Reliability of a Reinforcement-Learning Task Battery for Computational Phenotyping of Decision-Making in Adolescent Psychopathology

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Introduction

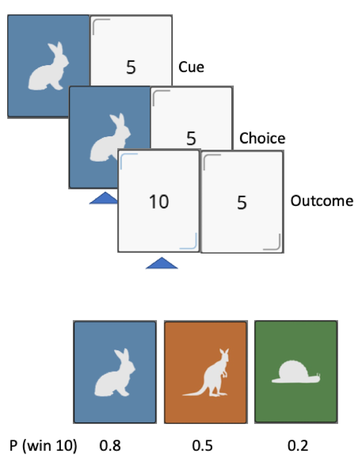
- Psychiatric disorders like depression, anxiety, OCD, and ADHD often first appear during childhood and adolescence[1].
- These disorders are often associated with maladaptive learning and decision-making processes, although the specific computations that contribute to vulnerability remain unclear.
- Our study seeks to characterize the developmental changes in decision-making phenotypes and their relationship to transdiagnostic psychiatric symptoms.
- The reliability of a measure dictates the highest possible correlation that can be observed between it and another measure, such as symptom scores[2].
- We have evaluated the test-retest reliability of three reinforcement-learning tasks in a developmental sample.
- These tasks enable the computational characterization of decision-making across five dimensions: model-free vs. model-based control, Pavlovian vs. instrumental learning, positive vs. negative outcome weighting, action/ inaction biases, and exploration.

Methods

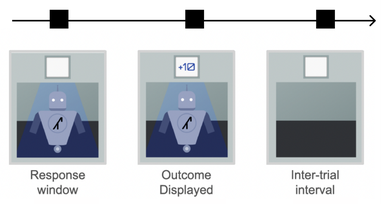
- 159 participants ages 10-25 completed the three tasks with a two weeks gap.
- We have modified the tasks to be gamified and added prerecorded audio instructions and practice block to improve engagement and reduce confusion
- In each task, participants' choice data was fitted by hierarchical reinforcement learning (RL) models where parameters were pooled both within- and across-participants[3]
- Test-retest reliability was calculated as the Pearson correlation between model parameters estimated from the two sessions.

Reinforcement Learning Tasks

A. Double-or-Nothing task



B. Pavlovian Go/No-Go Task



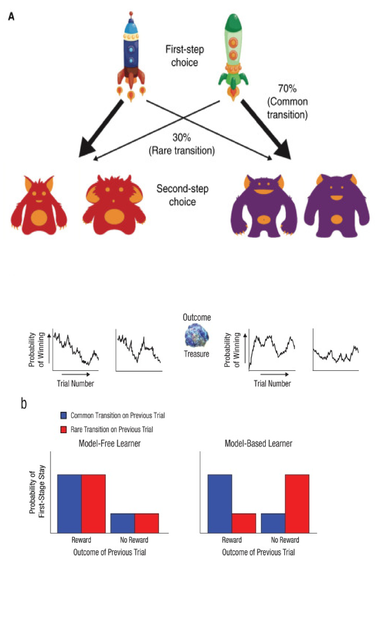
Outcome Domain

		Gain		Loss
Correct Response	+10	80%	0	80%
	0	20%	-10	20%
Incorrect Response	0	80%	-10	80%
	+10	20%	0	20%

Correct Response

	Gain	Loss
Go	Go to Win (GW)	Go to Avoid Losing (GAL)
No-Go	No-go to Win (NGW)	No-go to Avoid Losing (NGAL)

C. Two Step Task



Computational Models

A. Double-or-Nothing task

(1) $p(y = a_1) = \text{logit}^{-1}\left(\beta \cdot [Q(s, a_1) - Q(s, a_2)]\right)$

(2) $Q(s, a) \leftarrow \eta \cdot \delta$

(3) $\delta = r - Q(s, a)$

(4) $Q_k \leftarrow \begin{cases} \eta_+ \cdot \delta & \text{if } \delta > 0 \\ \eta_- \cdot \delta & \text{if } \delta < 0 \end{cases}$

B. Pavlovian Go/No-Go Task

(1) $p(y = \text{go}) = (1 - \xi) \cdot \text{logit}^{-1}\left(\beta_{v_k} \cdot [Q_k(\text{Go}) - Q_k(\text{NoGo})] + \tau_{v_k}\right) + \frac{\xi}{2}$

(2) $_k(\text{action}) \leftarrow \eta_{v_k} \cdot [r - Q_k(\text{action})]$

C. Two Step Task

(1)

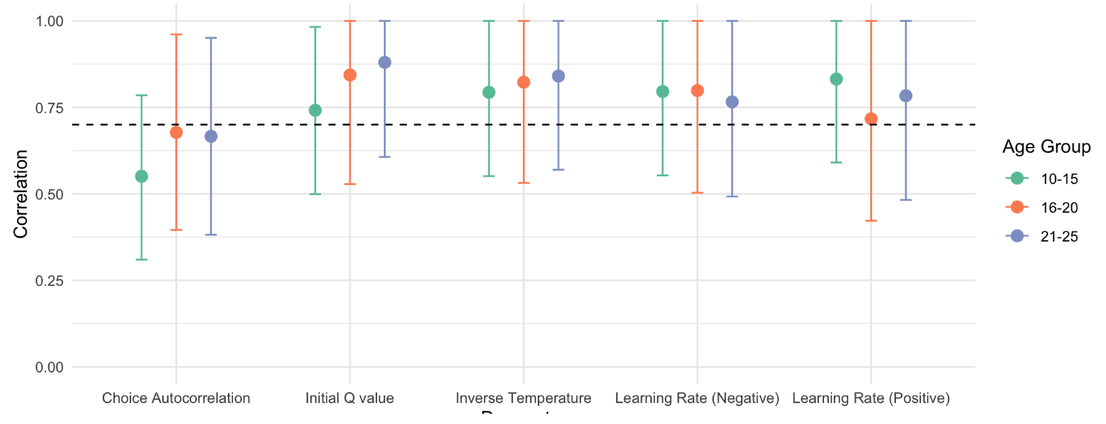
(2) $Q_{MF}(s_{1,t}, a_{1,t}) = Q_{MF}(s_{1,t}, a_{1,t}) + \alpha\lambda\delta_{2,t}$

(3)

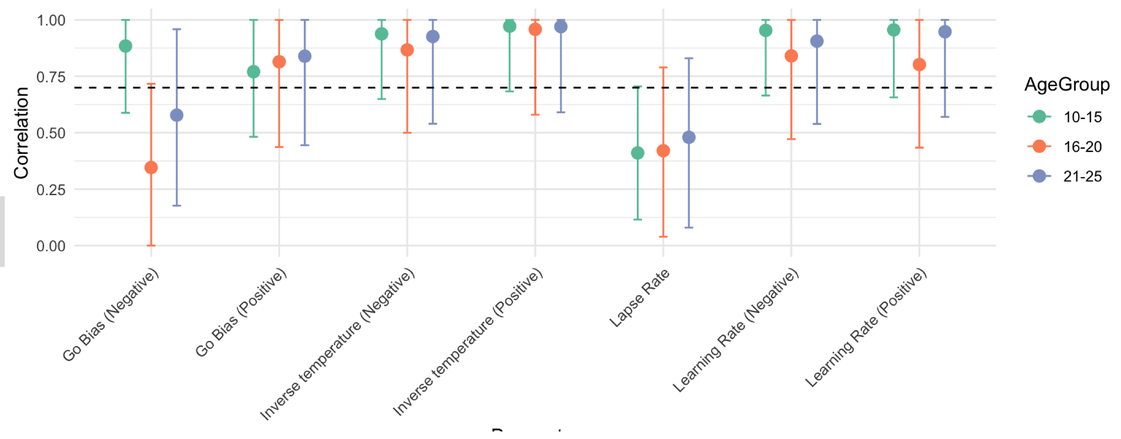
(4) $P(a_{i,t} = a|s_{i,t}) = \frac{\exp[\beta_{MF} * Q_{MF}(s_{i,t}, a) + \beta_{MB} * Q_{MB}(s_{i,t}, a) + p * \text{rep}(a)]}{\sum_{a'} \exp[\beta_{MF} * Q_{MF}(s_{i,t}, a') + \beta_{MB} * Q_{MB}(s_{i,t}, a') + p * \text{rep}(a')]}$

Test-Retest Reliability

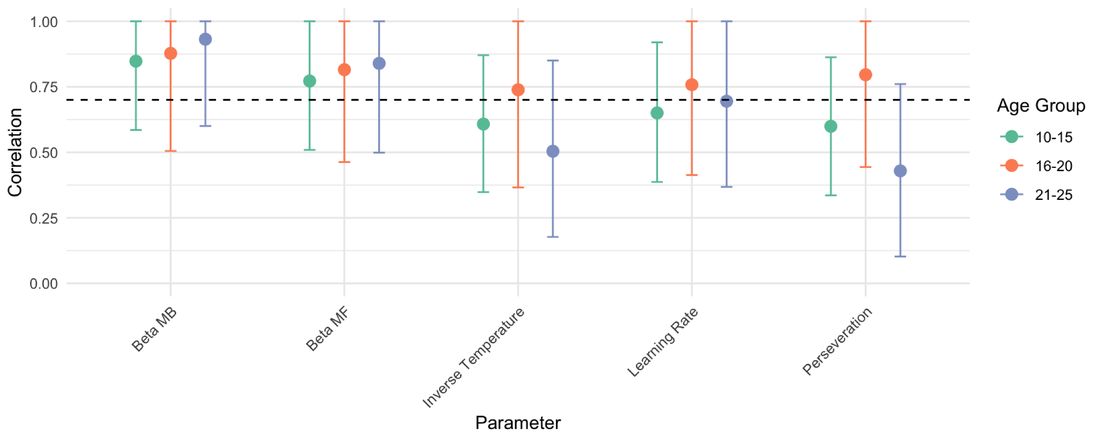
A. Double-or-Nothing task



B. Pavlovian Go/No-Go Task



C. Two Step Task



Discussion and Future Directions

- Across tasks, test-retest is improved relative to older task variants[4,5]
- Reliability is comparable across age groups
- Next, we will analyze this task using a joint modeling approuch
- The corespondent between parameter estimations and psychiatric symptomatology will be tested

Funding

This work was supported by an Israel-USA CRCNS grant from the National Institute of Mental Health (Grant No. R01MH125564) and the Binational Science Foundation (BSF grant no. 2019801)

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