Comparative Behavioural Neuroscience

Prof. Christopher Pryce

Department of Psychiatry, Psychotherapy & Psychosomatics
University of Zurich

christopher.pryce@bli.uzh.ch

Themes for Comparative behavioural neuroscience

1. Learning and memory

2. Emotional and cognitive stimulus processing

3. Animal models of human affective disorders

4. Pre-clinical psychopharmacology

# Themes for Comparative behavioural neuroscience

2. Emotional and cognitive stimulus processing

1. Learning and memory

4. Pre-clinical psychopharmacology

3. Animal models of human affective disorders
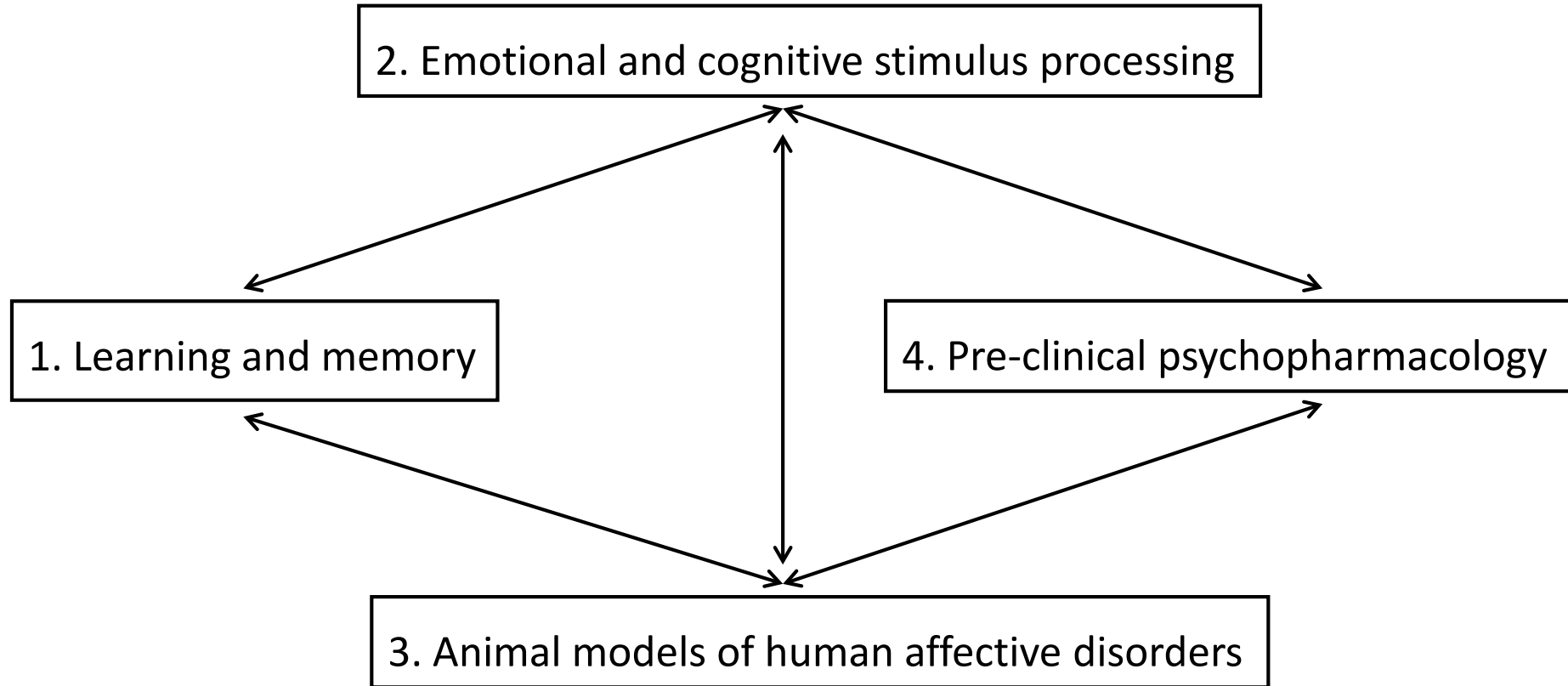
Aim: The whole is greater than the sum of its parts

Human-unique features of emotions
- Due to cognitive-CNS evolution, emotional feelings are probably uniquely human -

mental diseases/emotional feelings can be unique to humans since we have higher order concepts that other animals such as mice lack. we cannot exactly transfer these concepts such as *"I feel afraid" = "I am afraid"*
depression on animals, since they do not have the same self-awareness and conceptualizations as humans do
they can of course have an image of a reward or threat that influences their cognitive behaviour

Self-consciousness
Language

VISUAL CORTEX
VISUAL THALAMUS
AMYGDALA

HEART RATE
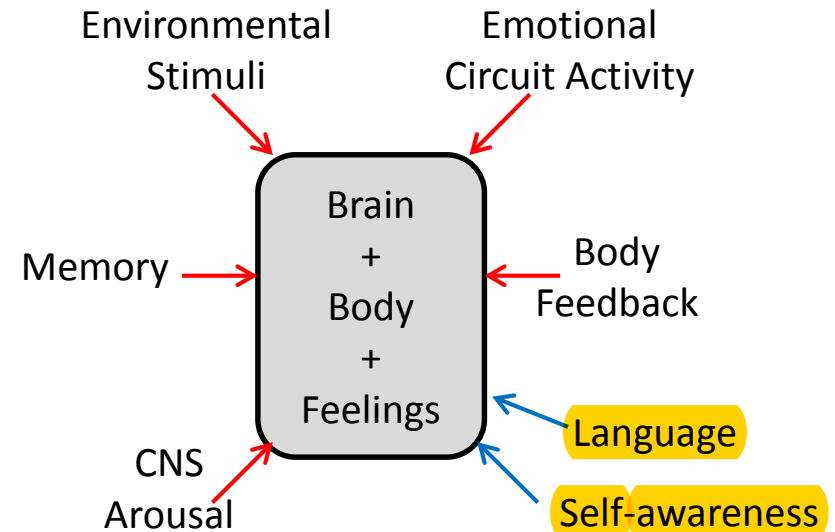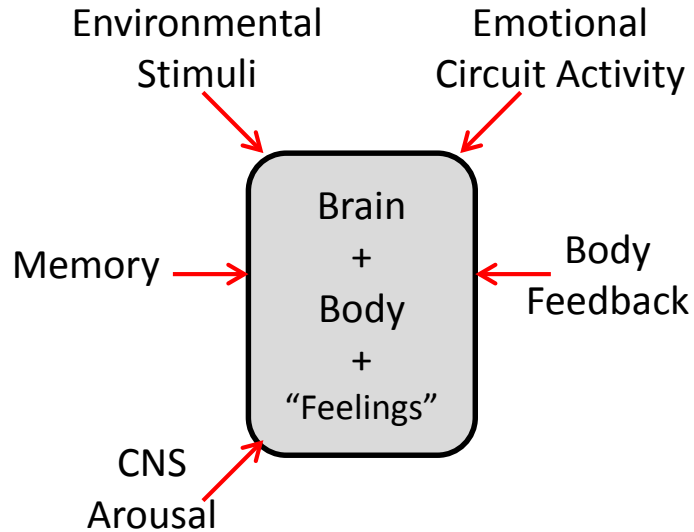BLOOD PRESSURE
MUSCLE

?
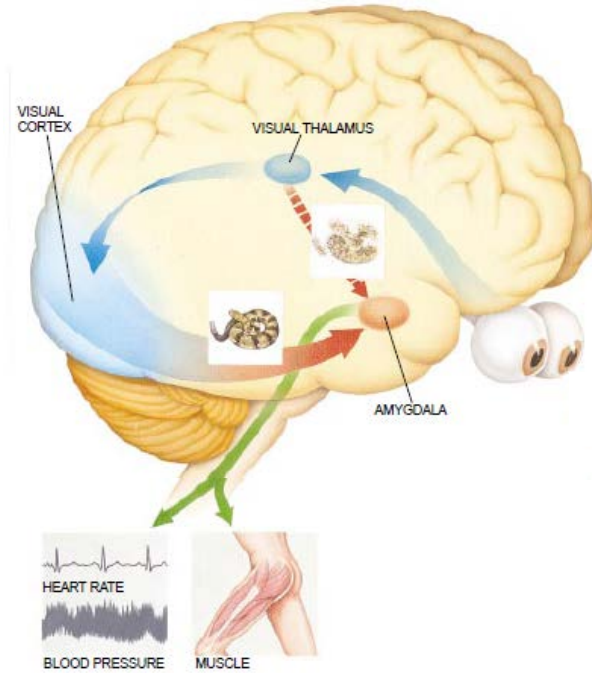
language: humans
vocalization: primates with meaningful sounds
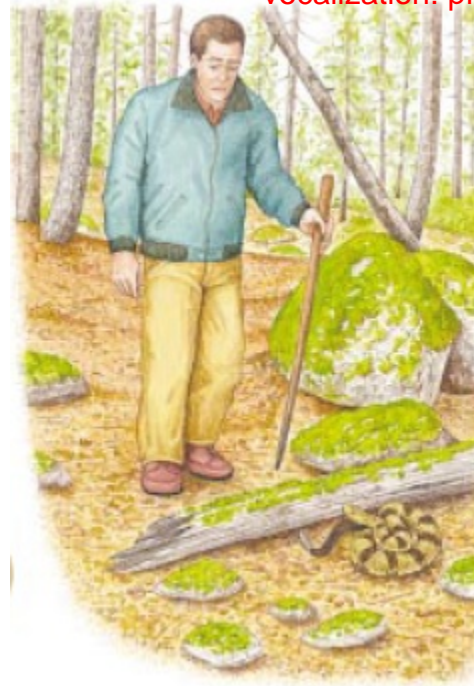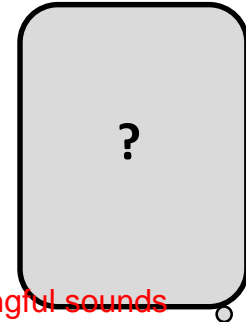
there are animals that have self-awareness:
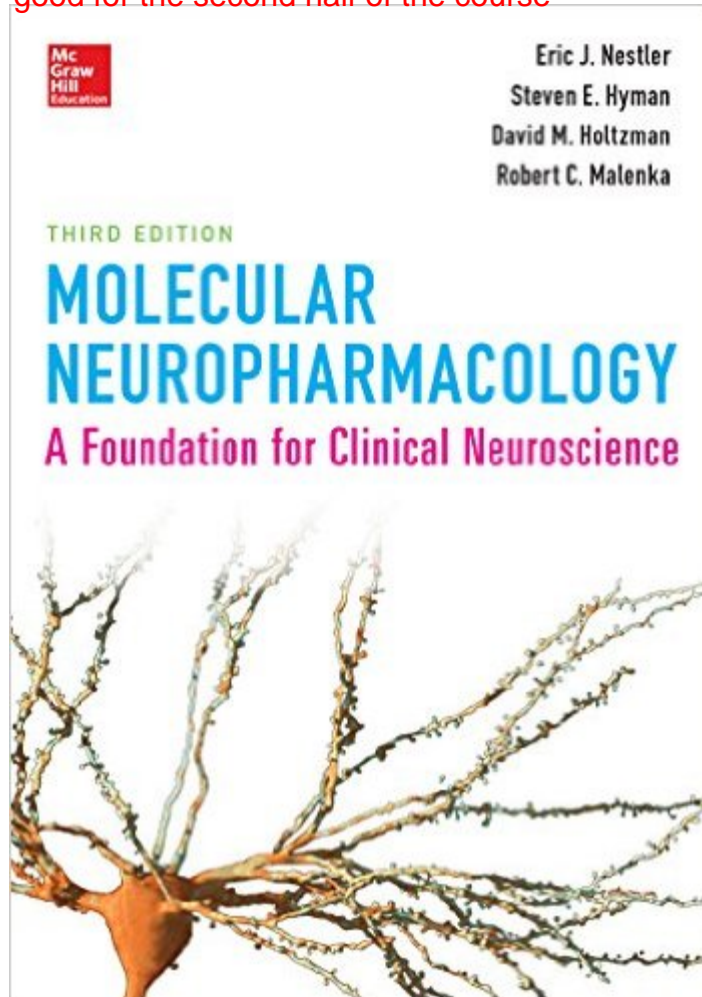primates/chimpanzees, dolphins

Summary of Universal and Human-unique features of emotions
- Much is universal, and what is universal is essential to that which is human -
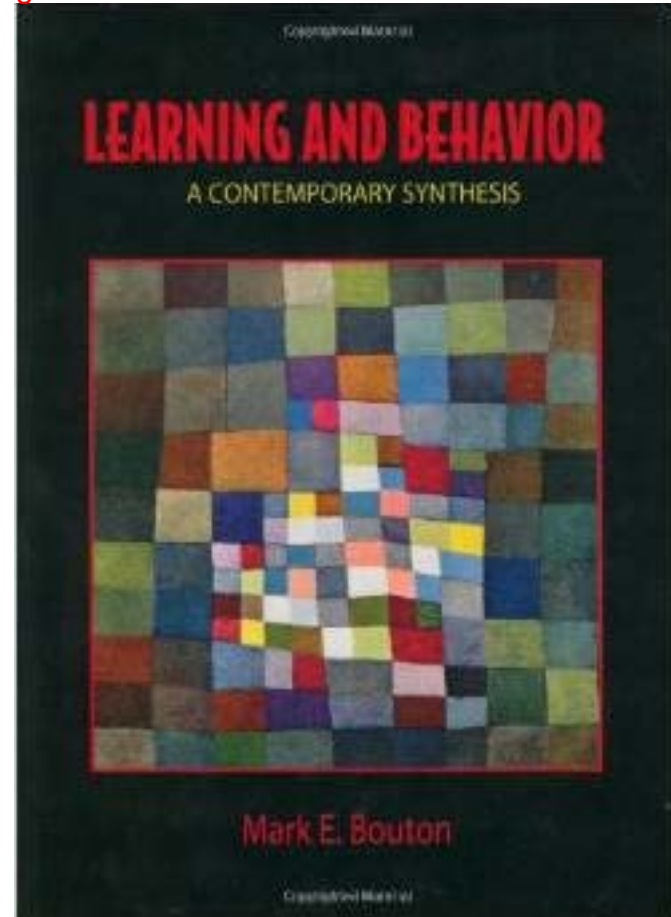
Recommended Text Books

good for the second half of the course

Mc
Graw
Hill
Education

Eric J. Nestler
Steven E. Hyman
David M. Holtzman
Robert C. Malenka

THIRD EDITION

MOLECULAR NEUROPHARMACOLOGY
A Foundation for Clinical Neuroscience

good for the first half of the course

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LEARNING AND BEHAVIOR
A CONTEMPORARY SYNTHESIS
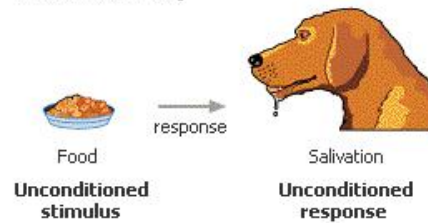
Mark E. Bouton

Copyrighted Material

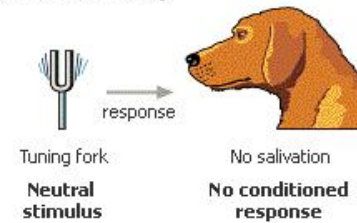# Learning and memory: Classical Conditioning

- Pavlovian conditioning
- Unconditioned stimulus (US, UCS)
- Unconditioned response (UR, UCR)
- Conditioned stimulus (CS)
- Conditioned response (CR)
- Conditioning trial
- CS-UCS Association
- Rescorla-Wagner conditioning model
- Surprise
- Associative strength
- Context
- CS-UCS Extinction

Appetitive classical conditioning: Food-conditioned autonomic response
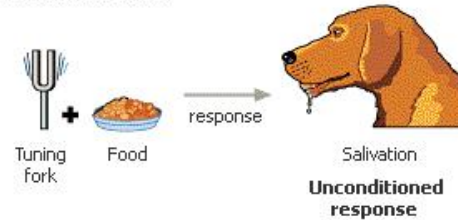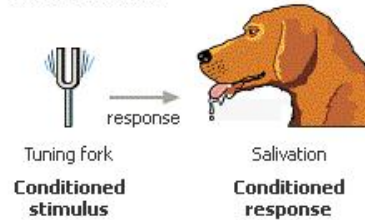

1. Before conditioning

Food → response → Salivation
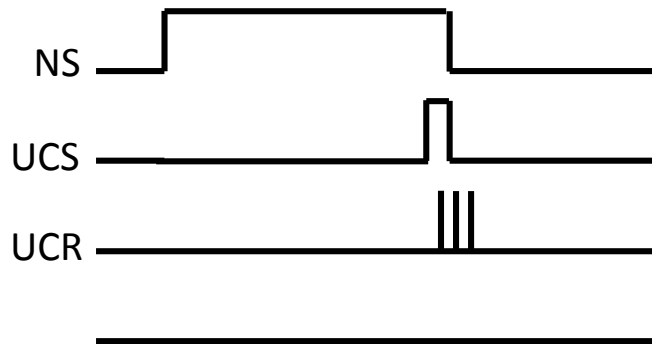**Unconditioned stimulus** → **Unconditioned response**

2. Before conditioning

Tuning fork → response → No salivation
Neutral stimulus → **No conditioned response**

3. During conditioning

Tuning fork + Food → response → Salivation
Unconditioned response

4. After conditioning

Tuning fork → response → Salivation
Conditioned stimulus → **Conditioned response**

Trial 1

NS

UCS

UCR

Trial 50

Tone   CS

Food   UCS

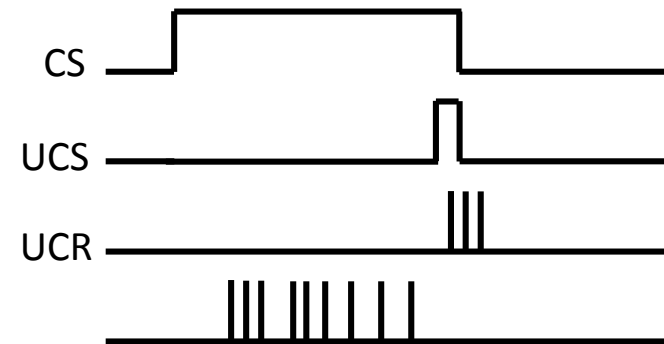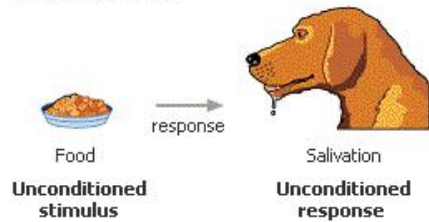Salivation   UCR

Salivation   Salivation

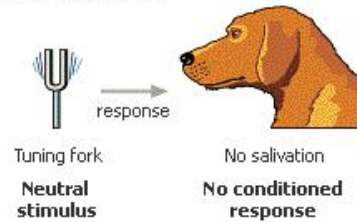# Appetitive classical conditioning: Food-conditioned autonomic response

1. Before conditioning
Food — response → Salivation
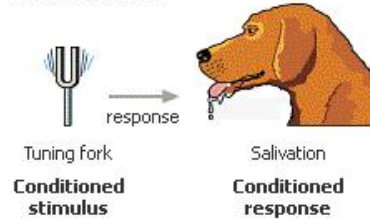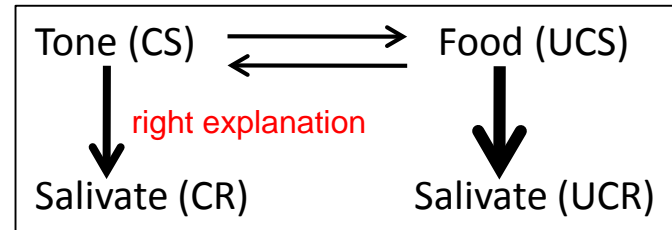**Unconditioned stimulus** — **Unconditioned response**

2. Before conditioning
Tuning fork — response → No salivation
Neutral stimulus — **No conditioned response**

3. During conditioning
Tuning fork + Food — response → Salivation
Unconditioned response

4. After conditioning
Tuning fork — response → Salivation
Conditioned stimulus — **Conditioned response**

Tone (CS) ⟶ Food (UCS)

this is the wrong explanation

Salivate (UCR)

CS-UCR No!

Tone (CS) ⇄ Food (UCS)

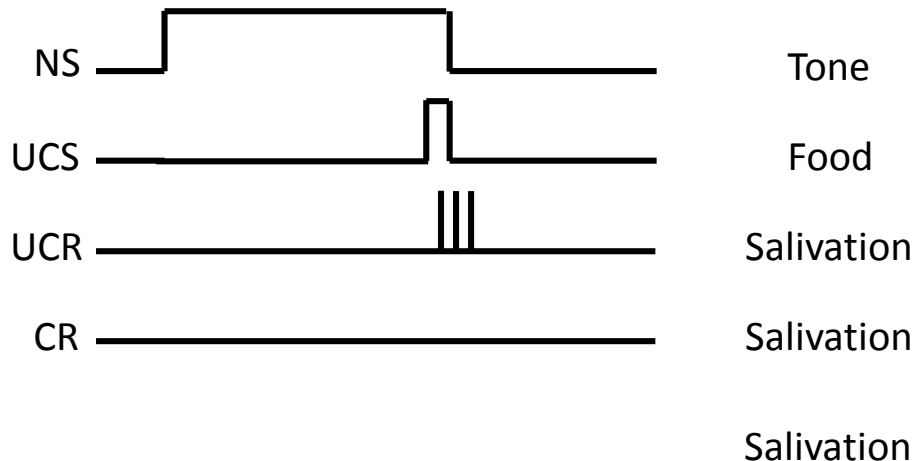right explanation

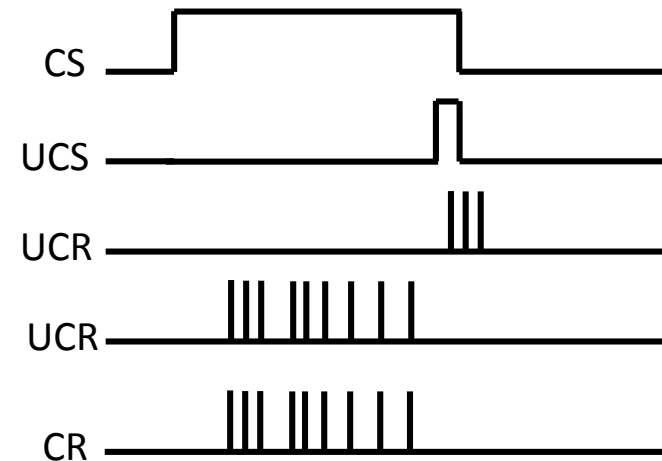Salivate (CR)   Salivate (UCR)

CS-UCS Yes!

CS is controlling the CR
CS starts to cause a CR
in pavlov exp: CR = UCR, but need not be

Trial 1

NS

UCS

UCR

CR

Tone

Food

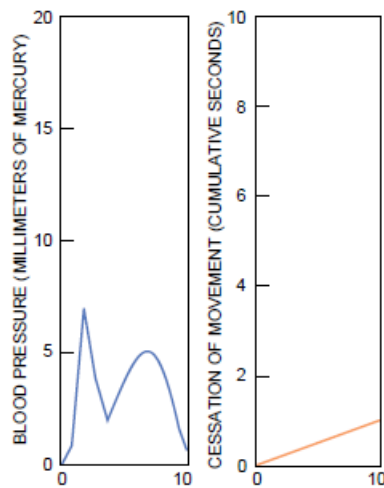Salivation

Salivation

Salivation

Trial 50

CS

UCS

UCR

UCR

CR

Aversive classical conditioning: Fear-conditioned "freezing" behaviour
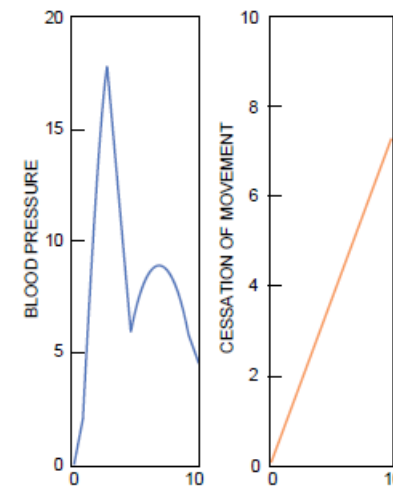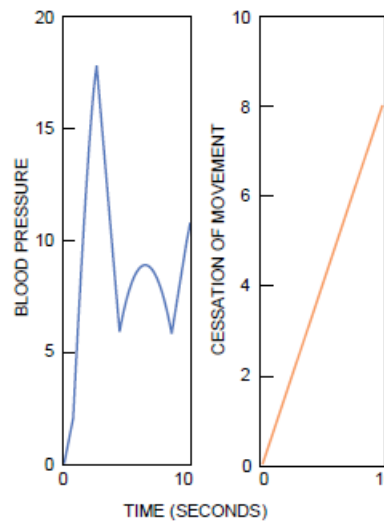
Trial 1

Trial 6   here: CR != UCR

NS	Tone	CS
UCS	Electro-shock	UCS
UCR	Running	UCR
CR	"Freezing"	CR
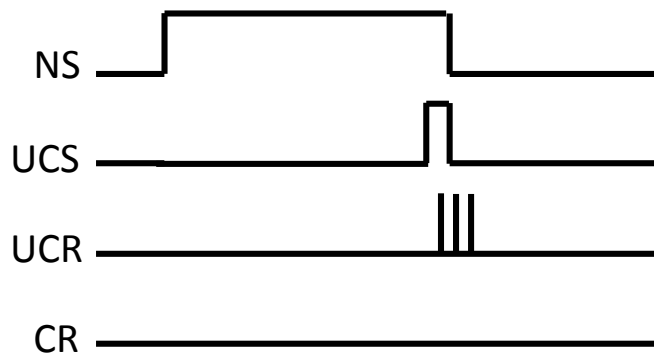
because flight of fight does not work
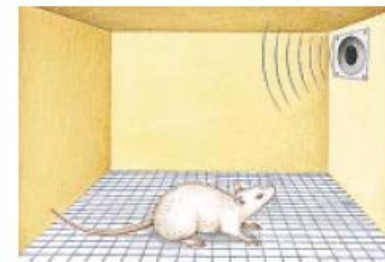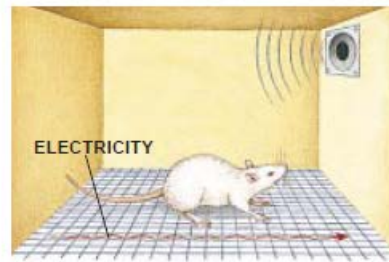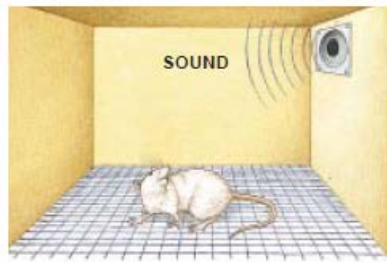
Aversive classical conditioning: Fear-conditioned "freezing" behaviour

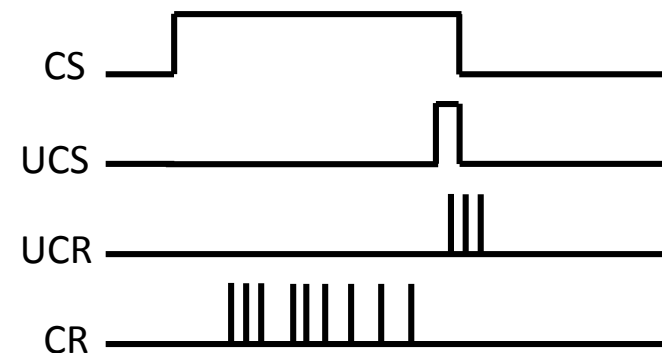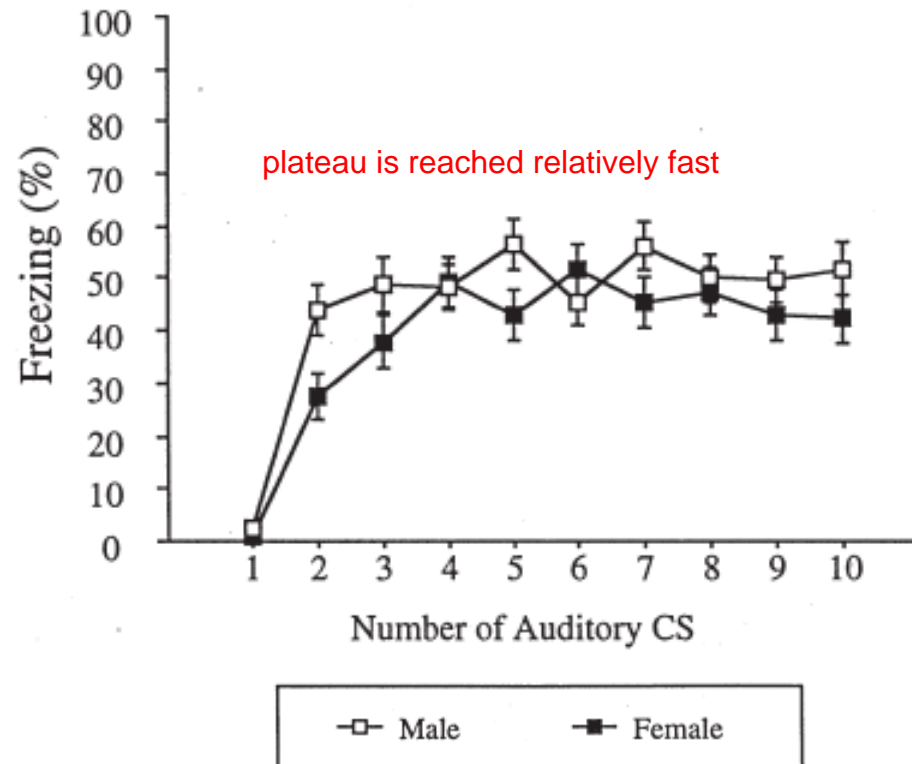Tone (CS) ⇄ E-Shock (UCS)

Tone (CS) → Freeze (CR)

E-Shock (UCS) → Jump, Run (UCR)
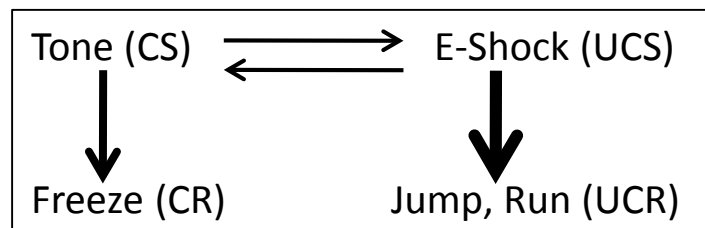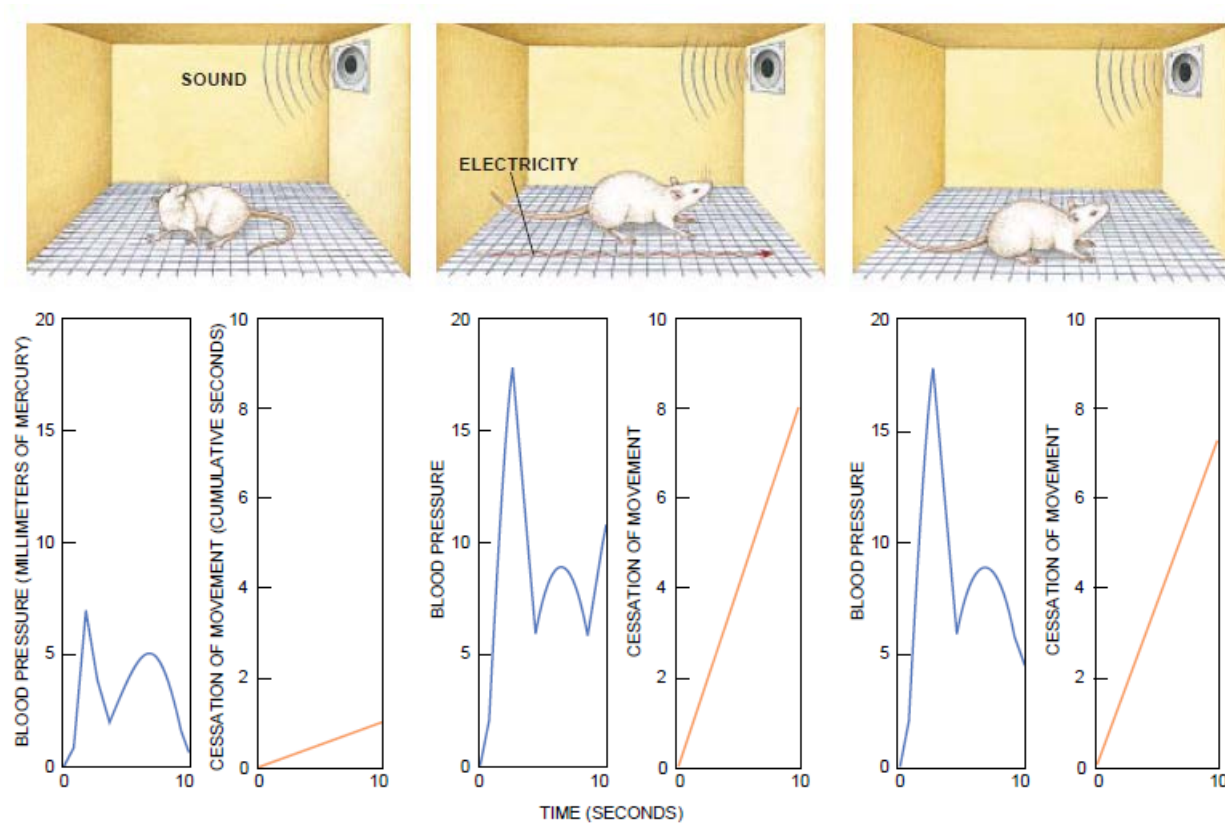
CS-UCS Yes!

the tone starts to control emotional behaviour
which is freezing

Fear-conditioned freezing behaviour: the learning curve

plateau is reached relatively fast
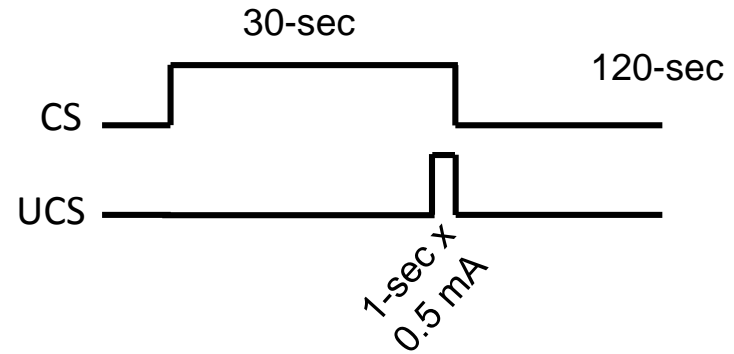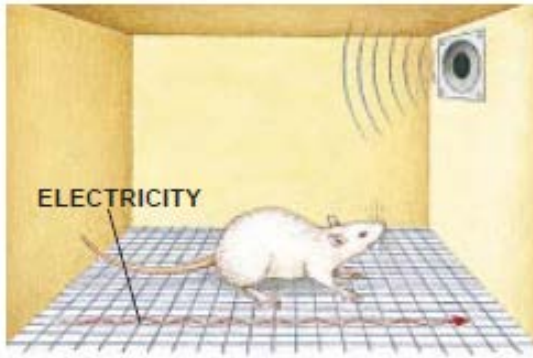
Fear-conditioned freezing behaviour: tests of what was learned

Conditioning

CS ⎍⎍⎍⎍

UCS ⎍⎍
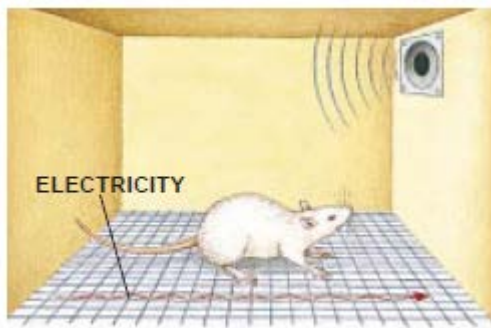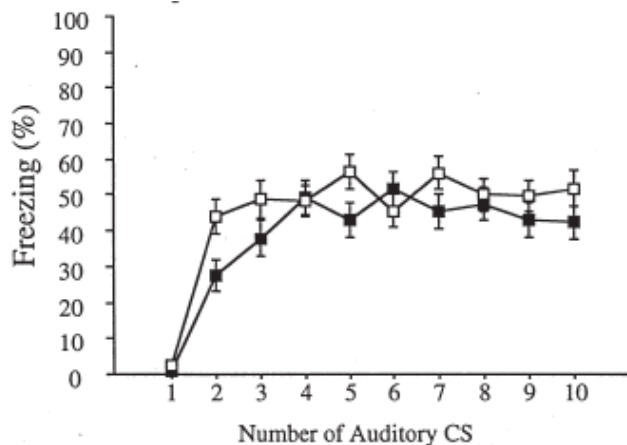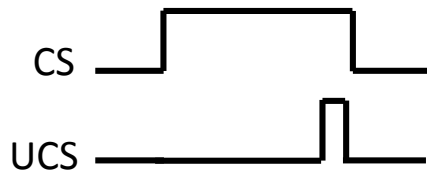
Context test

the animal shows freezing to purely being in the environment so the animal has learnt something about the context which is associated with the shock

CS test (New Context)

CS ⎍⎍⎍⎍
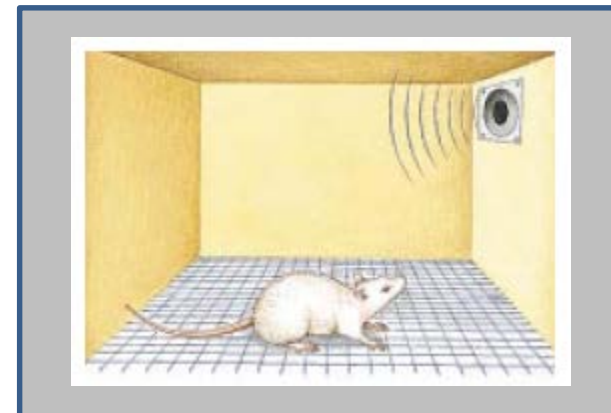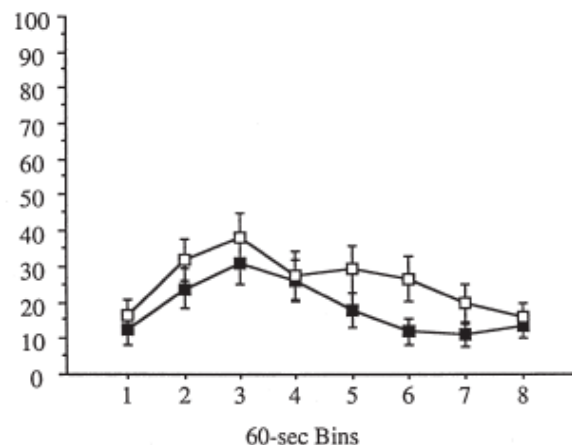
in a new context, the CS still works even if the context change: CS is the real danger/indicator to learn, but some info is also retained from the general context as seen in the middle example

Freezing (%) — Number of Auditory CS

60-sec Bins

60-sec Bins
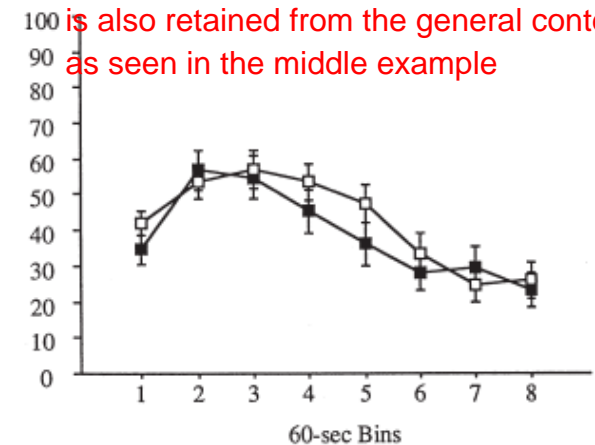
−□− Male   −■− Female

Classical conditioning models: Rescorla-Wagner "surprise" model

Assumptions:

1. Repeated pairing of CS with a UCS results in a gradual increase in the strength of association between them. This can be observed as the size of the CR.

2. Associative strength does not increase by a fixed amount, but is determined by the difference between current associative strength of the CS and the maximum possible for the UCS.

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

V, strength of CS-UCS association

ΔV, change in strength for any trial

λ (lambda), maximum CS-UCS association strength (determined by UCS intensity)

α, constant value between 0-1 (determined by CS)
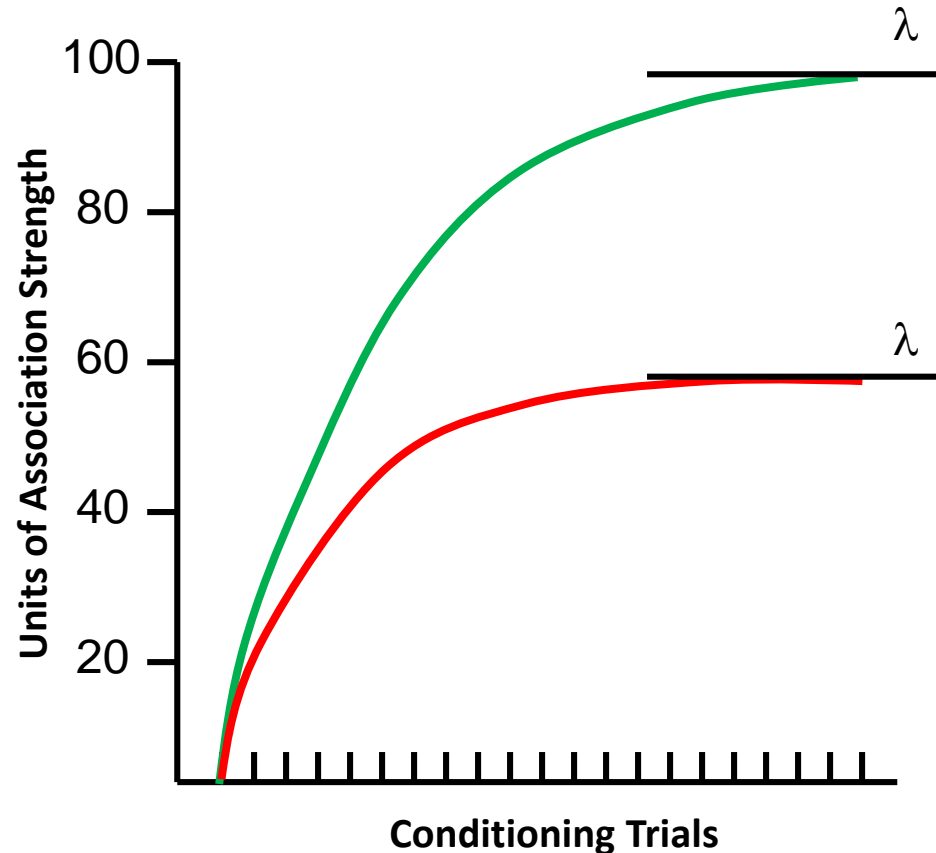
lambda determined by the emotional importance of stimulus

Example 1:
CS is novel
$\alpha = 0.2$ (moderate intensity)
$\lambda = 100$ ("emotionally strong")
Trial 1: $\Delta V = 0.20(100-0) = 20$
Trial 2: $\Delta V = 0.20(100-20) = 16$
Trial 3: $\Delta V = 0.20(100-36) = 12.8$

Example 2:
CS is novel starts at 0
$\alpha = 0.2$ (moderate intensity)
$\lambda = 50$ ("emotionally weak")
Trial 1: $\Delta V = 0.20(50-0) = 10$
Trial 2: $\Delta V = 0.20(50-10) = 8$
Trial 3: $\Delta V = 0.20(50-18) = 6.4$

Example 3:
CS is novel
$\alpha = 0.8$ (high intensity)
$\lambda = 100$ ("emotionally strong")
Trial 1: $\Delta V = 0.80(100-0) = 80$
Trial 2: $\Delta V = 0.80(100-80) = 16$
Trial 3: $\Delta V = 0.80(100-96) = 3.2$
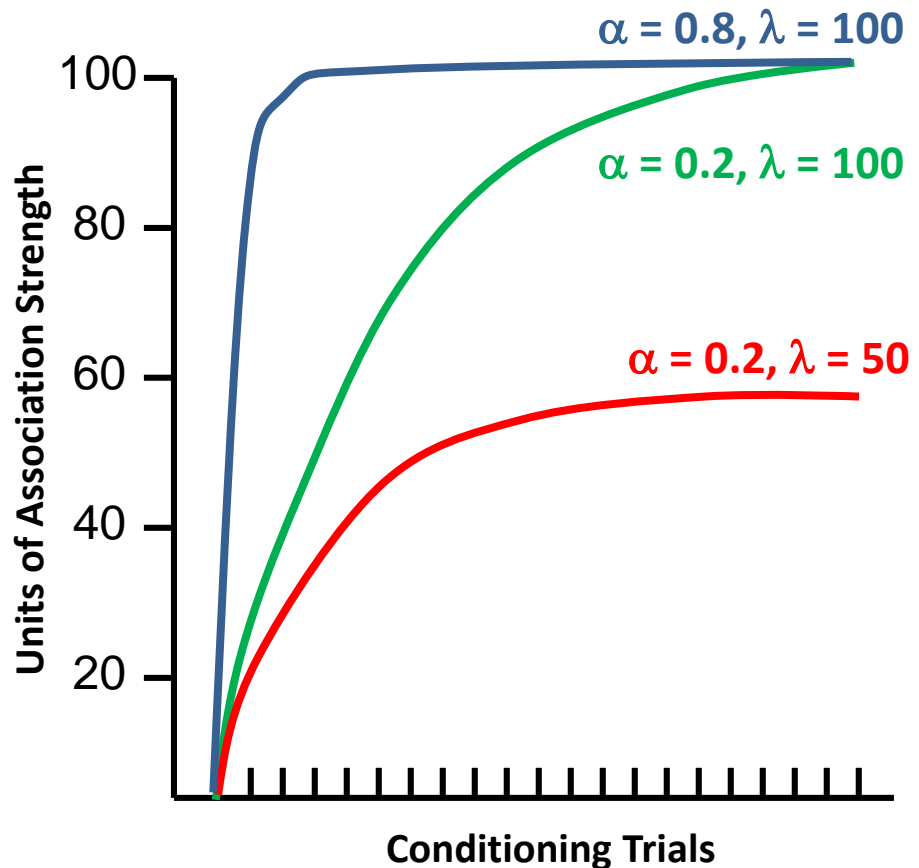
$\alpha = 0.8, \lambda = 100$
$\alpha = 0.2, \lambda = 100$
$\alpha = 0.2, \lambda = 50$

Units of Association Strength

Conditioning Trials

$\Delta V = \alpha(\lambda - V)$
V, strength of CS-UCS association
ΔV, change in strength for any trial
λ (lambda), maximum CS-UCS association strength
(determined by UCS intensity)
α, constant value between 0-1 (determined by CS)

Fear-conditioned freezing behaviour: extinction learning

CS test (New Context)

8 x 60-sec

CS

UCS
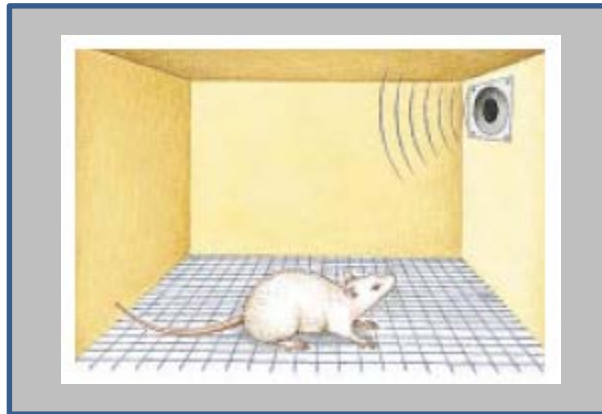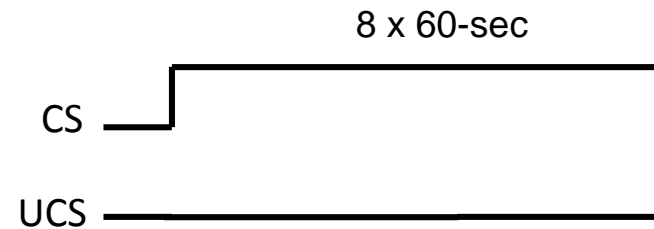
you will never forget that CS was dangerous, it will always remain in the brain and will always be in the amygdala.

in extinction learning, we learn a new relationship: the PFC learns the once dangerous stimuli becomes undangerous and will be the new prevalent memory - the PFC puts a break on the amygdala and suppresses it. it is NOT forgetting, but a new memory being learned

60-sec Bins

Extinction of Classical conditioning: Rescorla-Wagner "surprise" model

CS-UCS $\longrightarrow$ CS-No Stimulus

$\Delta V = \alpha(\lambda - V)$ the same formula also applies for extinction learning and lambda is always 0 in extinction learning

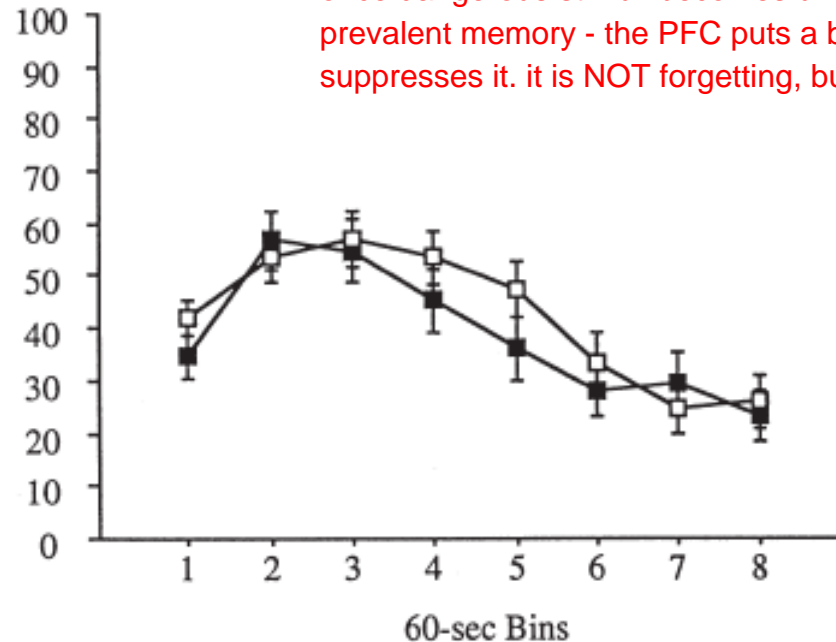V, strength of CS-UCS association

ΔV, change in strength for any trial

λ, maximum CS-UCS association strength (determined by UCS)

α, constant value between 0-1 (determined by CS)

Example:

V = 100

α = 0.2 (moderate intensity)
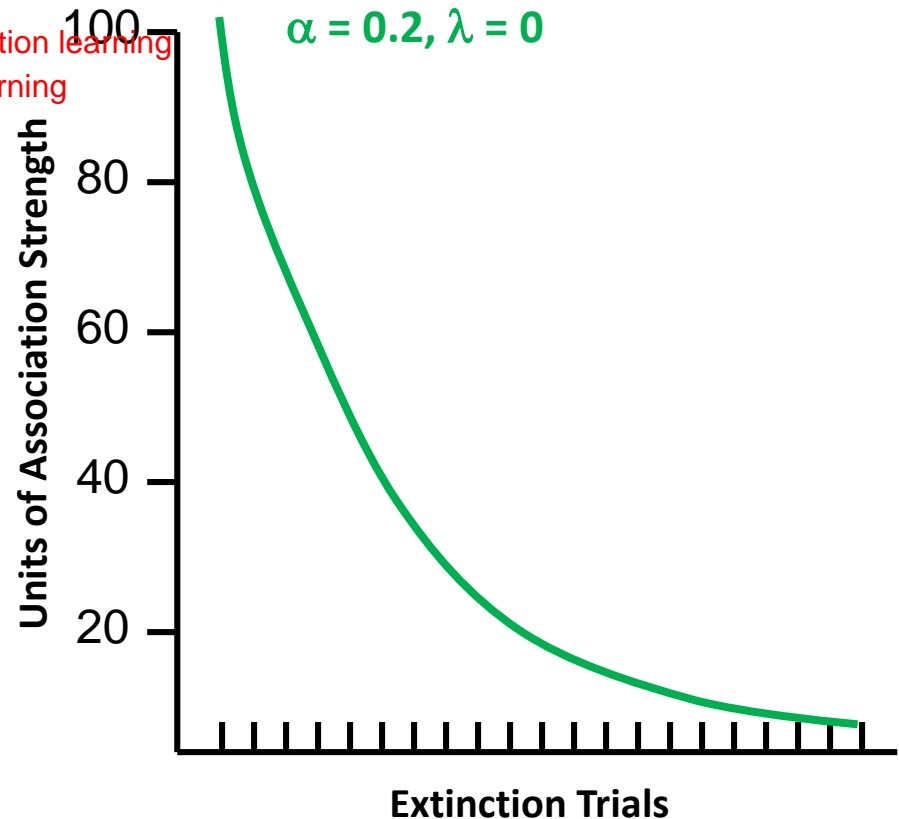
λ = 0 ("emotionally absent")

Trial 1: $\Delta V = 0.20(0-100) = -20$

Trial 2: $\Delta V = 0.20(0-80) = -16$

Trial 3: $\Delta V = 0.20(0-64) = -12.8$

$\alpha = 0.2, \lambda = 0$

Units of Association Strength

100

80

60

40

20

Extinction Trials

Pavlovian Conditioning

It's Not What You Think It Is

Robert A. Rescorla   *University of Pennsylvania*

Co-occurrence of the CS and US is not necessary to produce Pavlovian conditioning

Conditioned Inhibition or Safety learning

CS

UCS
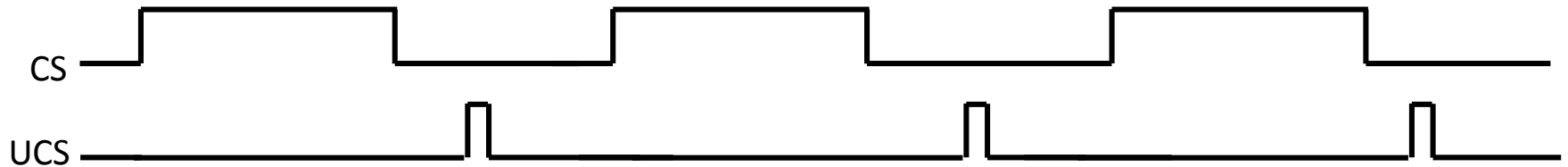
a predictive absence of a US can be learned, so it knows that when CS occurs, there is no electric shock

Rescorla (1988) Amer Psychol 43: 151-160

Co-occurrence of the CS and US is not sufficient to produce Pavlovian conditioning

Kamin Blocking Effect

we only learnt that light predicts US, but it cannot be co-learned with tone, so the tone produced no CR on its own

Light ———▶ US   Light + Tone ———▶ US   Tone ———▶ No CR

no initial conditioning

now the US is learned with light and tone   tone also produced CR

Light + Tone ———▶ US   Tone ———▶ CR

Rescorla (1988) Amer Psychol 43: 151-160

The CS does not become capable of causing the behaviour caused by the US

The response to the CS can be different to the response to the US

Tone (CS) ⇄ E-Shock (UCS)

Freeze (CR) ← Jump, Run (UCR)

ELECTRICITY
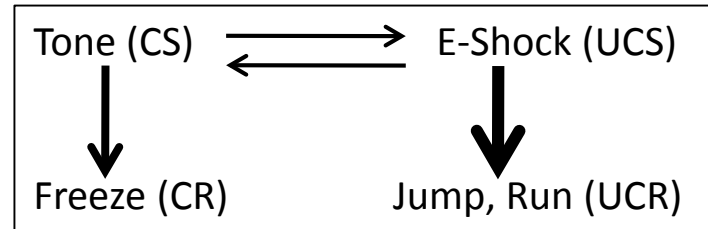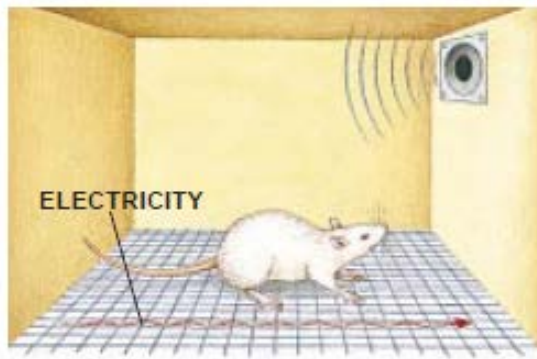
The response to the CS depends on the properties of the CS

Dependence of the Form of the Conditioned Response on the Identity of the Signal

LIGHT ---> FOOD
TONE ---> FOOD

X ---> LIGHT
Y ---> TONE

Pigeon Operant Chamber
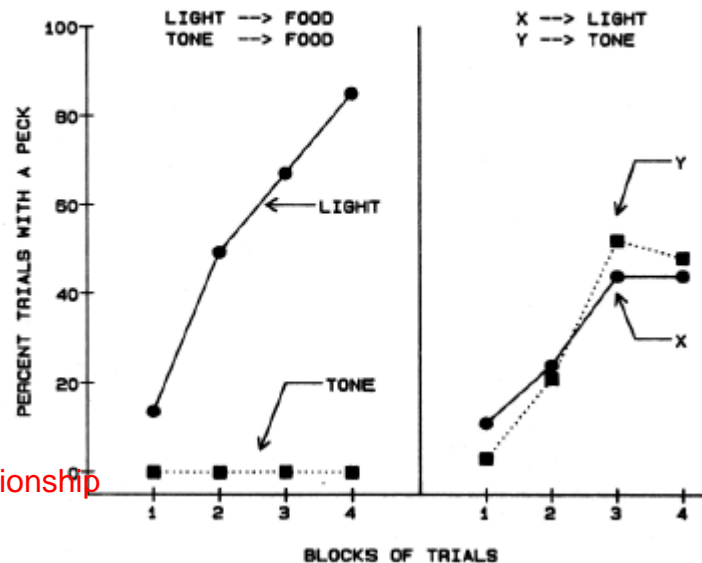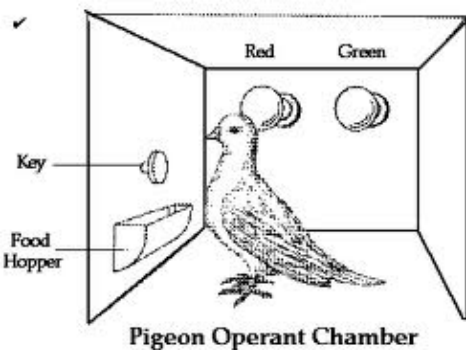
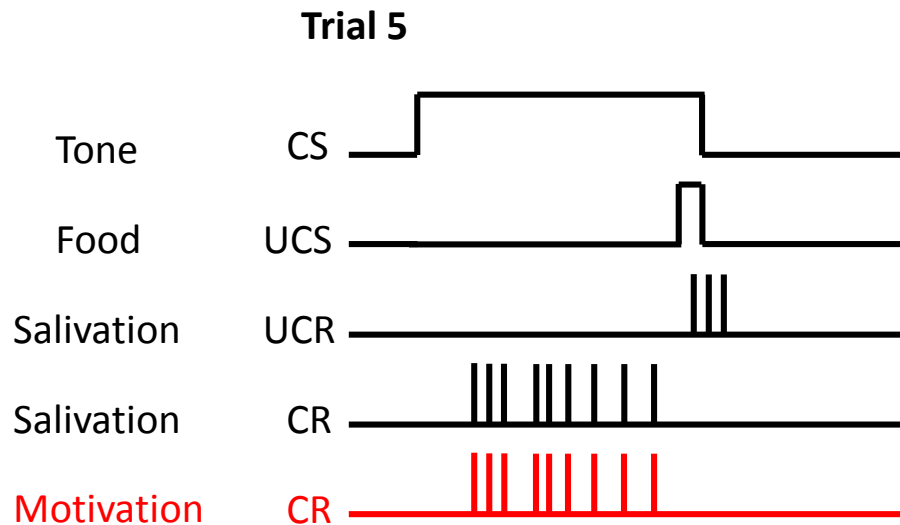X and Y are light stimuli that signal/predict light CS and tone CS, respectively

but lights can predict the tone stimulus

and then they can still eat food

pigeons apparently cannot learn relationship between food and tone

Rescorla (1988) Amer Psychol 43: 151-160

"Pavlovian learning provides a unique means to learn the motivational landscape of the environment, by coupling experience-based statistical learning with the wisdom of species-wide evolutionary inheritance."

1. Allows appropriate response in anticipation of the outcome.
2. Gives the CS motivational value, which can be exploited by other decision-making processes.

Trial 5

Tone	CS
Food	UCS
Salivation	UCR
Salivation	CR
Motivation	CR

Seymour & Dolan (2008) Neuron 58: 662

"A goal-directed action system that can exploit CSs struggles to compete with its Pavlovian (emotional) counterpart and in Western societies Pavlovian gluttony may have contributed to an epidemic of obesity."

Seymour & Dolan (2008) Neuron 58: 662
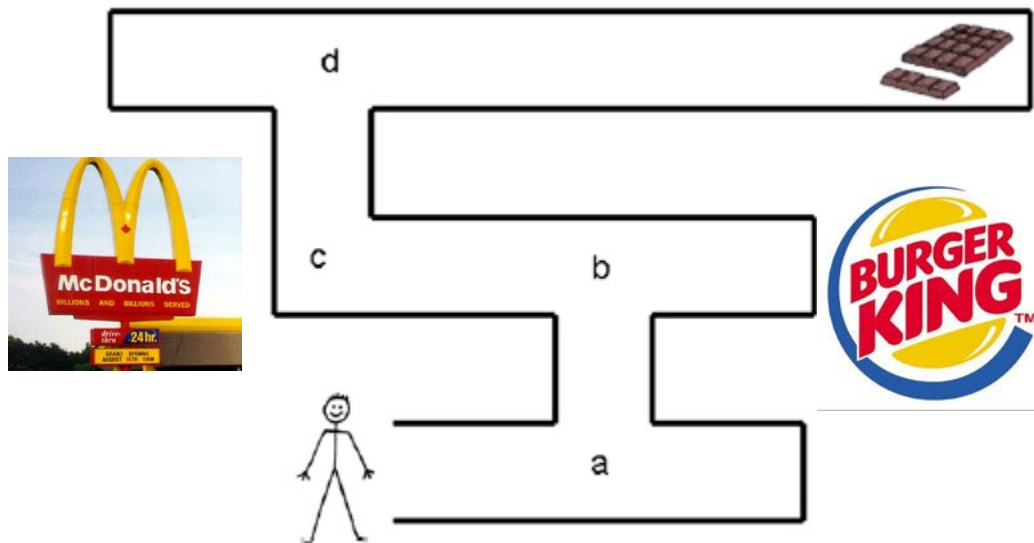
Classical Conditioning

- A neutral stimulus experienced in close temporal association with an emotional stimulus acquires its emotional properties = classical or Pavlovian conditioning

- The CS does not cause the behaviour that is caused by the UCS

- Classical conditioning occurs to rewarding and aversive unconditioned stimuli

- Classical conditioning learning curves exhibit a characteristic form that can be explained by the Rescorla-Wagner surprise model

- Classical extinction involves presentation of the CS without the UCS