the algorithm for evolution:

1. Heredity
2. Variation
3. differential SURVIVAL + REPRODUCTION

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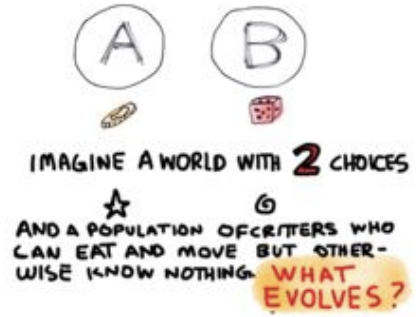
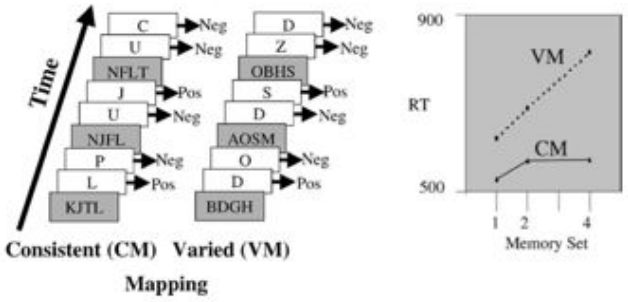


dual-process theory of mind :
automatic versus controlled processes



extended training with consistent mapping is required for automatic processing, whereas controlled processing can be learned very rapidly. Automatic processing, however, is fast and parallel, whereas controlled processing is slow and serial.

Shiffrin & Schneider, 1977

the stroop task

- once a process becomes automatic, it becomes difficult to control.
- e.g., once learned, reading becomes automatic -- ergo, the Stroop task is

Blue
Black
Yellow
Red
Green
Purple

say the font color of the word as quickly as you can.

this invites a dimensionalization