Why economists need to know the neuroscience

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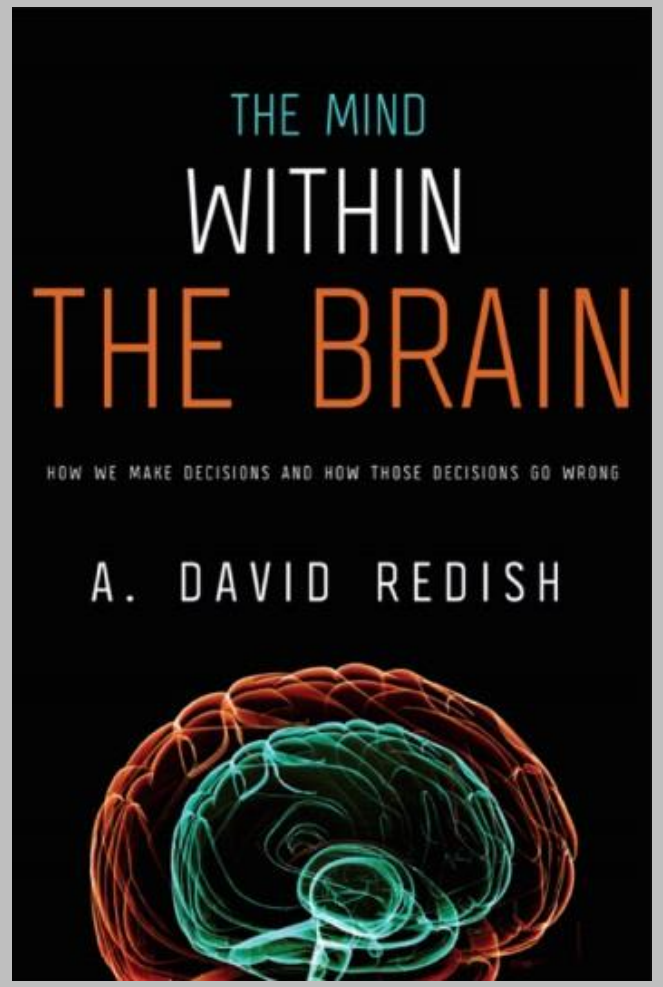
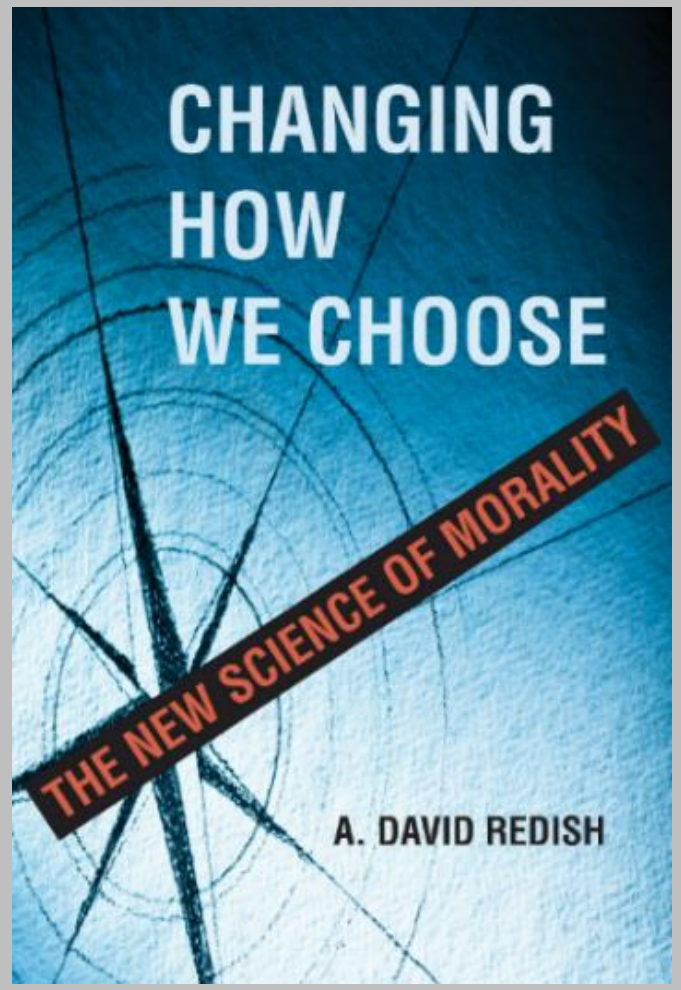


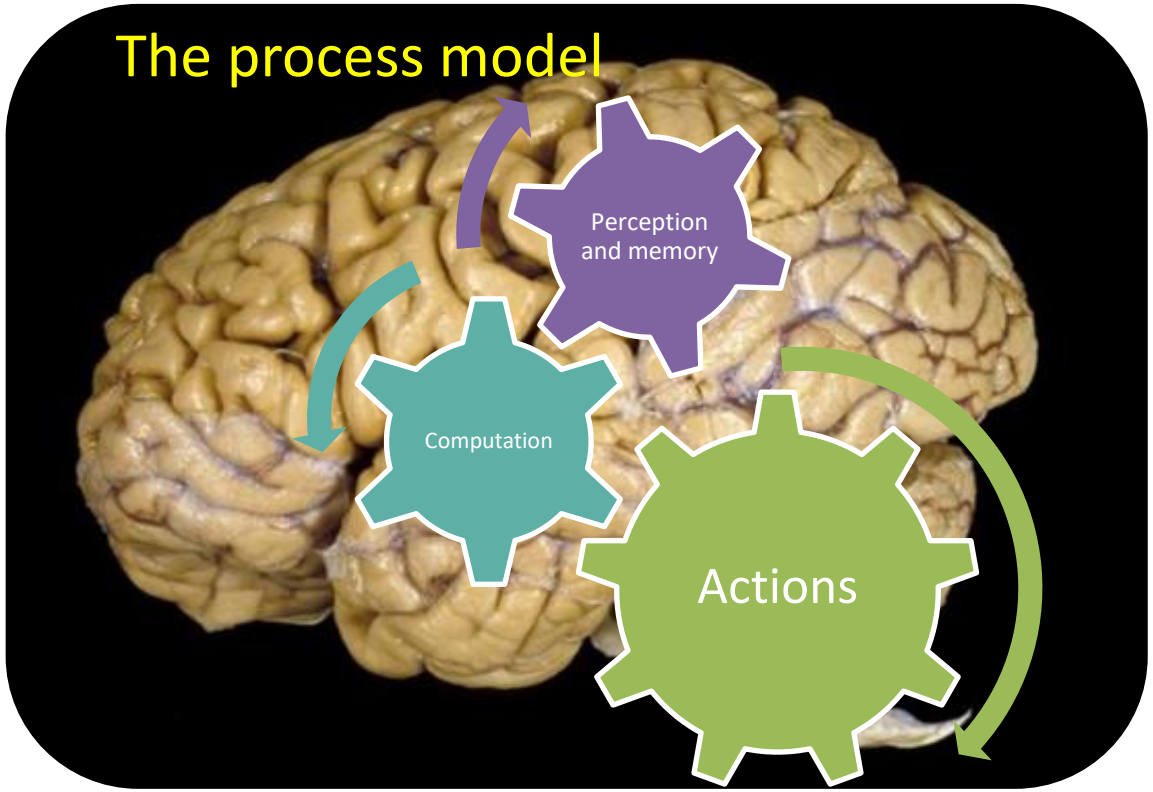


Any given normative model is only compatible with some process models.

Normative statements have (hidden) process assumptions.

The normative model

Utility functions

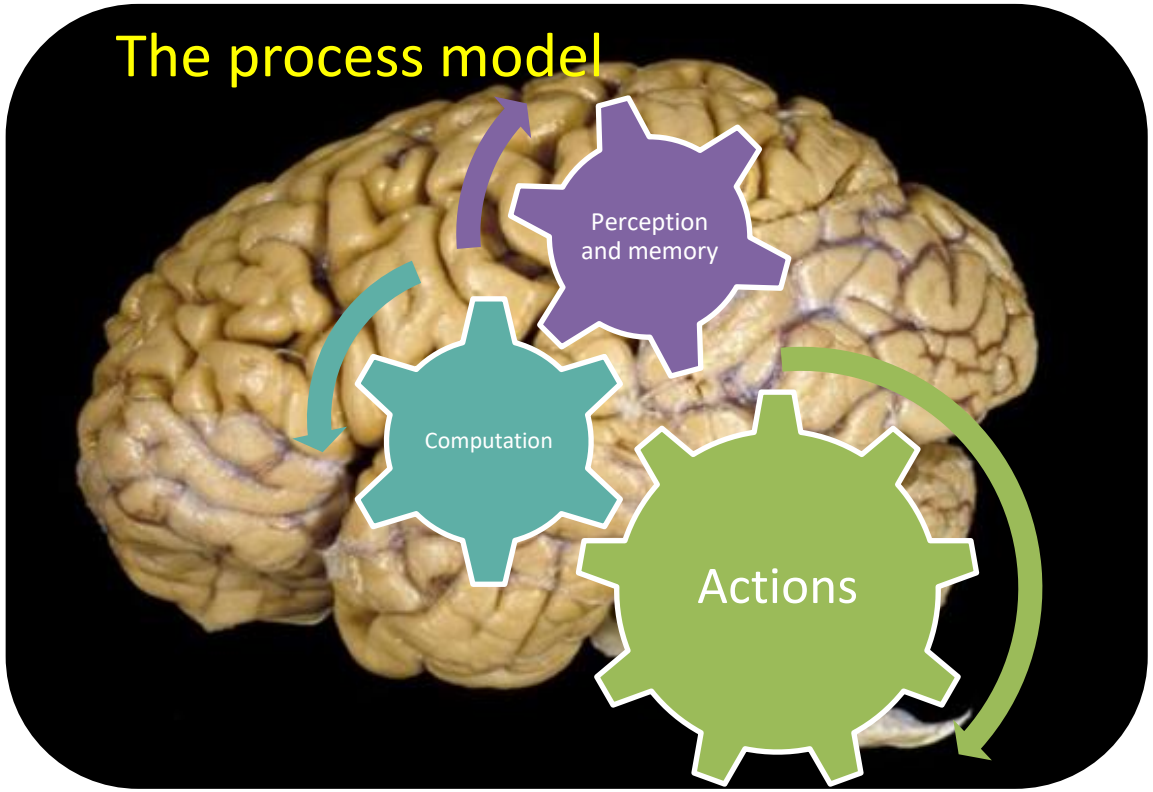


Process models change the space of normative options available.

Process models have normative consequences.

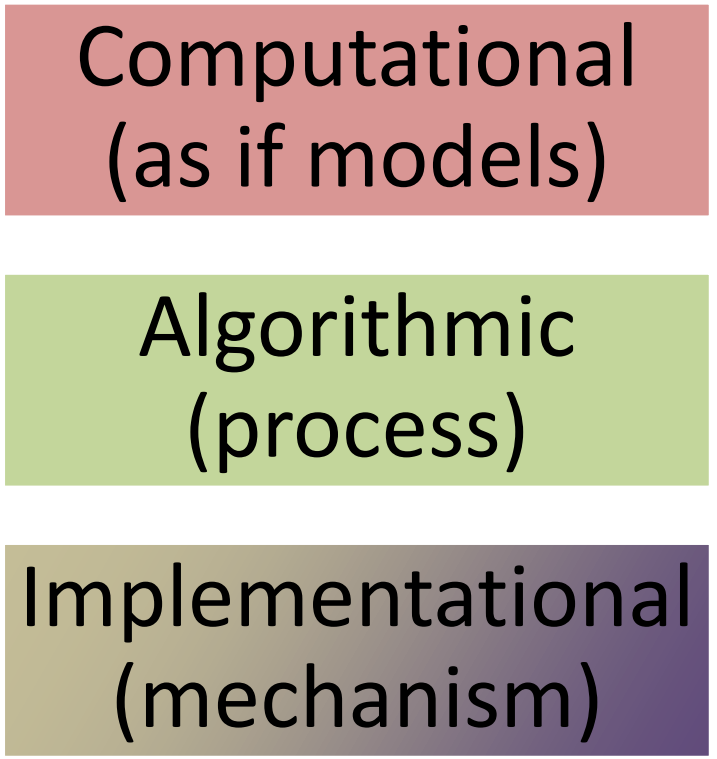
The normative model

Utility functions



Marr's levels

Representation limits the computation



Behavioral Economics

Neuroeconomics

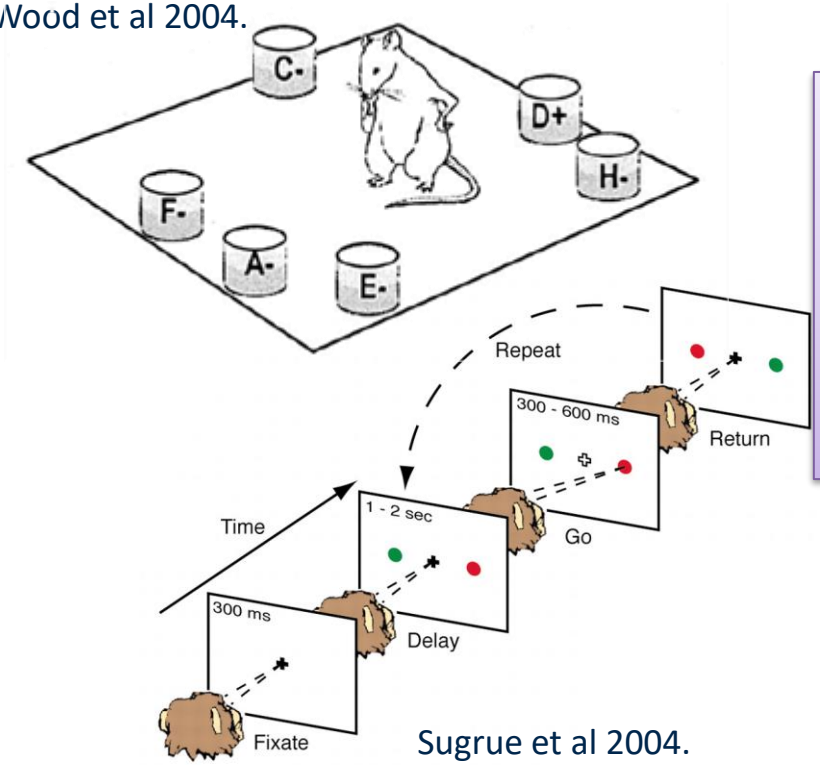
Let's first define *decision-making* as ***action-selection***

Carter and Redish 2016

Consumer purchases

Gambling

Wood et al 2004.



Sugrue et al 2004.

Buying a house…

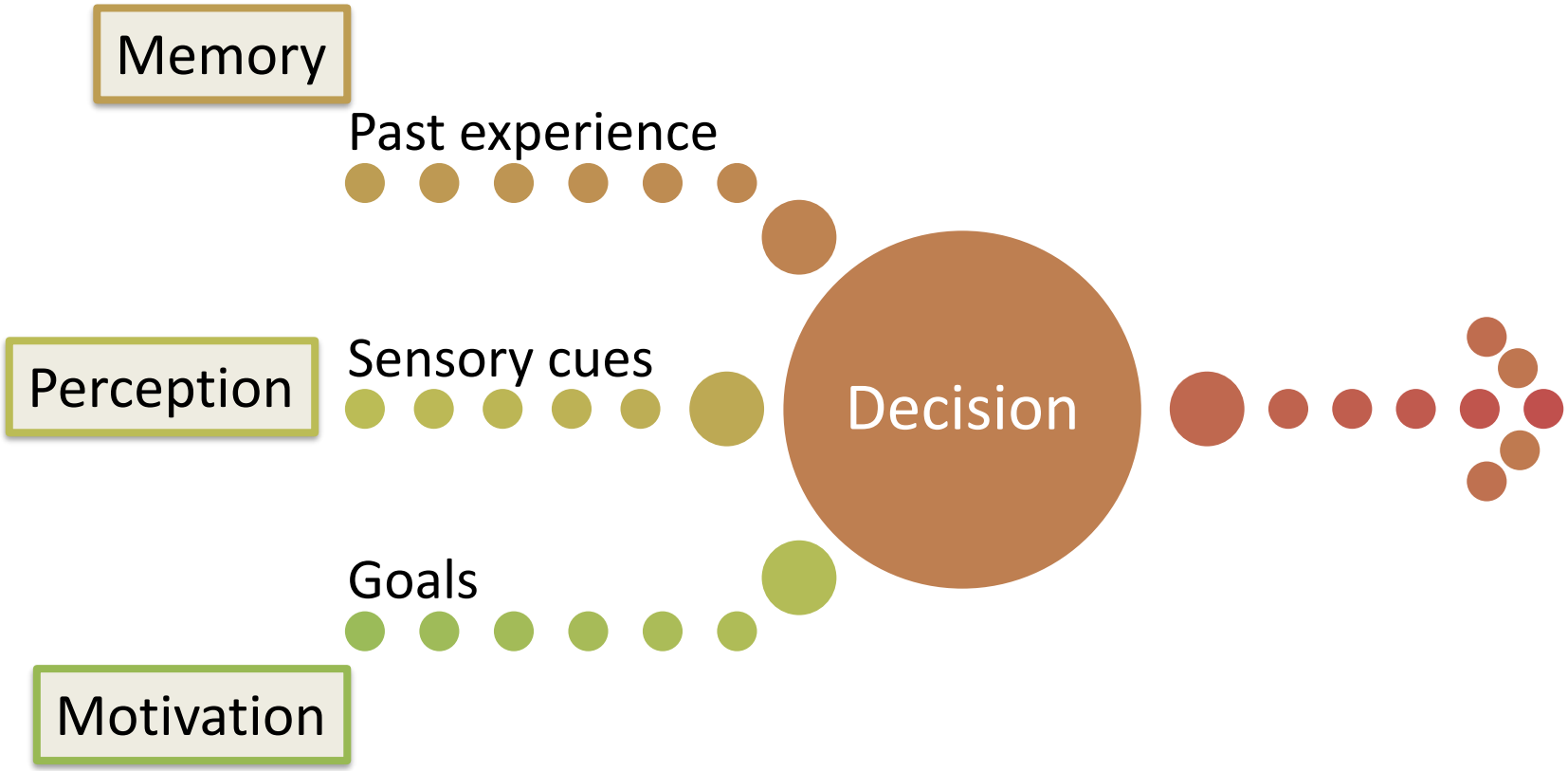
Taking drugs… or not…

What is the
information process
that led one
~~to make that decision~~
to take that action?

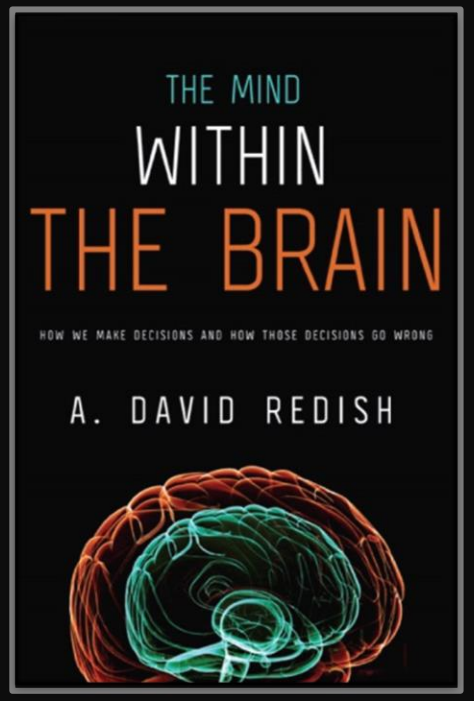
Buying or selling stocks

Computation is about how *information* is stored and transformed through the process.

Decisions are computations.



A new microeconomic model



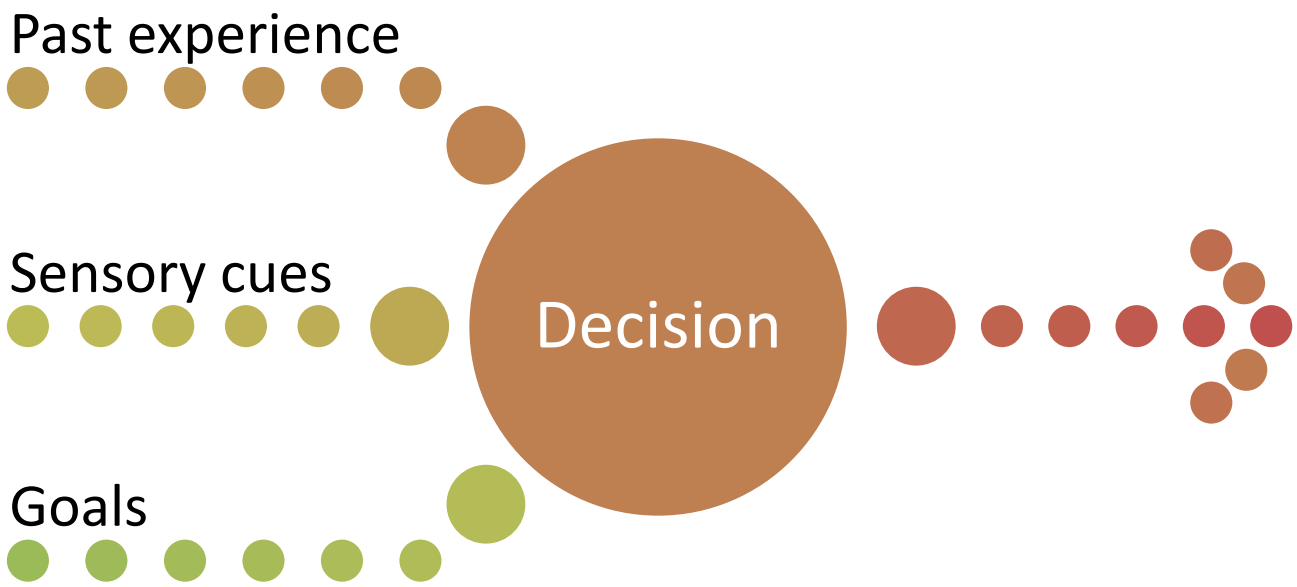
Decisions

Reflexes: prewired responses to stimuli.

Instinctual: learning the situation to release prewired actions.

Deliberation: search and evaluate potential consequences.

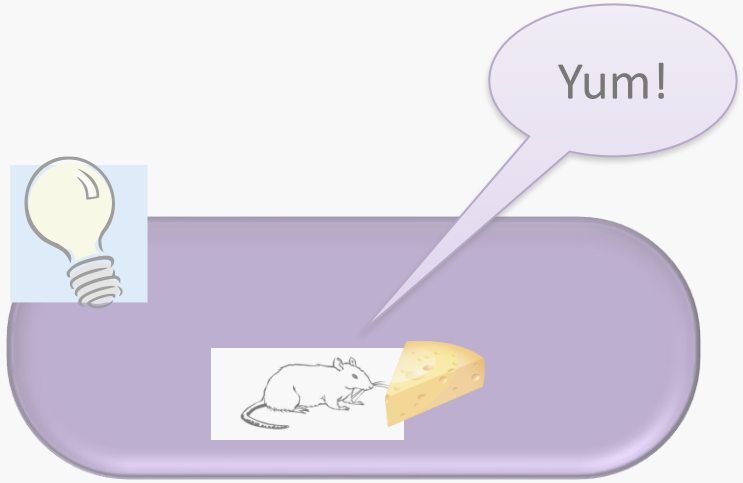
Procedural (habits):
cached action-chain sequences.



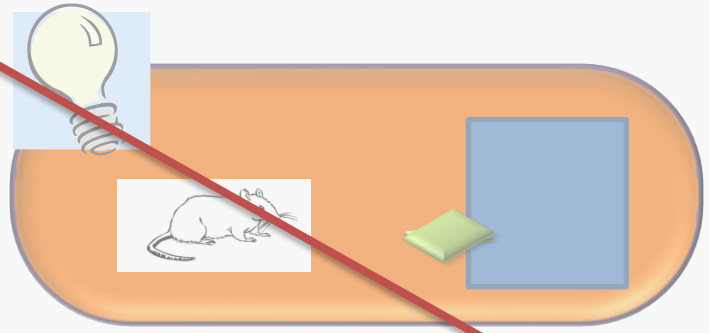
The classic psychology dichotomy

This takes the experimenter's point of view, not the subject's.

Pavlovian

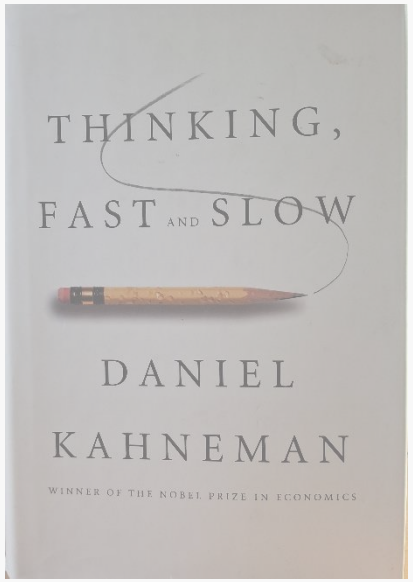


Instrumental



System I and System II

Following 1960's psychology, economics accepted the idea that there were two systems, **a *deliberative, rational* System II** and put everything else into **a *heuristic, biased* System I.**



The instinctual system is at least as different from procedural as either is from deliberation.

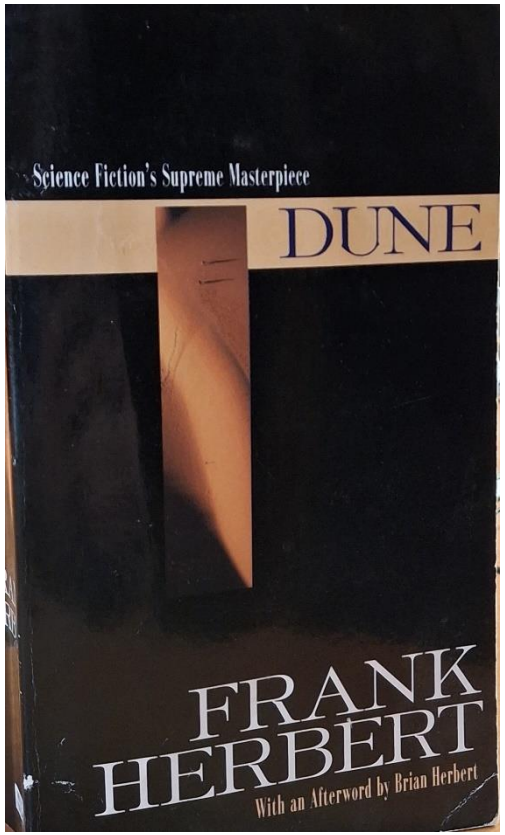
System I lumps all computational consequences together including not only decision-making but also the mechanisms of perception and attention, motor control.

Deliberation also has computational limitations.

Dual process theories

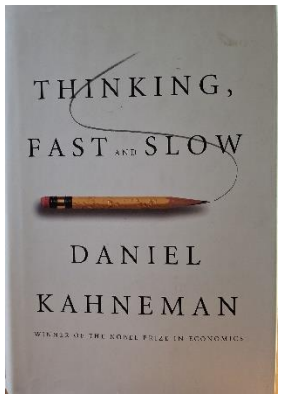
Classic psychology suggests
that we have
two decision systems:

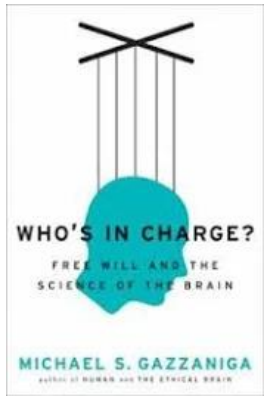
a *better (human) cognitive system*
and
a *worse "animal" one*.

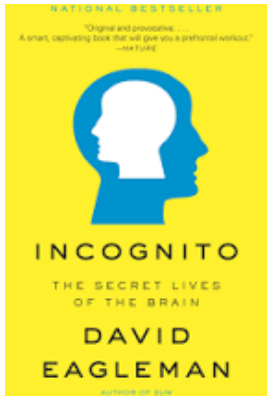


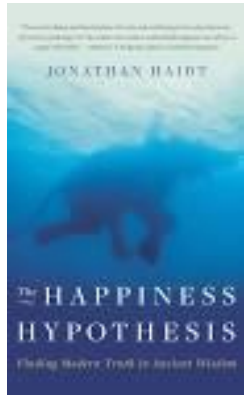
The Bene Gesserit *gom jabbar*
sifting for humans.

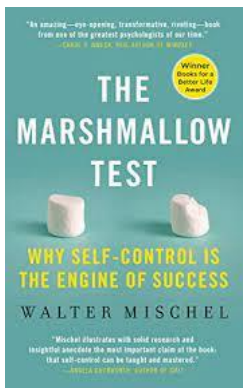
- *Dune* (Frank Herbert)











Dual process theories

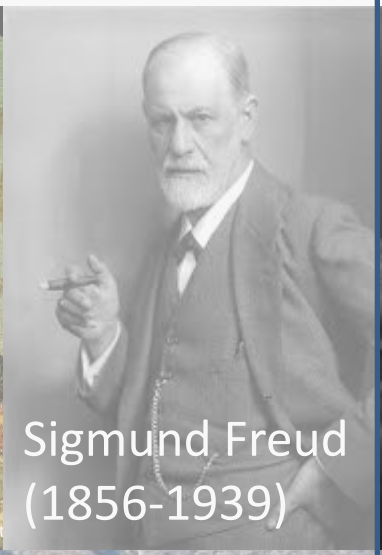
Classic psychology suggests that we have **two** decision systems:

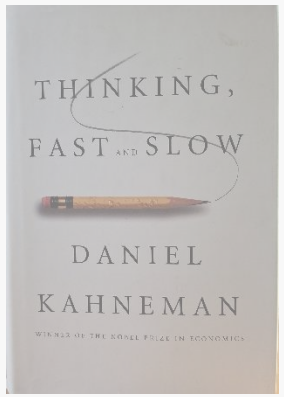
a *better (human) cognitive system* and
a *worse "animal" one*.

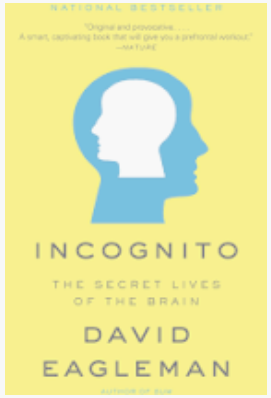
There are more than two systems.
All of these systems are useful.
They are optimized for different situations.

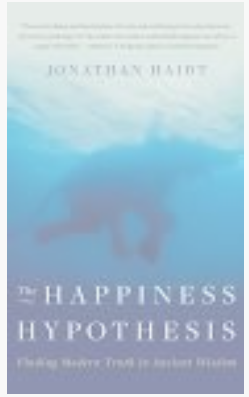

Plato of Athens (427-348 BCE)

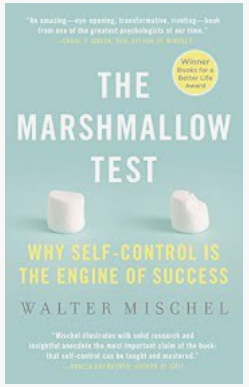

Augustine of Hippo (354-430)


Sigmund Freud (1856-1939)



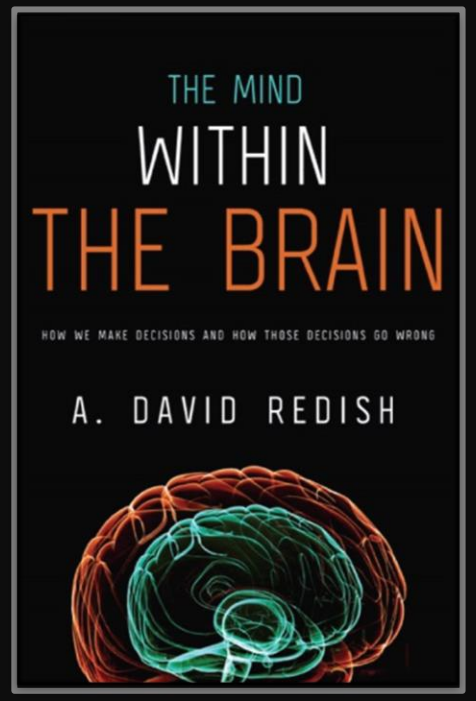







The "horse and rider" theory

A new microeconomic model



You are all of these systems.

We need to think computationally.

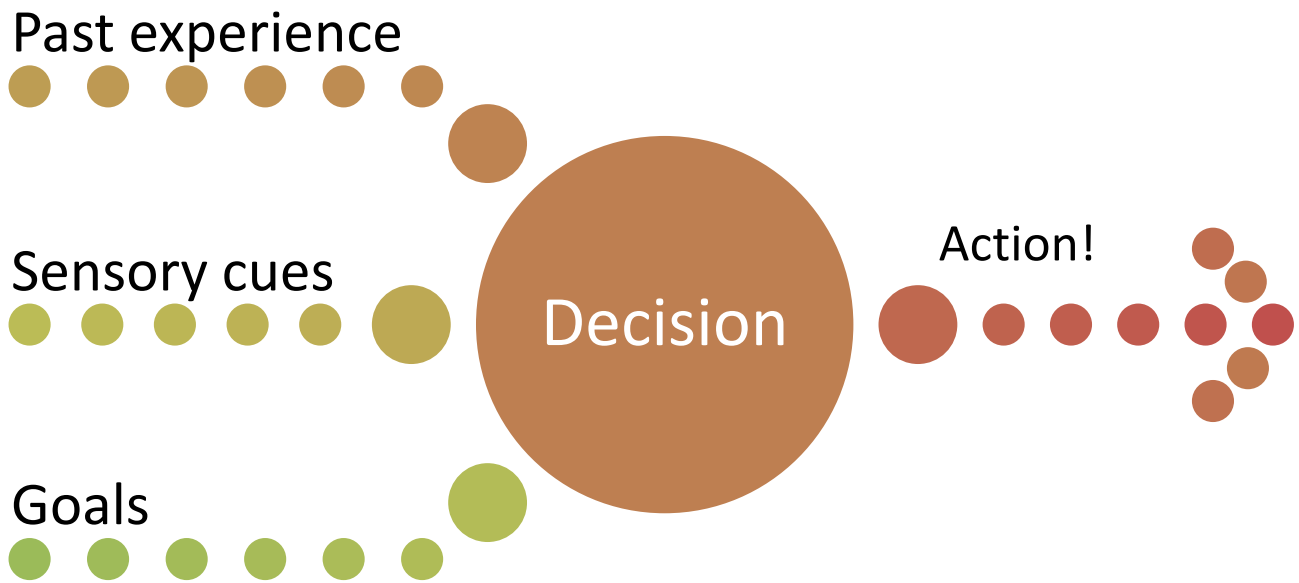
Decisions

Reflexes: prewired responses to stimuli.

Instinctual: learning the situation to release prewired actions.

Deliberation: search and evaluate potential consequences.

Procedural (habits): cached action-chain sequences.



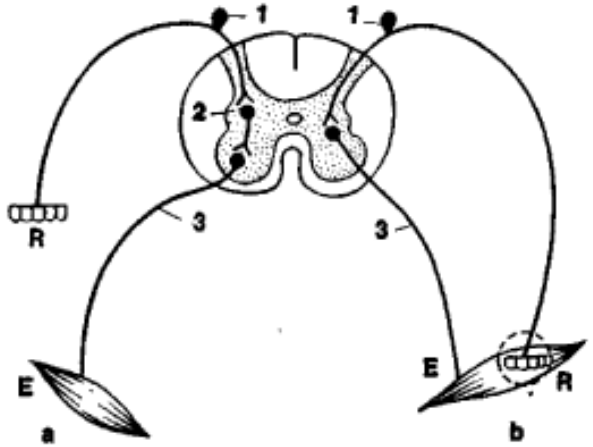
Reflexes

Reflexes are prewired responses to stimuli, learned over evolutionary time through genetic algorithms (trial search by sampling).

Learning within the lifespan is limited to habituation, sensitization, and simple threshold adjustments.

Downward Parachute Reflex

(Protective Extension Reaction Downward)



Depends on spinal function

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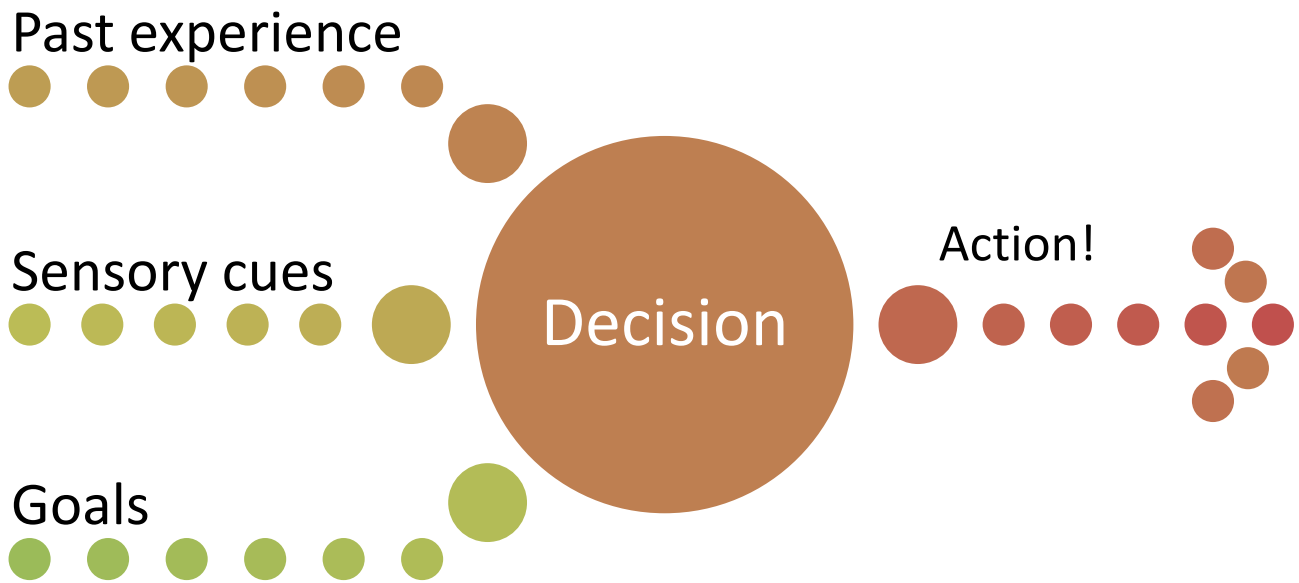
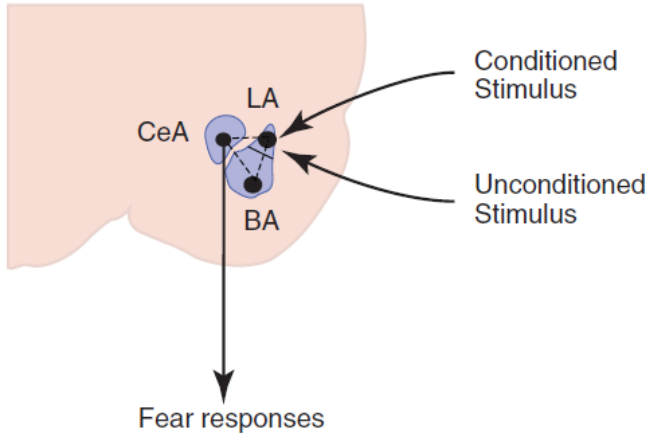
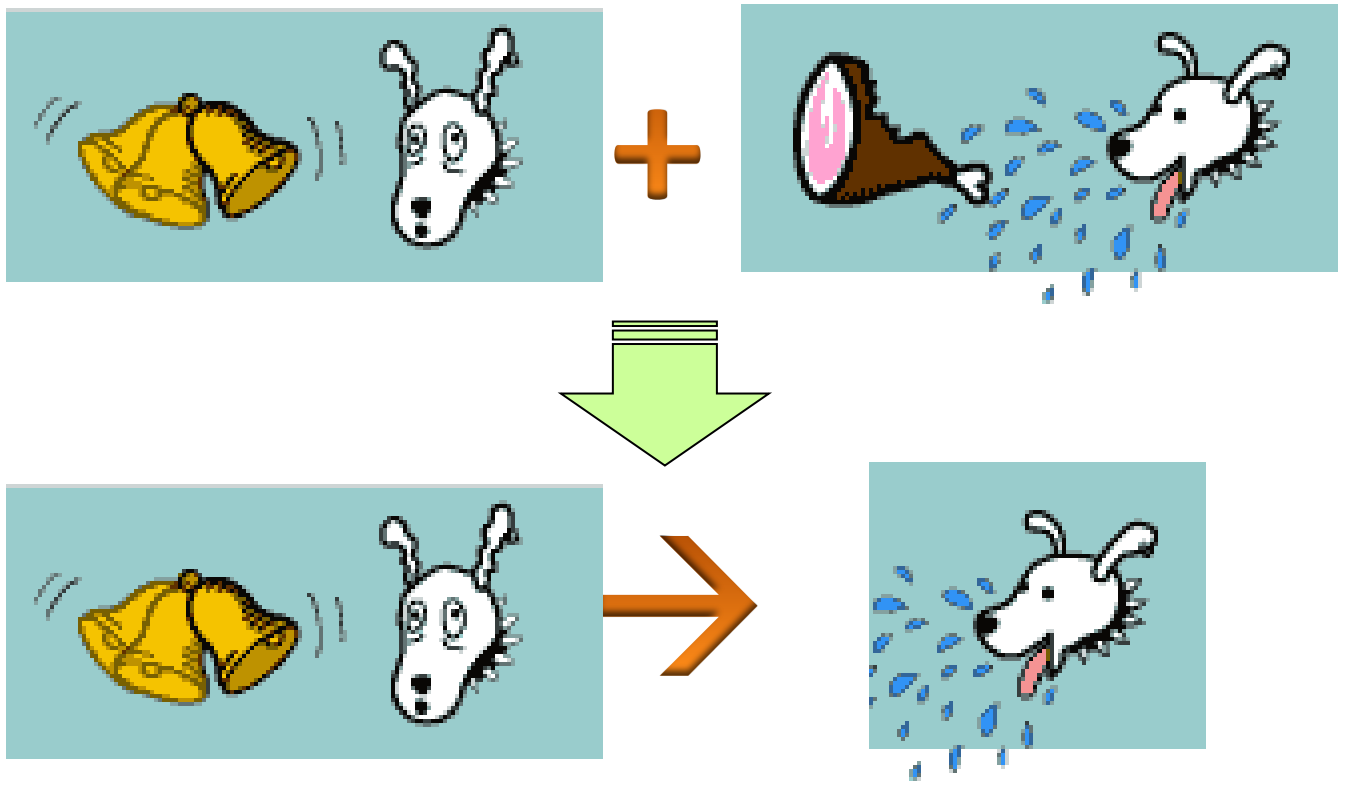


Pavlovian (Instinctual)



Instinctual systems associate stimuli with outcomes, so that observation of a stimulus will lead to the *expectation of an outcome*, leading to the release of *pre-wired actions*.

There is a limited repertoire of available actions.



Pavlovian (Instinctual)

The instinctual repertoire are the basic survival circuits of Fight … flight … food … and ~~reproduction~~ the mating dance (flirting).

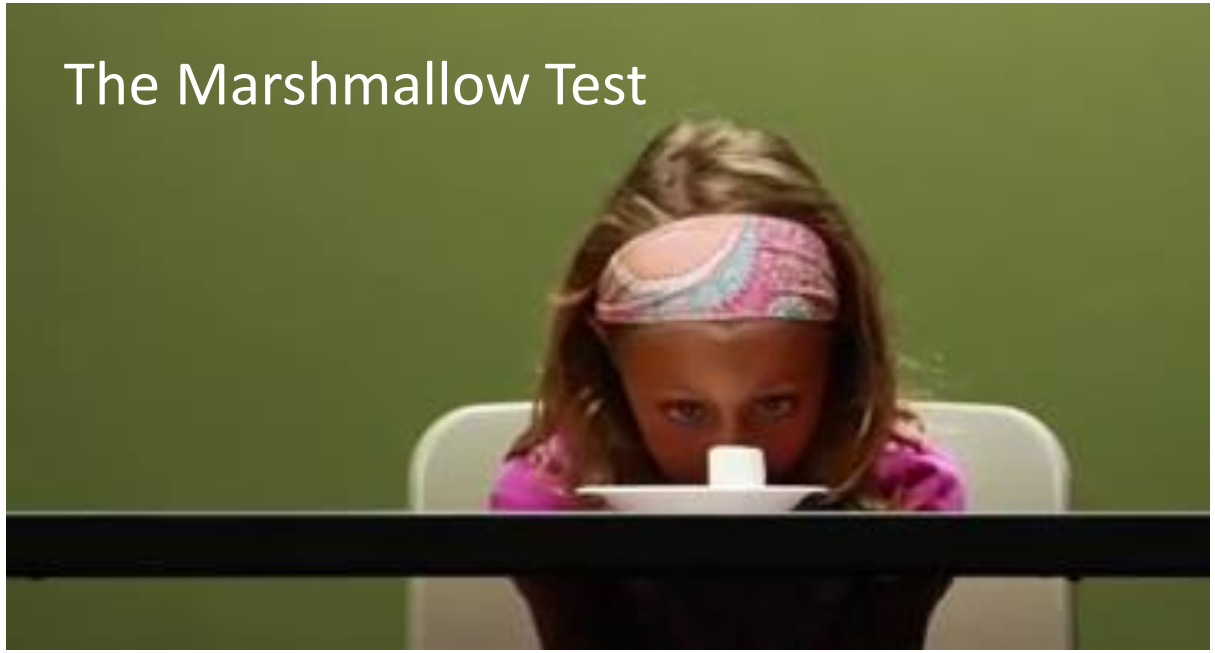
In fact a lot of social interactions are “Pavlovian” (instinctual) and use these **same** neural circuits.

Laughing with your friends is Pavlovian.

The endowment effect

Pavlovian systems can only access immediate rewards.

This provides an excess valuation to immediate options.



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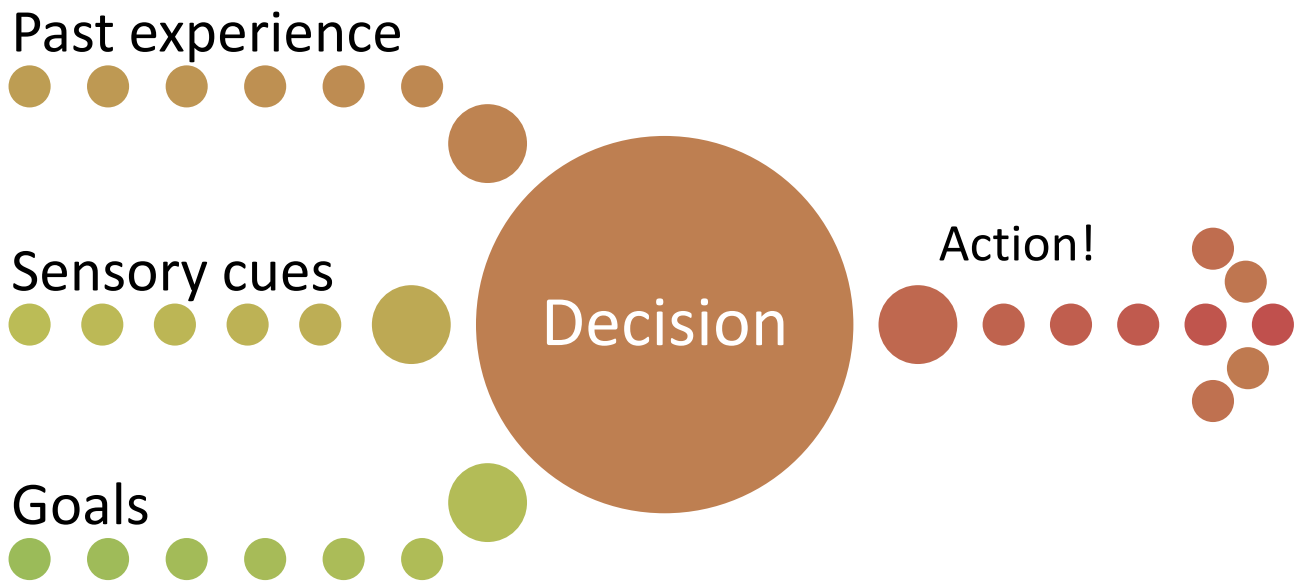
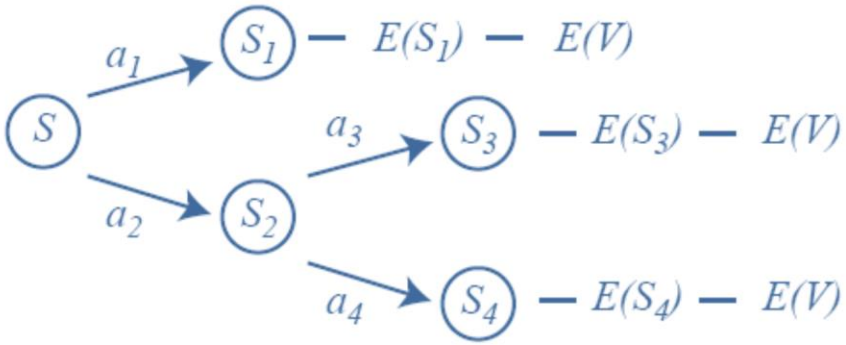
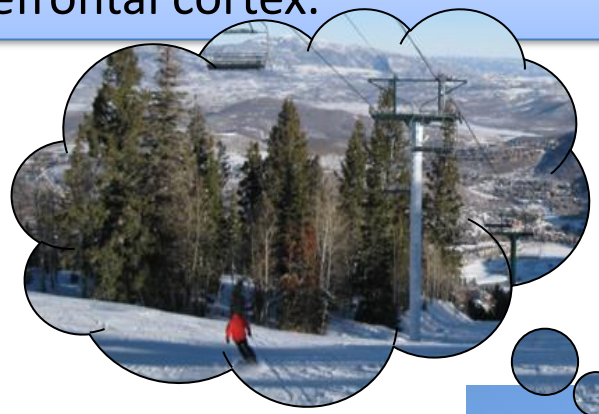


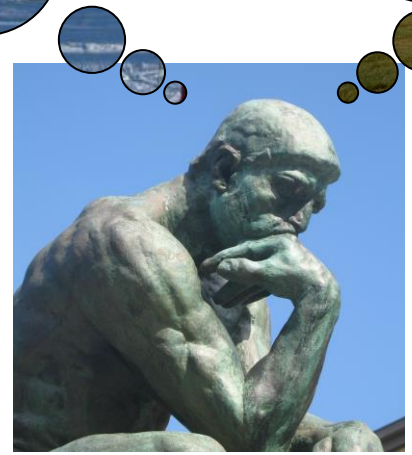
Deliberation

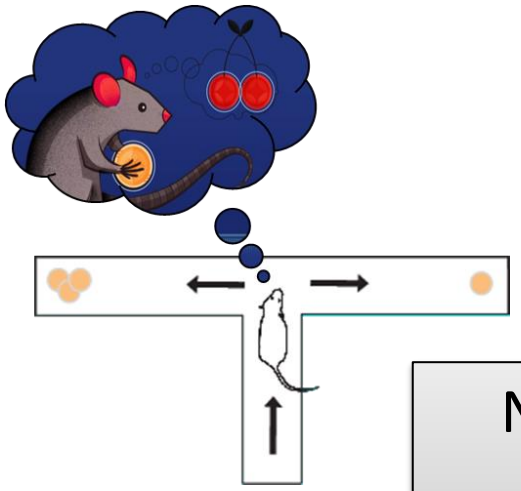
Depends on hippocampus, medial prefrontal cortex, orbitofrontal cortex, nucleus accumbens core, dorsolateral prefrontal cortex.

Deliberation entails actual imagination of potential outcomes, and then an evaluation of that outcome.









Notice that we are **computationally** defining (reifying) this process, which allows us to look for these processes in non-linguistic animals.

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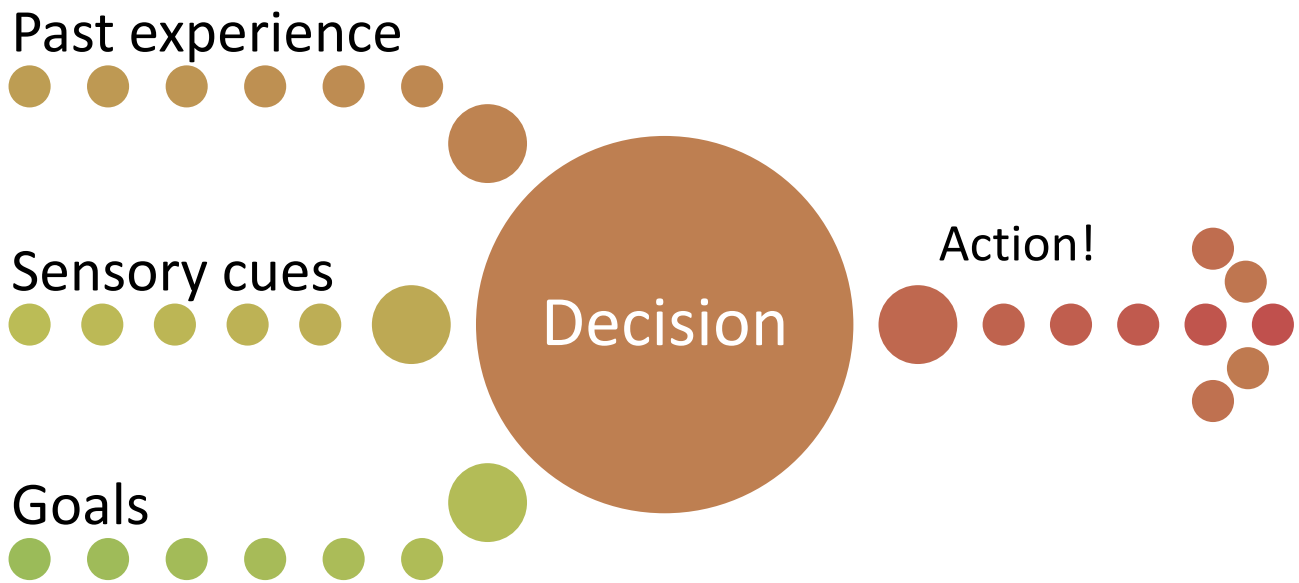


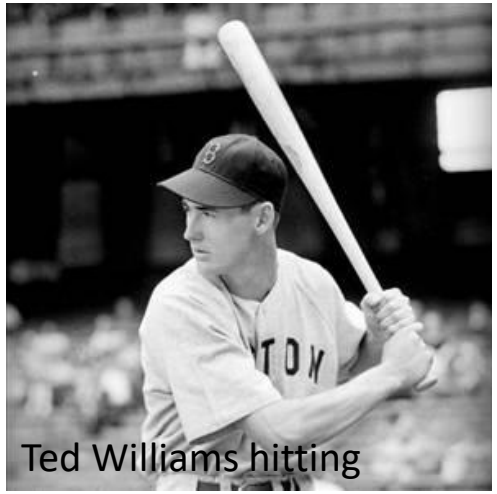
Procedural habits

Recognizing the situation

(Perception [cortex])

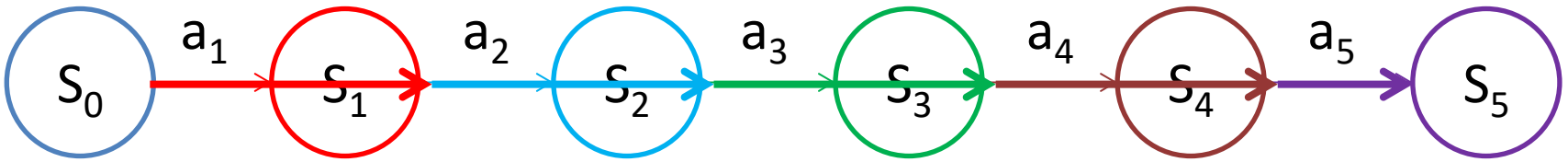
→ Release a well-learned (arbitrary) action chain [dorsolateral striatum]

Procedural habits are learned slowly, allowing them to be fast and reliable but inflexible in their execution.



Ted Williams hitting

Mao Asada performing a triple Axel jump



Actions without learning
Situations learned.

Actions and situations must both be reliable.

Learn structure of world.
Plan actions on it

Increasing regularity in the environment and actions taken

Actions without learning
Situations learned.

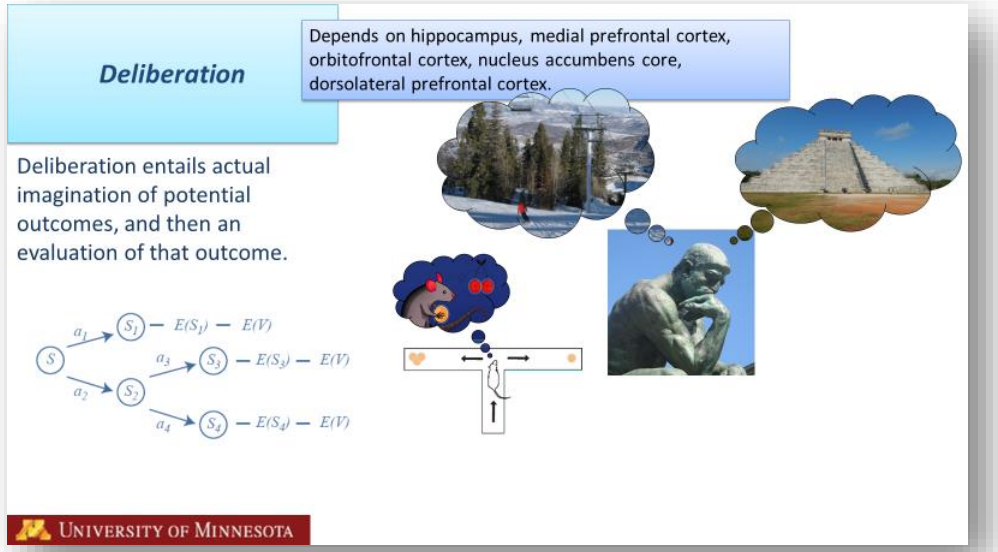
Learn structure of world.
Plan actions on it

Actions and situations must both be reliable.

Override as regularities are recognized

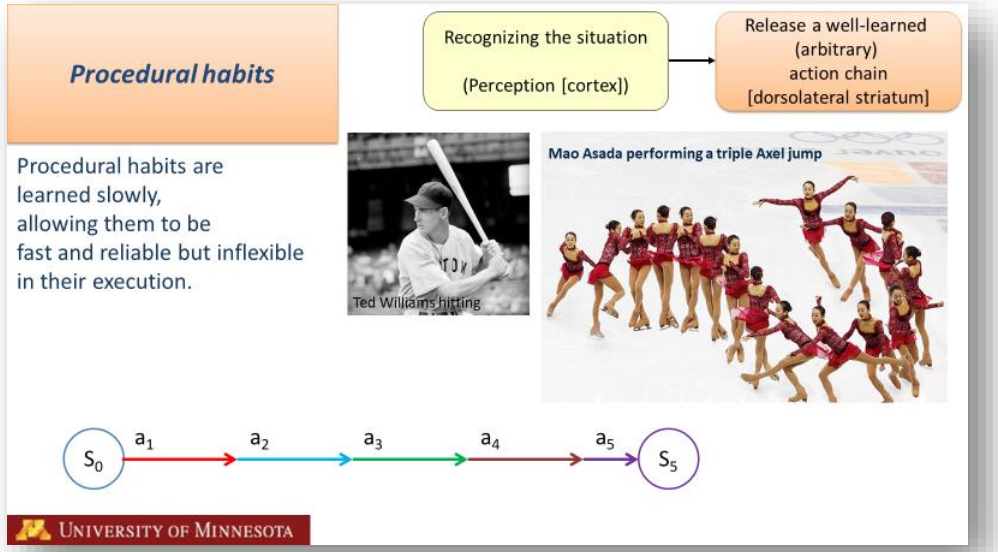
Pop-up in times of change

Utility theory



Deliberation depends on sampling.

This makes it **inconsistent**.



Procedural is a table-lookup.

This makes it **consistent**.

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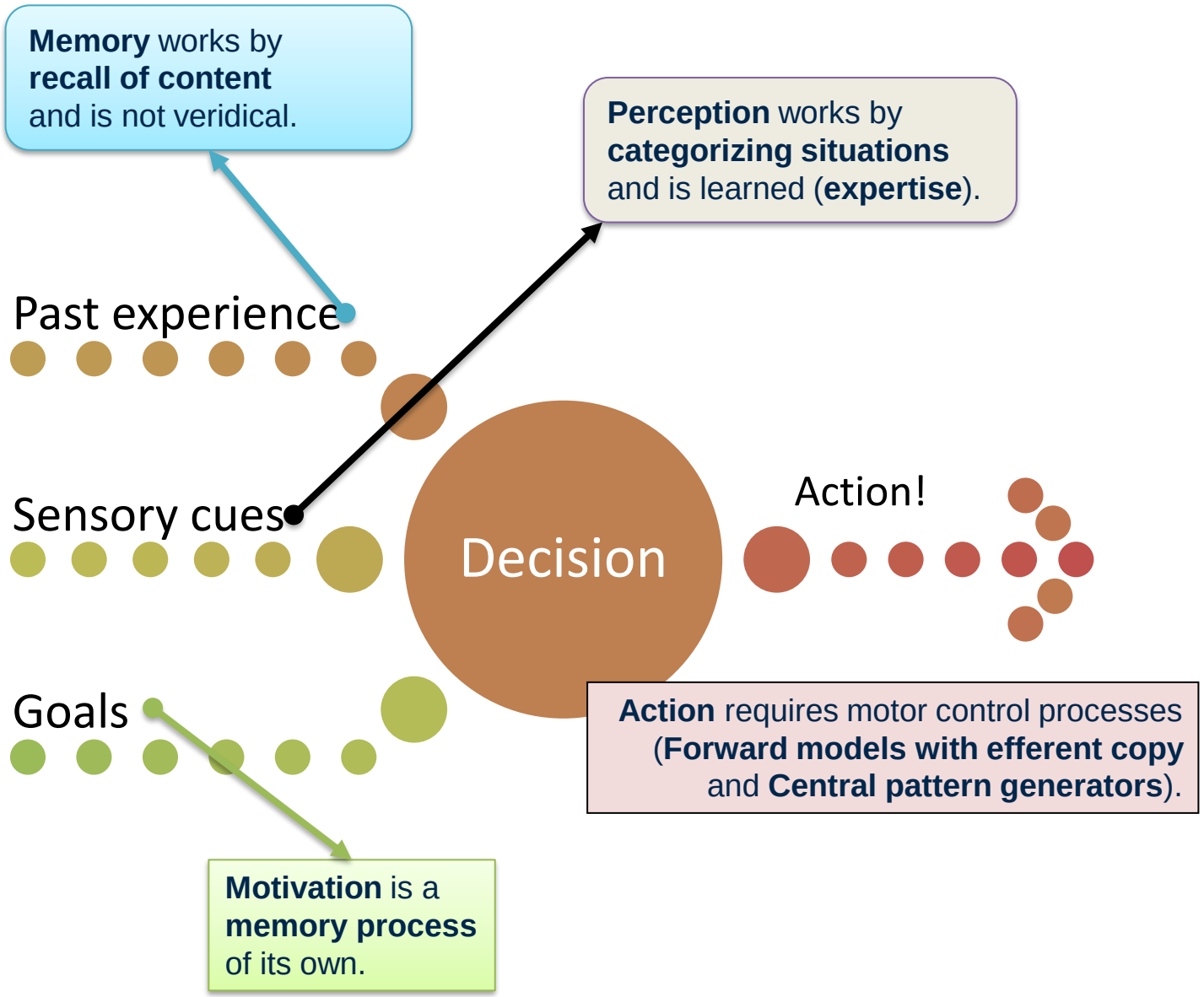
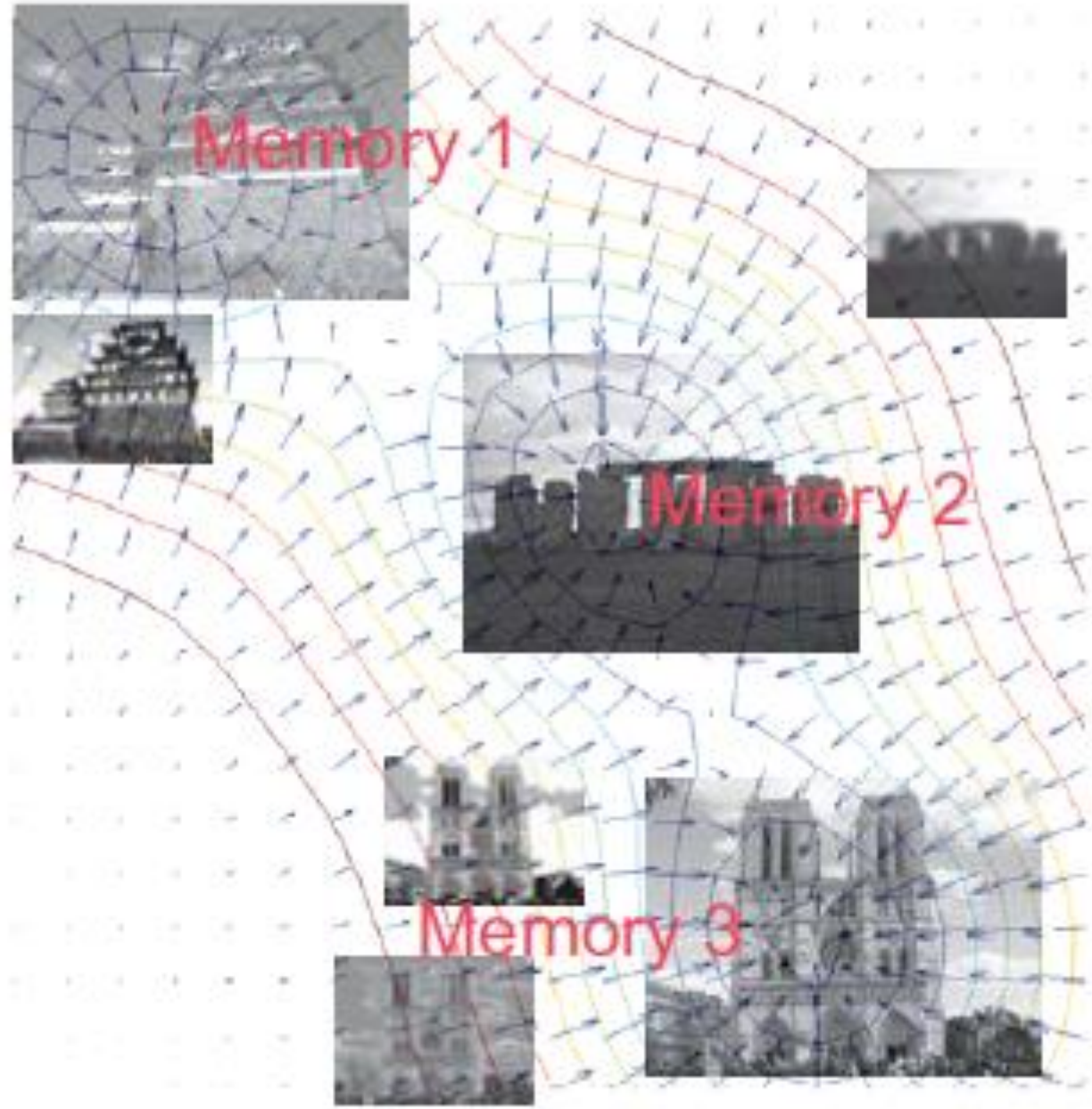


Memory is a process of moving the pattern of neurons to a previously stored pattern.

The means that memory is **constructed**.

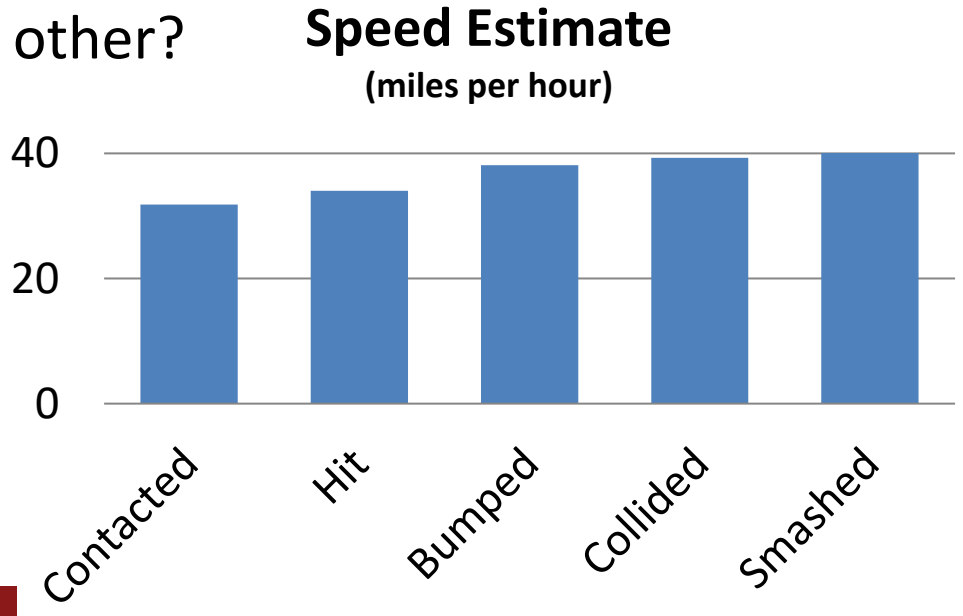
Memory is addressed by ***content***.



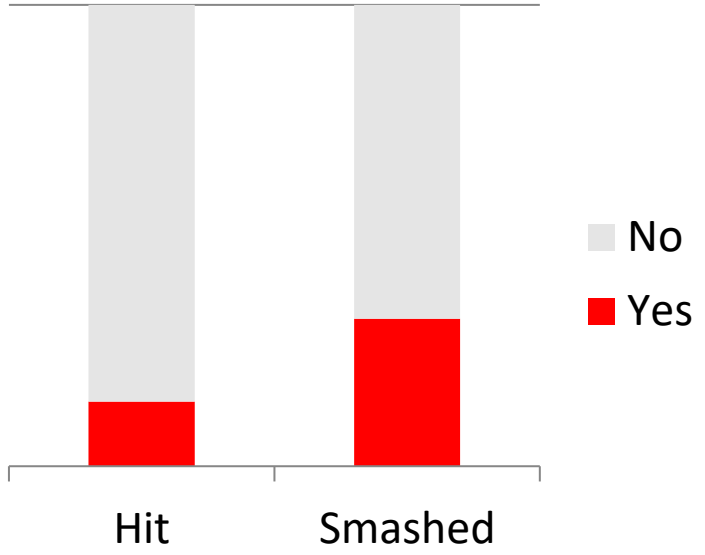
Memory is fragile, and suggestible

In 1974, Elizabeth Loftus and John Palmer found that the way a question was asked could change the memory.

How fast were the cars going when they _____ each other?



Was there broken glass?

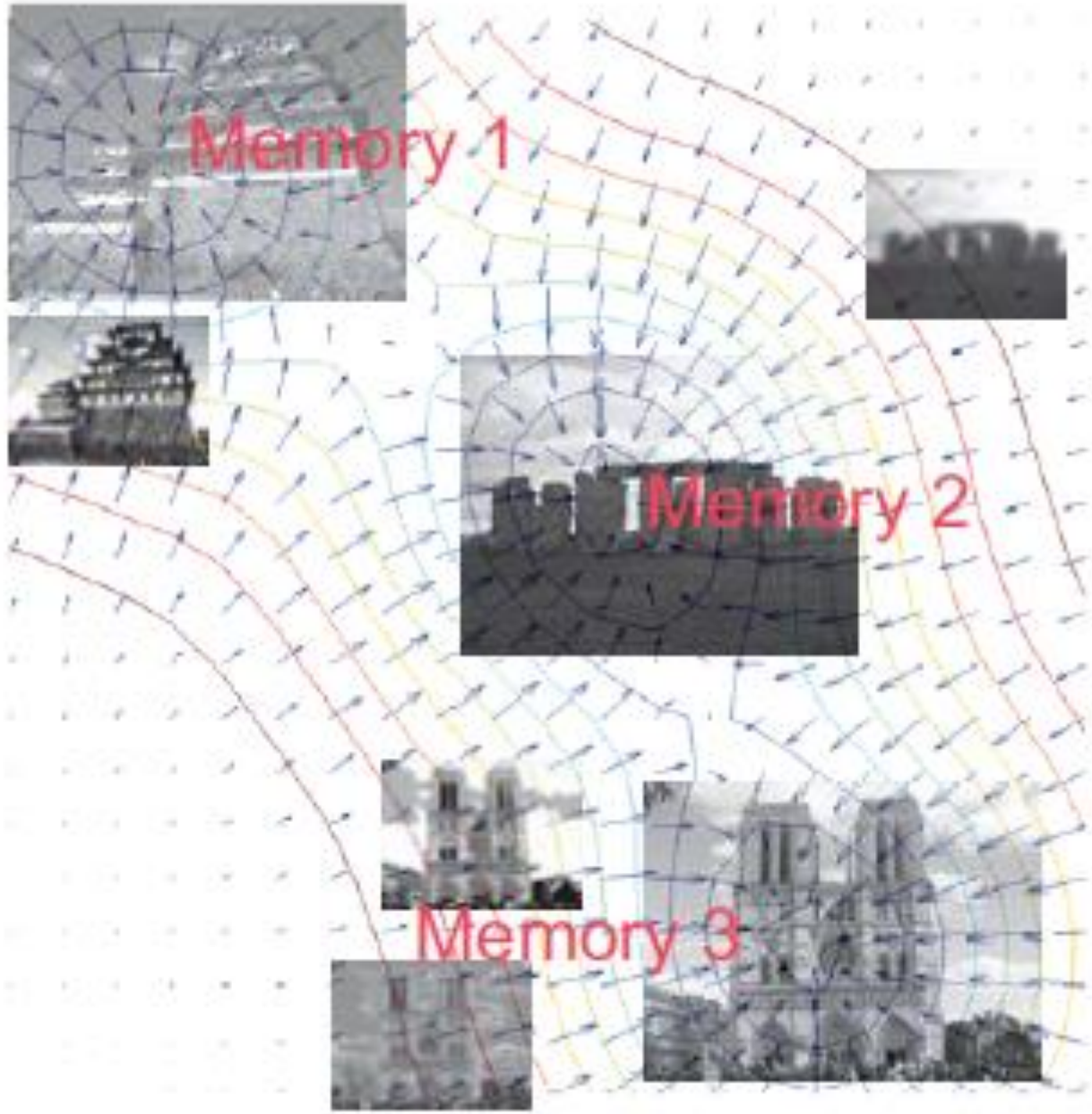


Notice that this gives you **hindsight bias**.

Framing

Because memory is
content addressable,

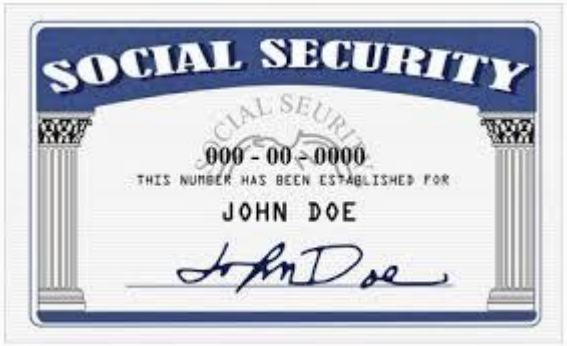
the initial pattern will modify
the final recalled pattern.



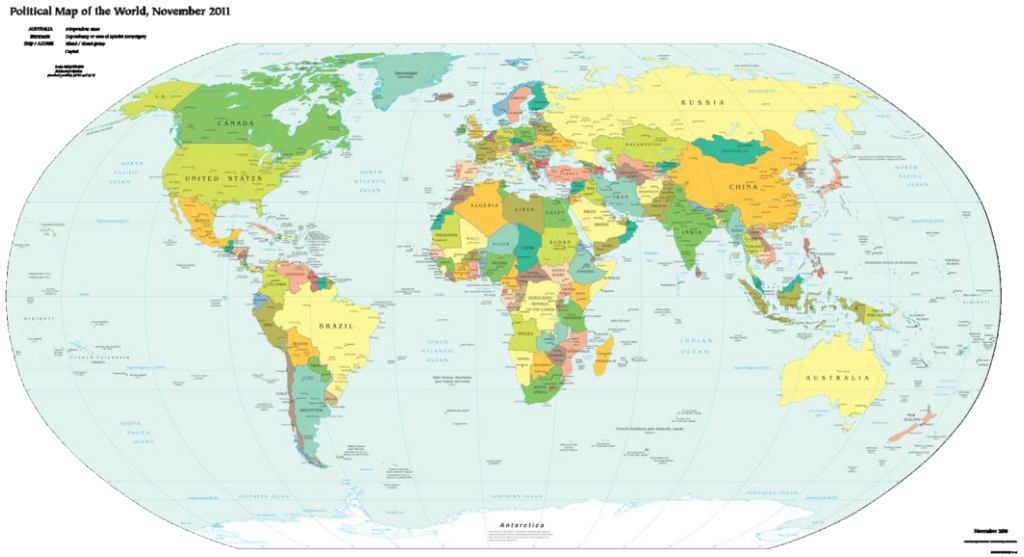
Runge, Johnson, Nelson, Redish (2023) *J Neurosci Psychology Economics*

The anchoring effect

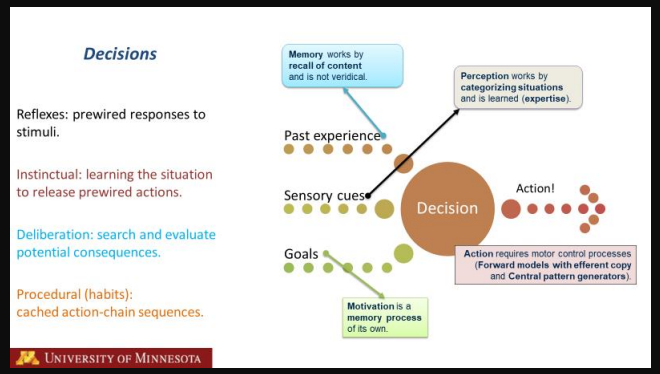
What are the last two digits of your social security number?

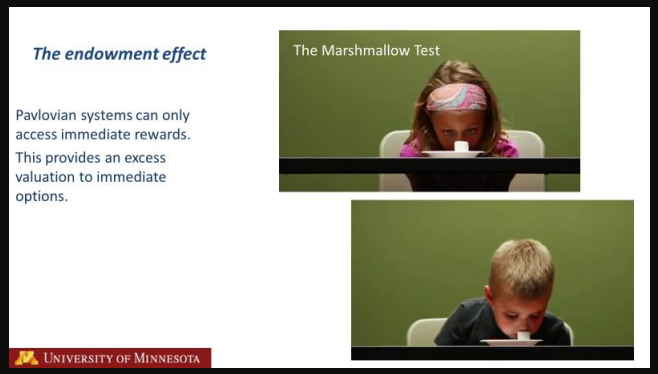


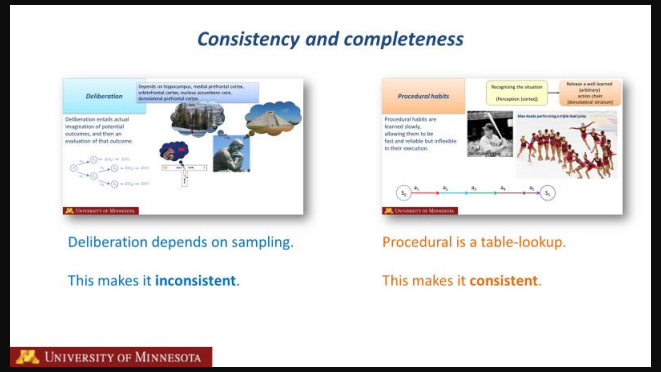
How many countries are in the UN?

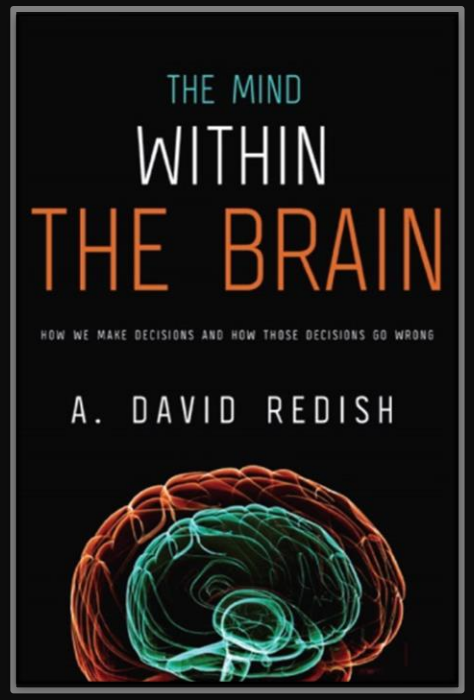


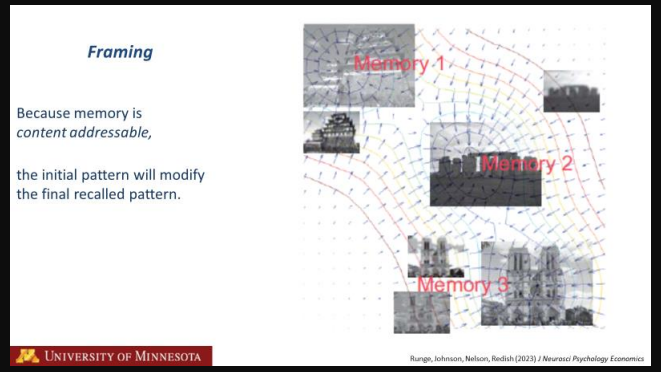
This is a new microeconomic model

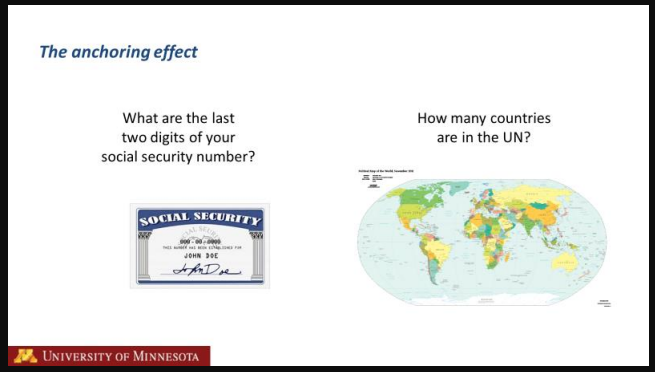




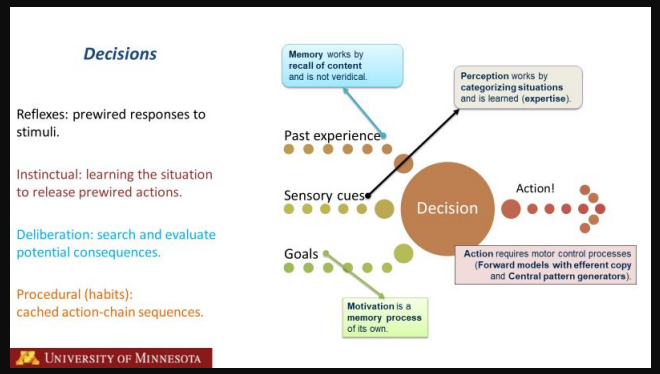


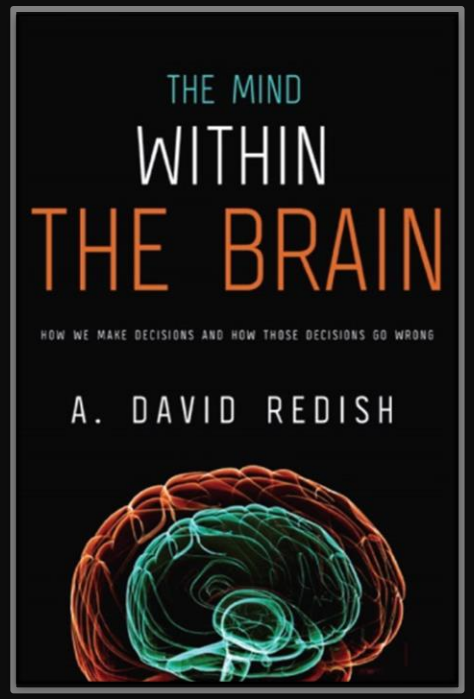






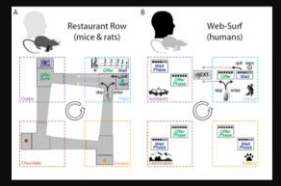
This is a new microeconomic model





1 A sensitivity to sunk costs

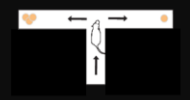
Economics in non-human animals



2 Contingency management

How you ask the question matters

Should I stay?



Which one?

Is it worth it?

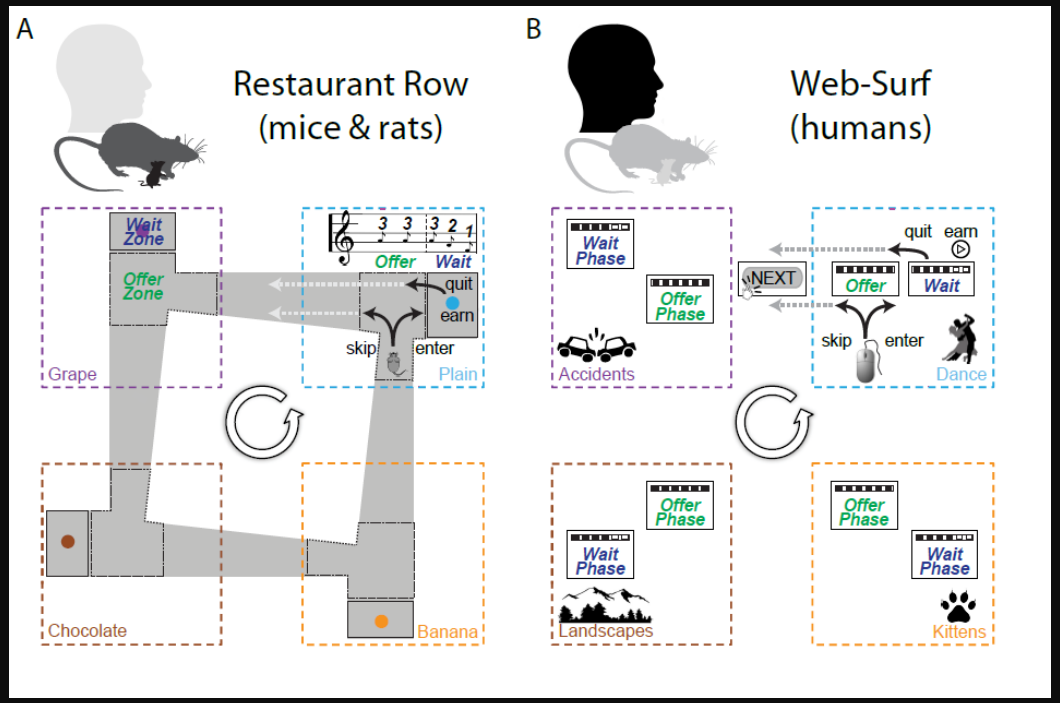
3 Trust and community

Making yourself vulnerable to others

1

A sensitivity to sunk costs

Economics in non-human animals

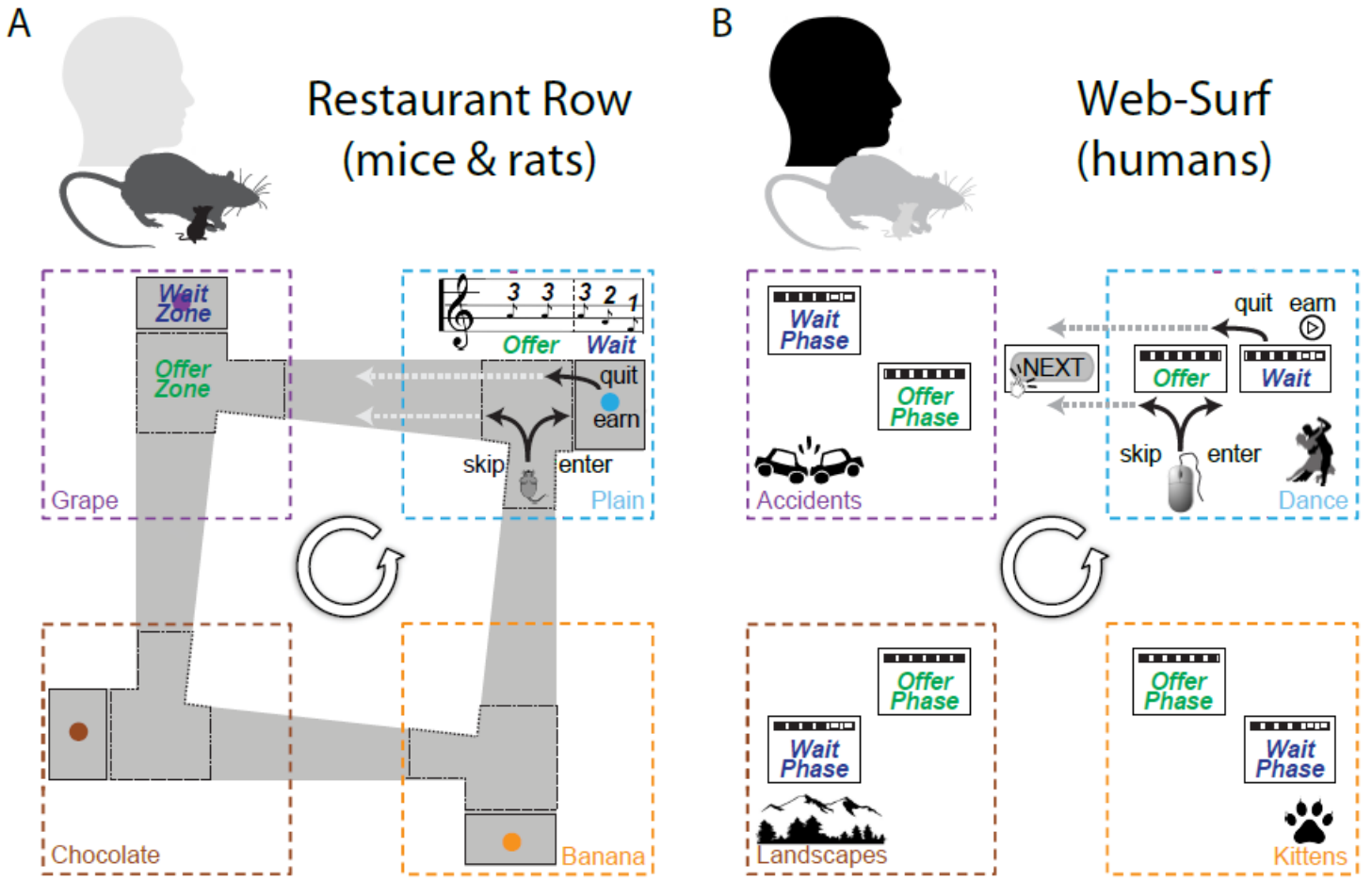


Sunk costs in mice, rats, and humans

Rats run around a circular track for food reward.

Humans surf a web interface for videos to watch.

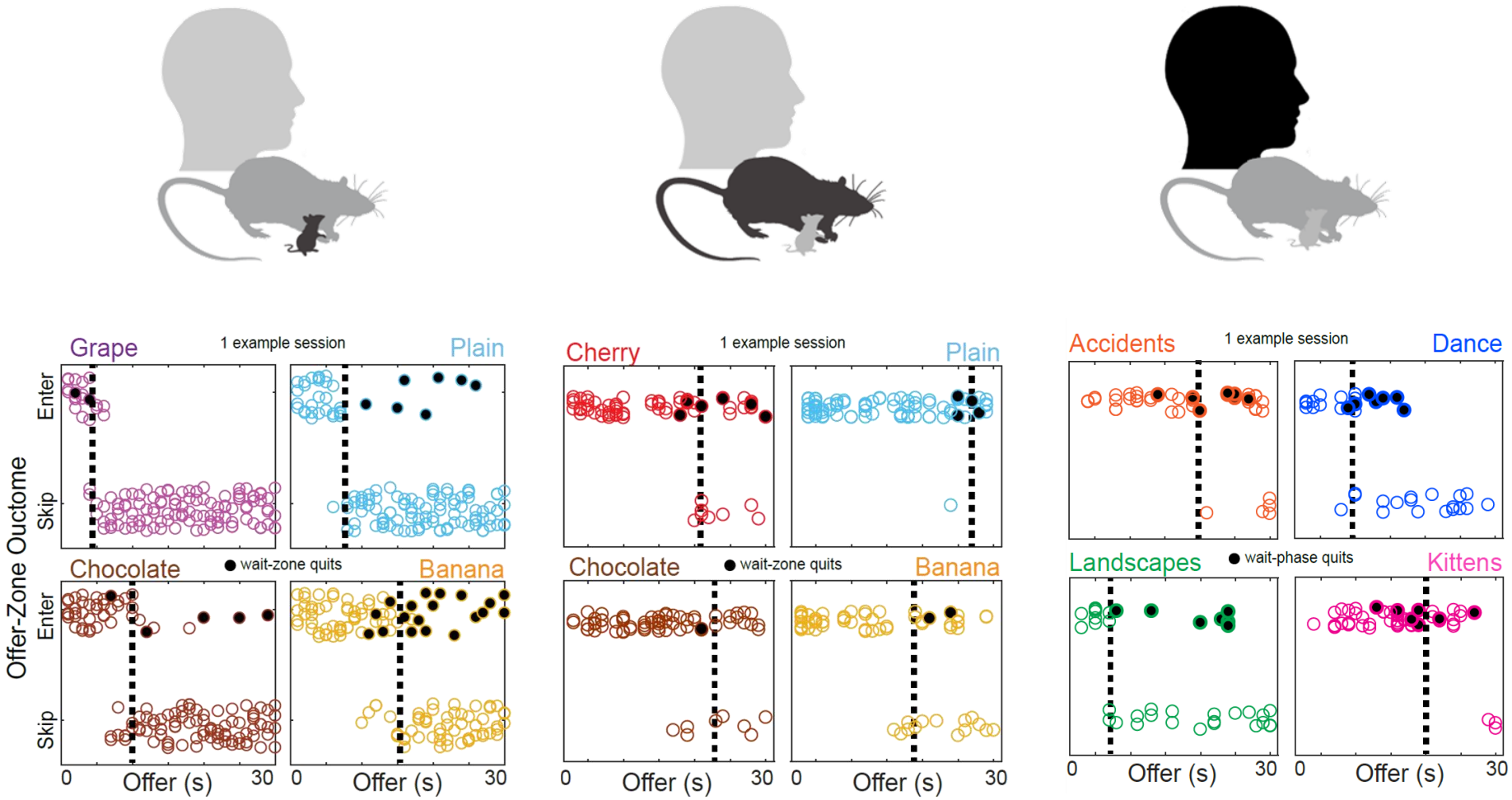
Because they have a **limited time on the track**, waiting for one reward must be balanced against waiting for another.



Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

Preferences

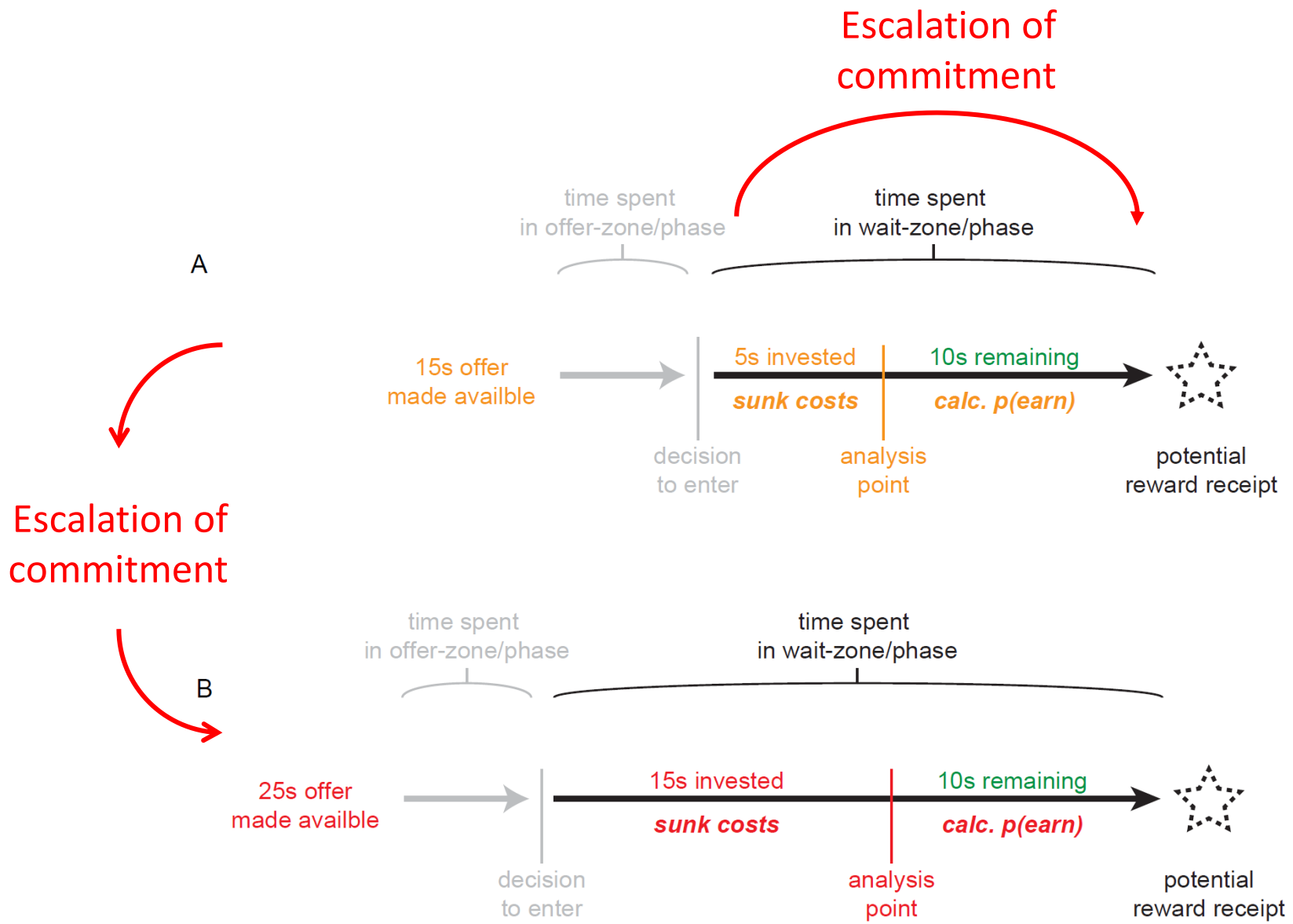
Every subject we've run on this task (mouse, rat, human) has shown measurable preferences.



Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

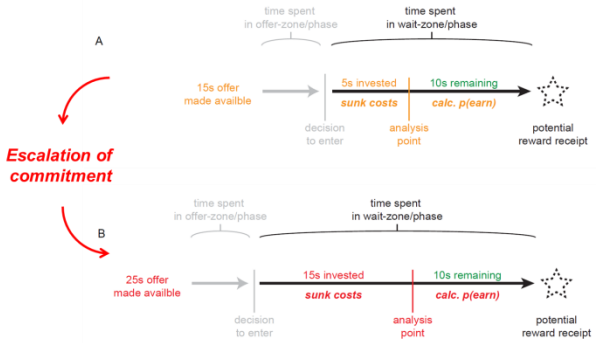
Operationalizing sunk cost sensitivity

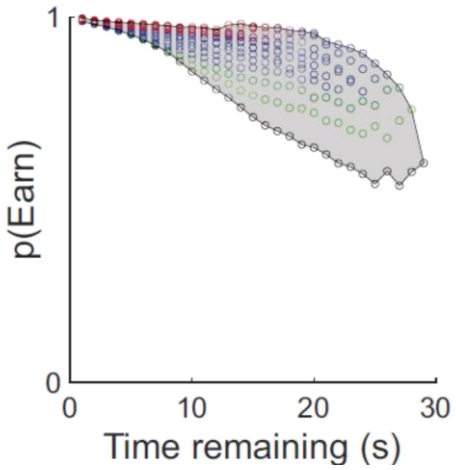
Sensitivity to sunk costs arises when decisions are made based on past expenses rather than future expectations.

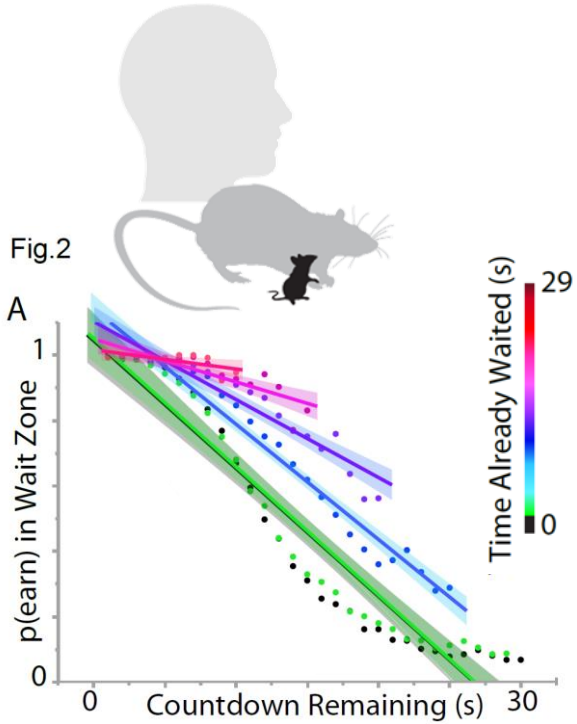


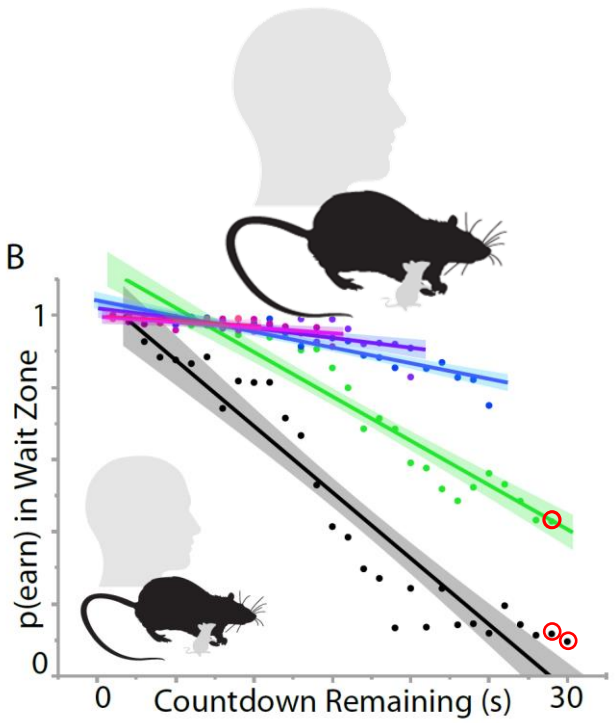
Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

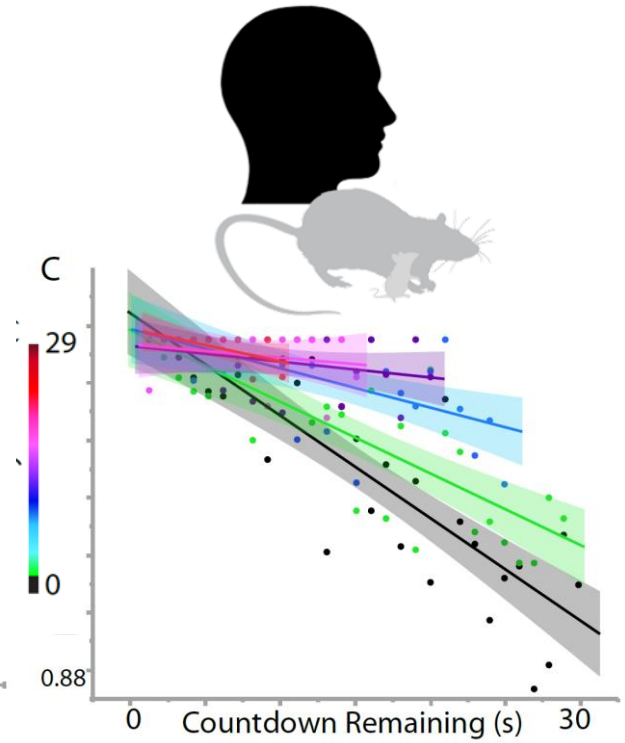
Sunk costs in the wait zone







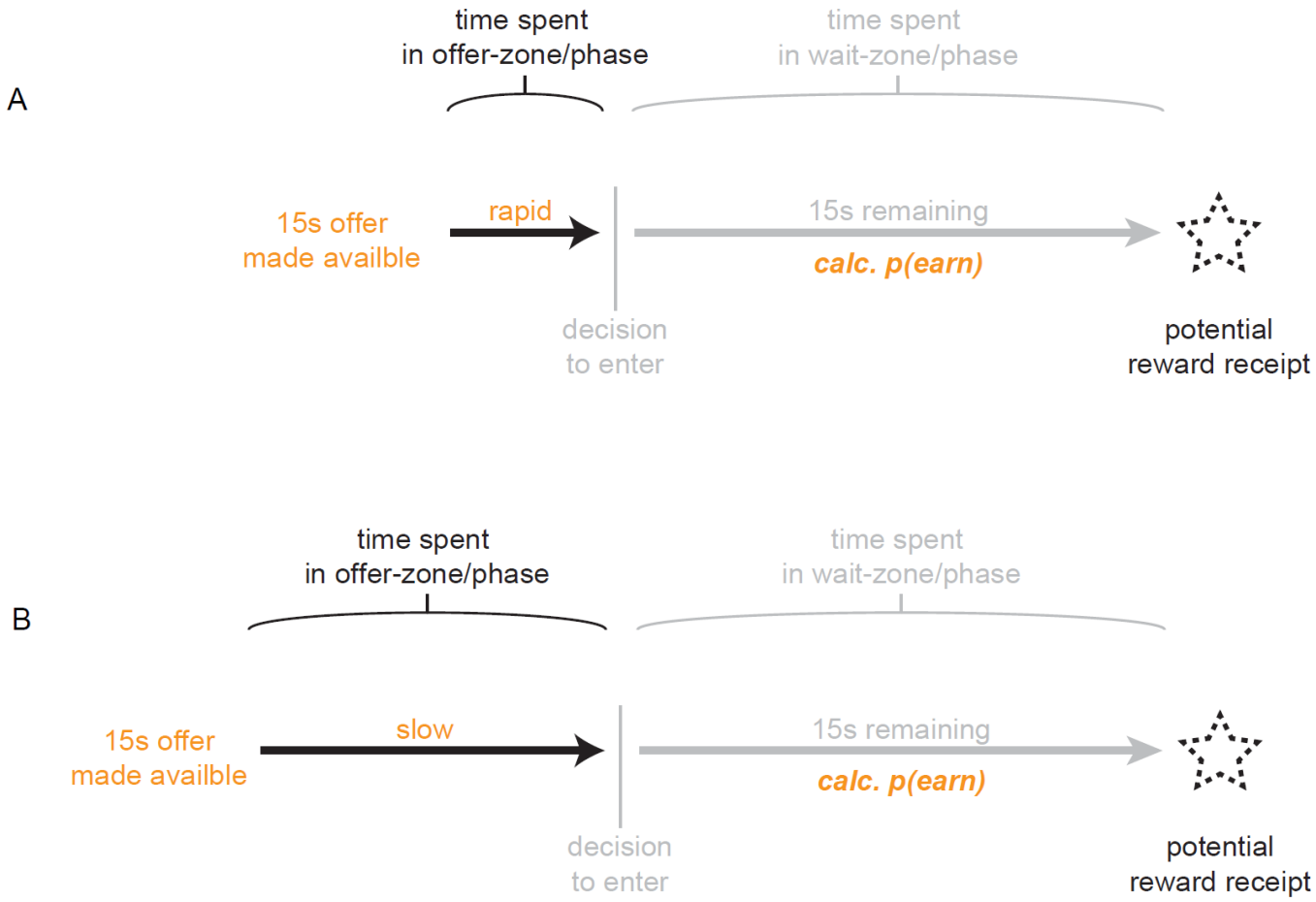




Redish, Abram, Cunningham, Duin, Durand-de Cuttoli, Kazinka, Kocharian, MacDonald, Schmidt, …
Schmitzer-Torbert, Thomas, Sweis (2022) *Communications Biology*
Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

Sunk costs in the offer zone

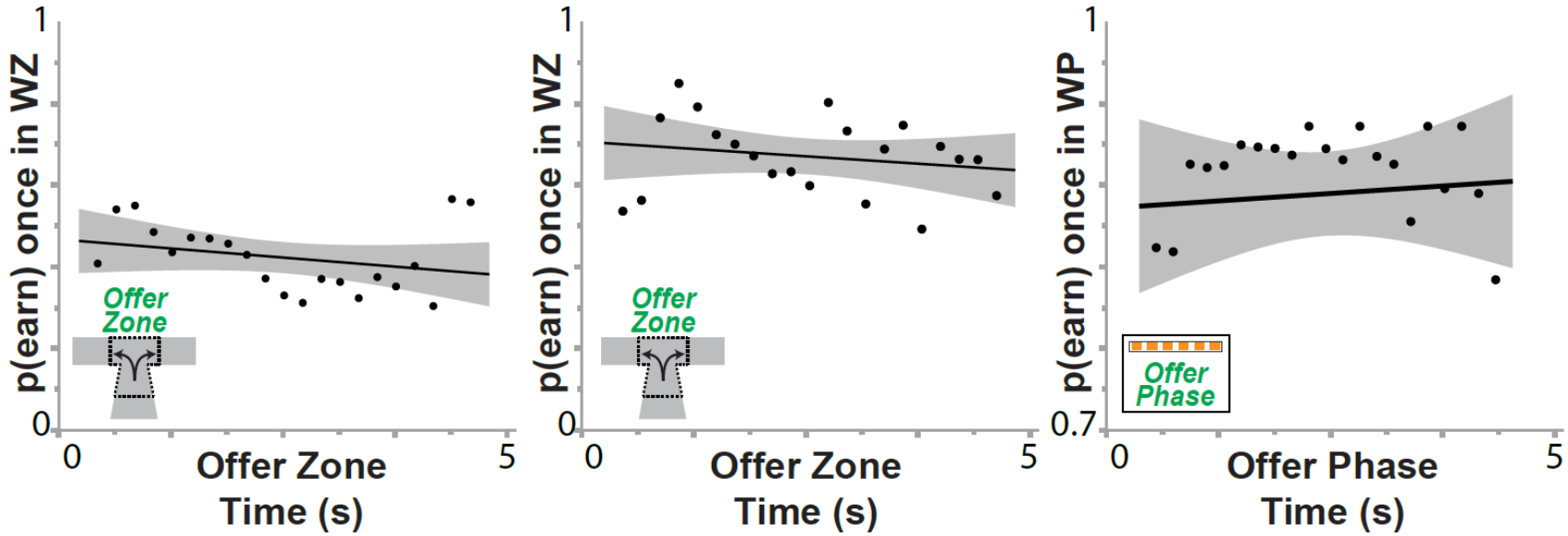
We can make
the same measurements based
on time spent in the offer zone.



Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

No sunk costs in the offer zone

Sunk costs only start to accrue after **investment** in a choice.



Sweis, Abram, Schmidt, Seeland, MacDonald, Thomas, Redish (2018) *Science*

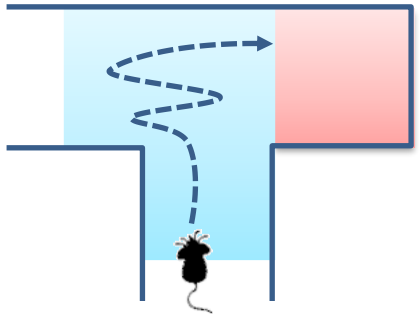
Sunk costs only start to accrue after **investment** in a choice.

In the human task literature,
one talks of a
commitment to task engagement
as “crossing the rubicon”.

Entering the wait zone is a *rubicon.*

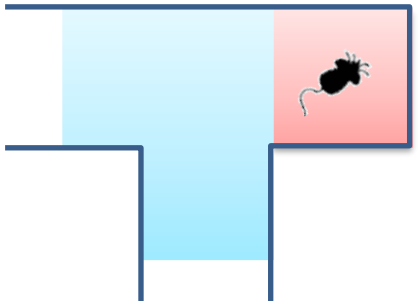
Sunk costs only start to accrue after investment in a choice

Deliberative planning systems



Dithering is a sign of deliberation, during which hippocampal representations sweep ahead of the animal along multiple choices, and depend on prefrontal cortical integrity.

Instinctual Pavlovian systems



Quitting arises from a re-evaluation of the choice and a prefrontal override.
Sunk costs are increased by increasing amygdala connections to the nucleus accumbens shell.

Redish (2016) *Nature Reviews Neuroscience*

Lind (Larson), Sweis, Asp, Esguerra, Silvis, Redish, Thomas (2023) *Communications Biology*

Sweis, Larson (Lind), Thomas, Redish (2018) *PNAS*

Kocharian, Redish, Rothwell (2024) *bioRxiv*

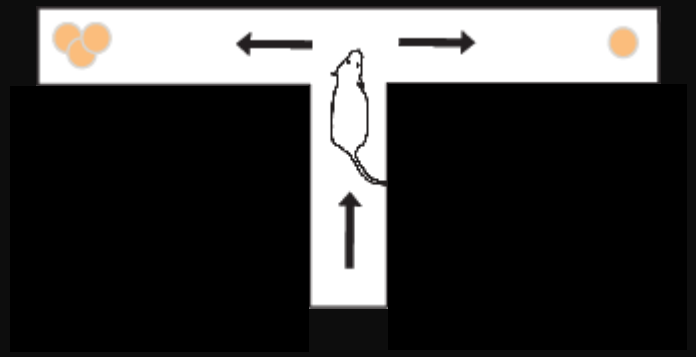
2

Contingency management

How you ask the question matters

regretfulrats.com

Should I stay?

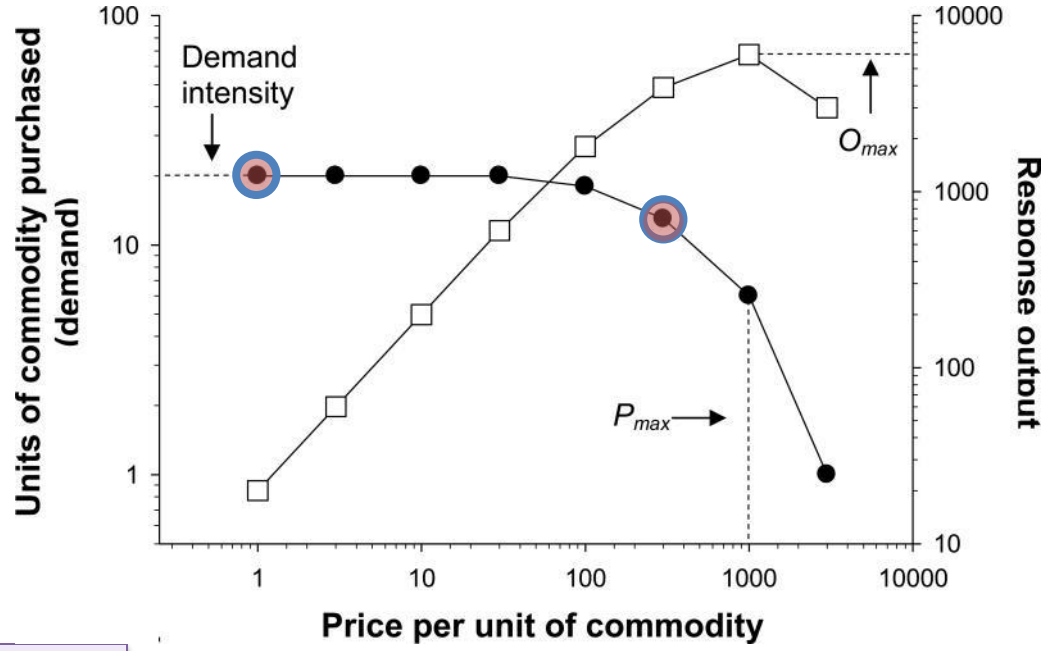


Which one?

Is it worth it?

Contingency management

If you don't use drugs for a week, then you receive a small reward.



Demand curve from Bruner and Johnson 2014

Current theory:

- The reward is an ***alternate reinforcer***.
- Losing it increases the ***opportunity costs*** of the drug.

But the rewards are small.

And drugs are supposed to be inelastic.

Regier, Redish (2015) *Frontiers in Psychiatry*

Contingency management

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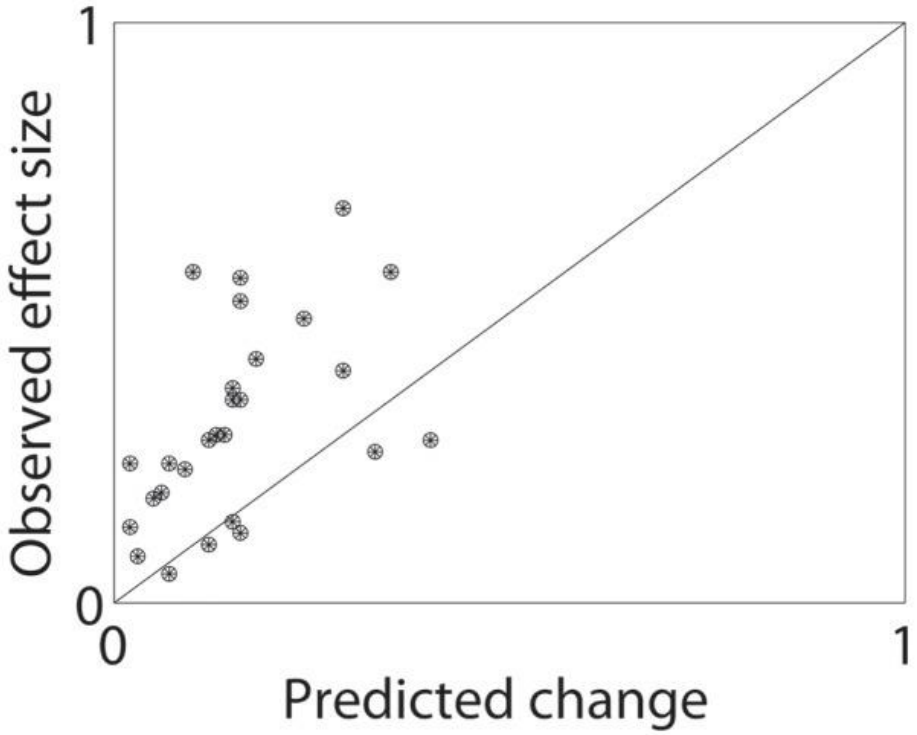

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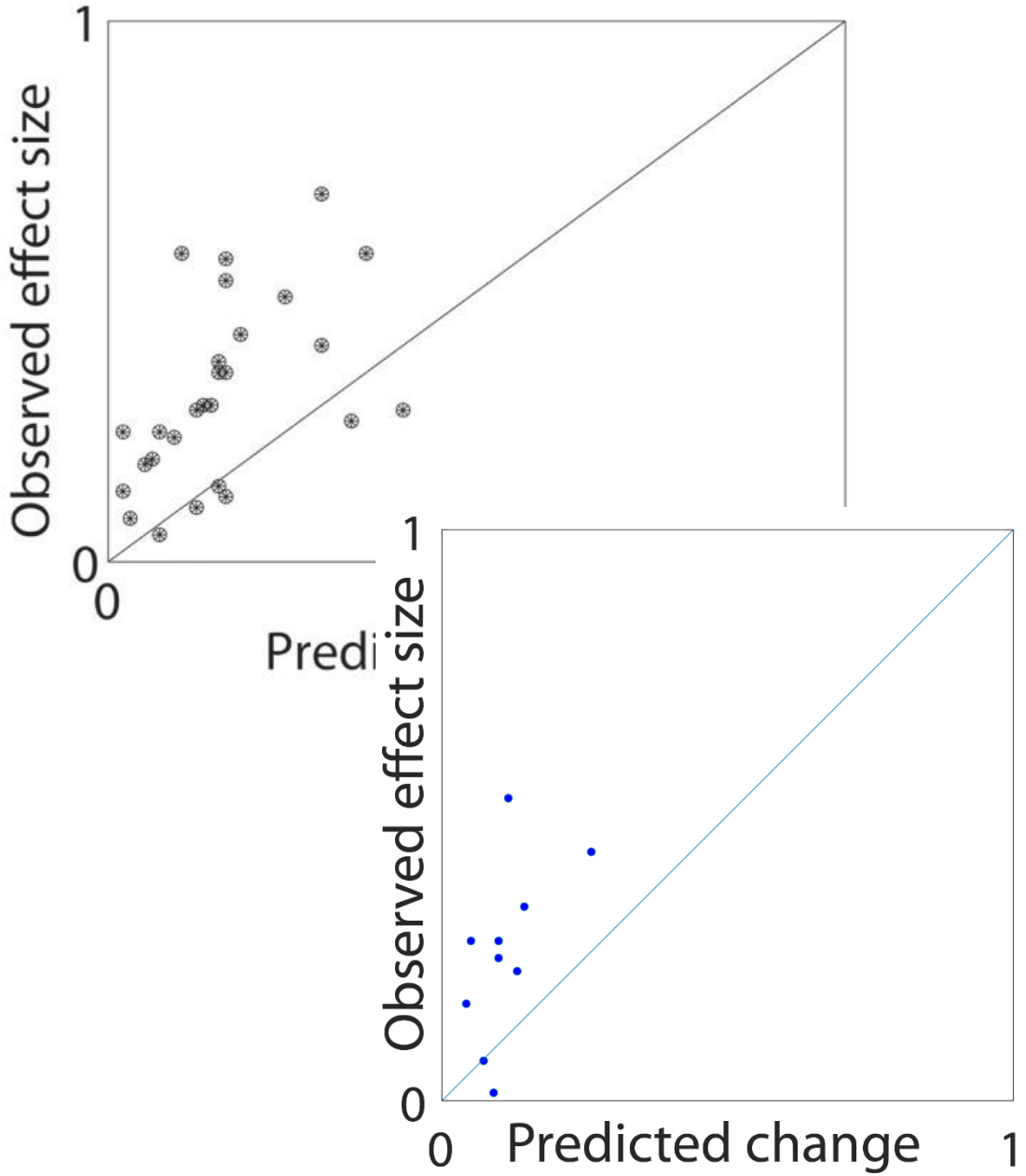
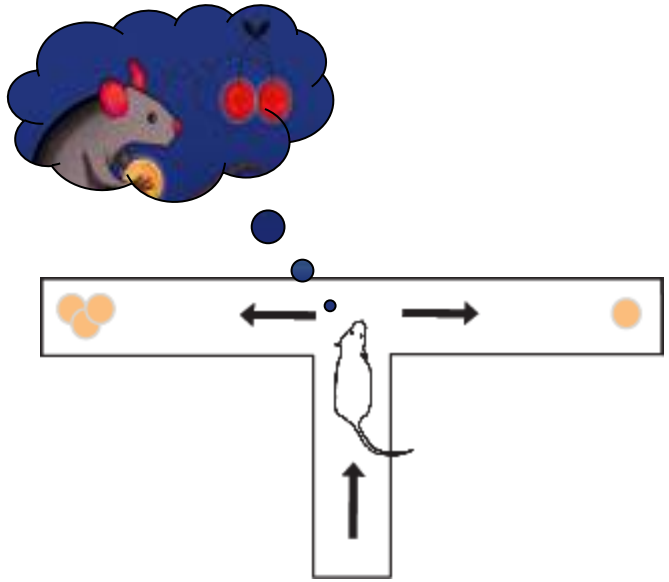


Regier, Redish (2015) *Frontiers in Psychiatry;*
Davidson, Traxler, DeFulio, Redish, Royle, Gass (2024) *Journal of Applied Behavioral Analysis*

An alternate hypothesis

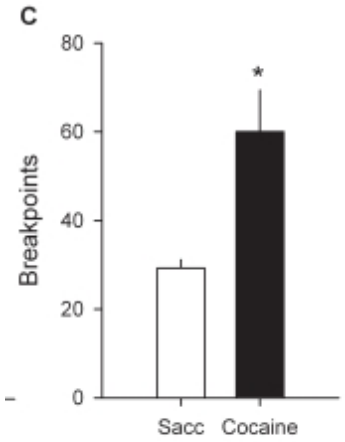
We know that there are multiple decision systems and that different situations can drive an animal to use different decision systems.

Maybe contingency management is transforming an *Is it worth it?* decision into a *Which one?* decision.

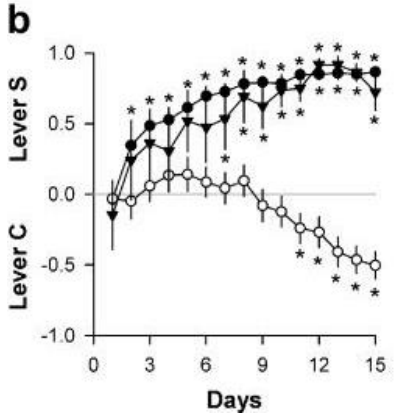


Is it worth it? → Which one?

Willing to pay ≠ choose between

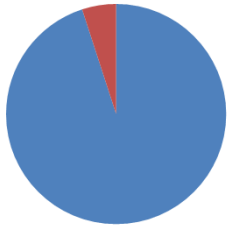


One-lever
Willing-to-pay
U(C) > U(S)
C ≻ S



Two levers
Choose between
S ≻ C
U(S) > U(C)

Bet A



Win $3
Lose $2

Expected value = $2.75

"I'd rather play Bet A than Bet B.

"I'll pay $2 to play Bet A."

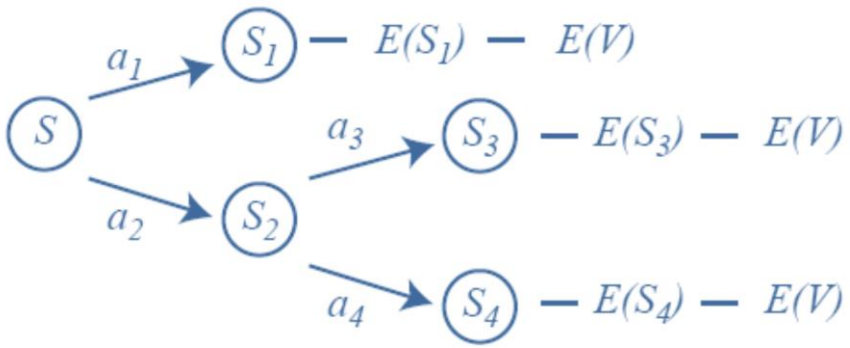
Bet B

Win
$6.50
Lose
1.00

Expected value = $2.75

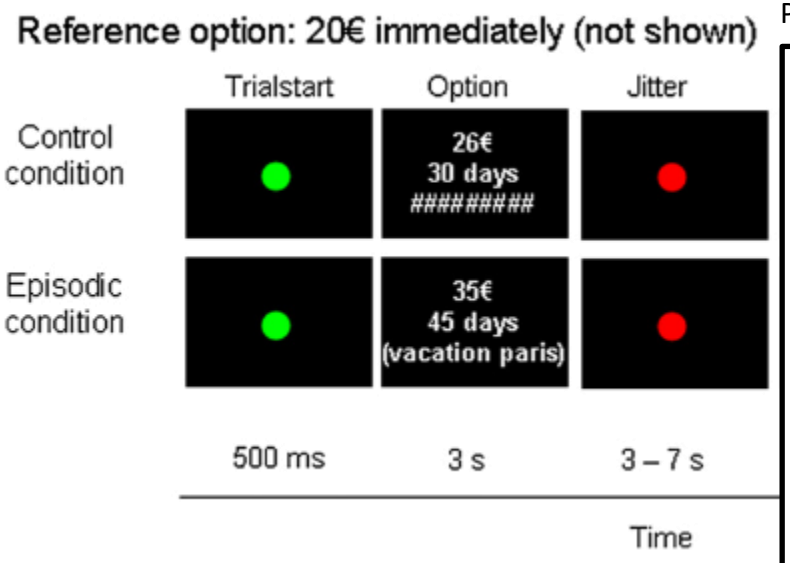
"I'll pay $2.50 to play Bet B."

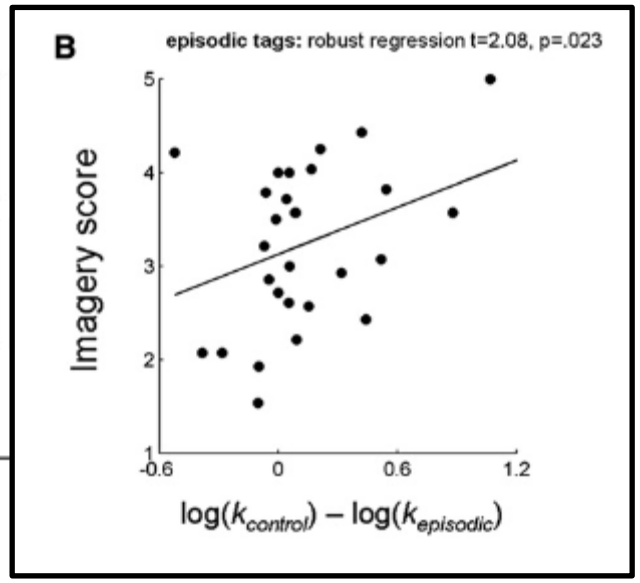
Deliberation depends on imagination



We can make the second option more concrete.

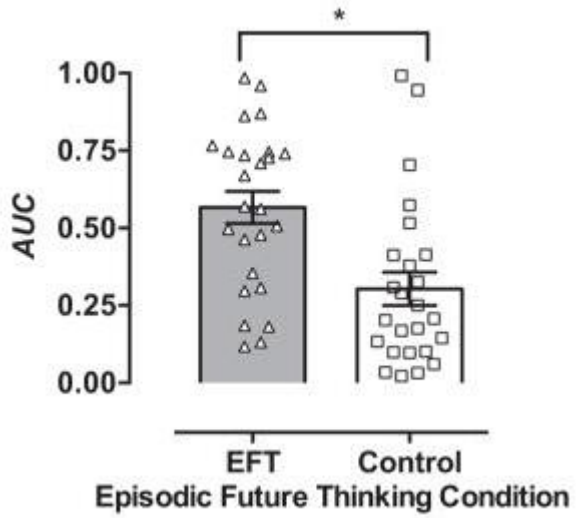
Peters, Buchel (2010) *Neuron*

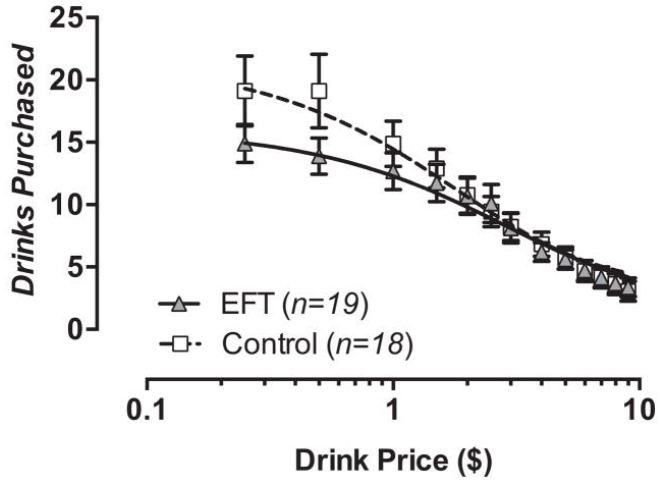




We can teach people to think about the future.

Snider, LaConte, Bickel (2016) *Alcohol Clinical Experimental Research*





3

Trust and community

Making yourself vulnerable to others

Trust

Trust is being willing to make yourself vulnerable to another.

Actions without learning
Situations learned.

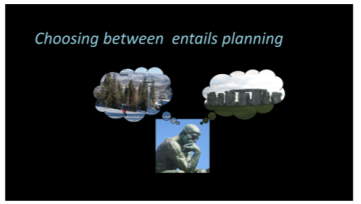
Learn structure of world.
Plan actions on it

Actions and situations must both be reliable.

Allen, Kizilcec, Redish (2024) *arXiv*
Redish, Chastain, Runge, Sweis, Allen, Haldar (2024) *Neuroeconomics: Core Topics and New Directions*

Trust

Actions without learning
Situations learned.



Learn structure of world.
Plan actions on it

Actions and situations
must both be reliable.

Trust is being willing to make yourself vulnerable to another.

Instinctual trust arises from family and tribalism.

It is based on community and is explicitly not transactional.

Allen, Kizilcec, Redish (2024) *arXiv*
Redish, Chastain, Runge, Sweis, Allen, Haldar (2024) *Neuroeconomics: Core Topics and New Directions*

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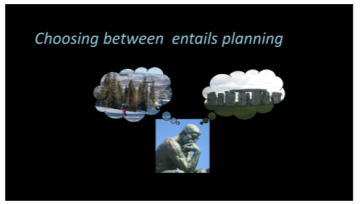


Learn structure of world.
Plan actions on it

Actions and situations
must both be reliable.

Trust is being willing to make yourself vulnerable to another.

Deliberative trust is based on the logic of prediction.

It is explicitly transactional, and depends on explicit expectations.

Allen, Kizilcec, Redish (2024) *arXiv*
Redish, Chastain, Runge, Sweis, Allen, Haldar (2024) *Neuroeconomics: Core Topics and New Directions*

Trust

Trust is being willing to make yourself vulnerable to another.

Procedural trust

Actions without learning
Situations learned.

Learn structure of world.
Plan actions on it

Actions and situations must both be reliable.

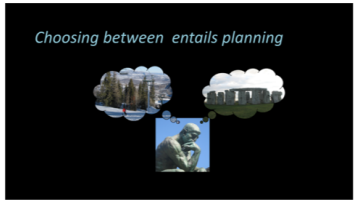
Allen, Kizilcec, Redish (2024) *arXiv*
Redish, Chastain, Runge, Sweis, Allen, Haldar (2024) *Neuroeconomics: Core Topics and New Directions*

Trust

Trust is being willing to make yourself vulnerable to another.

Procedural trust depends on practice and regularity of behavior.

Actions without learning
Situations learned.



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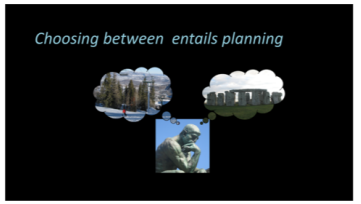
Allen, Kizilcec, Redish (2024) *arXiv*
Redish, Chastain, Runge, Sweis, Allen, Haldar (2024) *Neuroeconomics: Core Topics and New Directions*

Community

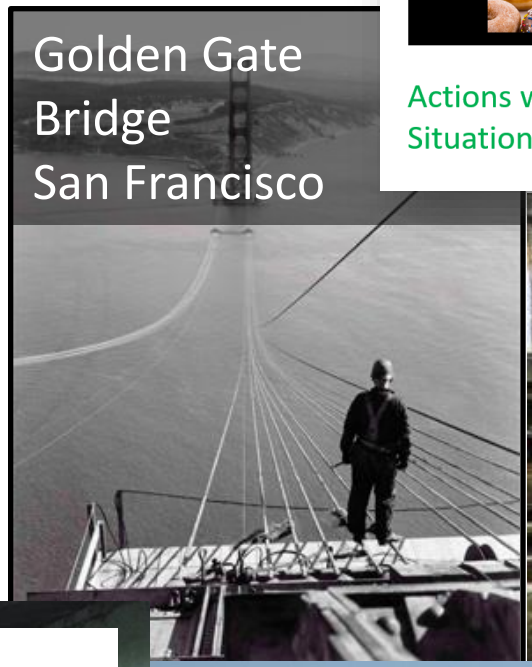
This means that building a community depends on community construction (social codes) that interact with these decision systems.

Actions without learning
Situations learned.

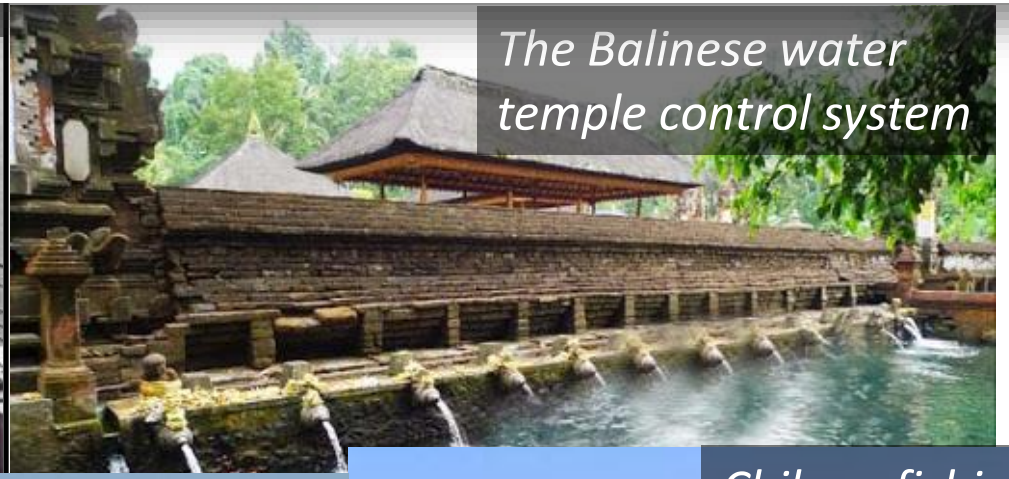


Learn structure of world.
Plan actions on it

Actions and situations must both be reliable.



Golden Gate Bridge San Francisco



The Balinese water temple control system

The Oosterscheldekering
Keeping out the North Sea

Chilean fishing boats

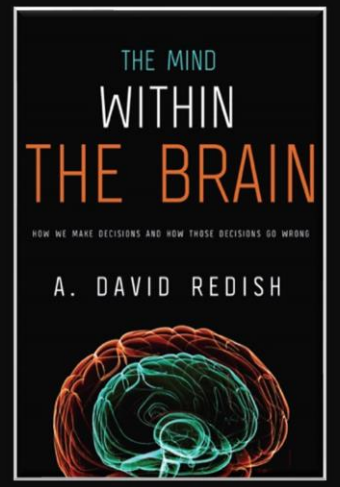
A. David Redish

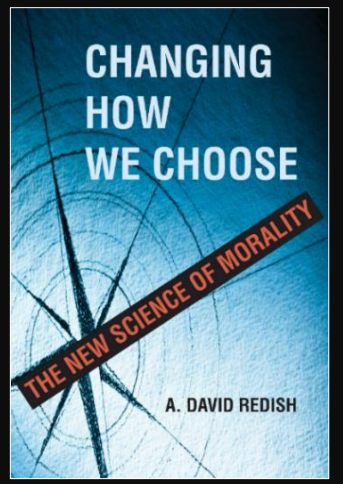
redish@umn.edu

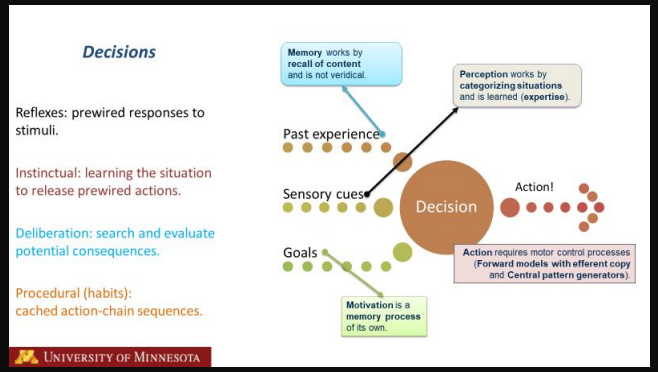
redishlab.umn.edu

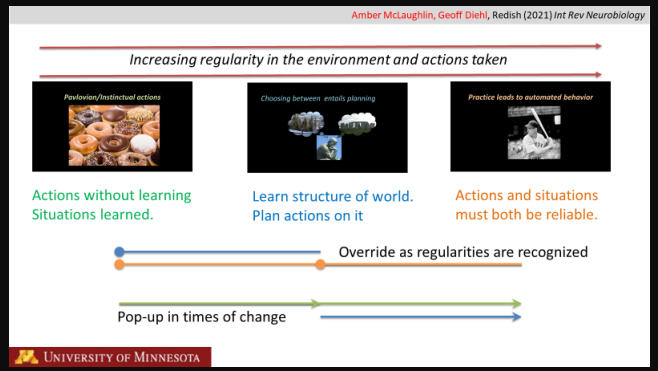
Why do economists need to know the neuroscience?

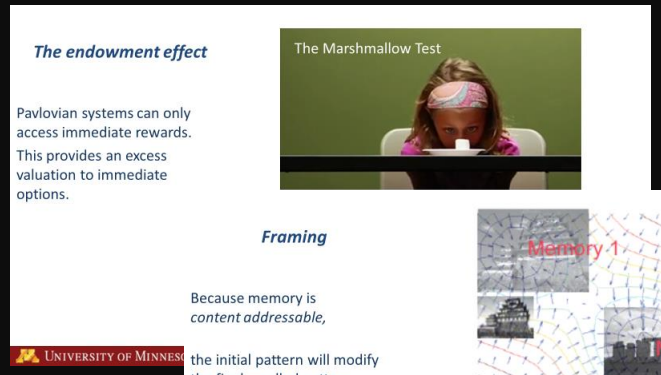
Because the neuroscience provides
a new microeconomic model…
with real policy consequences.

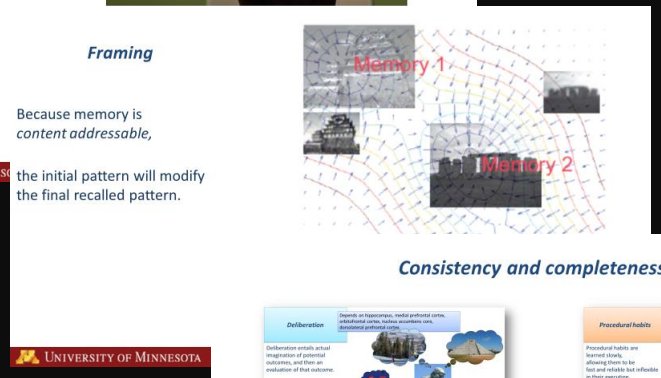


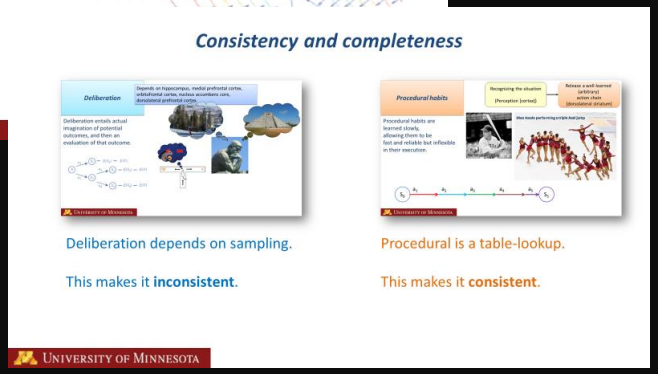


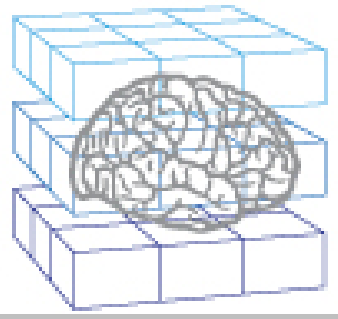












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SNE 2025
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Why do economists need to know the neuroscience?

Because the neuroscience provides
a new microeconomic model…
with real policy consequences.