



Losses-Disguised-as-Wins and Risky Choice in Rats: A Reinforcement Learning Perspective

Andrew T. Marshall[‡], Christian Davis, & Kimberly Kirkpatrick
Kansas State University (Manhattan, KS, USA)



INTRODUCTION

- Losses-disguised-as-wins (LDWs):** Objective losses that are presented along with win-related stimuli (e.g., flashing lights on slot machines).
- LDWs represent a nontrivial proportion of gambling outcomes.¹
- LDWs may cause gamblers to overestimate frequencies of winning.²
- Rats are riskier after zero-valued and non-zero-valued losses that occur at similar frequencies of large gains than losses that occur at different frequencies of large gains,³ suggesting that rats are sensitive to differential losses and may be susceptible to LDWs.
- Experimental goal:** Determine whether exposure to LDWs promotes increased risky choice in rats after recent and past losses.

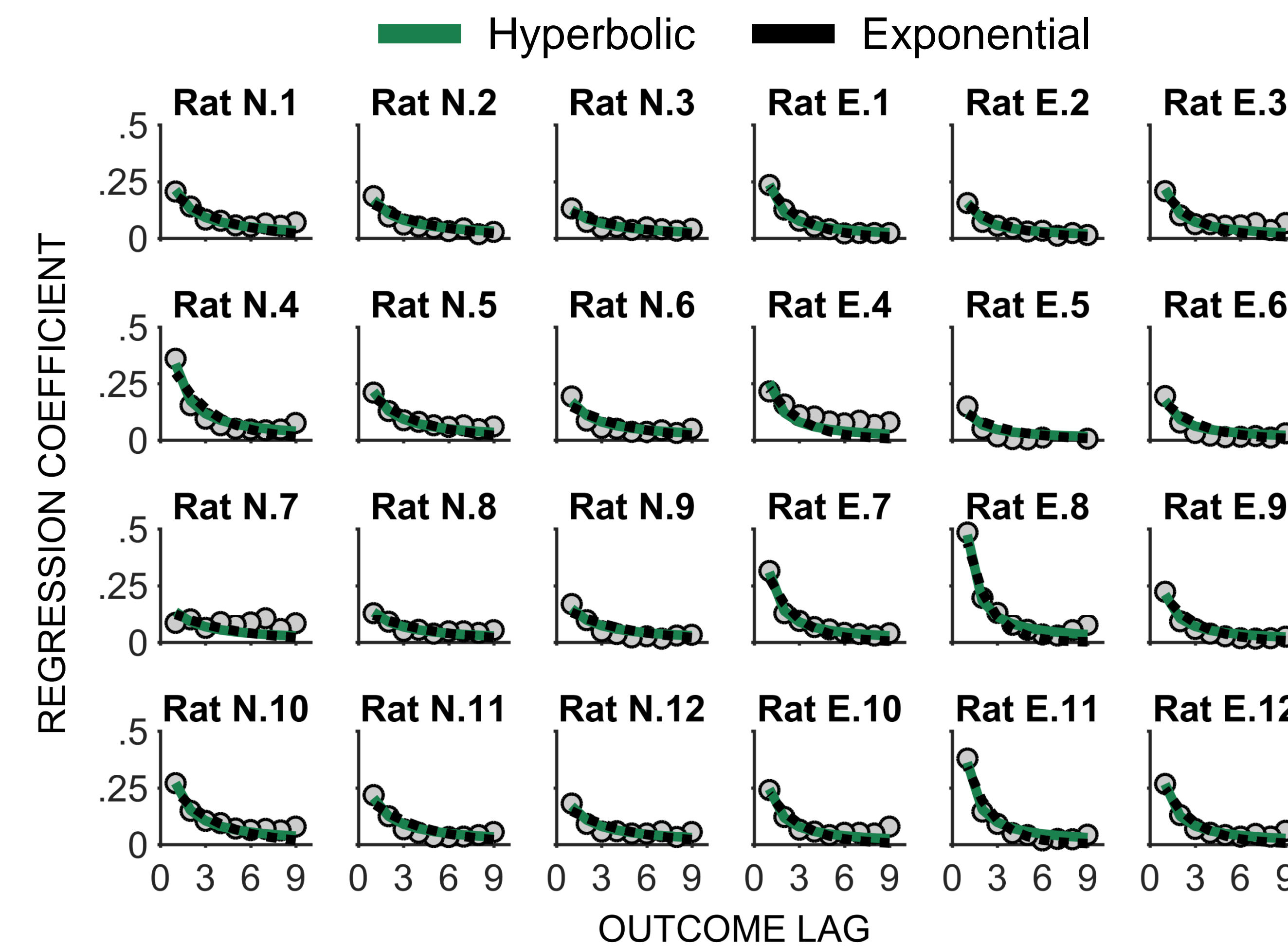
METHODS

- 24 experimentally-naïve male Sprague Dawley rats
- Risky choice (R-0, R-1, R-11 pellets) vs. certain choice (C-2, C-4 pellets)
 - P[0]: $p(R-0) = .1, .5, .9$; $p(R-1) = p(R-11) = .45, .25, .05$
 - P[1]: $p(R-1) = .1, .5, .9$; $p(R-0) = p(R-11) = .45, .25, .05$
- Two groups ($n=12$): Normal-Feedback, Extra-Feedback
 - Normal-Feedback:** For both choices, # nosepoke key flashes above chosen lever = # delivered food pellets
 - Extra-Feedback:** Certain choices: same as Group Normal-Feedback; Risky choices: 0, 1, or 11 delivered food pellets + 11 nosepoke key flashes above risky lever + 11 food pellets delivered to external receptacle (i.e., multimodal win-related stimuli of LDWs)



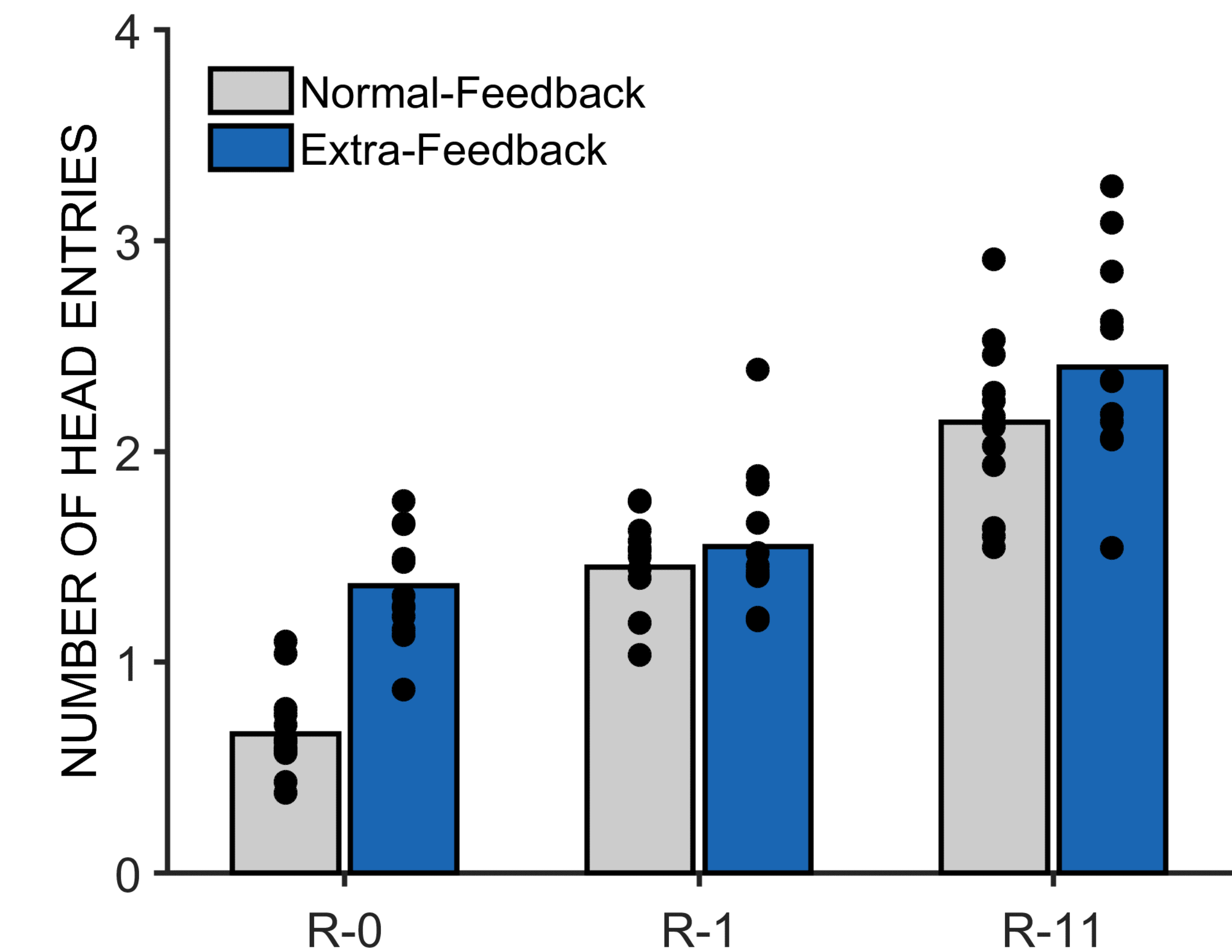
Operant chamber setup for Group Extra-Feedback.

RESULTS: REINFORCEMENT HISTORY



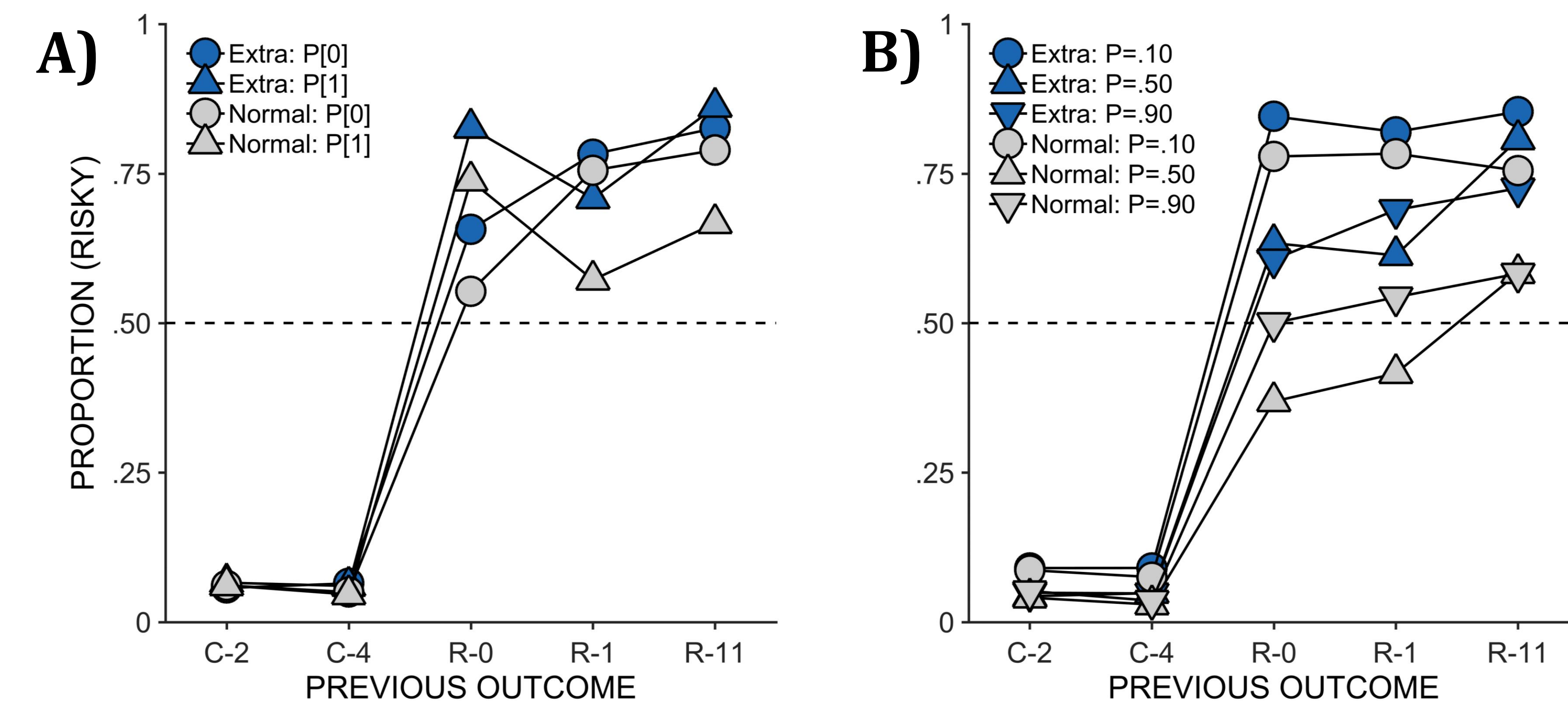
- Analysis:** Nonlinear mixed effects model
 - Criterion:** Regression coefficients of past 9 outcomes
 - Model:** Hyperbolic and exponential decay functions (random effects = intercept, decay rate of function)
- Results:** Steeper decay functions in Group Extra-Feedback; Better fit by hyperbolic decay function

RESULTS: GOAL TRACKING



- Analysis:** Generalized linear mixed effects model (Poisson)
 - Criterion:** Post-outcome head entries
 - Model:** Group \times Risky Outcome (random effects = risky outcome)
- Results:** Group Extra-Feedback: \uparrow head entries

RESULTS: PREVIOUS OUTCOME EFFECTS



- Analysis:** Generalized linear mixed effects model (binomial)
 - Criterion:** Certain choices (0) and risky choices (1)
 - Model:** Group \times Phase \times Previous Outcome, Group \times Probability \times Previous Outcome (random effects = phase, previous outcome)
- Results:** Group Extra-Feedback was riskier than Group Normal-Feedback after risky outcomes across phases (A) and probabilities (B); Post R-0 loss-chasing in P[1] condition in both groups (A).

RESULTS: REINFORCEMENT LEARNING (RL) MODEL

- Analysis:** Asymmetric RL

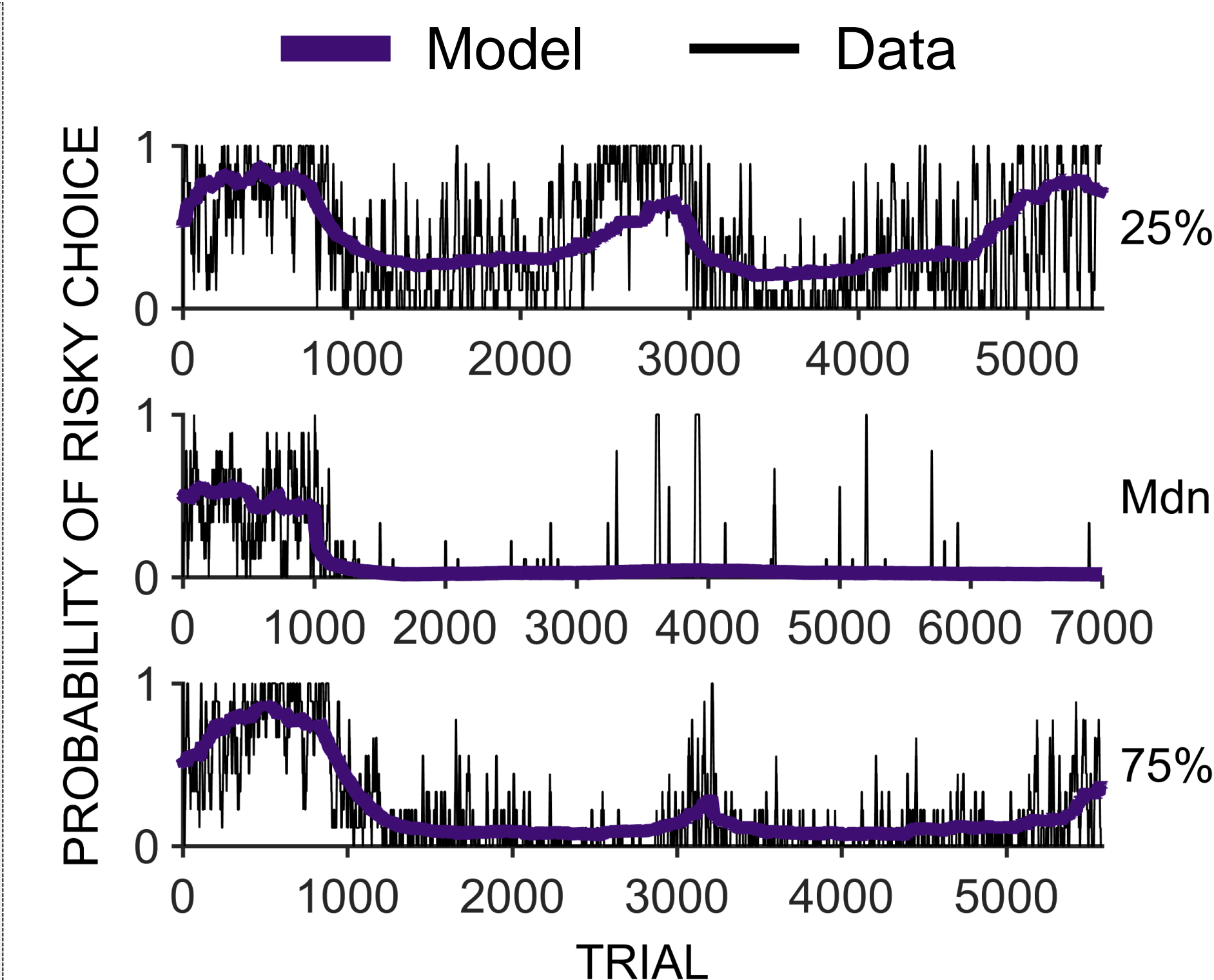
$$\delta_{N,T} = R_{N,T} - V_{N,T-1}$$

$$V_{N,T} = V_{N,T-1} + \alpha \delta_{N,T}$$

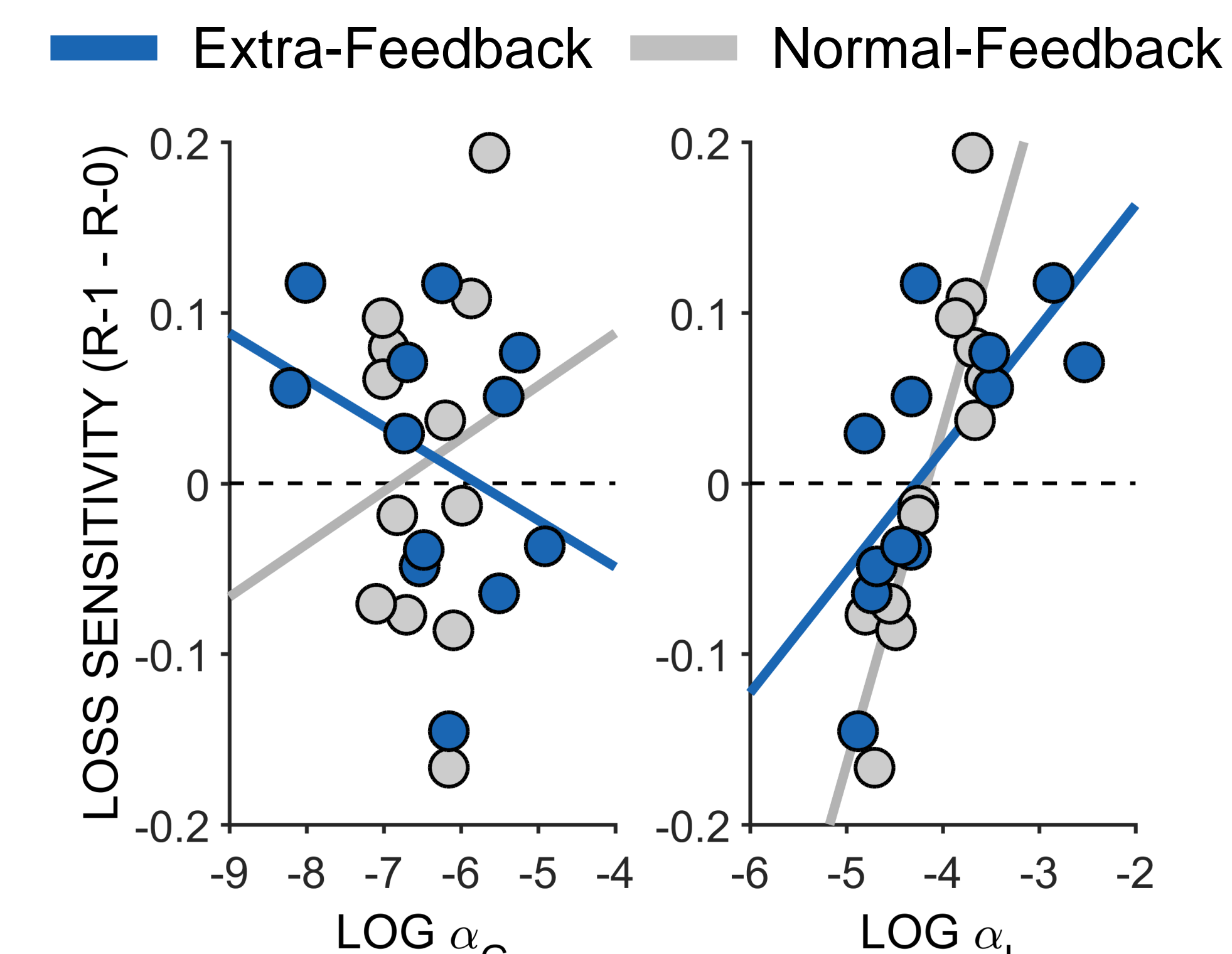
- $\delta_{N,T}$ = Prediction error for choice N on trial T
- $R_{N,T}$ = Reward magnitude
- $V_{N,T}$ = Reward value
- Assumption:** Separate value-updating rates for gains (α_G) and losses (α_L)

$$\alpha = \begin{cases} \alpha_G, \delta_{N,T} > 0 \\ \alpha_L, \delta_{N,T} \leq 0 \end{cases}$$

- Softmax decision rule



- Results:** Model fits corresponding to 25%ile, median, and 75%ile of ω^2 values (mean $\omega^2 = .50$); Model tracked rats' trial-by-trial behavior



- Results:** Left: α_G did not interact with group to predict loss sensitivity; Right: Group \times α_L interaction (i.e., shallower slope in Group Extra-Feedback)

DISCUSSION

- LDWs in Group Extra-Feedback increased risky choice, decreased relative effect of past reinforcement, and reduced loss sensitivity.
- Greater risk-taking given LDWs may be driven by deficits in learning from losses or a reduced sensitivity to differential losses.
- Greater loss-based value-updating indicative of loss aversion in rats.³

REFERENCES

- Dixon, M. J., Harrigan, K. A., Sandhu, R., Collins, K., & Fugelsang, J. A. (2010). Losses disguised as wins in modern multi-line video slot machines. *Addiction*, 105, 1819-1824.
- Dixon, M. J., Collins, K., Harrigan, K. A., Graydon, C., & Fugelsang, J. A. (2015). Using sound to unmask losses disguised as wins in multiline slot machines. *J Gambl Stud*, 31, 183-196.
- Marshall, A. T., & Kirkpatrick, K. (2015). Relative gains, losses, and reference points in probabilistic choice in rats. *PLoS ONE*, 10, e0117697.

ACKNOWLEDGMENTS

The research was supported by the National Institute of Mental Health (NIMH) via award MH085739. We would like to thank Jen Peterson, Catherine Hill, Sarah Stuebing, Jeremy Lott, and Jessica Pirklde for assistance with animal care and experimentation.

[‡]Email: atmarsh@k-state.edu