A Task-Based Model of Uncertainty's Impact on Reinforcement Learning: A Focus on Socioeconomic Status

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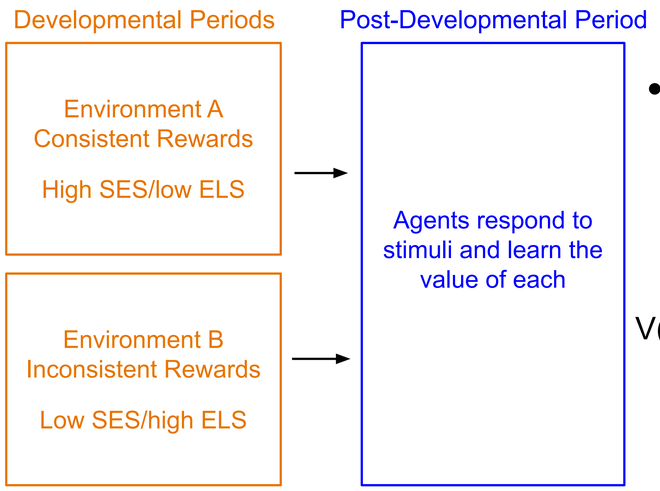
Background

- Aversive Life Circumstances - difficult or challenging events, experiences, or situations that occur in one's life.
- Adverse circumstances → **early life stress** (ELS) + neurostructural changes (Brietzke et al., 2010)
  - Emerging research points to reward-related neural circuitry
  - **ELS + aversive circumstances → blunted** activity in the ventral striatum (**reactivity** to **rewards** and **losses**) (Hanson et al., 2015)
- **Low socioeconomic-status** (SES) is widely considered synonymous with aversive life circumstances and ELS
  - Low-SES marked by **insecurity** and **uncertainty** of one's resources and, in some cases, survival (Marshall et al., 2023)
- Insecure access to necessary resources → **greater perceived salience** of rewards and losses?
- This reflects in the literature! In low-SES-focused samples:
  - **Greater** responsiveness to feedback in all measured brain regions (White et al., 2022)
  - **Heightened** neural sensitivity to the anticipation of loss (Gonzalez et al., 2016)
  - **Greater** activity in reward-related regions in anticipation of reward (Romens et al., 2015)

Critical gap in the ELS and aversive circumstance literature!

Current Study Design

- **Computational agents** in Python undergo one of two developmental periods
  - **Learning rates** are **optimized** in the agent's period of **rewards** & **losses**
- All agents then undergo a post-developmental period
  - They choose between two stimuli each trial (reward stimuli and loss stimuli)
  - Learning rates from developmental period applied in the post-developmental period



Rescorla-Wagner Model

- The following two equations were used to asses the agent's learning of reward value

$$\Delta V(CS)_t = \eta(R - V(CS)_t)$$

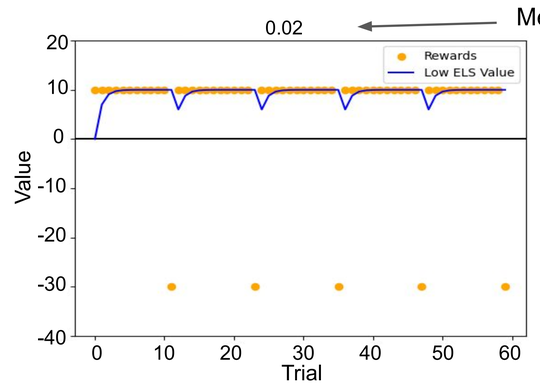
(Prediction Error)

$$V(CS)_{t+1} = V(CS)_t + \Delta V(CS)_t$$

η = Learning Rate
R = Reward
V = Value
CS = Conditioned Stimuli

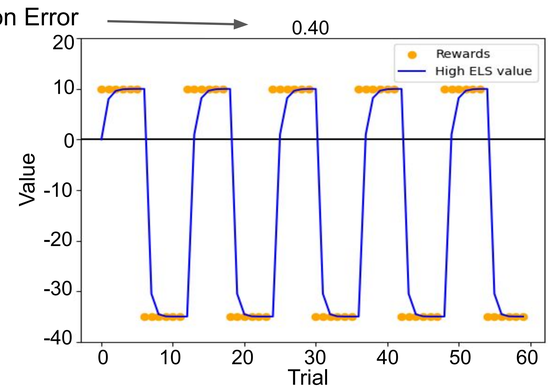
Developmental Period

Low Early Life Stress



- Relatively consistent rewards
- Value remains high despite occasional loss
- Reward Learning Rate: 0.7
- Loss Learning Rate: 0.1

High Early Life Stress

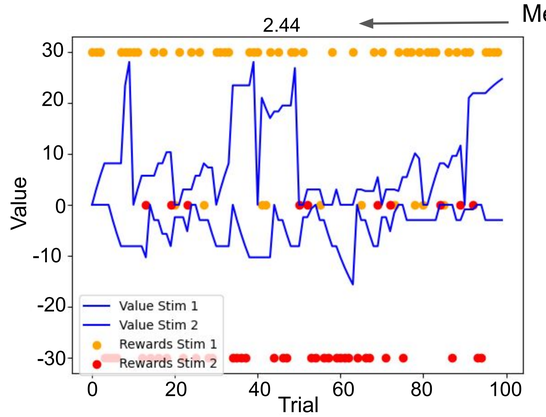


- Long periods of rewards and losses
- Greater value range
- Reward Learning Rate: 0.8
- Loss Learning Rate: 0.9

Post-Developmental Period

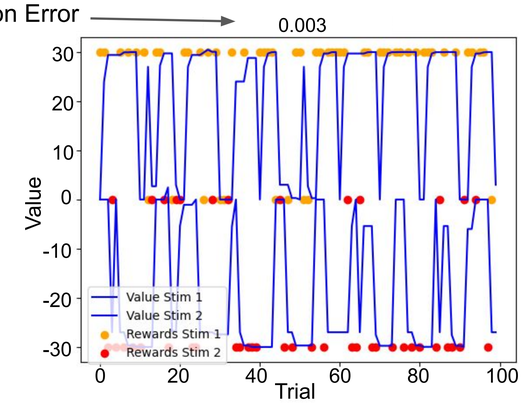
Over several trials, how well can the agent learn the value of each stimuli with their respective learning rates?

Low Early Life Stress



- Losses are not predicted as accurately

High Early Life Stress



- More accurate prediction of both losses and rewards

Implications

- Simulation can be used to assess early life stressors and later life reward and loss sensitivity
- Development in an uncertain environment → Greater salience to rewards and losses
- **Low SES & High ELS → Greater perceived salience to rewards and losses**
- Future Research: Uncertainty reflected in neuroimaging? Qualitative implications?

Citations and Other Readings! →