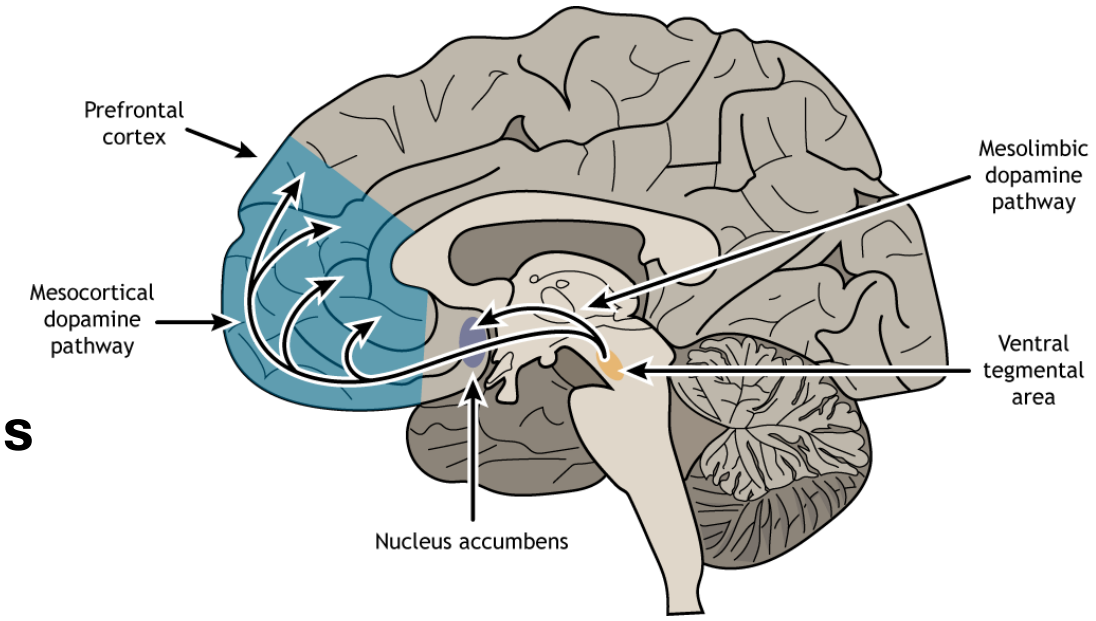
10/10/2024

# Action – Motivation, Expertise

# Motivated Behavior

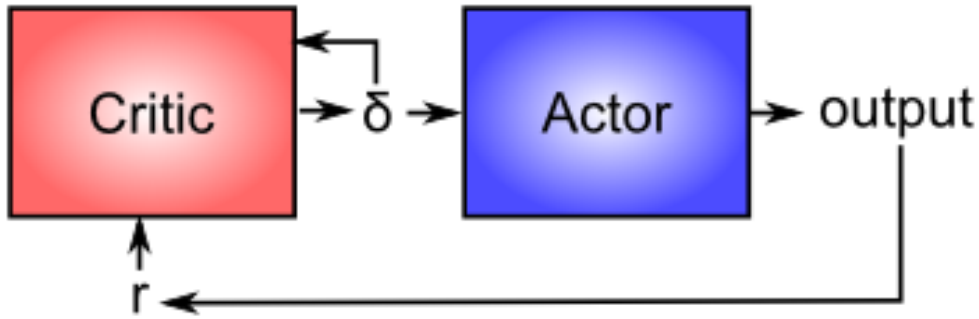
- **Drive states** generate motivated behaviors
  - Hunger, thirst, sleep, pain avoidance, thermoregulation, social, sexual, explore/exploit
- Maintaining **homeostasis** is the primary motivator
  - **Hypothalamus** and **brainstem** regulate signals around hunger, thirst, energy levels
- For more complex behavior, **reward systems** are needed to learn and reinforce behaviors
- **Mesolimbic/mesocortical dopamine pathway**
  - **Ventral tegmental area (VTA)** produces **dopamine**, connects to **nucleus accumbens** and **prefrontal cortex (PFC)**



# Dopamine is a motivation signal

- Dopaminergic neurons fire in response to **positive prediction error**, when the reward is greater than what was anticipated
- Once the reward matches expectations, the dopamine stops being released
- A **negative prediction error** – when the reward is less than what was anticipated – can cause a decrease in dopamine
- Prediction errors can strengthen or weaken the association to a cue in reinforcement learning
- This is why early learning can be so exciting and motivating, and then as you keep going it gets more boring – the rewards are based on prediction error. Once you stabilize the error, you stop getting positive prediction error!

# Actor-Critic Model




- A theory of reinforcement learning in which the **actor** (**basal ganglia**) selects actions, and the **critic** (**midbrain dopamine system**) estimates the value of the action
- The actor's role is to choose actions that maximize **expected rewards**, by continuously updating its model using **feedback** from the critic
- The critic evaluates the actor's actions by computing the difference (δ) between expected and actual reward value (r), providing a **learning signal**
- This method is widely used in AI deep learning, robotic control

# Addiction

- Drugs of abuse (cocaine, opioids) or behaviors (gambling, gaming, social media, porn) can hijack the mesolimbic pathway, causing excessive dopamine release in the nucleus accumbens
- The brain adapts to excessive dopamine by downregulating dopamine receptor availability, leading to tolerance and withdrawal
- Repeated drug use reduces sensitivity to natural rewards, making drug-seeking the primary motivational focus
- Long-term addiction impairs the PFC, weakening its ability in decision-making and impulse control
  - Reduced sensitivity to dopamine, disruption in glutamate
  - Structural and connectivity disruptions, weakened top-down control

# Hormonal Effects on Motivation

- **Cortisol** – "stress hormone"
  - Enhances dopamine in PFC during acute stress, boosting motivation and focus
  - Chronic stress can impair PFC functioning
- Ingestive behavior
  - **Ghrelin**: promotes food-seeking by activating reward pathways
  - **Leptin**: decreases food motivation by reducing dopamine reward circuits
- Risk-taking
  - **Testosterone**: increases risk-taking and status-seeking
  - **Estrogen**: enhances reward sensitivity, modulates risk-taking contextually
  - **Progesterone**: reduce risk-taking, goal-directed behavior, can modulate mood
- Social
  - **Oxytocin**: increases social-bonding, group contrast, by enhancing reward value of social interactions

# Motor Expertise

- Precise and efficient execution of complex movements
- Can see enlargement of motor areas relating to body parts associated with expertise (e.g., hands for pianists)
- **Neural efficiency hypothesis**: expertise makes the brain more efficient, reducing unnecessary activation and connection to non-essential brain regions
- **Motor programs**: automated repetitive sequences of actions that can be refined
- High-level expertise can also lead to rigidity – you get locked into the programs you refined, making you less adaptable!
- **Deliberate practice**: the key to developing expertise is quality of quantity in practice
  - Focus on specific goals, particular aspects of the practice
  - Engage in challenges that are just beyond the skill level (~85% success is near optimal)
  - Immediate feedback enhances learning circuits to make and encode adjustments
  - Engage with full intention, attention, in a structured, aimed way