Computational Clinical Psychology Lab

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Attenuated sensitivity to action-values explains inconsistent behavior in ADHD in outcome-distant states

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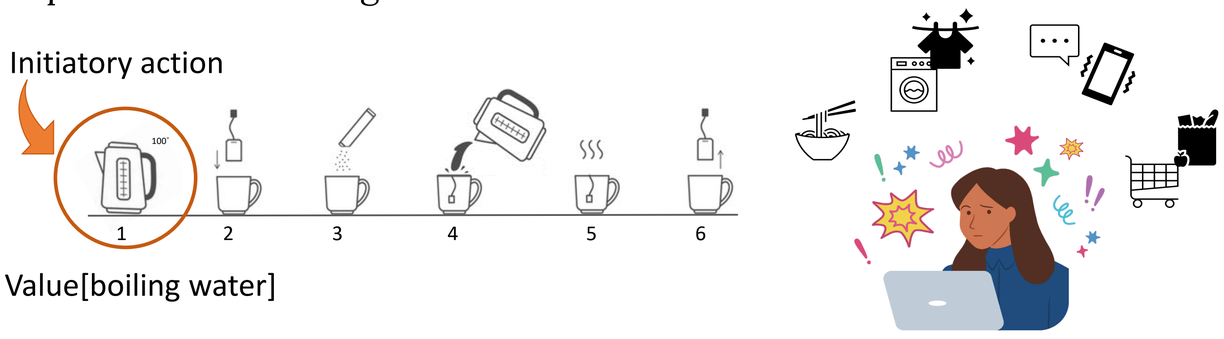
BACKGROUND

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.



METHOD

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 puppy").

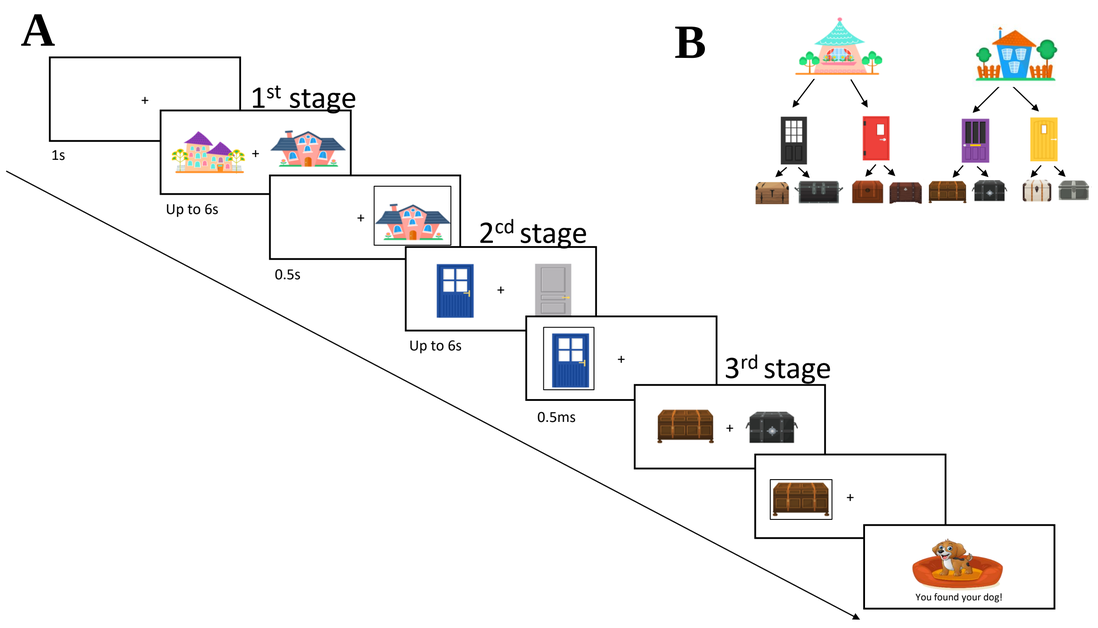


Figure 1. Sequential decision task. (A) Trial sequence where individuals made three choices to gain reward (finding a hiding puppy). (B) State-action transition structure.

RESULTS

Accuracy rates. Hierarchical Bayesians regression of Group (HC or ADHD) X Stage (I, II or III) X expected-value differences (defined as the delta between the maximal expected values of every two presented choices, i.e., |ΔEV|) showed a substantial group difference for Stage I X |ΔEV| that disappears on Stage II on Stage III (Figure 2A).

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

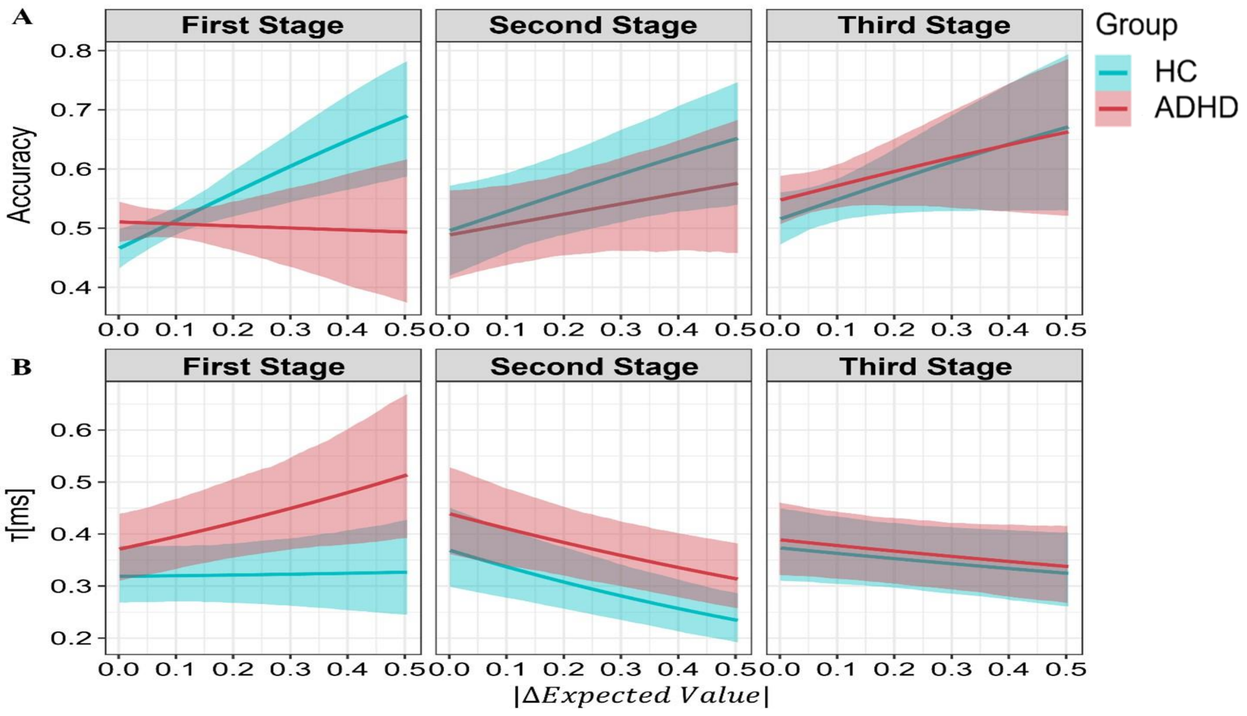


Figure 2. Accuracy and RTV.

Computational modeling and estimation of internal action value. Here, we sought to estimate the internal action value in action-outcome sequences using the eligibility-trace model (Figure 3A)..

First, using simulated data of the eligibility-trace model[2], we showed it is recoverable, so that we were able to extract and recover the predefined latent parameters (Figure 3B). Next, we fitted the eligibility-trace model to the behavioral data to estimate the participants' internal action value.

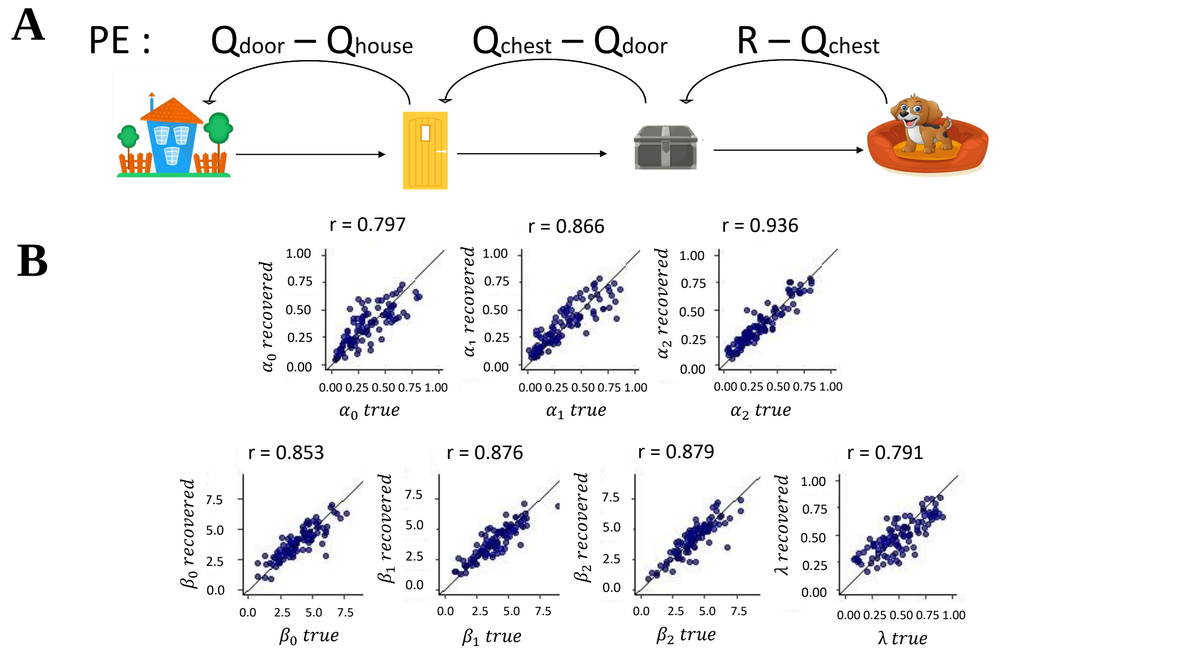


Figure 3. Eligibility-trace model and parameter recovery.

Estimating choice accuracy and RTV according to internal action values. Two analysis (logistic regression and Ex-Gaussian) of absolute difference in internal action value (i.e., |ΔQ|), Group (HC or ADHD) and their paired interaction as predictors for internal choice accuracy or the tau parameter in an ex-Gaussian distribution showed a substantial group x difference in internal action value interaction for Stage I but not for Stage II nor Stage III (Figure 4).

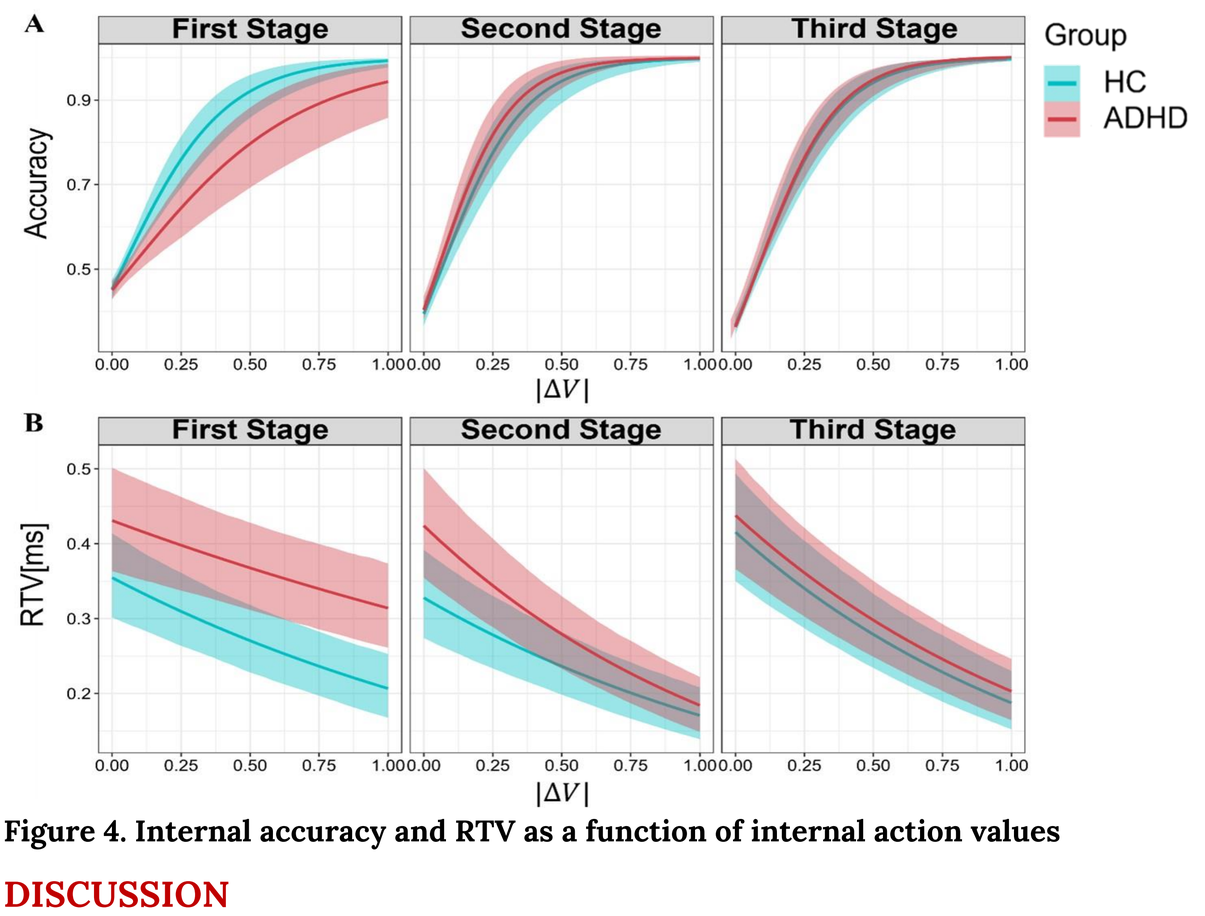
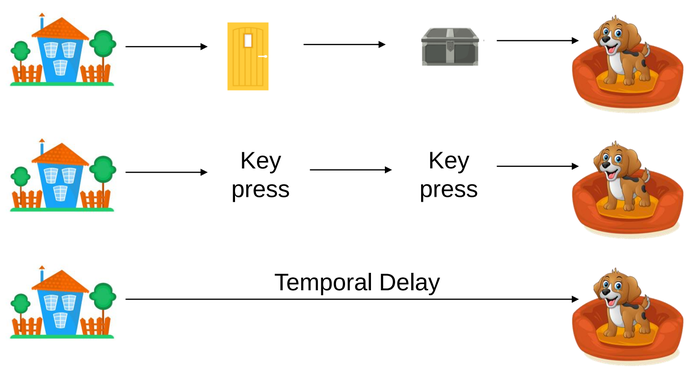


Figure 4. Internal accuracy and RTV as a function of internal action values

DISCUSSION

In the present study, we demonstrated an ADHD deficit to act upon action-outcome associations across different stages of a sequential reinforcement learning task. This experimental design allowed us to explore the value-based mechanism underlying inconsistent behavior of actions coupled with outcome-distance, as well as to examine the extent to which internal action-values and outcome proximity moderate such inconsistent behavior.



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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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