## Project Proposal

**Behavioral Research: Statistical Methods**

# Reinforcement Learning Shapes Memory Specificity across Lifespan


**TEAM REWARD**

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## 0.1 Overview: Initial Topic Selection

The study explores the connection between learning, decision-making, and memory across different life stages—children, adolescents, and adults. We aim to understand how individuals adjust mental representations during value-based learning for effective decision-making. Using reinforcement learning experiments, we examine how learned representation specificity influences subsequent memory.

## 0.2 Dataset

- The dataset used in this study originates from the conducted reinforcement learning experiments.
- Comprises behavioral data collected from participants of different age groups through two experiments (N = 224)
- It comprises raw behavioral data, subject data, and memory performance metrics. The dataset can be accessed here.

### 0.2.1 Tables

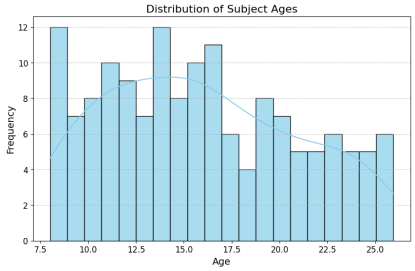
The datasets consisted of four main tables:

1. **Subject Ages**: This table contained information about the participants, including their subject IDs and ages. Each row represented a unique participant.
2. **Learning Data**: This table contained data from the reinforcement-learning task, including participants' approach/avoid decisions, reaction times, and points earned or lost. Each row represented a trial within the task.
3. **RL Data**: This table contained additional data from the reinforcement-learning task, such as stimulus categories, block conditions (e.g., category-predictive, exemplar-predictive), and trial information. Each row represented a trial within the task.
4. **Memory Data**: This table contained data from the memory task, including participants' memory accuracy, response times, and confidence ratings. Each row represented a trial within the memory task.

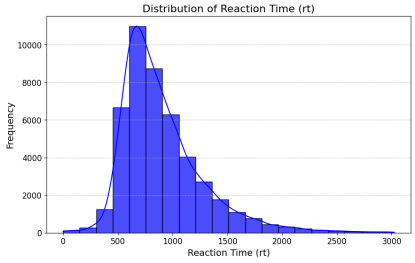
## 0.3 Exploratory Data Analysis (In Progress)

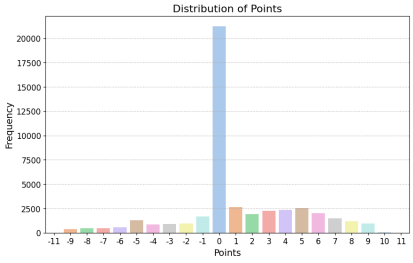
By applying exploratory data analysis techniques, we were able to identify patterns and trends in the data, leading to the formulation of specific hypotheses about the relationship between reward structures and memory.

### 0.3.1 Subject Data

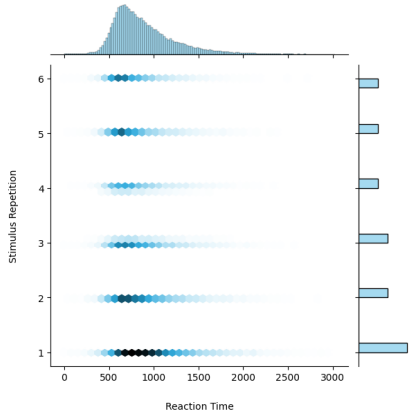


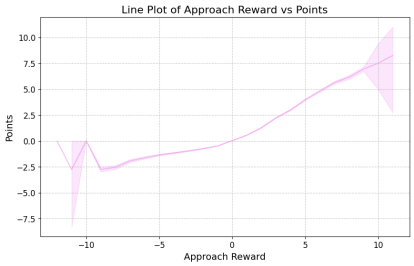

### 0.3.2 Learning Data



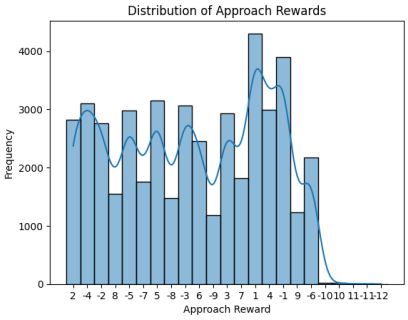




Hexbin Plot of Reaction Time vs Stimulus Repetition

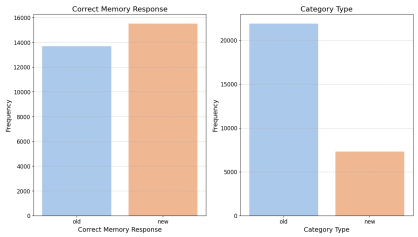


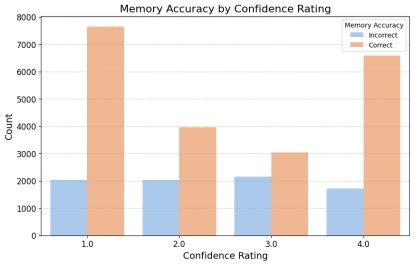



### 0.3.3 RL Data




### 0.3.4 Memory Data




## 0.4 Objectives: Description of what we intend to study

- Study the dynamic relationship between learning, decision-making, and memory across different life stages.
- Characterize how individuals of different age groups adapt the specificity of their representations during value-guided learning.
- Explore how the specificity of these learned representations impacts subsequent memory by manipulating reward structures in two experiments.
- Address developmental questions about adaptive behavior and its significance for memory formation, providing valuable insights into the complex relationship between experience, cognition, and memory throughout life.

## 0.5 Proposed Hypotheses: What the Data Analysis Is Expected to Teach Us?

### 0.5.1 Specificity in Learning Flexibility

Participants of all ages will adapt the specificity of their information representation during value-guided learning. This adaptation towards more specific representations will increase with age.

- **H0**: There is no significant relationship between age and the adaptation towards more specific representations.
- **H1**: Adaptation towards more specific representations increases with age.

### 0.5.2 Influence of Specificity on Memory

The specificity of stimuli used during value-based choice will influence the specificity of information representation in memory. Specific memory for information encountered in contexts where detailed information was crucial for decision-making.

- **H0**: The specificity of stimuli used does not influence the specificity of information representation in memory.
- **H2**: The specificity of stimuli used influences the specificity of information representation in memory.

### 0.5.3 Individual and Developmental Differences

Individual differences in the specificity of learning computations will be reflected in subsequent memory. People who prioritize detailed information during learning will show corresponding enhancements in memory specificity.

- **H0**: Individual differences in the specificity of learning computations will not be reflected in subsequent memory representation.
- **H3**: Individual differences in the specificity of learning computations will be reflected in subsequent memory representation.

### 0.5.4 Strengthening Influence with Age

The influence of learning on memory will strengthen across development. Adults will demonstrate a tighter coupling between the specificity of their learning computations and subsequent memory representations compared to children and adolescents.

- **H0**: The influence of learning on memory will not strengthen across development.

- **H4**: The influence of learning on memory will strengthen across development.

## 0.6 Data Analysis Plan: How the Analysis Will Be Performed?

### 0.6.1 Hypothesis 1: Specificity in Learning Flexibility

- Conduct descriptive statistics to analyze the distribution of responses across age groups.
- Two-sample Test: To compare means of continuous variables between different age groups.
- Effect Size (Cohen's d): To quantify the magnitude of differences between age groups

### 0.6.2 Hypothesis 2: Influence of Specificity on Memory

- Compute memory specificity scores based on the proportion of correctly recognized stimuli and confidence ratings.
- Pearson correlation coefficient to assess the relationship between memory specificity and specificity in decision-making.
- Bonferroni Correction: To correct for multiple comparisons when analyzing correlations.

### 0.6.3 Hypothesis 3: Individual and Developmental Differences

- Compare memory specificity scores across individuals with varying preferences using Independent samples t-test
- Mann-Whitney U Test: To compare memory specificity scores between individuals with different learning preferences.

### 0.6.4 Hypothesis 4: Strengthening Influence with Age

- Pearson Correlation: To examine the relationship between age and the specificity of learning computations on memory specificity.
- Bootstrapping or Permutation Test: To test whether age moderates the relationship between learning specificity and memory specificity.