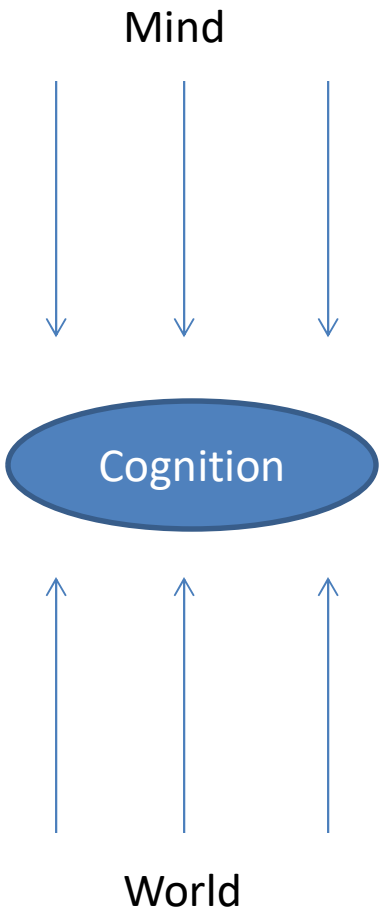
Association

Nisheeth

5th August 2024

Welcome to CS786 - a computational cognitive science course!



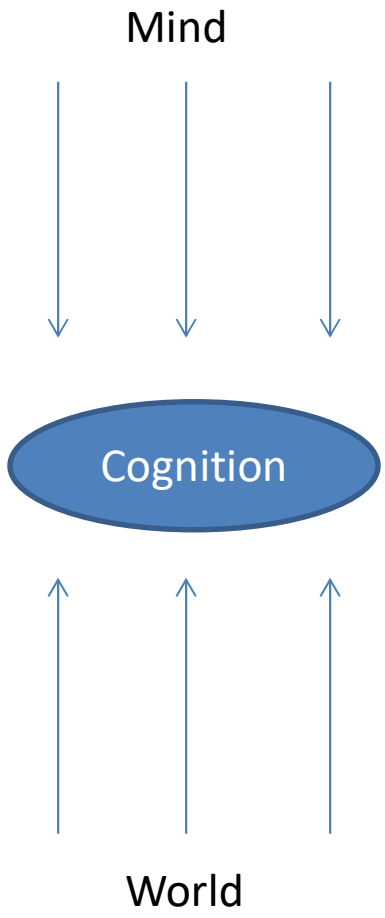
Cognitive Science investigates the data structures that the mind uses

Nature vs nurture

Developmental psychologists have found that even newborns come with a large bag of phenotypic and genetic experience

Cognition and computation

- Cognition is fundamentally path-dependent
- Purely analytic approaches fare poorly with path-dependence
- Computation maps on to cognitive path-dependence well



About me

- I’m Nisheeth
- I sit in ESB2-602
- Class timings are :
  - Monday 1535-1650
  - Tuesday 1400-1515
- All classes in RM101, except the ones I move online
- Office hours for this course will be by email appointment
  - Informal office hours right after the class everyday
- Email : nsrivast at iitk.ac.in

Course evaluation policy

- 4 take home programming assignments (15% of course grade each)
  - Programming prep needed
    - ESC101
    - python
    - Courage
- 20% course credit for a 2000-word research paper, either improving upon a published model, or surveying modeling literature in an area
- 10% course credit from attendance
- 10% course credit for active participation in class discussions
  - Just engaging actively on the course forum will be adequate to get full marks for this component

Course structure

- Broadly five segments
  - Association
  - Reinforcement
  - Accumulation
  - Embodiment
  - Learning
- Each segment will last about 5 lectures, bookended by a forum discussion and assignment
- Reading material will be assigned as web-links within each lecture
  - If you don't read, you won't be able to contribute in the discussions, which will draw upon these readings
  - Students are also encouraged to suggest their own readings; I will add them to the list if they seem relevant
  - Don't have to read all the material assigned, but the more you do, the more fun you will have in the panel discussions

Course policies

- Add-drop deadline
  - Drops beyond that will require instructor and DUGC permission
  - My permission can be taken for granted
- Assuming good faith on your part (regular attendance and participation in evaluation and experiments), the lowest possible grade you will get is B

Course philosophy

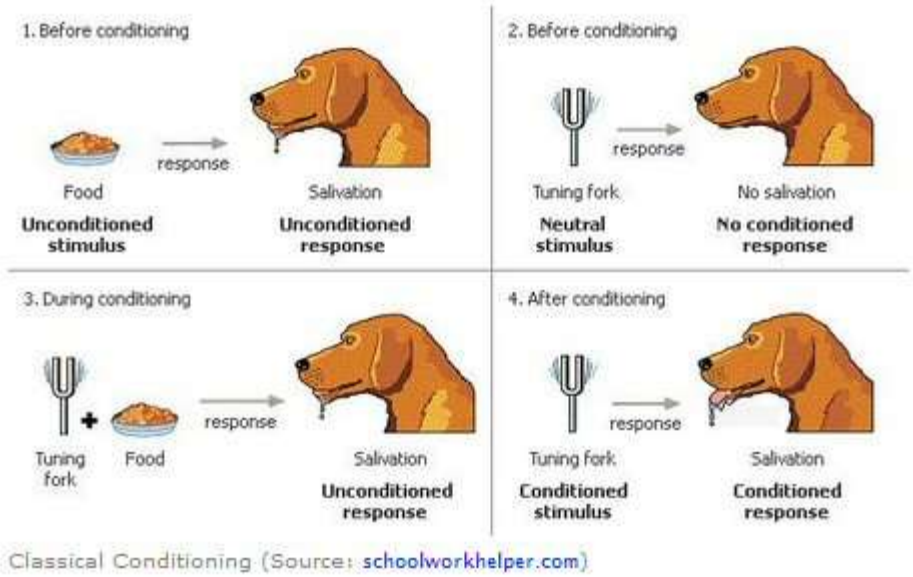
- This is a science course, not an engineering course
  - Emphasis is on following the chain of understanding where it leads
  - We will cover a lot of topics, sometimes unrelated to each other
- Assignments will often be challenging
- Collaboration in programming assignments is acceptable (with acknowledgement)
- There will be math
  - Don’t let it scare you

Association

- A computer stores information randomly. A mind contains concepts associatively

What is relatedness?

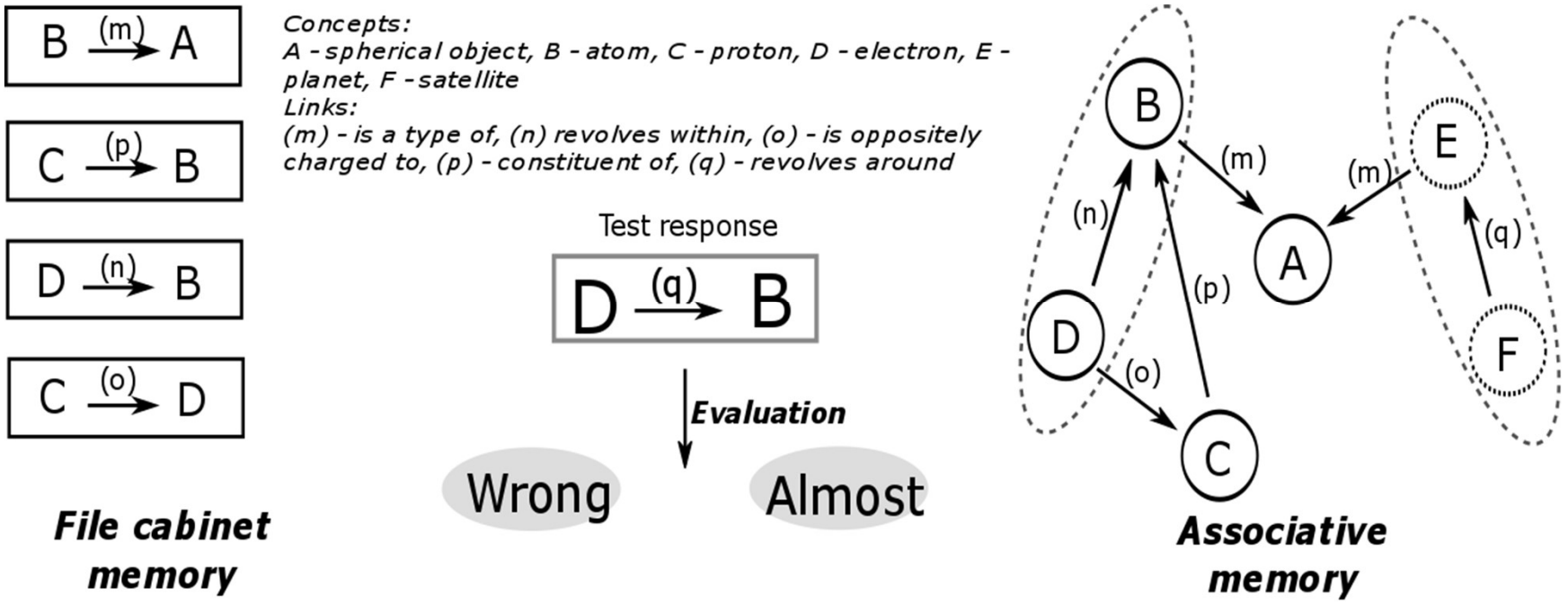
- Co-occurrence → Among the first behavior invariants discovered
- Functionally unrelated concepts become related when they are presented together
- Pavlov's dogs learned to *associate* sound with food.



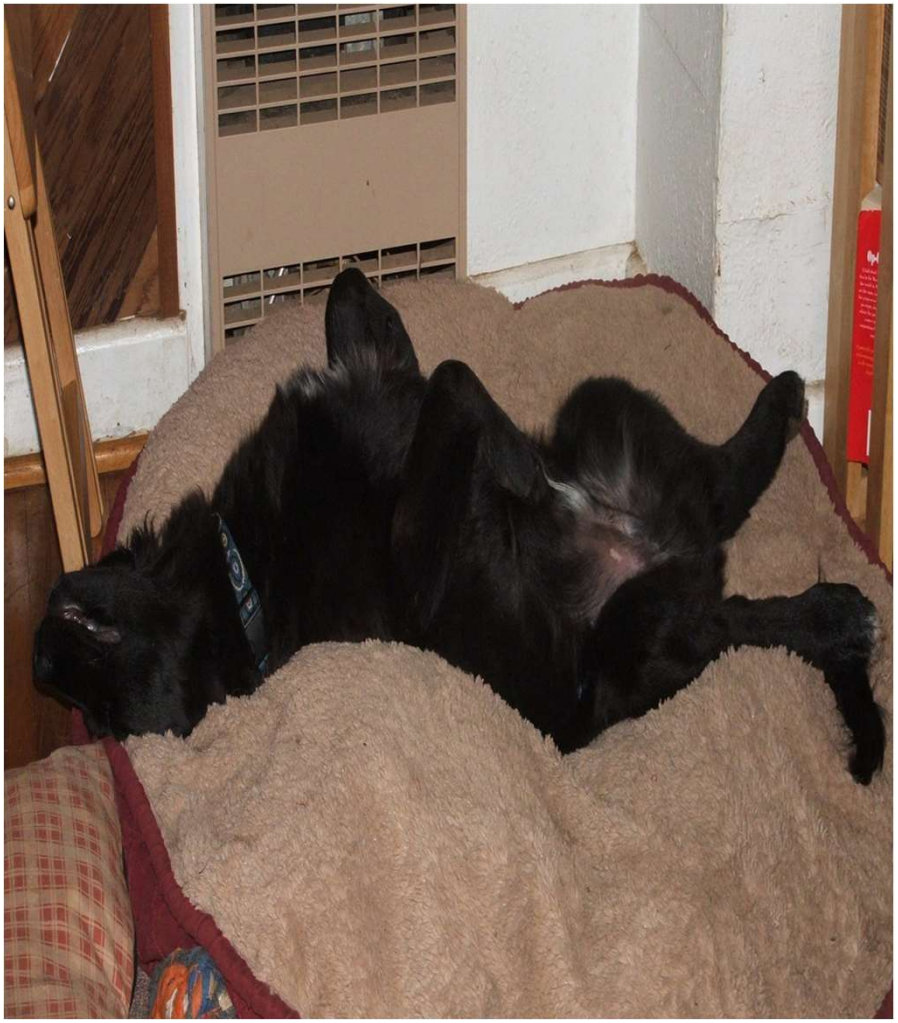
Classical Conditioning (Source: schoolworkhelper.com)

Knowing concepts associatively

- *Related concepts* are activated concurrently



Appearance of stimulus is closely followed by a particular behavior



CS: conditioned stimulus

US: unconditioned stimulus

Real-Life Examples of Classical Conditioning

Gustavson and Gustavson (1985) – Conditioned Taste Aversion

Coyotes killing sheep – problem to sheep farmers

Study conditioned coyotes not to eat the sheep

Sheep meat (CS) sprinkled with a chemical (UCS) that would produce a stomachache (UCR)

After coyotes ate the treated meat,
they avoided the live sheep (CR)

This humane application of conditioned taste aversion might be used to control other predators as well

Real-Life Examples of Classical Conditioning

Metalmikov & Chorine (1926, 1928) – Immune System

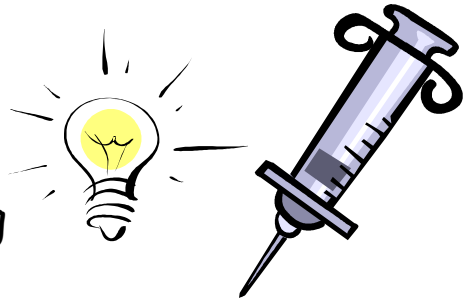
Injected Guinea Pigs with Foreign agents (non lethal)
→ antibodies → boost their immune system

Then paired injections with Lights

Lights + Injections = better immunity

Lights alone = better immunity

Later Injected Cholera: animals with prior conditioning
better survival vs controls with no conditioning



Closer home …

- The average person picks up their phone 80+ times a day
- More than 2k interactions per day

Modeling classical conditioning

- Most popular approach for years was the Rescorla-Wagner model

$$\Delta V_X^{t+1} = \alpha_X \, \beta(\lambda - V_{tot}),$$

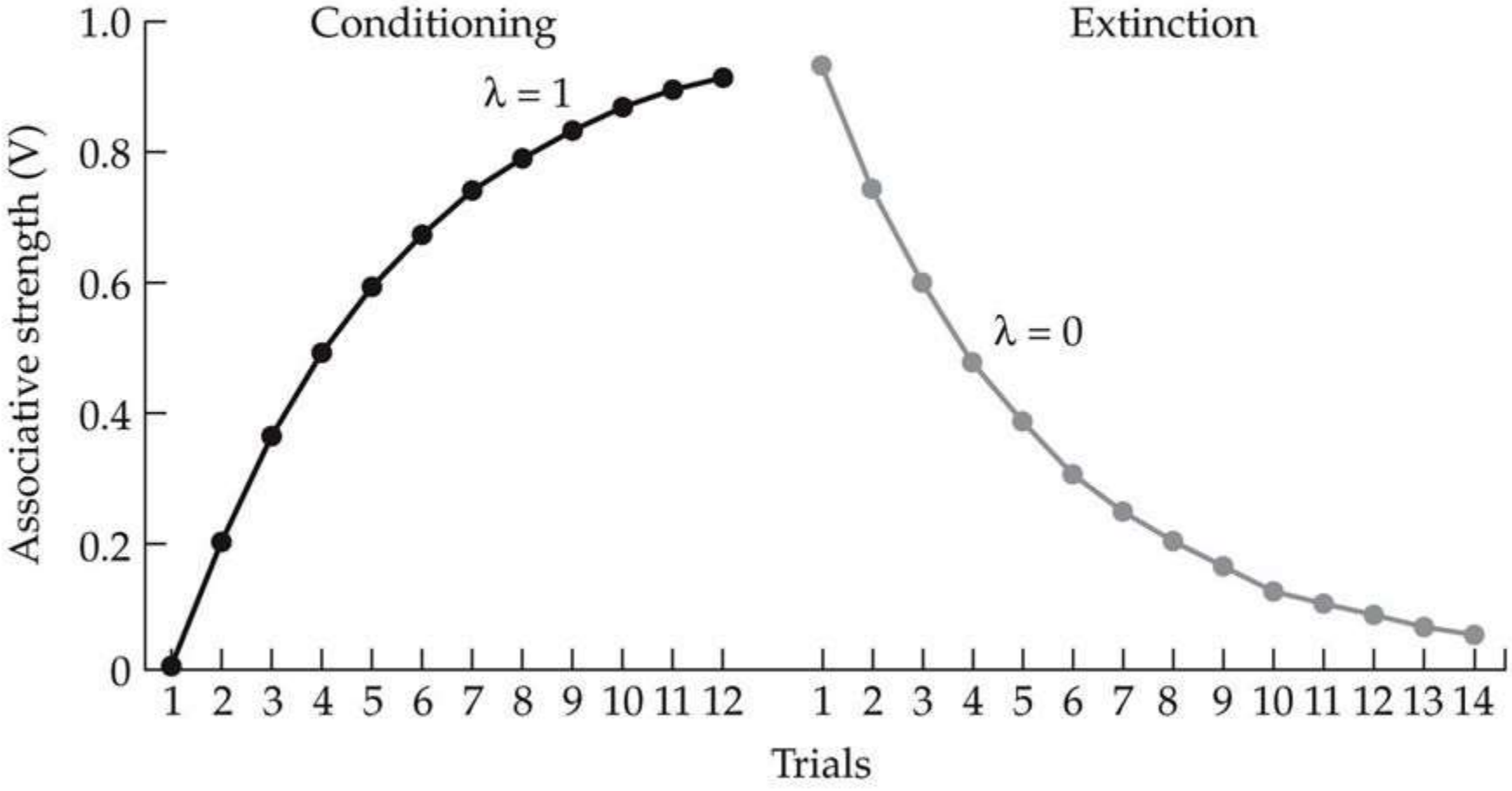
$$V_X^{t+1} = V_X^t + \Delta V_X^{t+1}$$

Some versions replace V_{tot} with V_x; what is the difference?

- Could reproduce a number of empirical observations in classical conditioning experiments

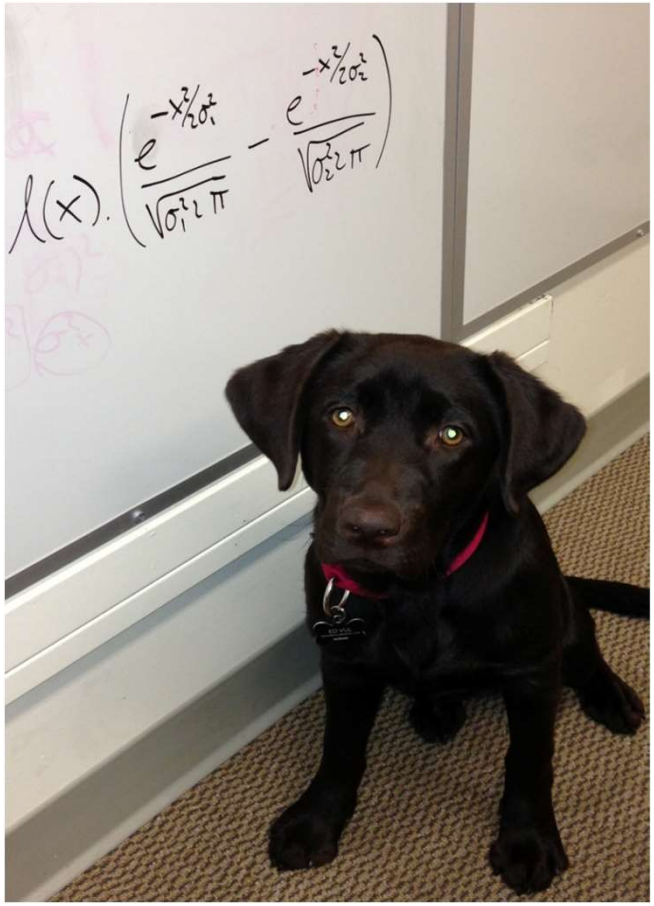
http://users.ipfw.edu/abbott/314/Rescorla2.htm

4.3 Conditioning and extinction in the Rescorla-Wagner model



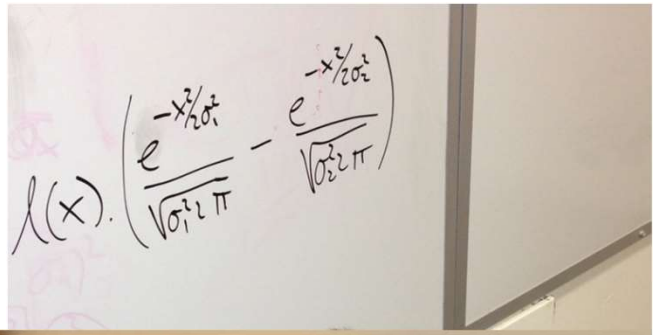
LEARNING AND BEHAVIOR, **Figure 4.3** © 2007 Sinauer Associates, Inc.

What RW could explain



What it couldn’t

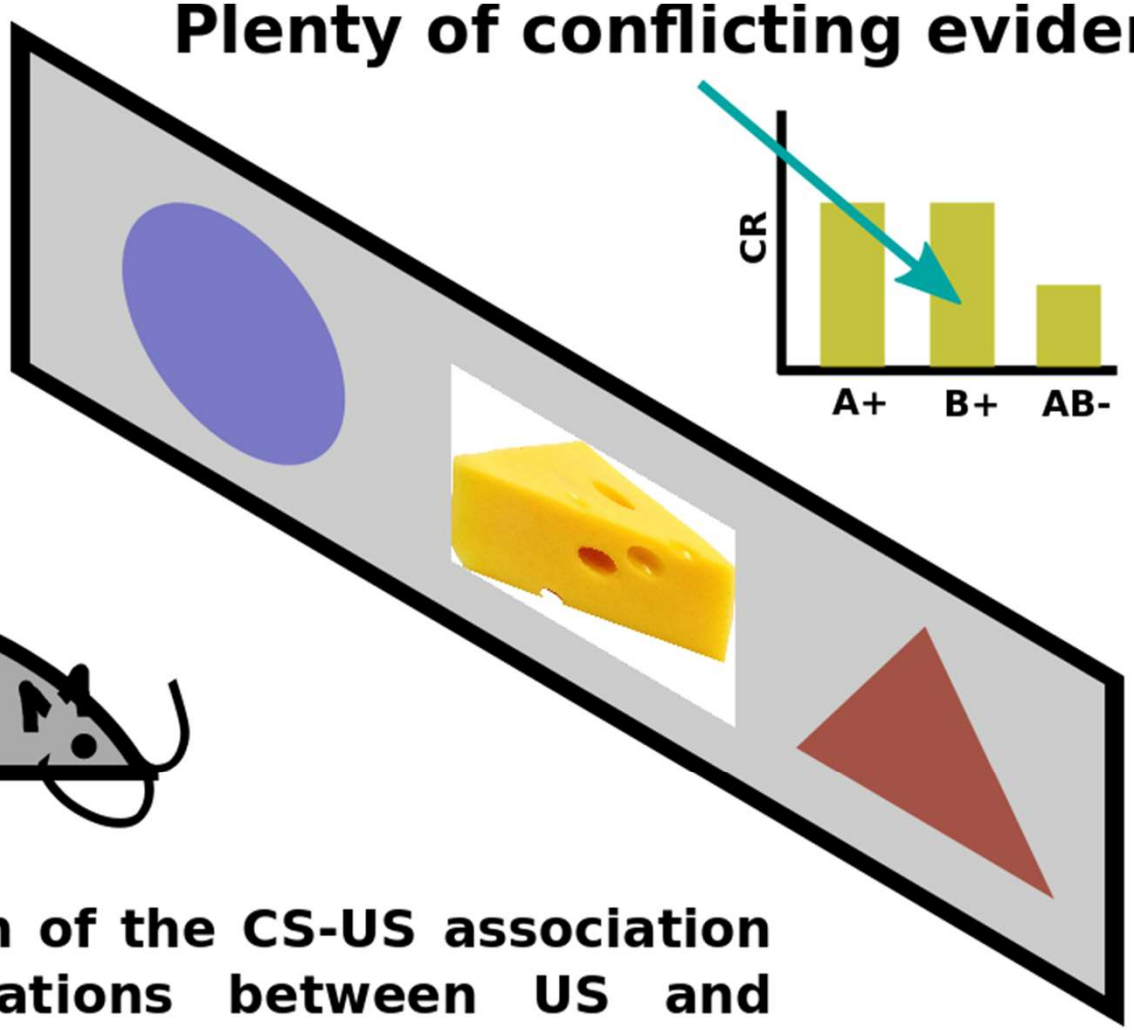
Pre-exposed

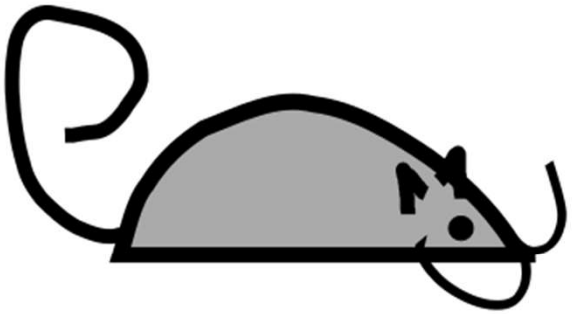


Latent inhibition

If value were just CS-US association, RW style models would be sufficient

Plenty of conflicting evidence

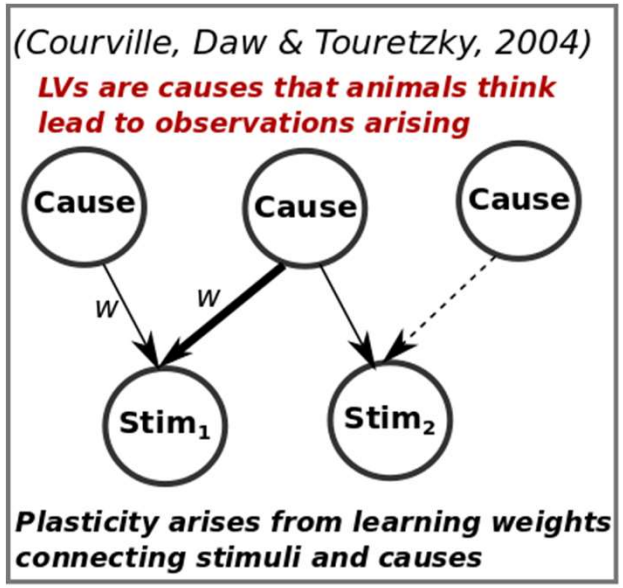


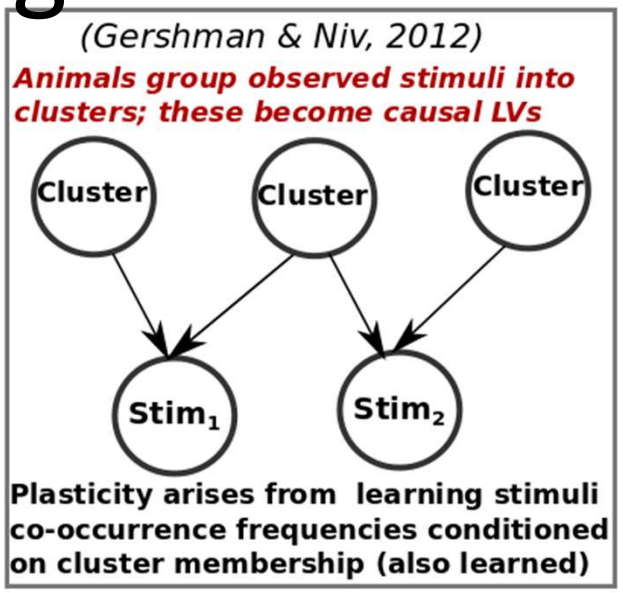


It looks like strength of the CS-US association depends on associations between US and other stimuli too. Why not model these relationships stochastically?

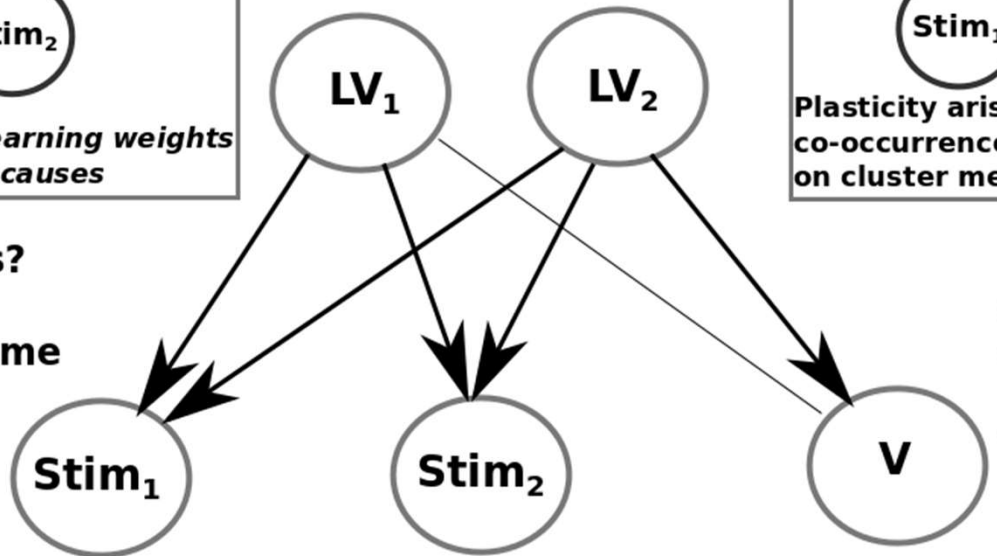
https://en.wikipedia.org/wiki/Rescorla%E2%80%93Wagner_model

Bayesian models of classical conditioning





How to interpret latent variables?



How many causes?

Where do they come from?

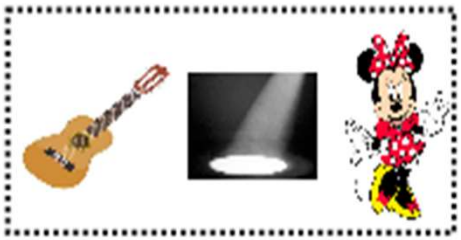
Fails to predict summation-based conditioning effects.

What does clustering buy us?

*Interpret latent variables as **situations**.*
*not **causes***



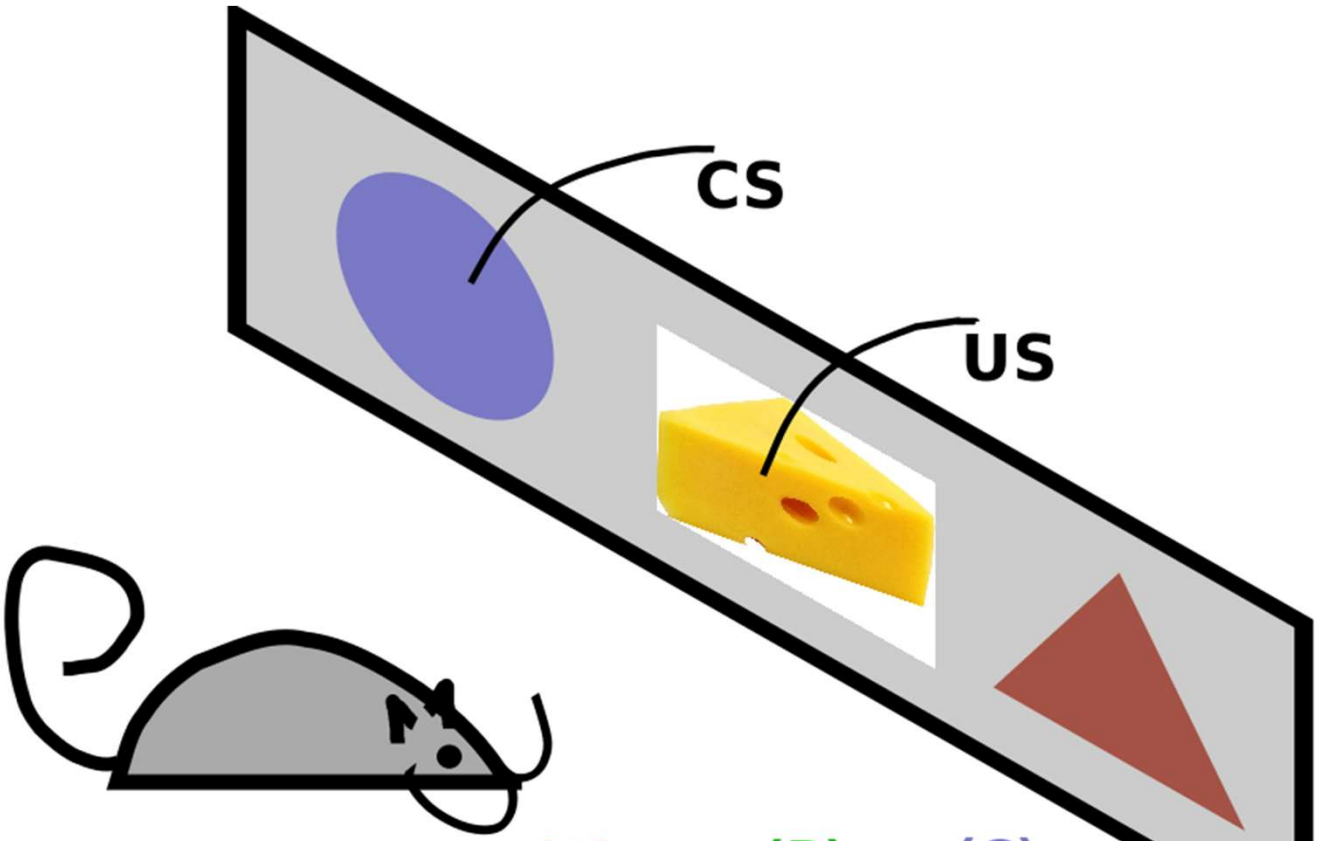
Index **situations** by stimuli co-occurrence patterns


s = **Yeah!**


s = *Smoooth ...*


s = **Yikes!!!**

https://link.springer.com/article/10.3758/s13420-012-0080-8



$$p(\text{🧀}|\text{●}) = \frac{\overbrace{\Sigma_s p(\text{🧀}|\text{●},s)}^{(A)}\overbrace{p(\text{●}|s)}^{(B)}\overbrace{p(s|o_{1:t})}^{(C)}}{\Sigma_s p(\text{●}|s)p(s|o_t)}$$

(A) Association computation

$p(\text{🧀}|\text{▲},s) = 1$ iff $s =$ 🧀 ? ▲

(B) Likelihood computation

$p(\text{■}|s) = 1 \quad p(\text{☕}|s) = 0 \quad p(\text{●●}|s) = 0$

Summary

- The mind learns by association
  - Associates novel with known, based on a number of ways of relation
- Association of novel to known causes generalization
- Association of known with known causes reinforcement
- We will talk more about reinforcement soon