



Higher Risk Taking in Individuals with Methamphetamine Use Disorder during the Balloon Analogue Risk Task: Evidence from Computational Modeling

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INTRODUCTION

Methamphetamine use has caused considerable economic, social, and disease burdens to society. Previous studies have demonstrated that methamphetamine use results in extensive neural damage, which is associated with cognitive impairments, high impulsivity, and poor psychological well-being.



Risky decision making is one of the cognitive domains in which drug users are commonly impaired, and impairments in decision-making abilities are considered to contribute the development and maintenance of drug-use disorders.

Few studies have investigated the underlying mechanism of risk preferences among individuals with methamphetamine use disorder (MUD) with computational approach. We conducted two experiments by using the Balloon Analogue Risk Task (BART) (Lejuez, et al., 2002) with and without methamphetamine-related pictures and the method of computational modeling.

METHODS

Participants

Experiment 1	MUD <i>n</i> = 63 males	HC <i>n</i> = 33 males	<i>t</i>	<i>p</i>
Age (years)	35.65 ± 8.09	36.52 ± 12.39	-0.36	.719
Education (years)	9.03 ± 2.97	10.18 ± 3.05	-1.79	.077
Duration of current abstinence (months)	7.83 ± 6.13	NA		
Duration of methamphetamine use before abstinence (years)	7.63 ± 4.42	NA		
Dosage of methamphetamine use before abstinence (g/month)	14.91 ± 13.59	NA		
Experiment 2	MUD <i>n</i> = 63 males	HC <i>n</i> = 31 males	<i>t</i>	<i>p</i>
Age (years)	35.84 ± 7.30	36.94 ± 12.04	-0.47	.644
Education (years)	9.40 ± 3.16	9.65 ± 2.67	-0.36	.716
Duration of current abstinence (months)	7.37 ± 5.43	NA		
Duration of methamphetamine use before abstinence (years)	7.84 ± 4.65	NA		
Dosage of methamphetamine use before abstinence (g/month)	12.08 ± 12.83	NA		

Craving measures

- A 5-minute video of methamphetamine use was displayed to evaluate the subjective craving of individuals with MUD
- Individuals with MUD rated their craving using a visual analog scale 5-minute video of methamphetamine use
0 = not at all, 100 = very likely to use

METHODS

BART

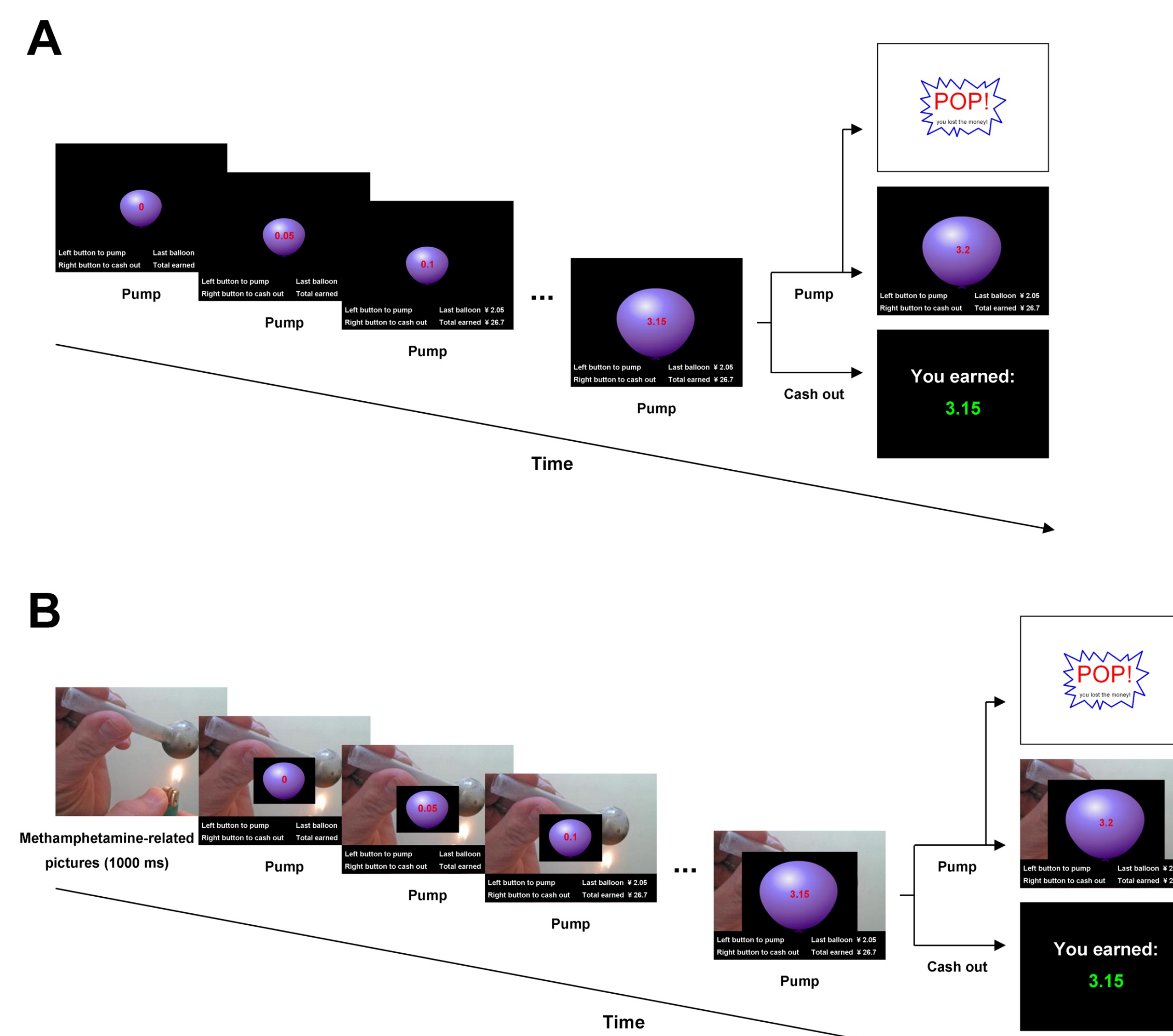


Figure 1. (A) Schematic of BART in Experiment 1. Participants clicked the left mouse button to inflate the balloon. Every successful pump added ¥0.05 to their temporary bank for that balloon. If the balloon exploded before participants cashed out then nothing was won on that trial. If participants clicked the right mouse button to cash out and they retained the earnings accumulated; (B) Schematic of BART in Experiment 2.

Computational modeling

hBayesDM: *bart_4par* (Ahn, Haines & Zhang, 2017)

- 4 parameters
- ϕ : prior belief of balloon not bursting
- η : updating coefficient
- γ : risk-taking propensity
- τ : inverse temperature

RESULTS

Adjusted pumps

- The average number of pumps on unexploded balloons across all trials

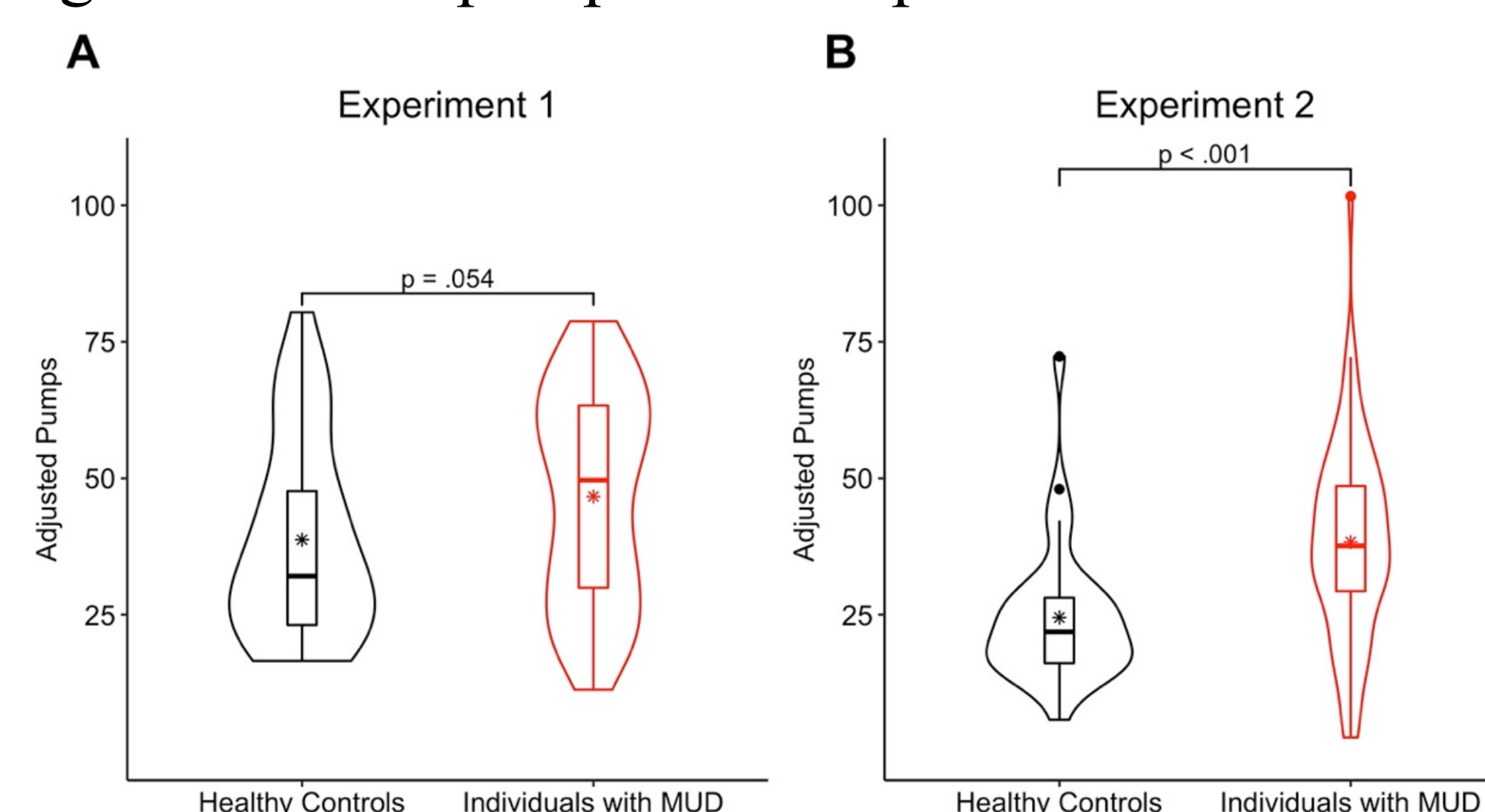


Figure 2. Violin-box plots showing the results of adjusted pumps. The violin-shaped surrounding of the box plot represents the estimated probability density function of the data. Asterisks denote means.

Model validation

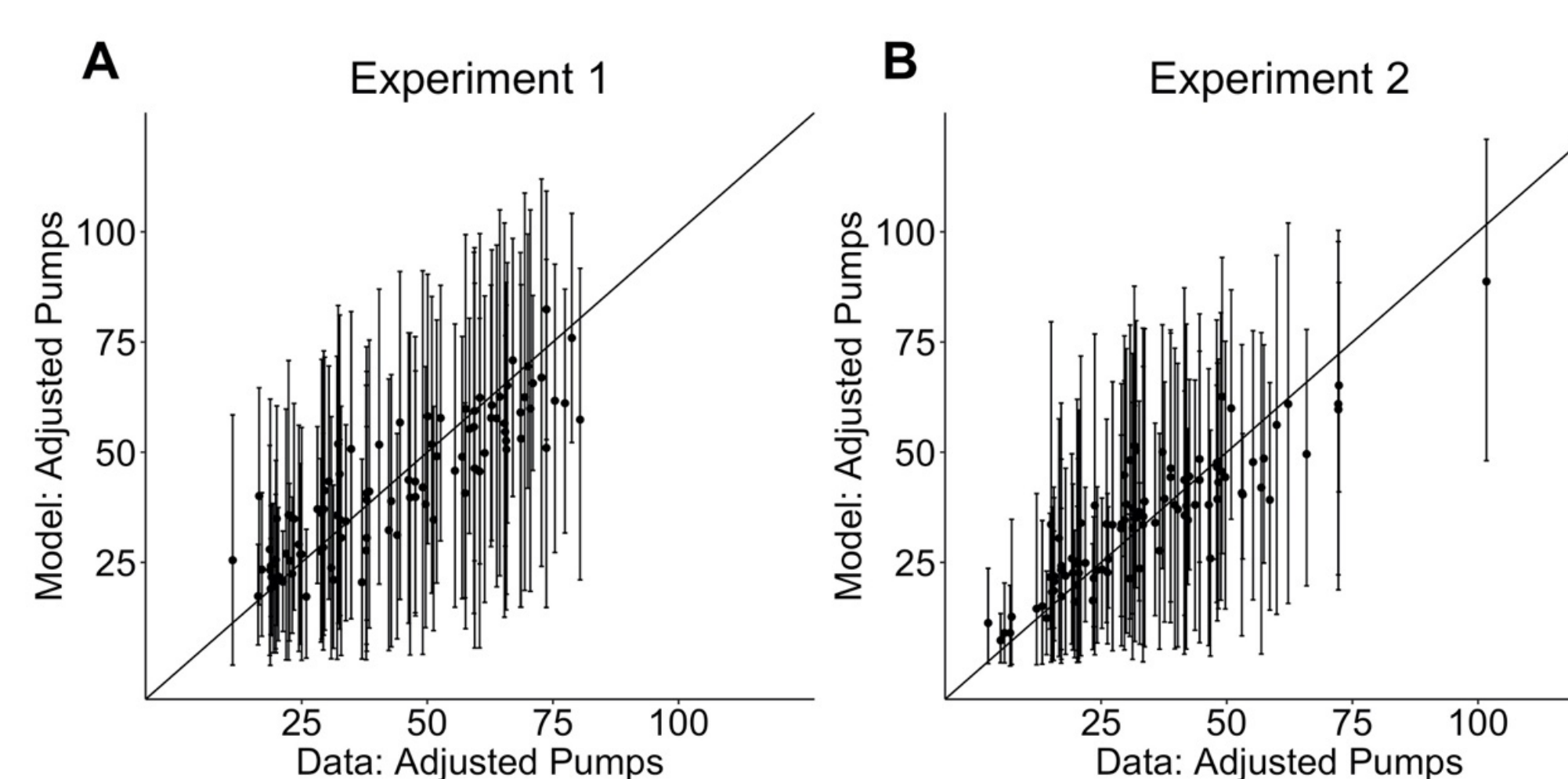


Figure 3. Model validation with posterior predictive check (PPC). Individual's model prediction compared with actual data, in relation to the identity line. Error bars depict the 95% HDI of the posterior distribution.

RESULTS

Computational modeling: Group comparison

Bayesian method - 95% Highest density interval (HDI)

- Experiment 1: No significant difference
- Experiment 2: γ was larger in individuals with MUD than in healthy controls (95% HDI: [0.0797, 0.4014])

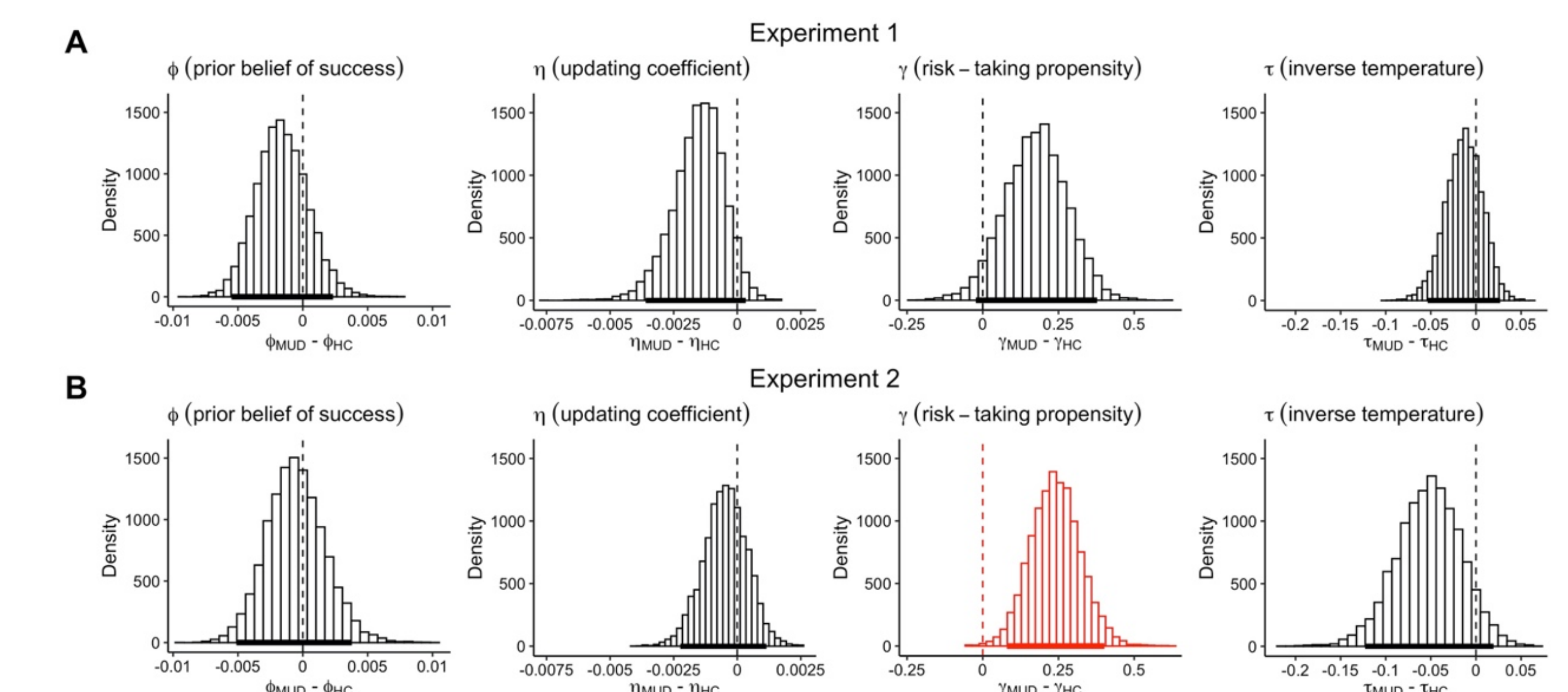


Figure 4. Posterior distributions of differences of group mean parameters between individuals with MUD and healthy controls. The black and red line indicates the 95% HDI. If the 95% HDI did not overlap zero, the effect was considered significant. MUD, individuals with MUD; HC, healthy controls.

Correlation analysis

- Experiment 1: No significant correlation
- Experiment 2: Subjective craving was positively correlated with η ($r = 0.38$, $p = .002$) and γ ($r = 0.27$, $p = .036$)

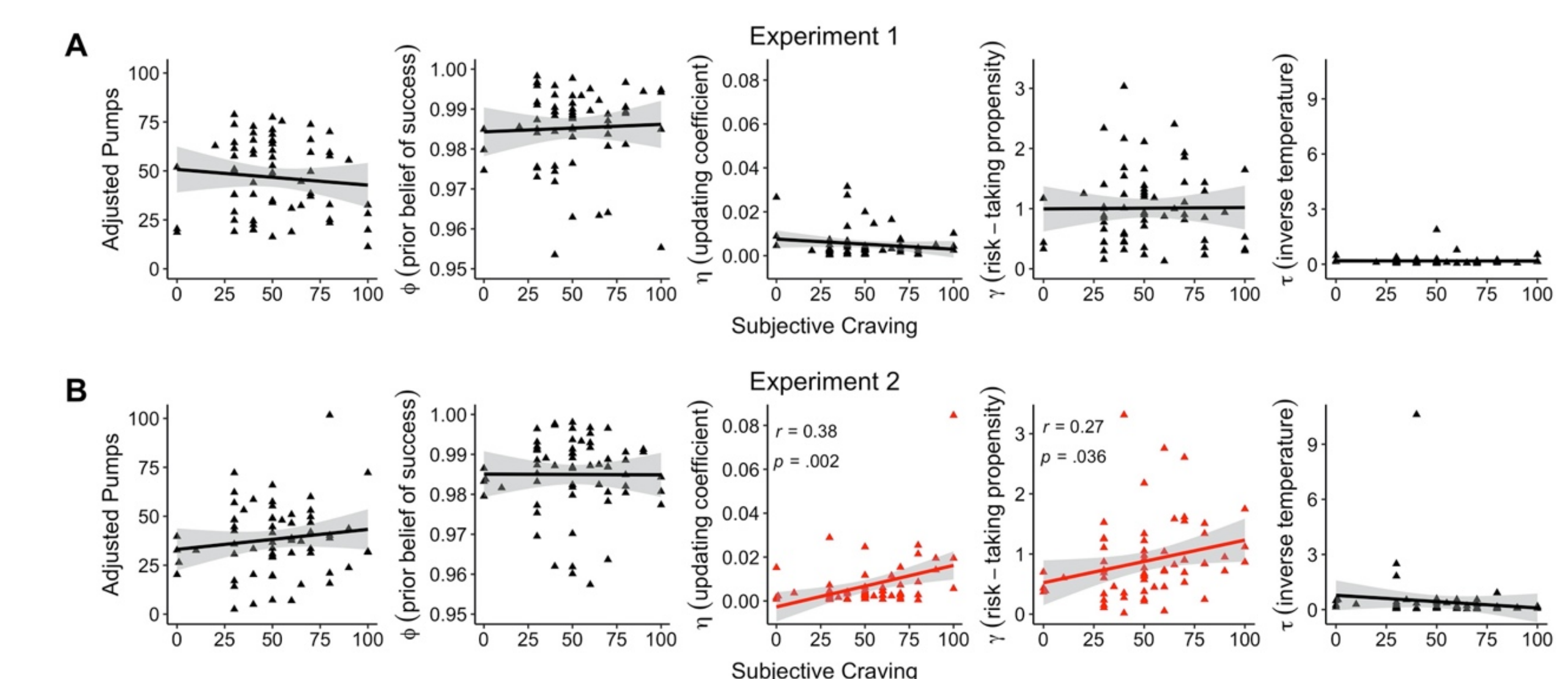


Figure 5. The correlation between subjective craving and adjusted pumps, ϕ , η , γ and τ in individuals with MUD

CONCLUSION AND DISCUSSION

- Individuals with MUD displayed higher risk preferences than healthy controls. Cognitive performance deficits in individuals with MUD were more pronounced during exposure to methamphetamine-related pictures.
- Given that γ determines how people value outcomes, the high risk preferences in individuals with MUD were possibly due to their impaired outcome evaluation. The correlation between subjective craving and γ suggested that individuals with MUD who reported higher craving scores had more impaired outcome evaluation.
- Given that η indicates the degree how participant's belief are affected by the observed data, the correlation between subjective craving and η suggested that individuals with MUD who reported higher craving scores had stronger recency effects and more rapidly forgot past outcomes when exposed to methamphetamine-related pictures.

REFERENCES

- Ahn, W. Y., Haines, N., & Zhang, L. (2017). Revealing neurocomputational mechanisms of reinforcement learning and decision-making with the hBayesDM package. *Computational Psychiatry*, 1, 24–57.
- Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., ... Brown, R. A. (2002). Evaluation of a behavioral measure of risk taking: the Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied*, 8(2), 75–84.

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