Exploring the steps of learning: Computational modeling of initiatory-actions among individuals with Attention-Deficit/Hyperactivity Disorder

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BACKGROUND

Individuals with ADHD are known to show difficulties in completing everyday tasks. This work examines the value-based mechanism that might underlay ADHDs' difficulty to complete a series of actions required to achieve a goal

METHODS

In a clinical study 54 (28 ADHD, 26 HC) participants performed a sequential decision task (Figure 1). Clinical diagnosis was confirmed using a dedicated interview (DIVA-5)[1]. Each trial participants were asked to make three actions in order to gain reward ("find the dog").

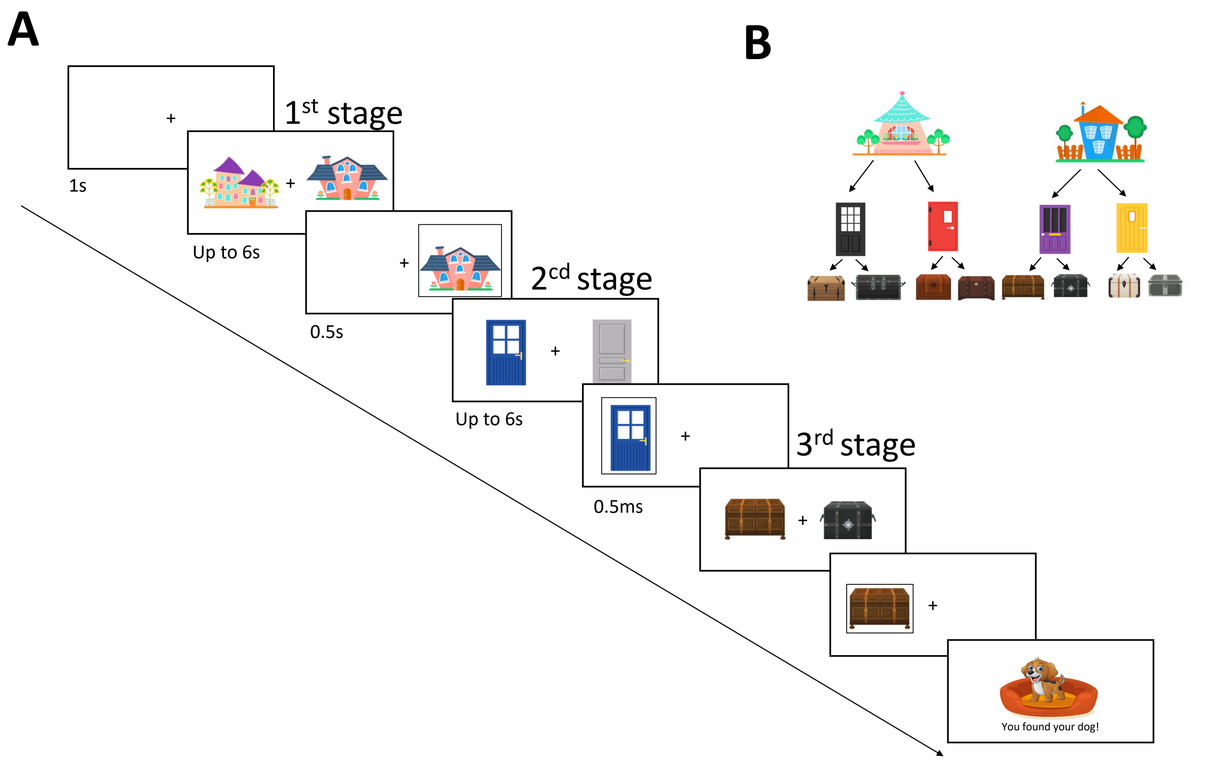

Figure 1. Sequential decision task. (A) Trial sequence where individuals made three choices to gain reward (finding a hiding dog). (B) State-action transition structure.

RESULTS

Accuracy rates. Hierarchical Bayesians regression showed a Group (HC or ADHD) x Stage (I, II or III) interaction for choice-accuracy (0 vs 1) showing group differences at the 1st and 2nd stage, but not the 3rd (Figure 2A).

Reaction time variability. Similar regression showed a Group (HC or ADHD) x Stage (I, II or III) interaction on reaction-time variability (RTV) estimates (tau parameter in an ex-Gaussian distribution). We found RTV group differences at the 1st and 2nd stage, but not the 3rd (Figure 2B).

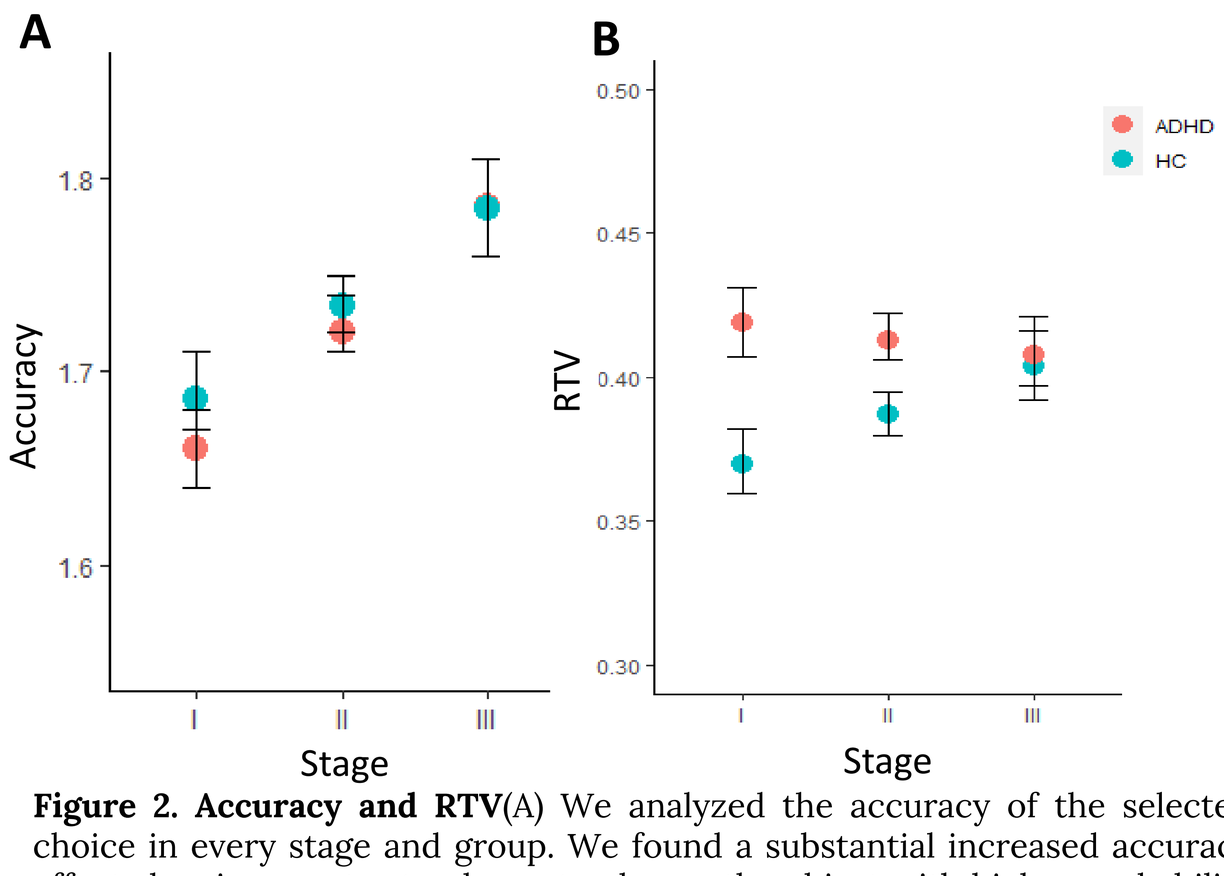

Figure 2. Accuracy and RTV(A) We analyzed the accuracy of the selected choice in every stage and group. We found a substantial increased accuracy effect showing greater tendency to choose the object with higher probability to reward where the stage is closer to feedback (stage 3). (B) We analyzed the reaction time variability in every stage and group. We found a substantial decrease in reaction time differences between the HC and ADHD groups where the stage is closer to feedback (stage 3).

Credit-assignment updating. We estimated the latent process of credit assignment to initiatory-actions in action-outcome sequences using the eligibility-trace model[2] (Figure 3A). Using simulated data of the eligibility-trace model, we showed it is recoverable, so that we were able to extract and recover the predefined latent parameters (Figure 3B). In addition, we used the model to estimate the participants' credit assignment updating process (Figure 3C).

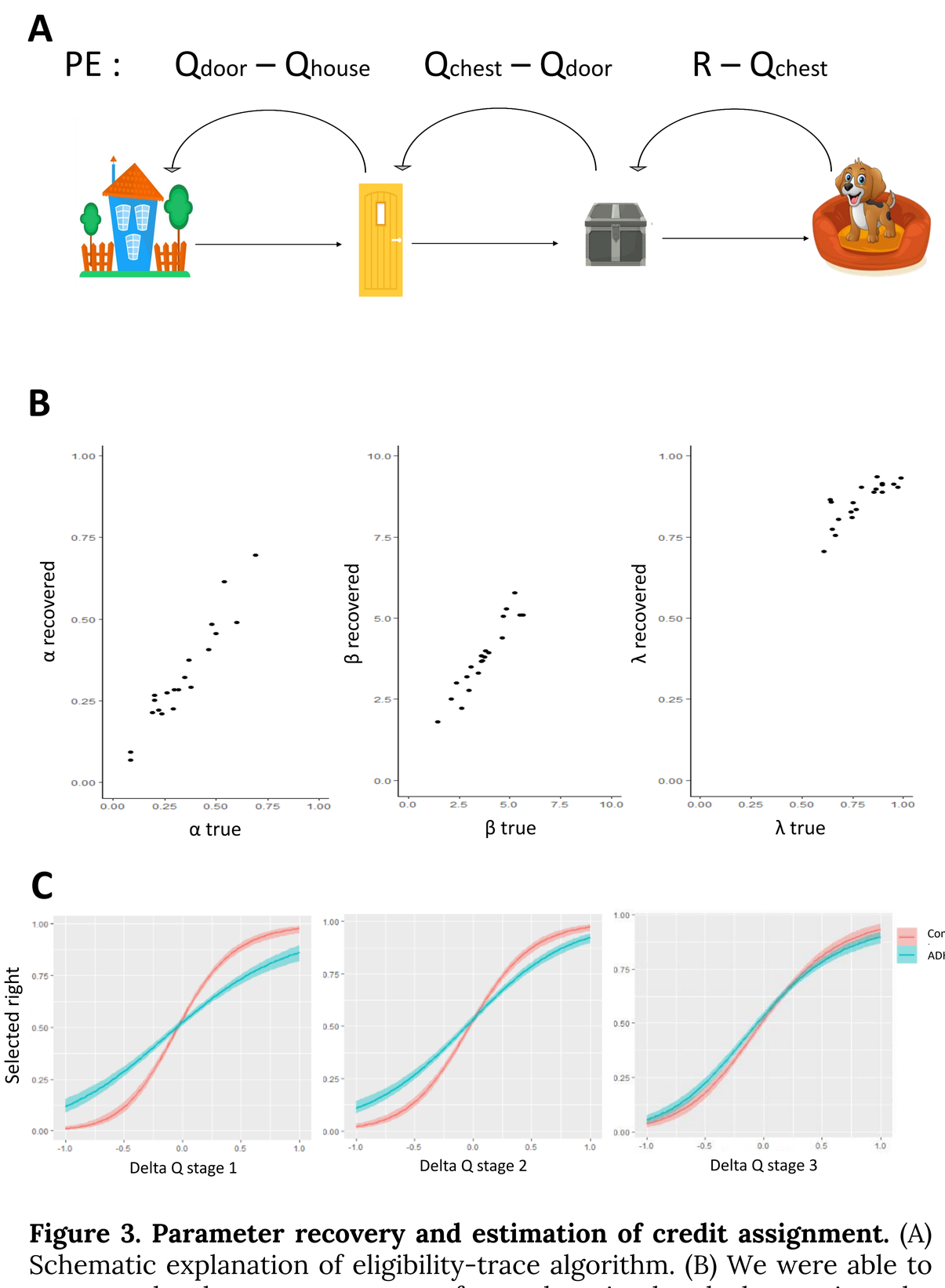

Figure 3. Parameter recovery and estimation of credit assignment. (A) Schematic explanation of eligibility-trace algorithm. (B) We were able to recover the latent parameters from the simulated data using the eligibility-trace model. The correlations between true and recovered parameters are: alpha r=0.96, beta r=0.95, lambda r=0.82. (C.) We were able to estimate the credit assignment values for stage and group using the eligibility-trace model and found lower value updating in the ADHD group vs. HC group on the first and second stage but not on the third stage.

DISCUSSION

We estimated the credit assignment process among individuals with and without ADHD. In addition, we used state-of-the-art reinforcement learning methods in order to simulate similar data and estimate value updating. Further research is needed to disentangle the involvement and influence of value updating process with initiatory-actions credit-assignment among different clinical groups.

References

1. Kooij J. J. S., Francken M. H., Bron T. I., McCarthy J., Perera B. D. Diagnostic Interview for ADHD in Adults With Intellectual Disability (DIVA-5-ID) *Journal of Mental Health Research in Intellectual Disabilities*. 2017;10(1):64–65. doi: 10.1080/19315864.2017.1368259.
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