Learning & Memory (Ch.17) I

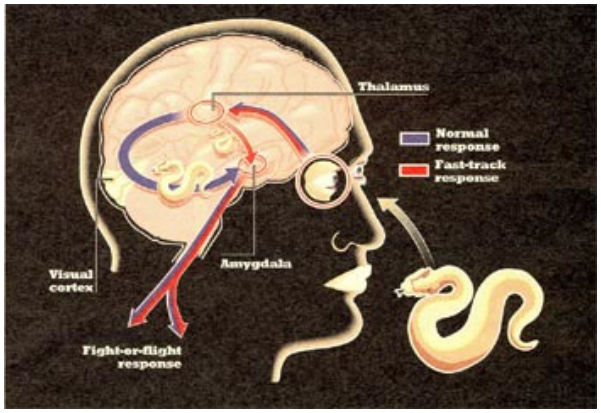
- The Neural Basis of Associative Learning
- Aversive (Fear) and Appetitive Associative Learning
  - Contributions of the Amygdala and Striatum
  - Instrumental learning and conditioned reinforcers

  - Relevant textbook pages: Chapter 15: 504-507
    For this lecture Chapter 17: 573-575

  - Note: pgs 587-589 (Invertebrate nervous system, Cerebellum learning) – No lectures, you will not be tested on this content

The Amygdala and Fear

- Fear is an adaptive trait
  - Keeps us away from bad things
- Some stimuli evoke an innate fear response (no learning required)
  - Snakes, spiders, big moving objects, novelty



- Animals or humans with lesions to the amygdala display “fearless”-like behaviours
  - E.g.; Primates innately scared of snakes, but lesions of the amygdala abolish this fear
- With many other harmful things in our environment, we learn to be afraid of them
  - **Amygdala** plays an essential role in learning to be afraid of potentially harmful things

Pavlovian (Classical) Conditioning (I)

- Virtually all animals display Pavlovian conditioning
  - Helps organism prepare for biologically significant events in response to cues that predict those events

- Four main elements
  - **Unconditioned Stimulus (US)** = the biologically significant event (meat powder in Pavlov's dog's mouth)
  - **Unconditioned Response (UR) =** normal response to significant event (salivation)
  - **Conditioned Stimulus (CS) =** *Previously neutral* cue that reliably predicts significant event (bell predicts meat powder)
  - **Conditioned Response (CR) =** The body's response to the CS alone (salivating to the bell)

Pavlovian (Classical) Conditioning (II)

- Five key points:

1) CS must reliably predict the US

2) Delivery of CS & US are **uncontrollable** by the organism

3) The CR is also **uncontrollable**

  - Typically an autonomic response (e.g.: heart rate) but can also be motor (**Pavlovian approach**)

4) In humans, the CR typically occurs in absence of conscious knowledge

5) Very long lasting:

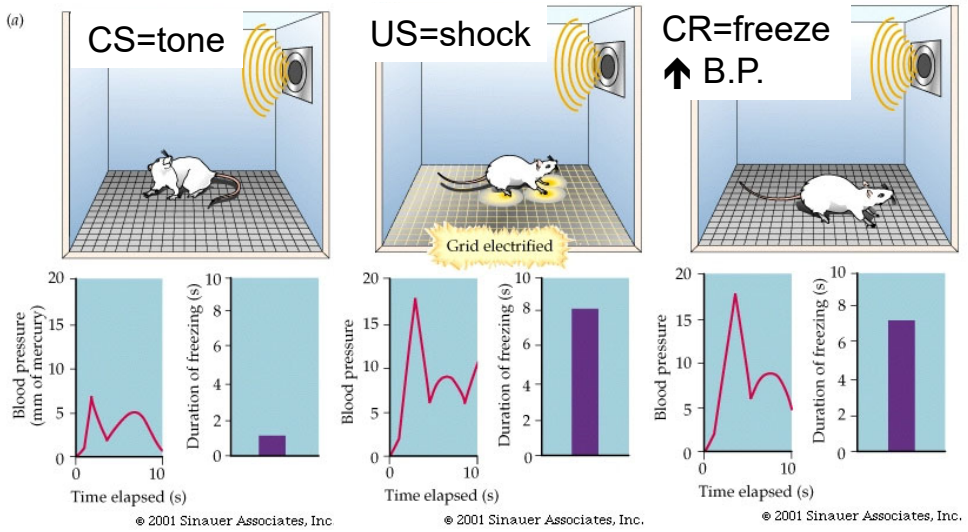
  - Can be extinguished, but reinstated very quickly with another CS-US pairing

The Amygdala and Fear Conditioning (I)

➢ Auditory Fear Conditioning:

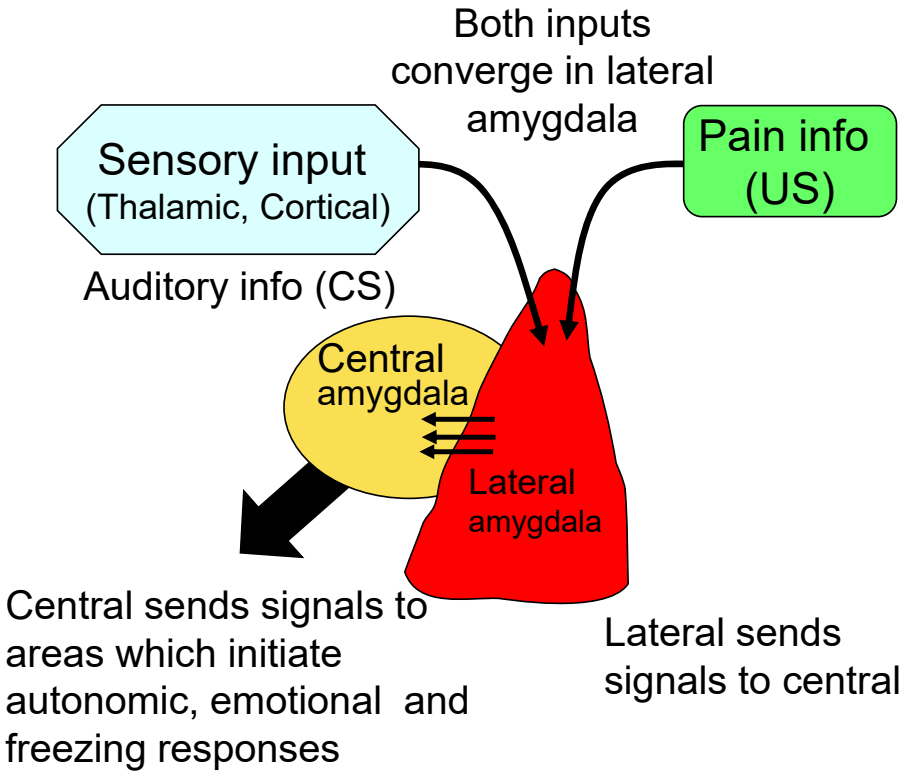
-Freezing natural defensive response for rodents

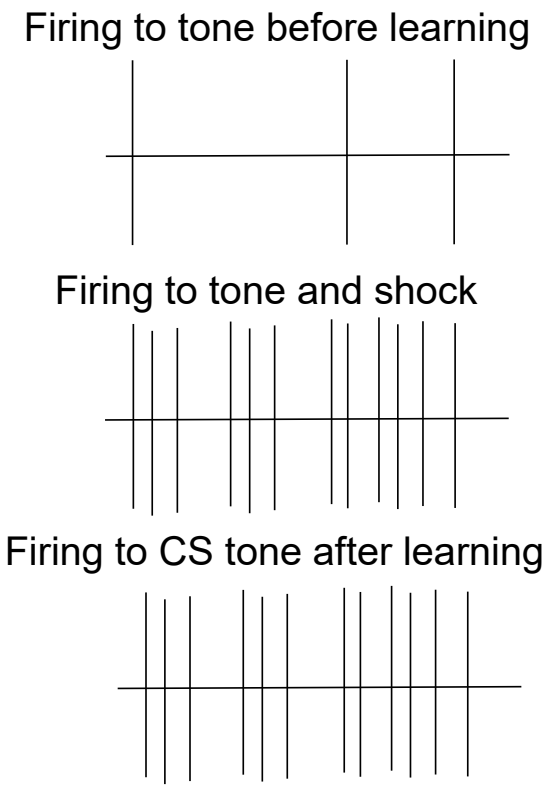
-In the lab, tones easier to deal with than visual cues



- Lesions to amygdala subnuclei abolish ↑ freezing and autonomic response to the **tone (CS)**
- Lesions made ***prior*** to conditioning (**acquisition**) or ***after*** conditioning (**expression)** both disrupt conditioned response (so you need the amygdala to both ***learn*** and ***recall*** fear)
- These lesions **do not affect** response to shock
- Similar results in ***humans*** with **Amygdala damage** = disrupted fear conditioning (blood pressure, heart rate)

The Amygdala and Fear Conditioning (II)

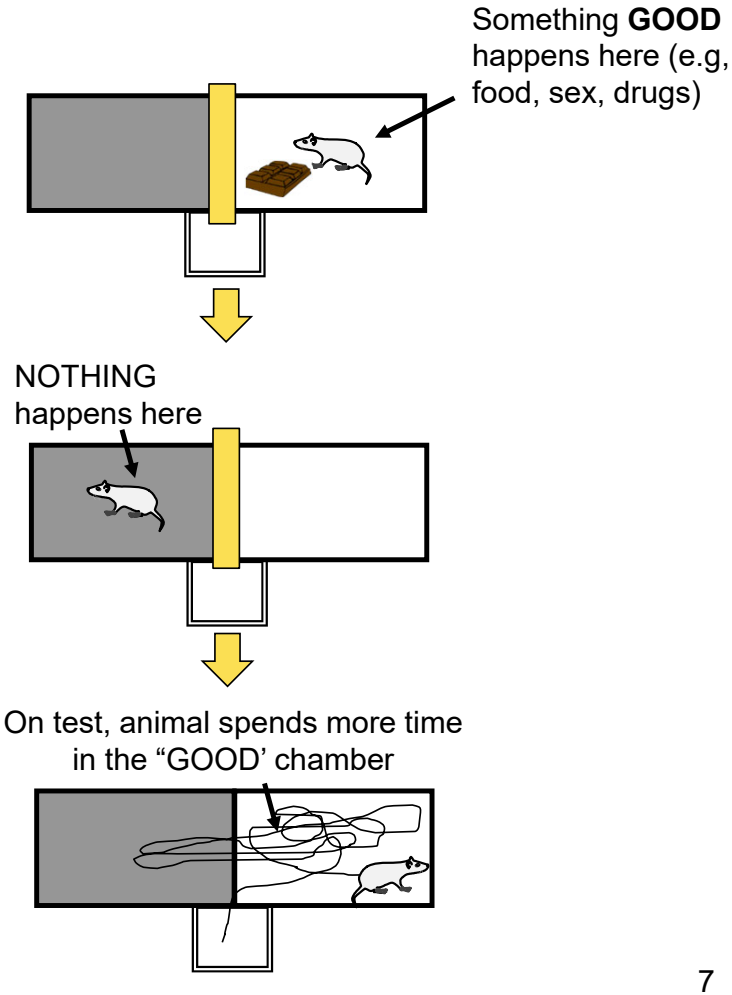




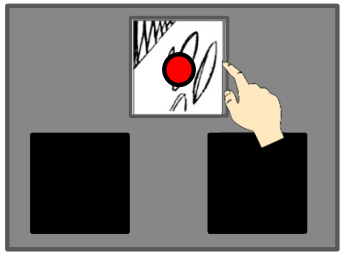
- Neurons in lateral amygdala show changes in firing to CS tone over the course of learning that parallels emergence of conditioned response
  - **Human Imaging studies** = increase activation in amygdala to CS after conditioning

Amygdala and Appetitive Conditioning (I)

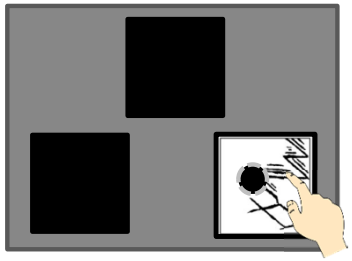
- The amygdala also regulates Pavlovian conditioning for rewarding stimuli
  - Conditioned response typically approach behaviour (e.g: **conditioned place preference**)
  - The "place" where reward was received becomes attractive → elicits approach towards those stimuli (*Pavlovian approach*)
- Lesions of the **lateral amygdala** disrupts conditioned place preference for all types of rewards (food, sex, drugs)
  - **Note:** amygdala lesions **do not** disrupt *consumption* of reward (food, sex, etc)
  - Only interferes with how **conditioned stimuli** linked with primary reward affect behaviour



Amygdala and Appetitive Conditioning (II)



Red ball, medodic tone +



Black ball, buzzer, NO reward

-Subjects conducted a "memory task" (find the red ball, not the black ball)

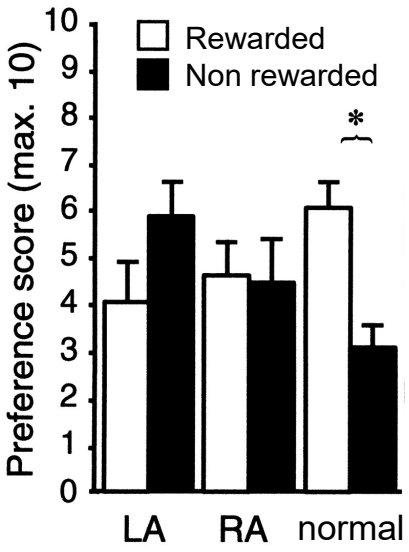
-Finding the **RED** ball = pleasant tone, **with distinct patterned background** and a food reward

-Black Ball = Buzzer, no reward, other pattern

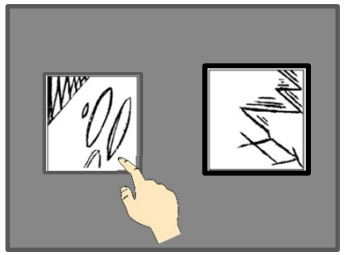
-***PREFERENCE TEST***: Subjects shown different patterns, including ones linked to "Red ball-reward" responses: asked to choose which pattern they prefer

-**Results:** healthy humans preferred pattern associated with reward

-Left or Right amygdala lesions (LA / RA):
➔ **NO PREFERENCE**



Preference Test



➢ -When controls asked "why do you prefer this one?": ➔ **no conscious association** with pattern & reward

e.g.: "looks like the sun", "reminds me of pizza", " is a little more complicated", "is symmetrical", "I liked the lines and curves", "was an interesting sort of pattern, caught my eye."

➢ **Reward-associated cues can control our behaviour, sometimes without us being aware**

Instrumental Conditioning (I)

- *Pavlovian Conditioning:* association of a neutral stimulus with a biologically-significant event (no control over what happens, organism can only react/prepare)

- **Instrumental Conditioning: (aka operant conditioning)**

  association with a particular action/motor response and its consequences (i.e.: reinforcement)

  → Here the organism can control what happens

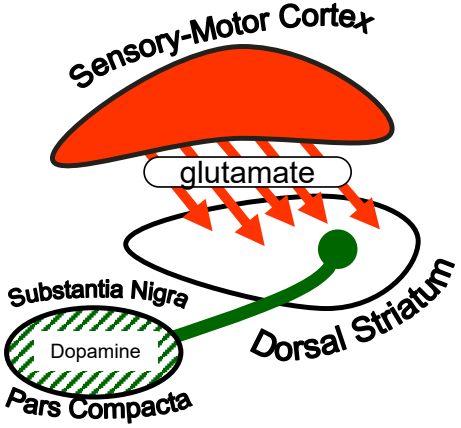
  – **Reinforcer**: something that increases or decreases likelihood of response occurring again

  – e.g.; Rat presses lever to obtain food, learning to ride a bike (skill learning).

Instrumental Conditioning (II)

- Regions of the **striatum** (part of a larger subcortical system called the **basal ganglia**) regulates action selection and instrumental conditioning

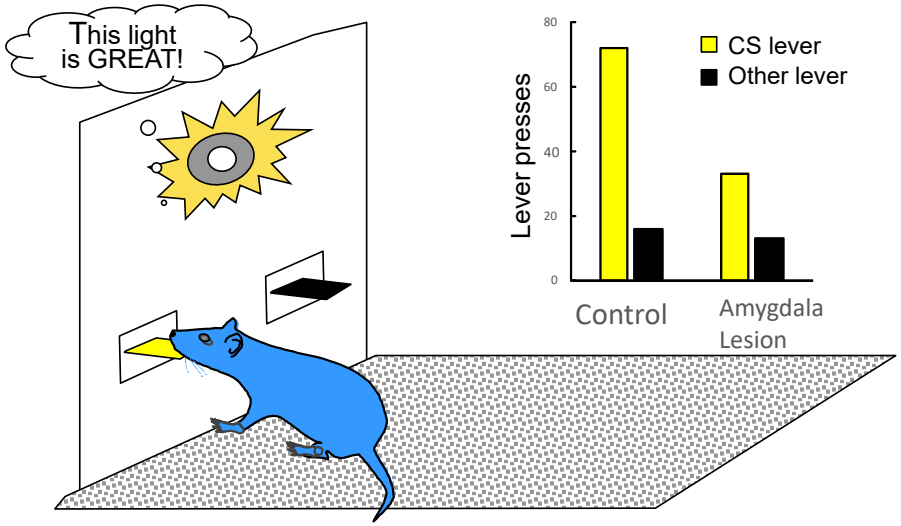
➢ Striatum receives converging inputs from sensory/motor cortex and dopamine system – both are activated when actions are reinforced to facilitate learning



➢ Instrumental learning goes through phases
  - Early in learning = goal-directed, responses are made to obtain a goal, sensitive to levels of motivation
  - Late in learning = responses become more automatic (habitual) → mediated by **dorsal striatum**
    - The transition from goal-directed to habitual actions is also mediated by the dorsal striatum

- The **amygdala** sends input to the striatum and can influence instrumental action

Amygdala and Appetitive Conditioning (III)



Conditioned Reinforcement:

-CS light comes on that predicts reward presentation (e.g.; food)

-After learning, levers are inserted to chamber

-One lever gives CS light that **was associated with food**, other gives nothing (***lever presses never*** deliver reward)

- Rats press lever **just for CS**, even though that ***never*** gives reward
  - Light becomes reinforcing, animals will work for it
- Lesions to **lateral amygdala disrupts preference for lever that produces the CS (no *conditioned* reinforcement)**
  - Yet, they consume reward normally, press levers for **food** normally,
- **Cues associated with reward can control our behaviour, even though we may be unaware of their control**