Unit 1: Simple Neural Networks

3. Associative Learning

9/8/2020

Office hours

In the future: Tuesdays 4:30-6:30

This week: by appointment
I have lots of time tomorrow morning/afternoon

HW1 out late today/early tomorrow

Associative Learning

1. Associative learning is a simple model of learning applicable across domains

2. Prediction error is a unifying framework for modeling associative learning

3. The Rescorla-Wagner model of associative learning accounts for interesting phenomena like blocking, conditioned inhibition, etc.

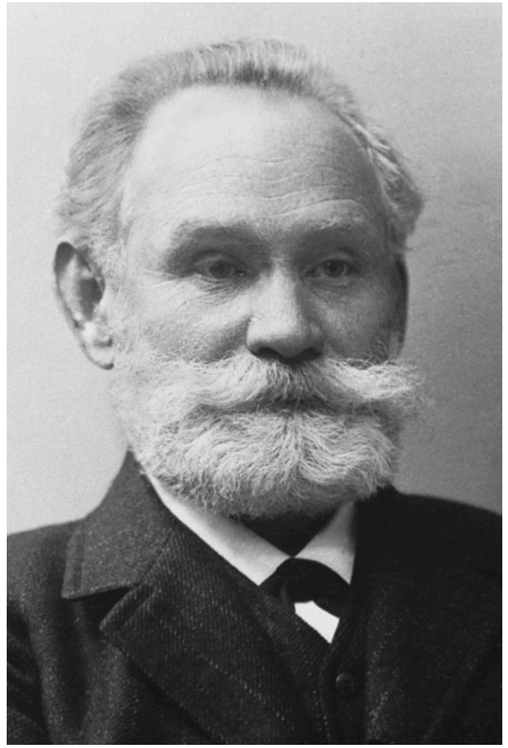
What is associative learning?

Learning that two events go together (or are associated)

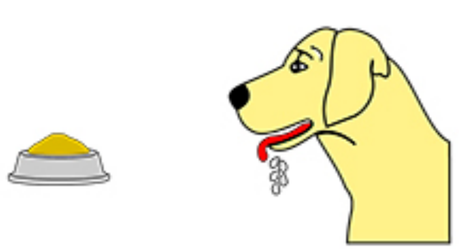
From your our affinity diagram:
- playing guitar (chord progressions)
- How to drive (turn signals, steering wheel rotation)
- Play video games (level layouts, item statistics)
- English alphabet (sequence, shapes)
- How to read (common exceptions)

....

Pavlov’s dogs



Classical conditioning



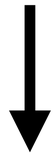
Unconditioned Stimulus (US)

Unconditioned Stimulus (US) + Conditioned Stimulus (CS)

Conditioned Stimulus (CS)

Unconditioned Response (UR)

Unconditioned Response (UR)



Conditioned Response (CR)

Classical conditioning in humans

Watson (1920)

Eye blink conditiong

Air puff (US) → Blink (UR)

Air puff (US) + Tone (CS) → Blink (UR)

Tone (CS) → Blink (CR)

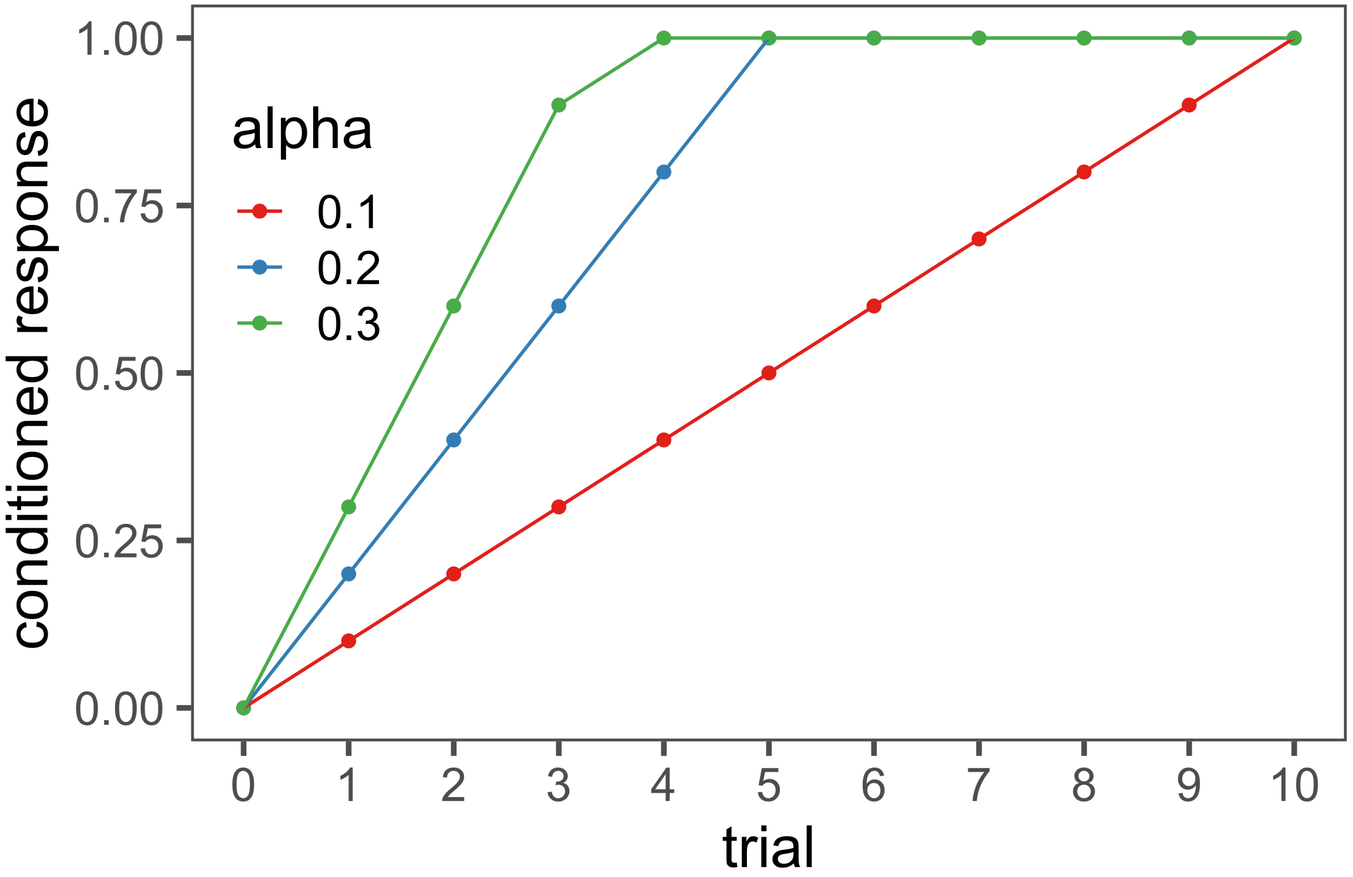
https://sandiegoinstruments.com/

Building a model of eye blink conditioning

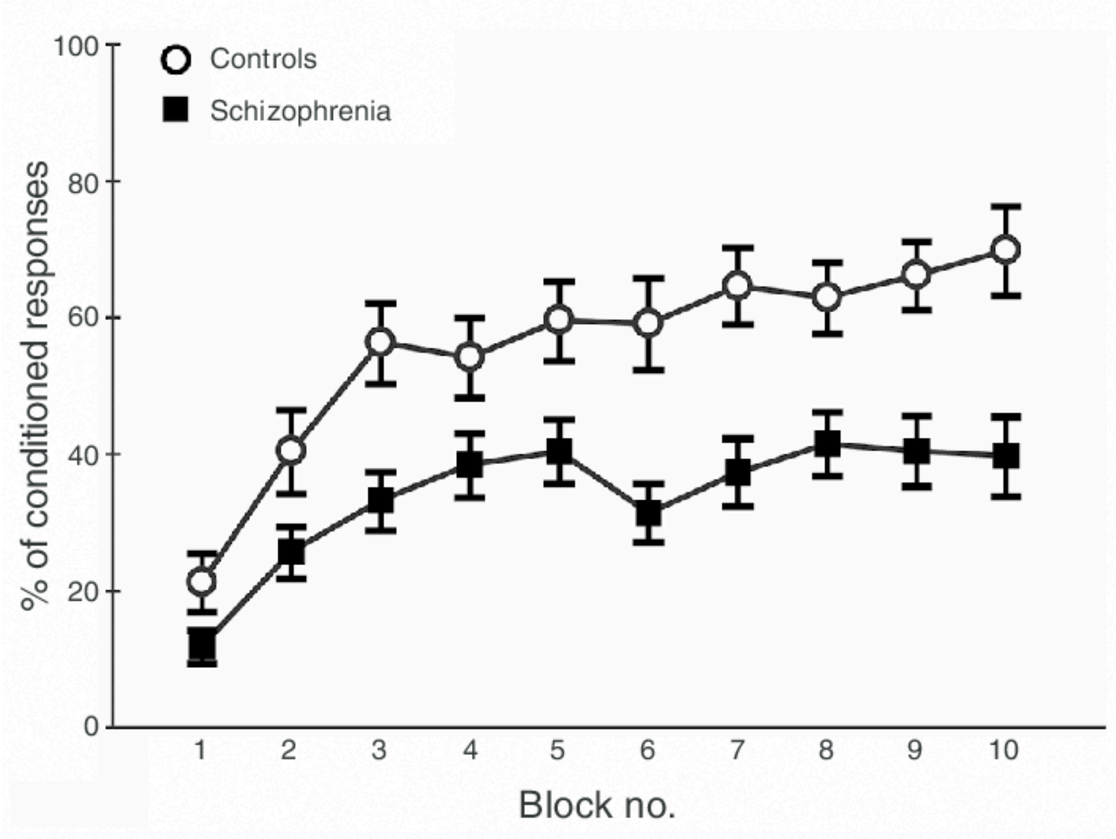
V Value of stimulus

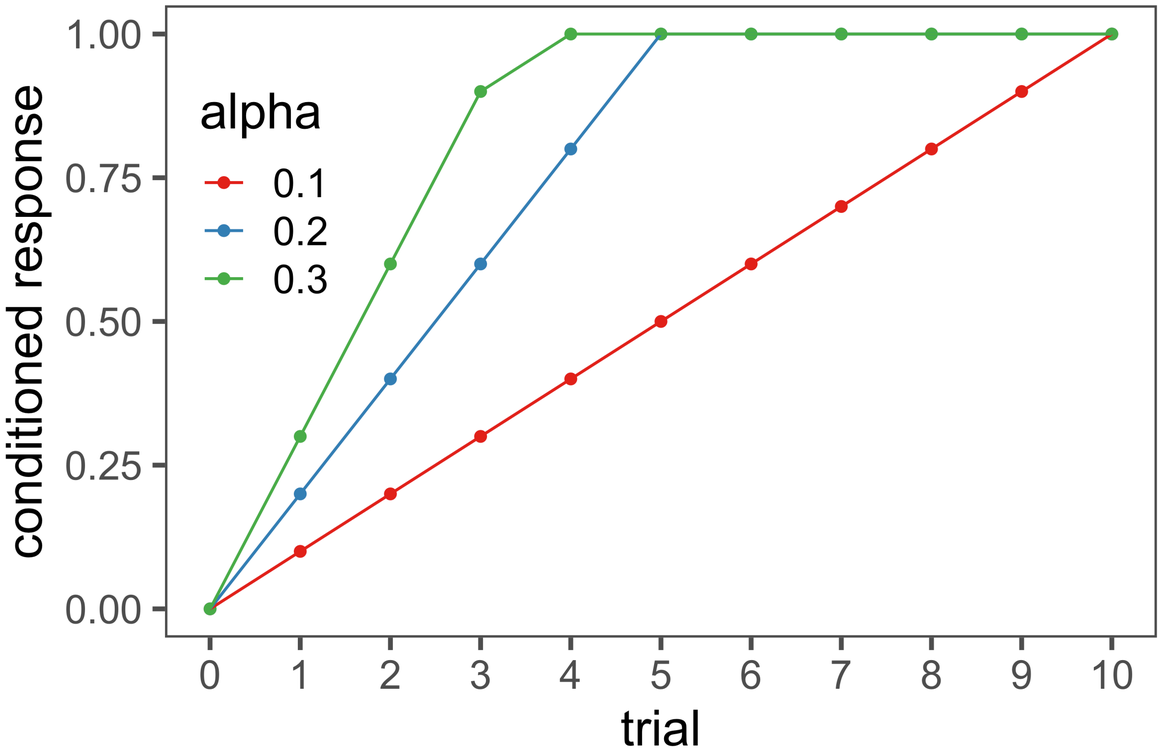
$$P\left(blink\right) = \min\left(V,1\right)$$

$$\Delta V = \alpha$$



Eye blink condition in humans (Coesmans et al., 2014)





Towards a better model of eye blink conditioning

1. **Learning doesn't seem to be linear**
   People learn faster at first and then slow down

V Value of stimulus

$$P\left(blink\right) = V$$

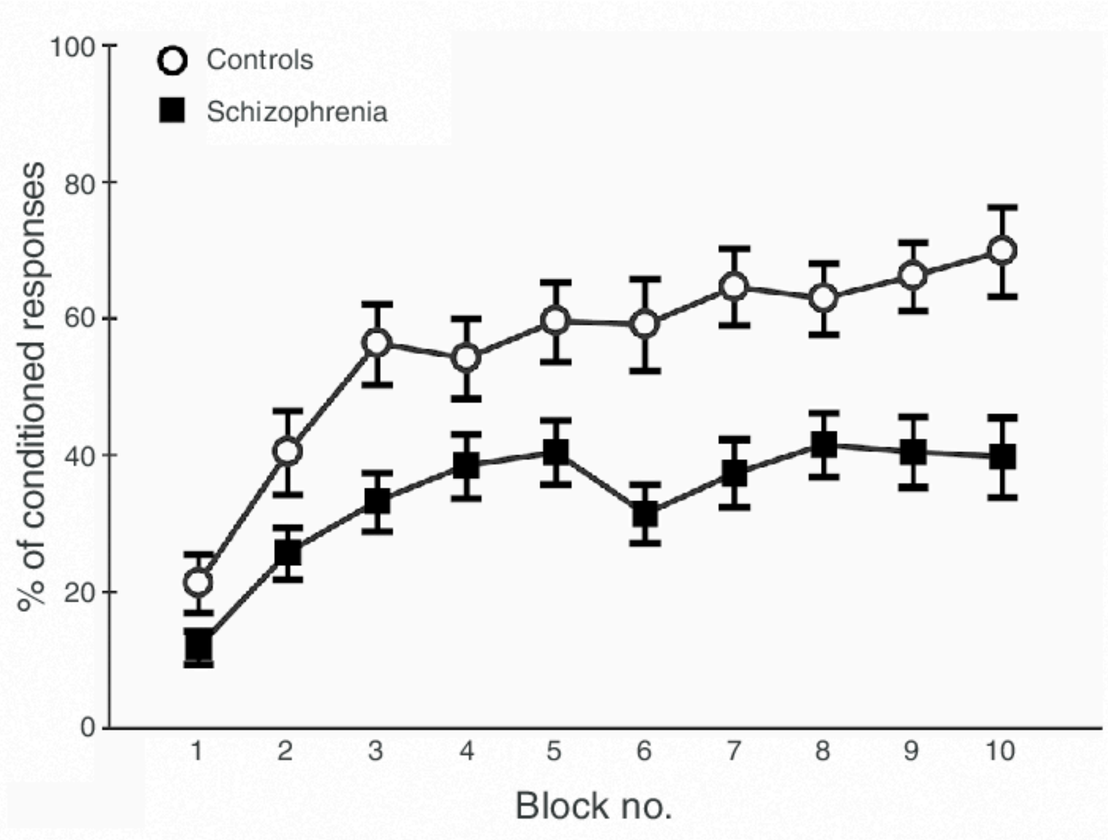
$$\Delta V = \alpha \cdot f(V)$$

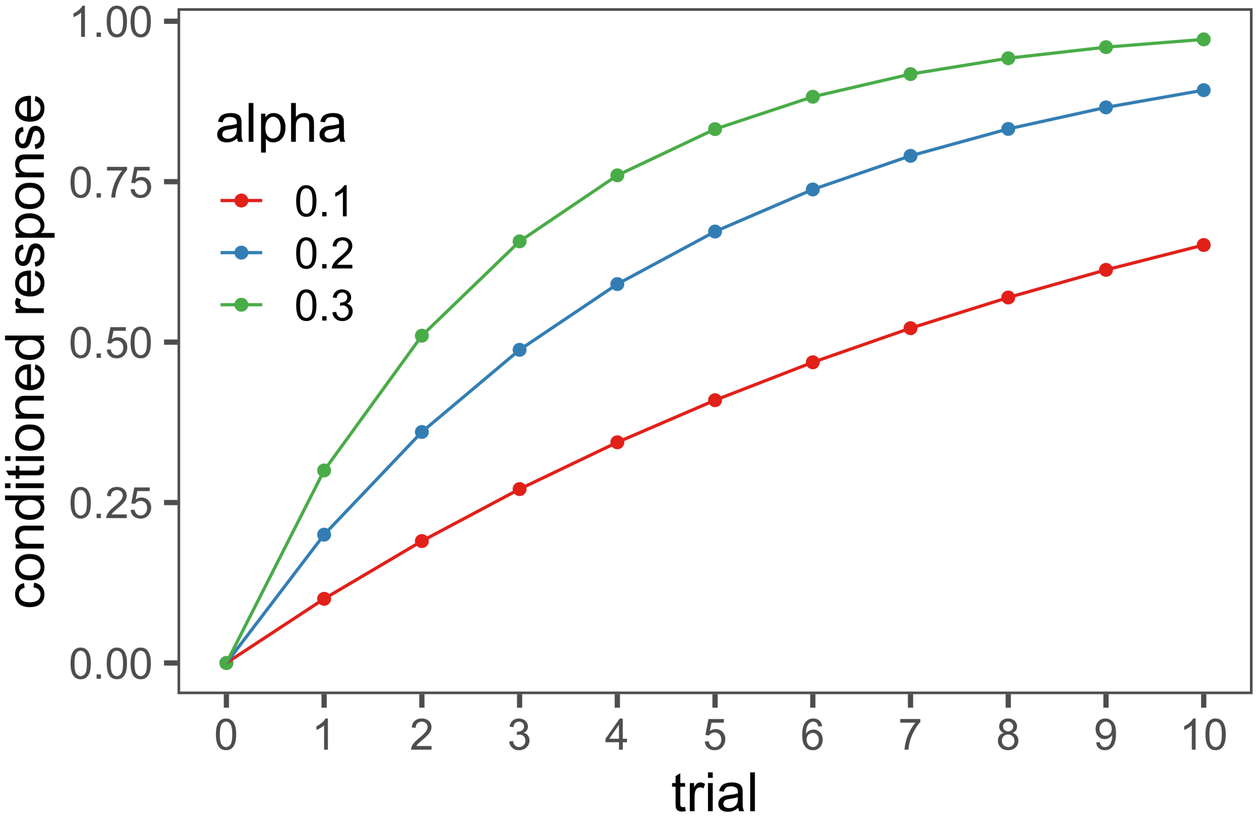
One option: $$\Delta V = \alpha \cdot \frac{1}{V}$$

Another option: $$\Delta V = \alpha \cdot (1 - V)$$

These are conceptually really different theories

Learning via prediction error





Towards a better model of eye blink conditioning

1. **Learning doesn't seem to be linear**
   People learn faster at first and then slow down

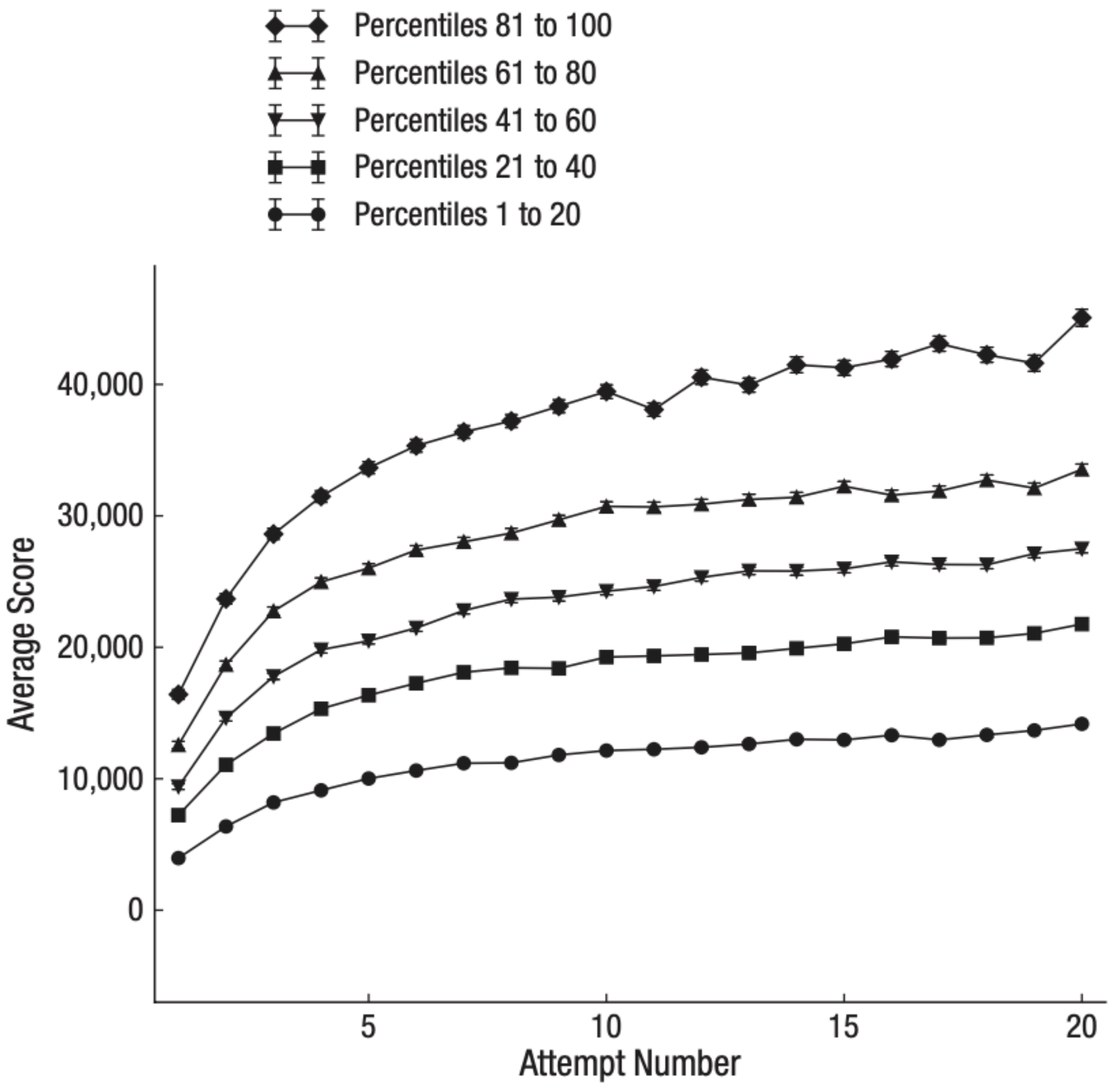
2. **Learners have different plateaus**
   There seems to be some limit on learning

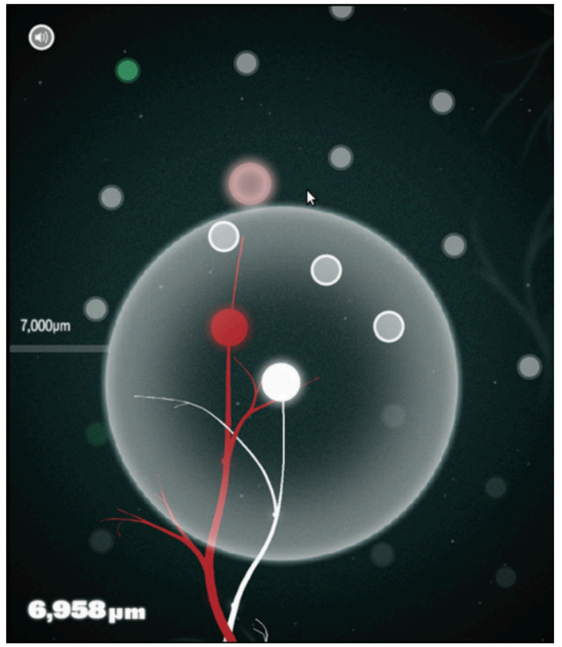
V Value of stimulus

$$P\left(blink\right) = V$$

$$\Delta V = \alpha \cdot (\lambda - V)$$

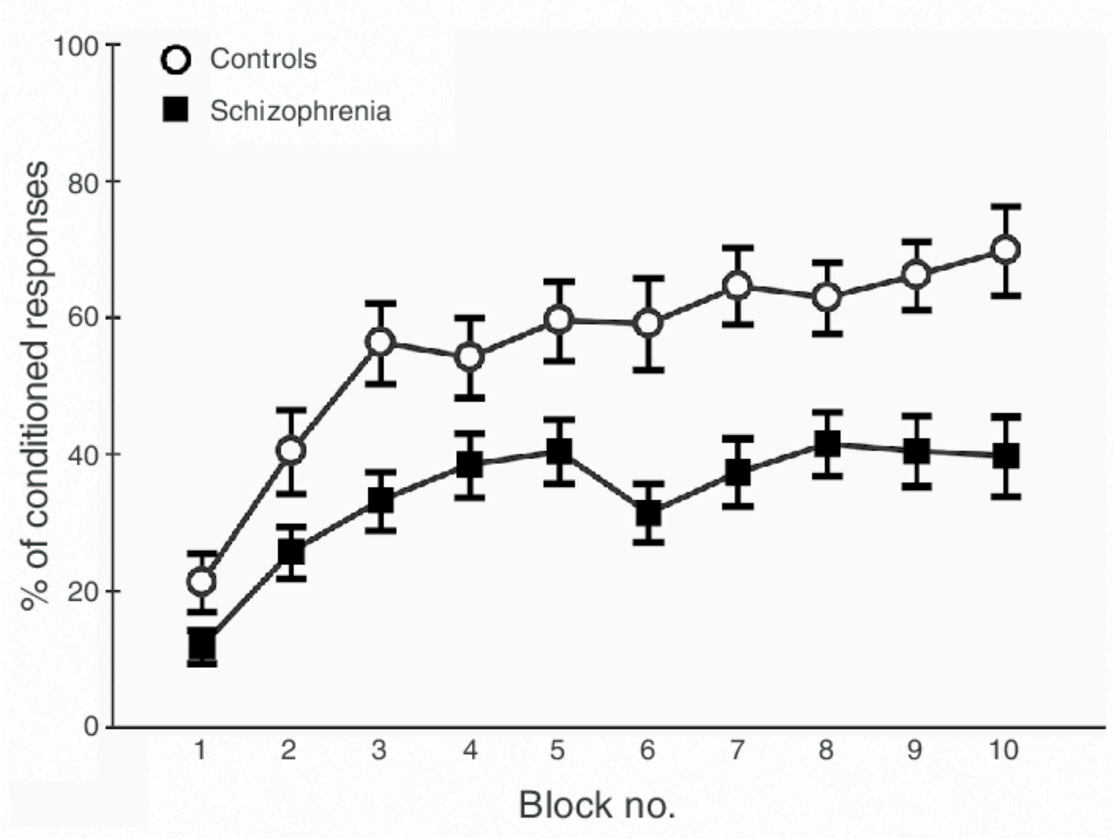
Learning rate and plateau in a natural experiment (Stafford & Dewar, 2014)

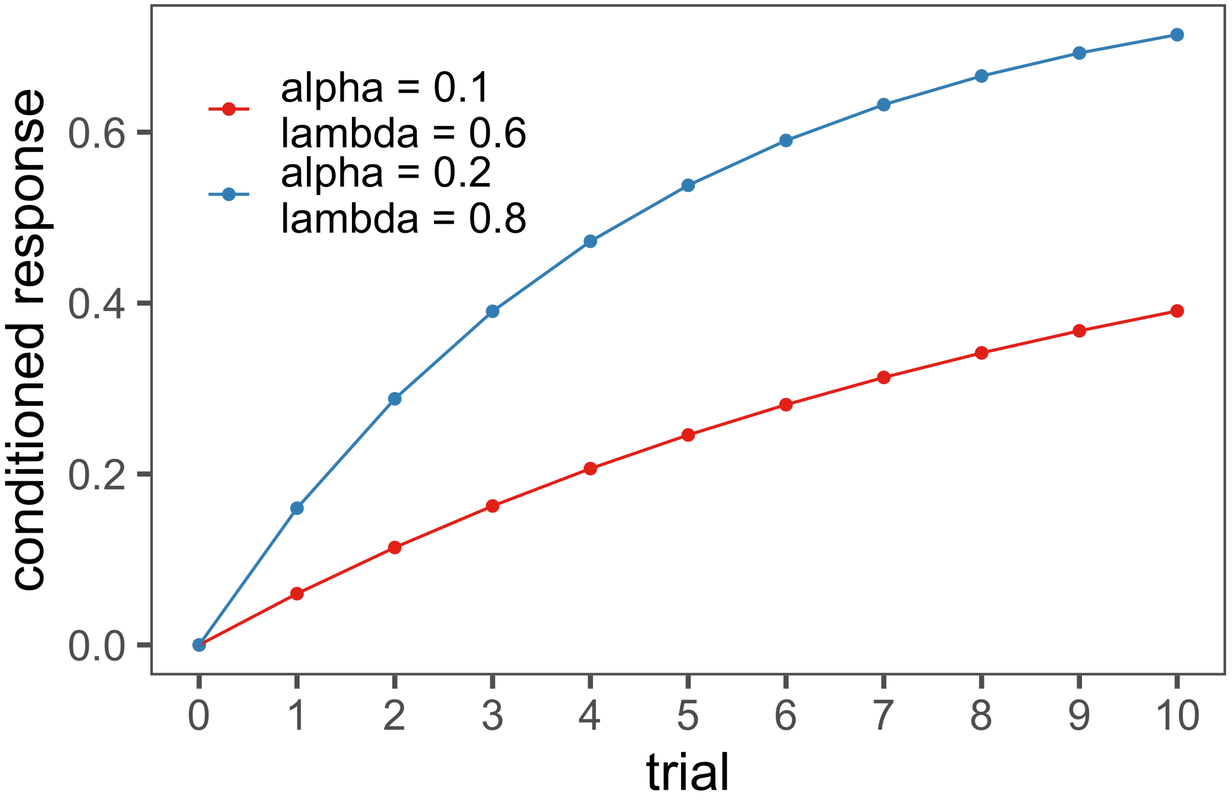




N > 850,000

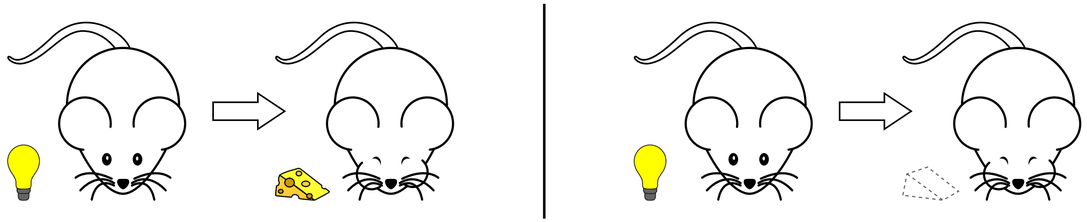
Learning via prediction error with different assymptotes



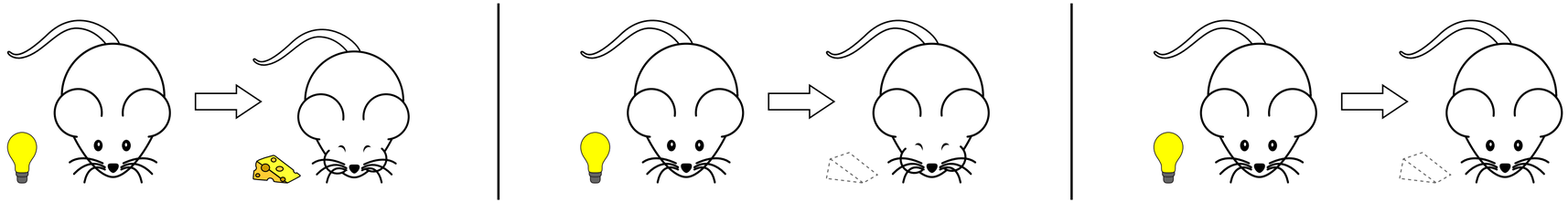


A plethora of reliable effects in classical conditioning

FORWARD CONDITIONING

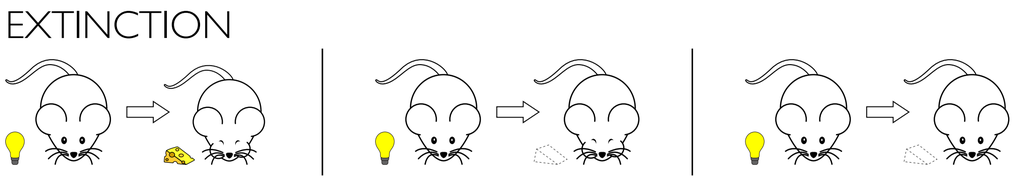


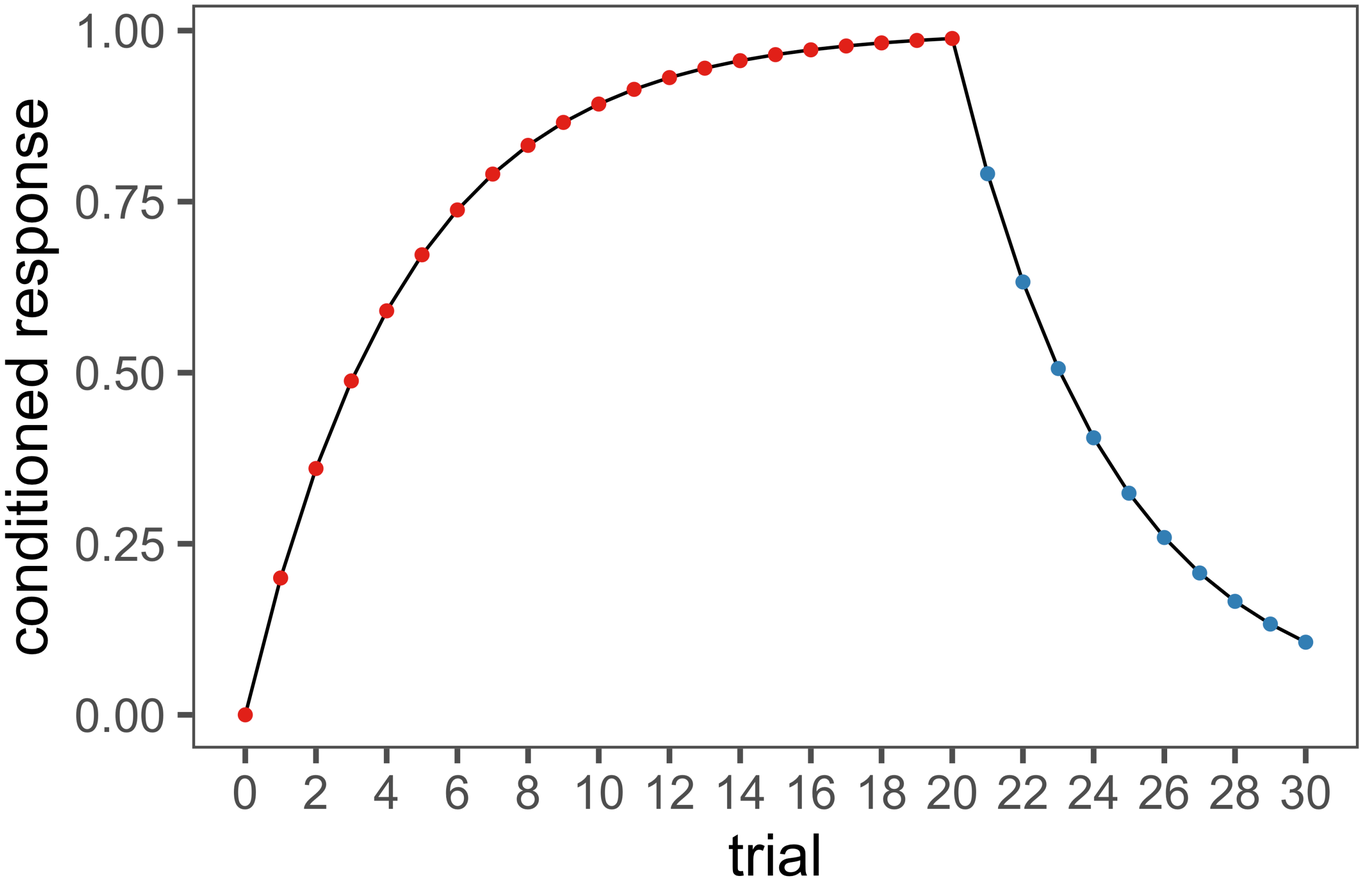
EXTINCTION



$$\Delta V = \alpha \cdot (1 - V) \qquad \Delta V = \alpha \cdot (0 - V)$$

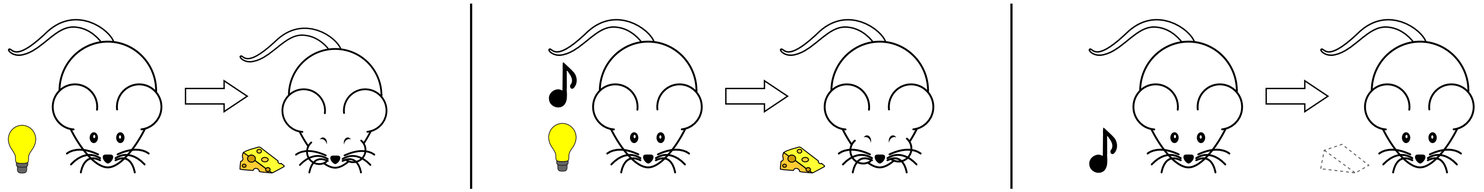
Prediction error gives accounts for extinction





Can prediction error account for blocking?

BLOCKING



Not the current model

The Rescorla-Wagner model of conditioning (1972)

$$\Delta V_x = \alpha \cdot \beta \cdot (\lambda - V_{total})$$

Salience of x

Learning rate of UR

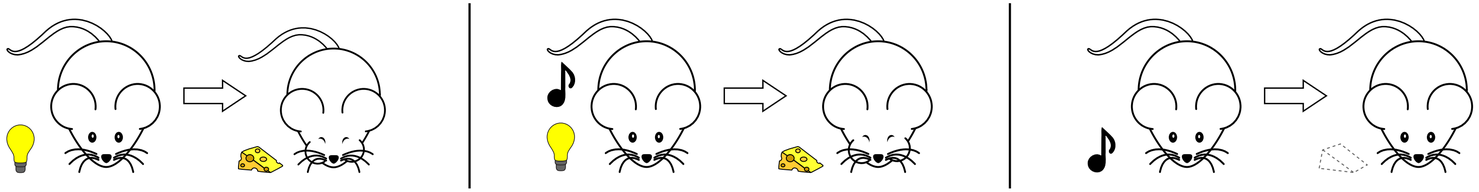
Maximum conditioning possible for UR

Strength of all cues

We're going to ignore the distinction between α and β

Towards a better model of eye blink conditioning

BLOCKING



V_x Value of stimulus *x*

V_x

$V_{xy} = V_x$

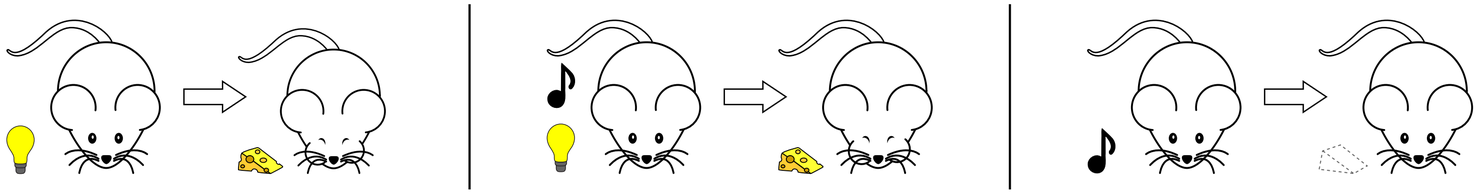
V_y

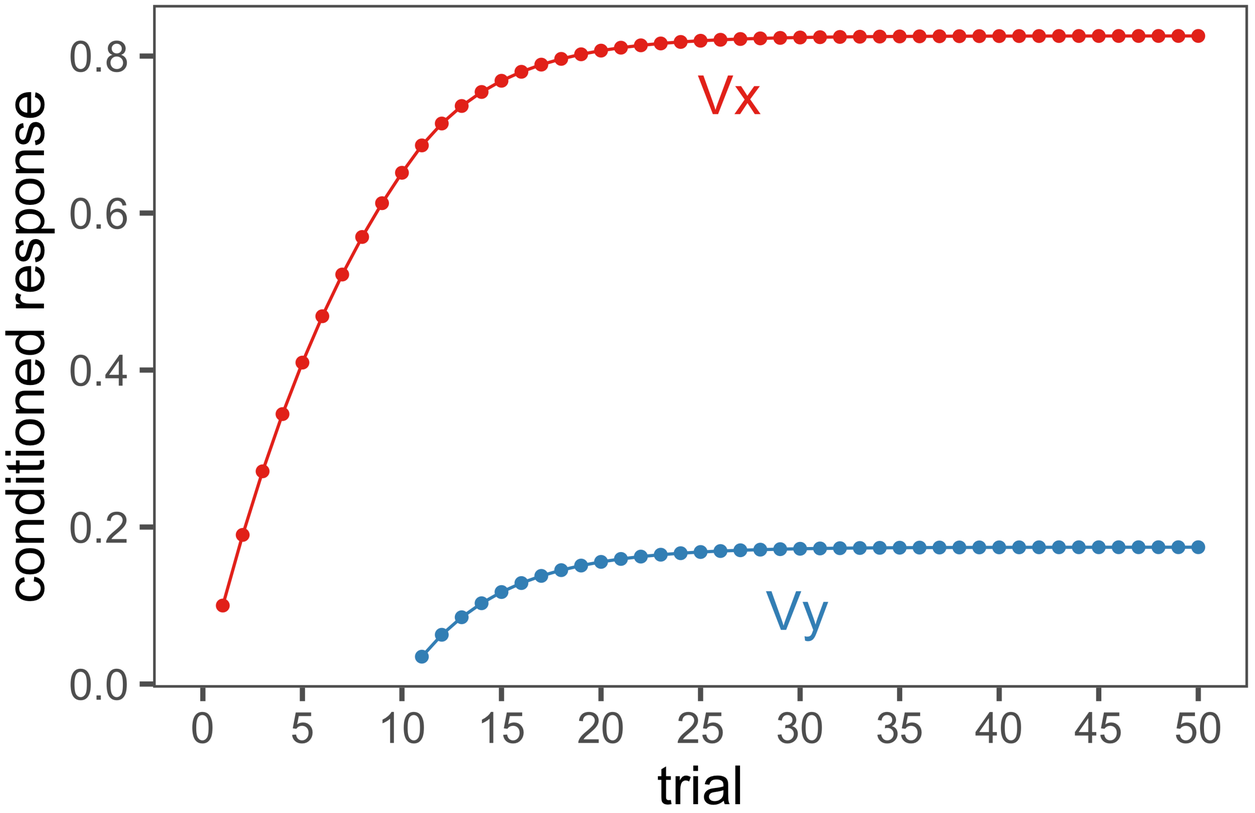
$$V_{xy} = V_x + V_y$$

$$\Delta V = \alpha \cdot \left(\lambda - V_{total}\right)$$

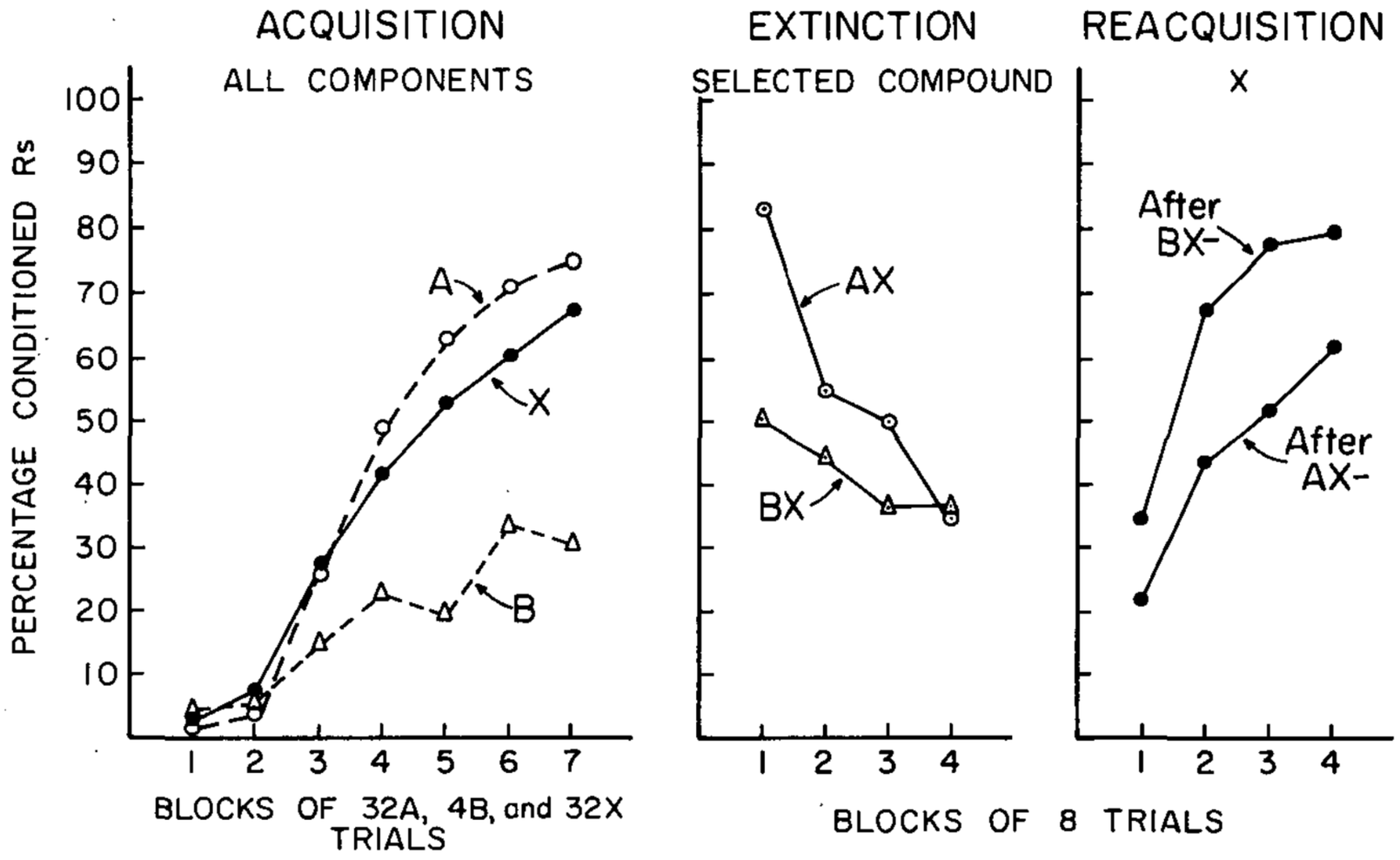
Towards a better model of eye blink conditioning

BLOCKING

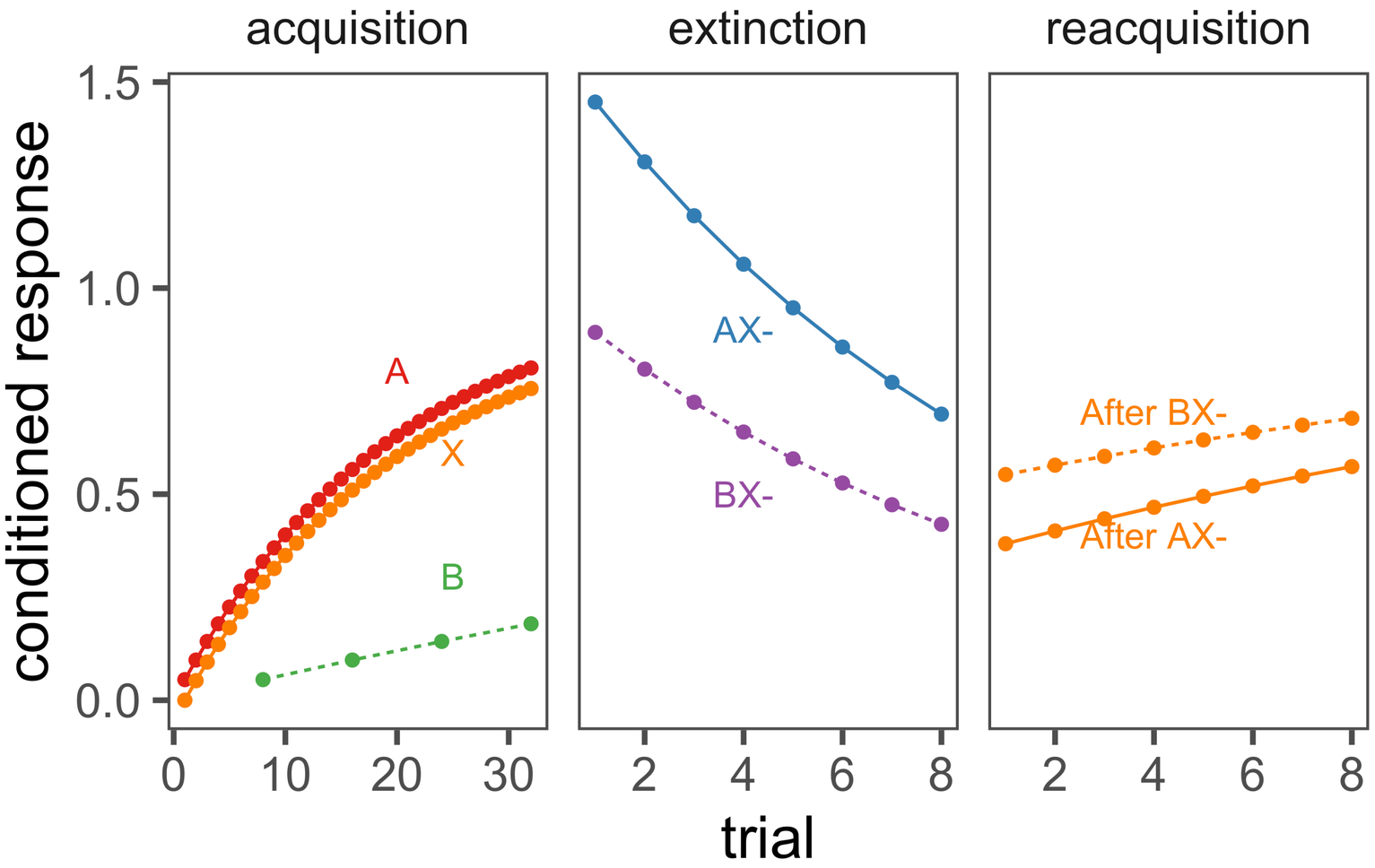




The key experiment in Rescorla & Wagner (1972)

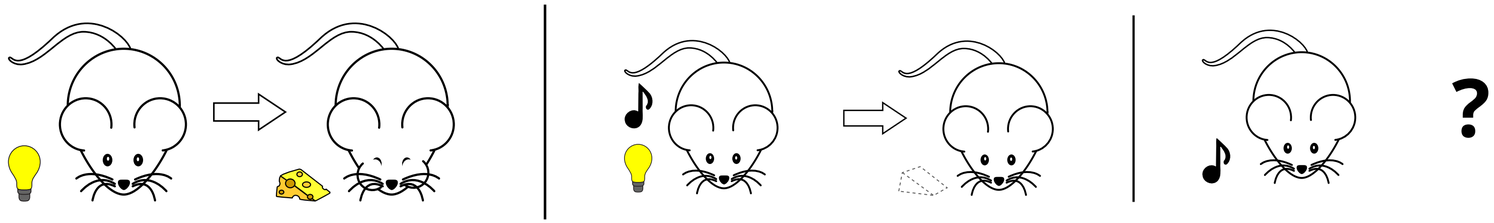


Rescorla Wagner model predictions

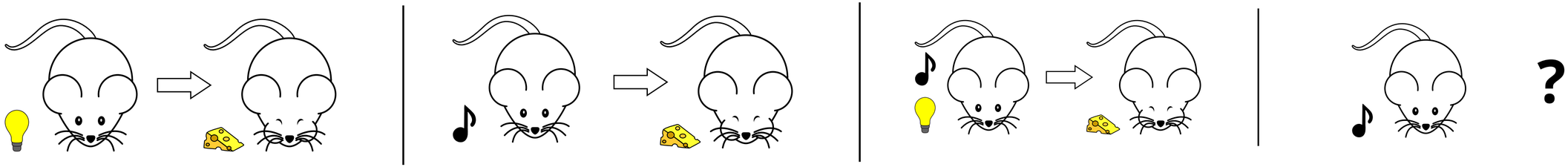


Some other predictions of RW

CONDITIONED INHIBITION

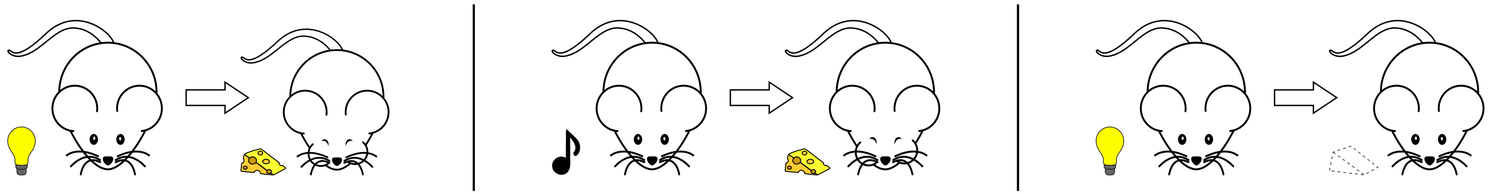


OVEREXPECTATION

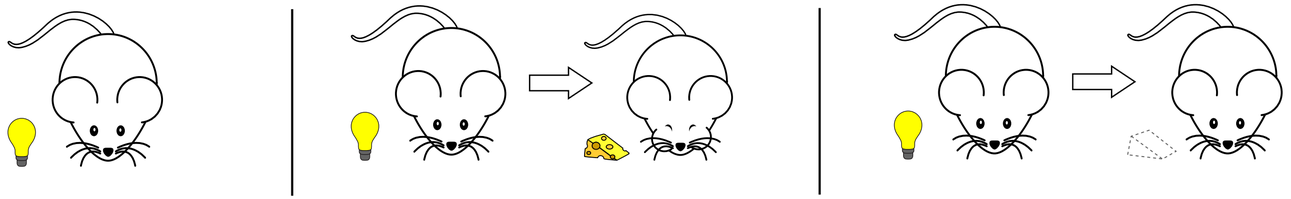


Some shortcomings of Rescorla-Wagner

INHIBITION



LATENT INHIBITION



$$\Delta V_x = \alpha \cdot \beta \cdot \left(\lambda - V_{total}\right)$$

Associative Learning

1. Associative learning is a simple model of learning applicable across domains

2. Prediction error is a unifying framework for modeling associative learning

3. The Rescorla-Wagner model of associative learning accounts for interesting phenomena like blocking, conditioned inhibition, etc.

For Thursday

1. Read 2 papers on the schedule

2. Submit a commentary to Piazza