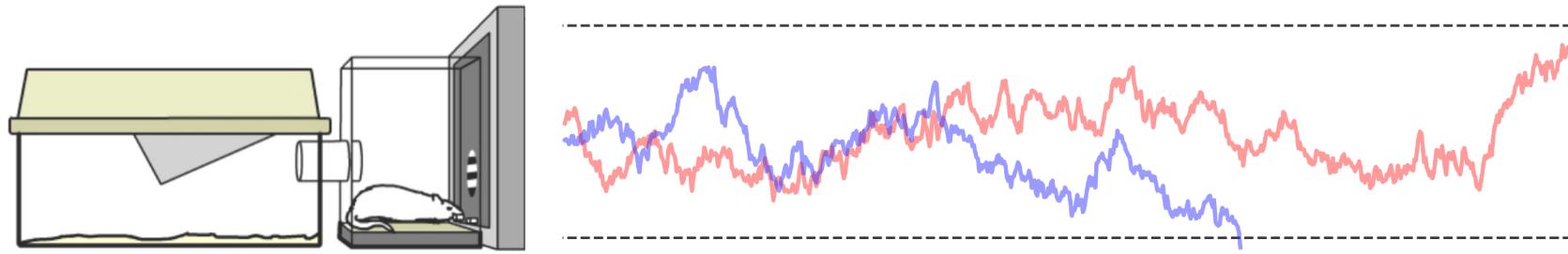


Measuring Model Uncertainty for Time-Dependent Decisions



Gabriel Riegner¹, Armin Schwartzman^{1,2}, Pamela Reinagel^{1,3}

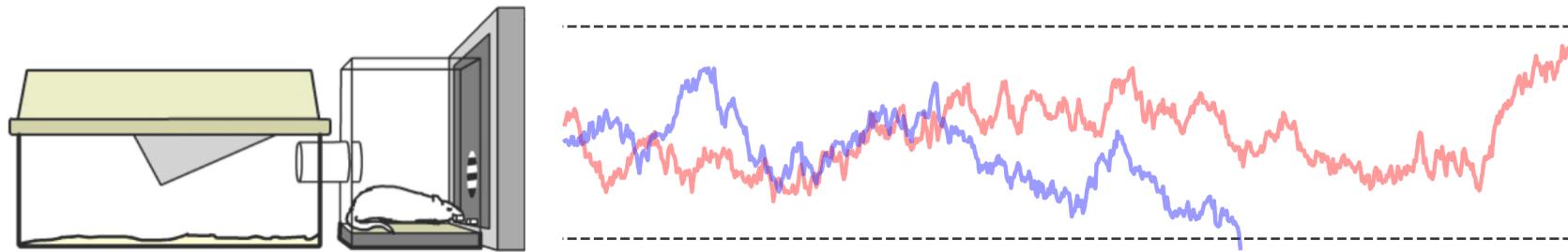
¹Halıcıoğlu Data Science Institute, UC San Diego

²Division of Biostatistics, UC San Diego

³Department of Neurobiology, UC San Diego

with support from NIH/NINDS funded through the BRAIN Initiative

Measuring Model Uncertainty for Time-Dependent Decisions

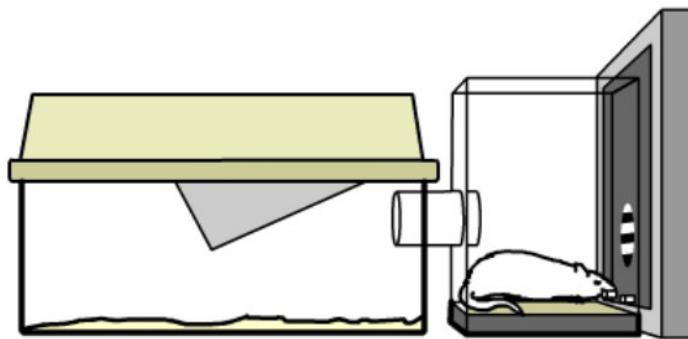


Outline:

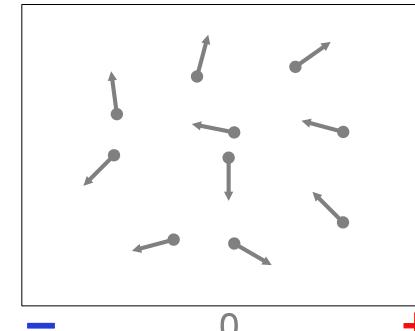
- | | |
|-----------------------------|-----------------|
| 1. Experimental Design | 4. Simulations |
| 2. Drift-Diffusion Model | 5. Applications |
| 3. Estimation and Inference | 6. Conclusions |

Experimental Design

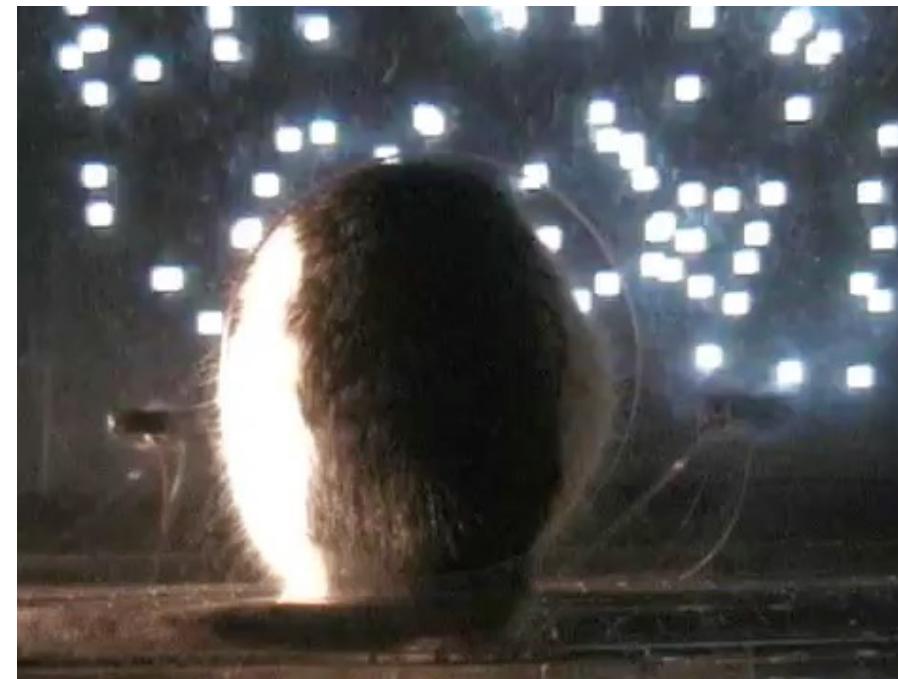
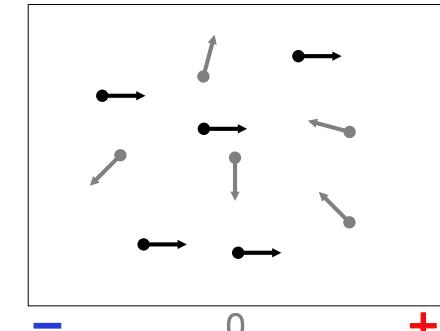
Two-Alternative Forced Choice (2AFC)



0% Rightward Motion
(100% Random)

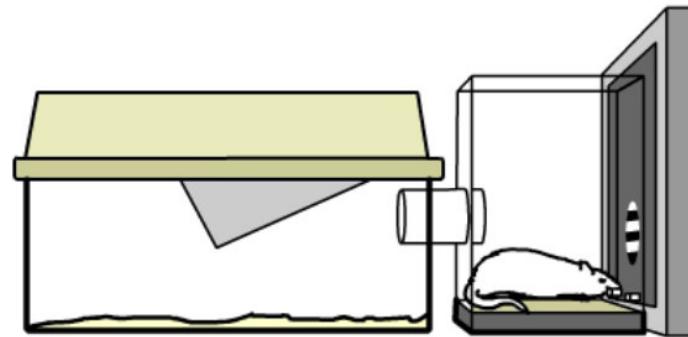


50% Rightward Motion
(50% Random)

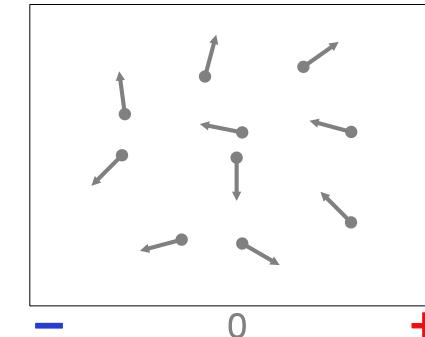


Experimental Design

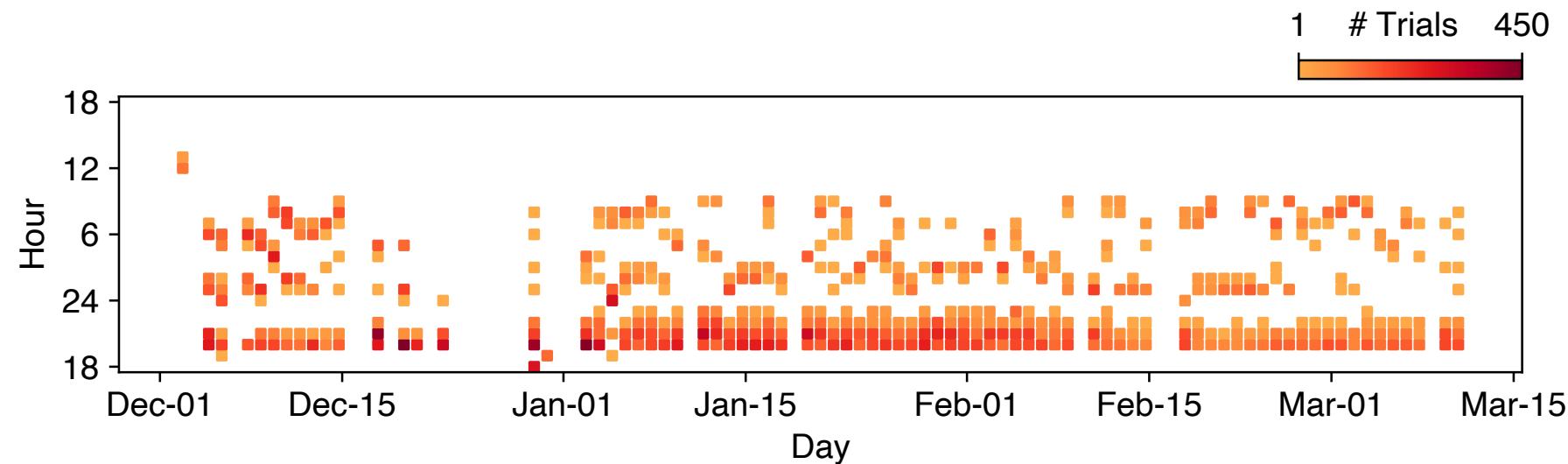
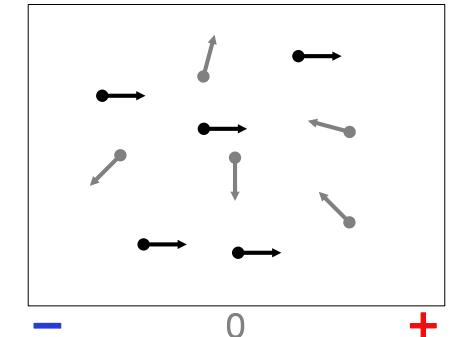
Two-Alternative Forced Choice (2AFC)



0% Rightward Motion
(100% Random)

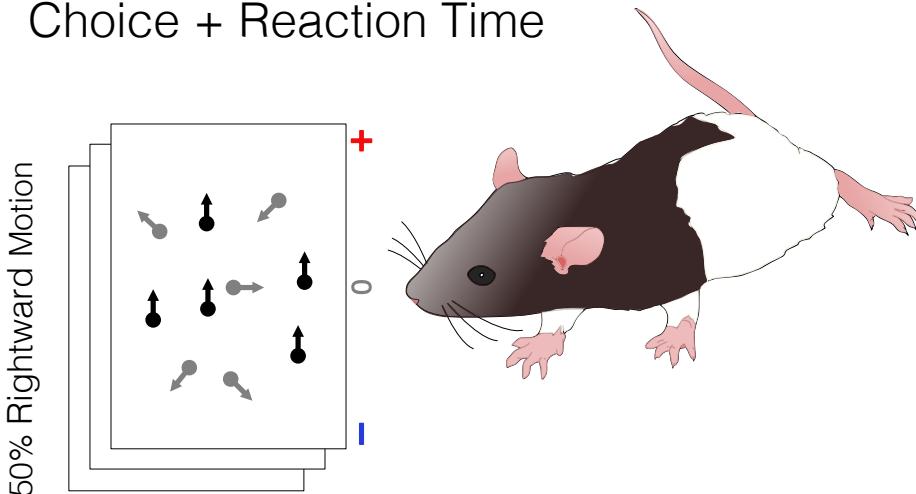


50% Rightward Motion
(50% Random)

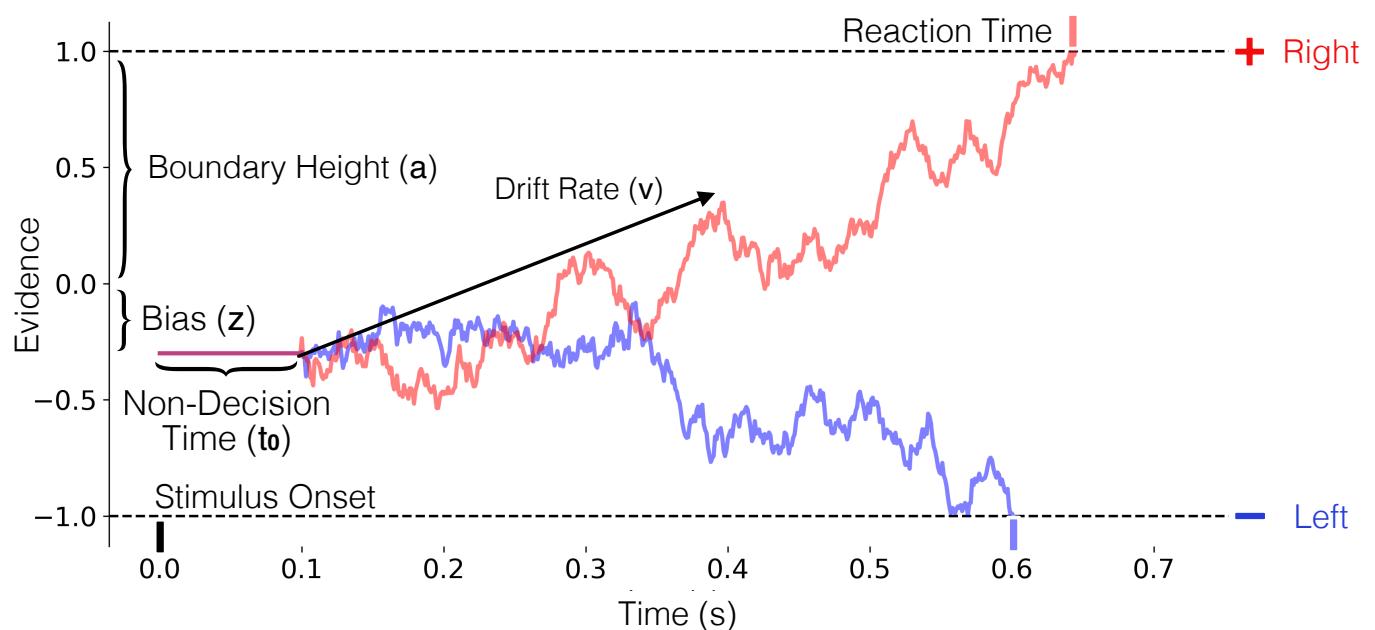
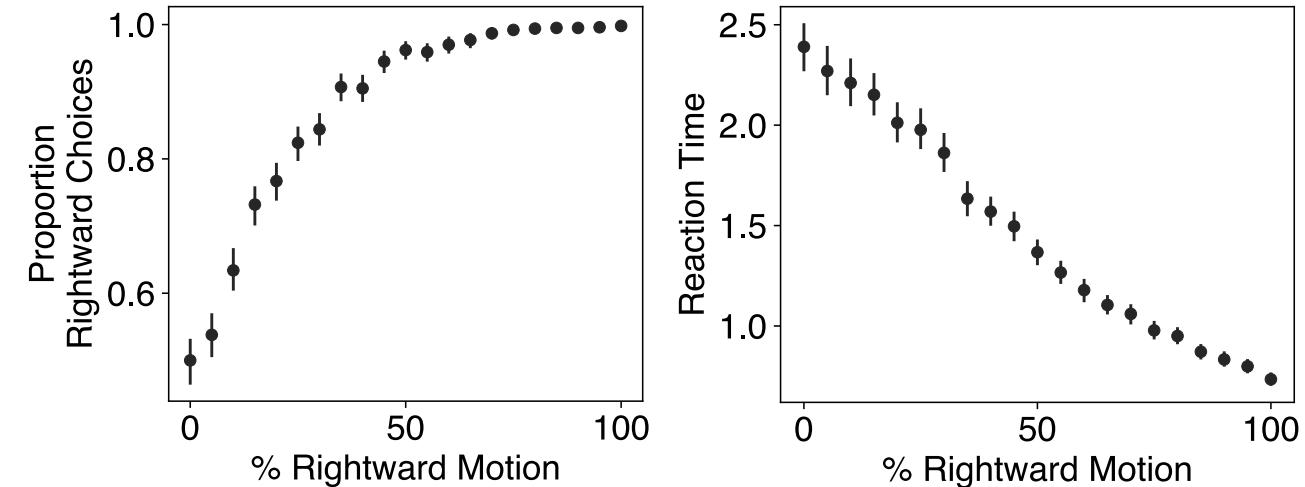
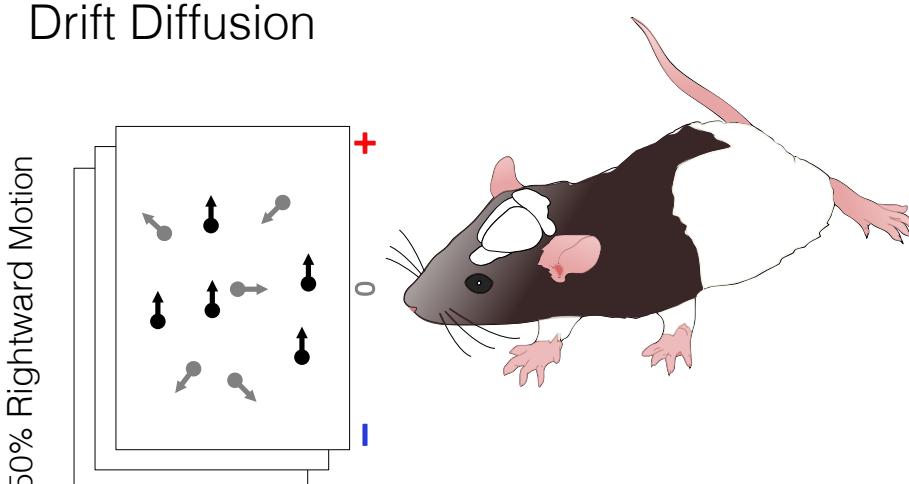


Decision-Making Process

Observed Behavior:
Choice + Reaction Time



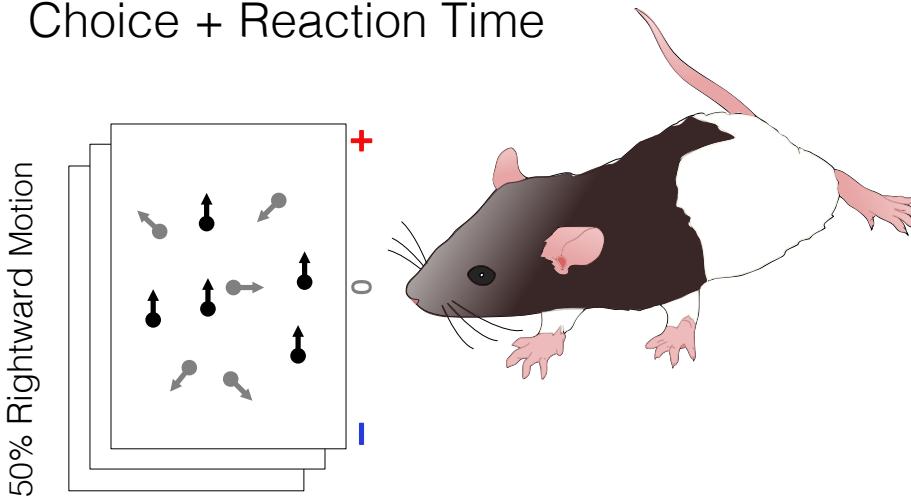
Unobserved Decision-Making Process:
Drift Diffusion



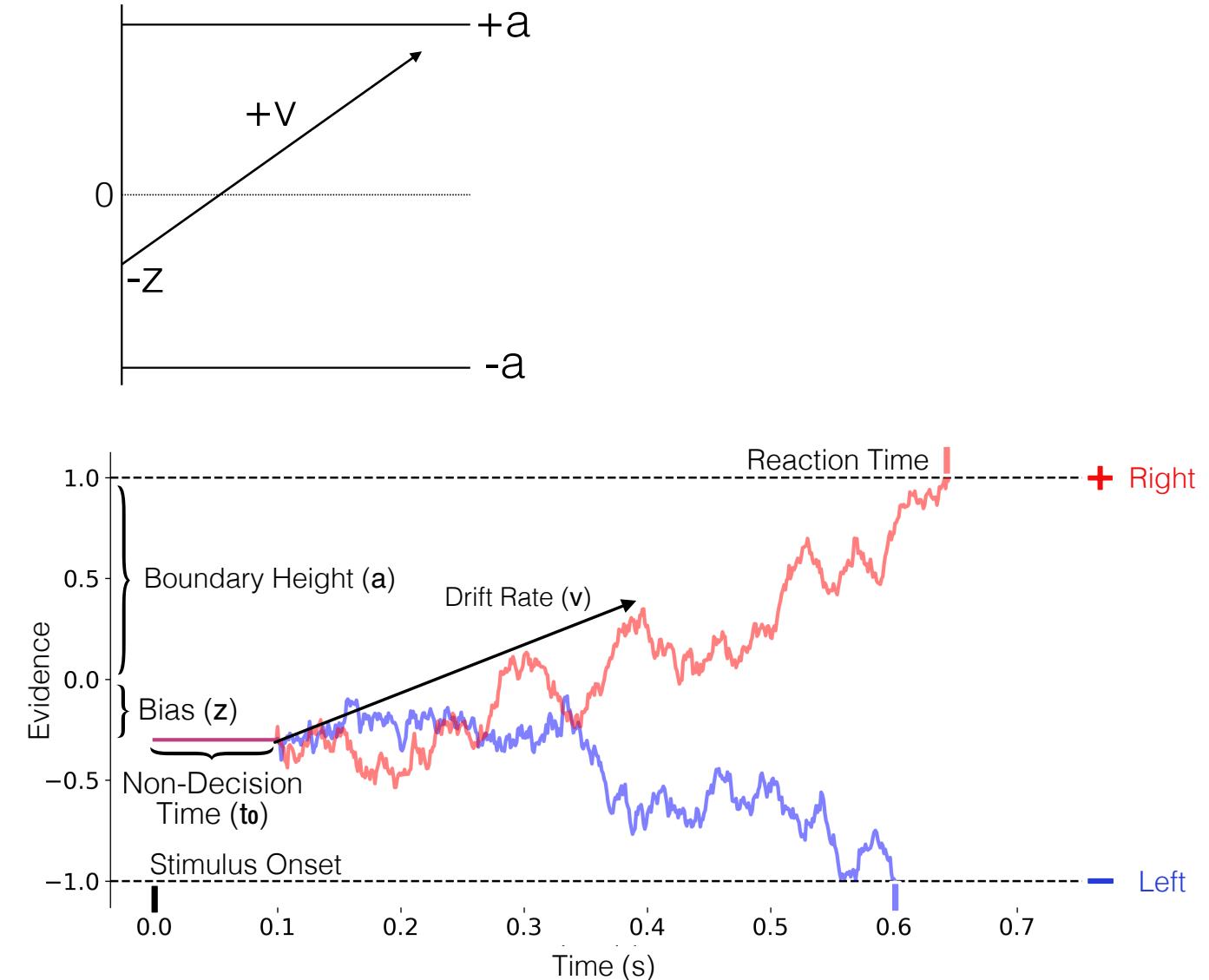
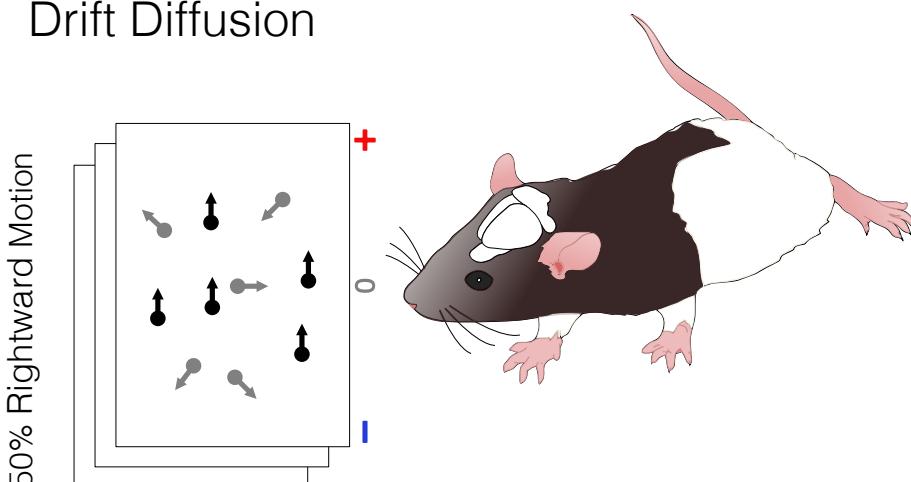
Decision-Making Process

Observed Behavior:

Choice + Reaction Time

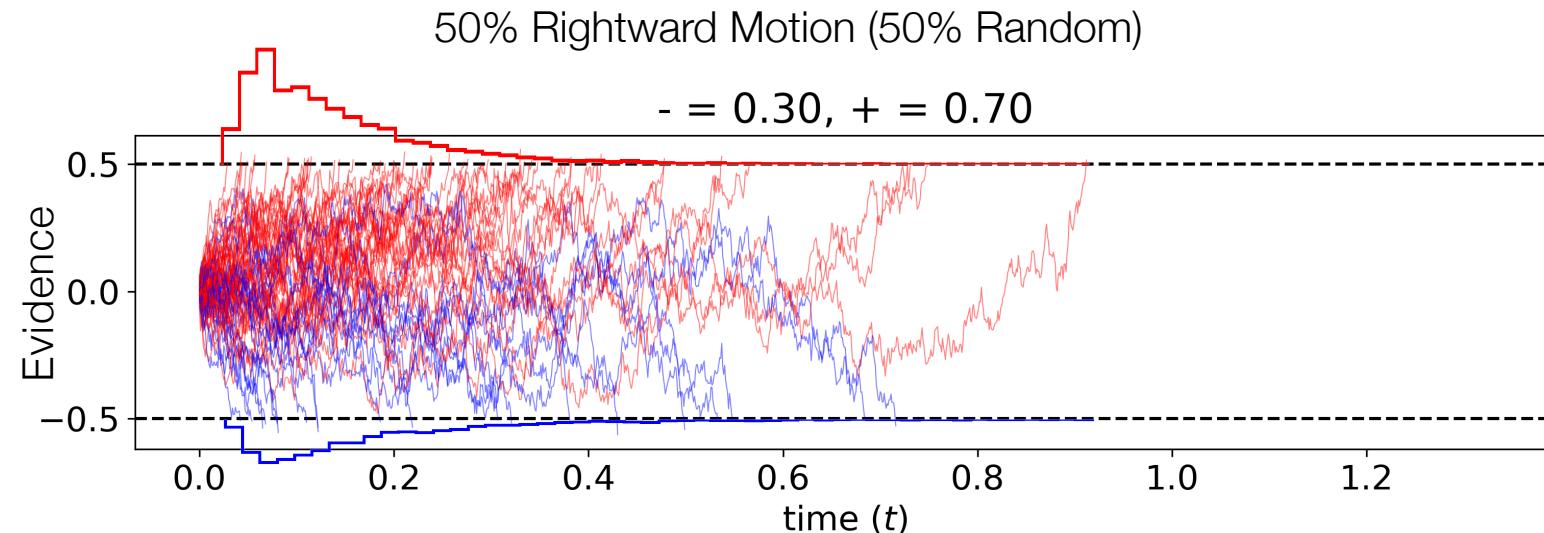


Unobserved Decision-Making Process:
Drift Diffusion

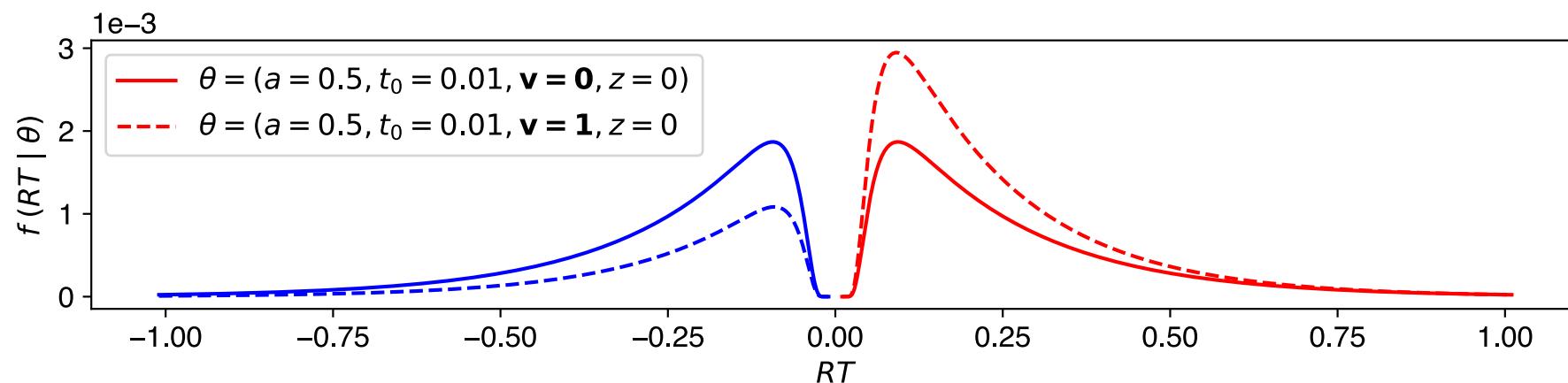


Drift-Diffusion Model (DDM)

Histograms of Trial-by-Trial Decisions



Probability Density Function (Navarro and Fuss 2009)



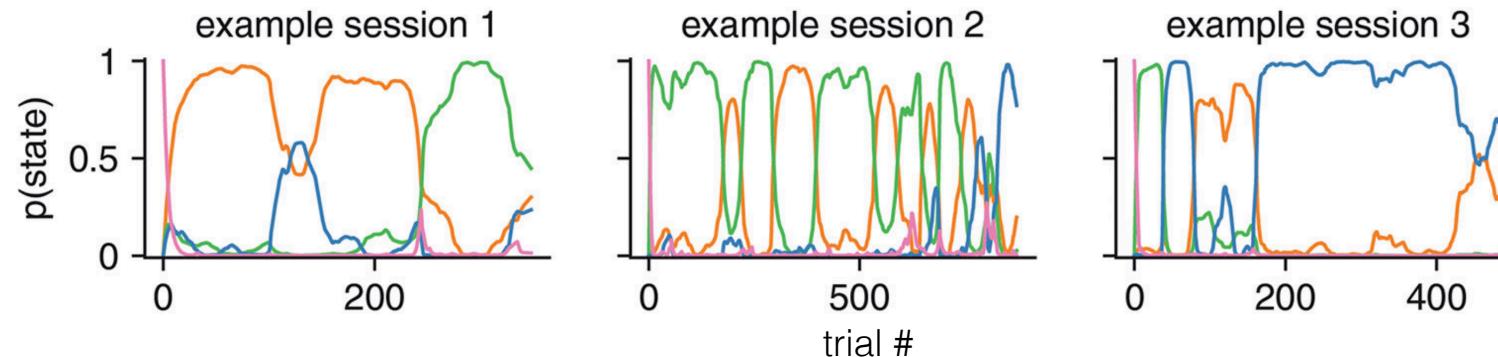
Unrealistic Assumptions of the Drift-Diffusion Model (DDM)

“You can never step in the same river twice” (Heraclitus)

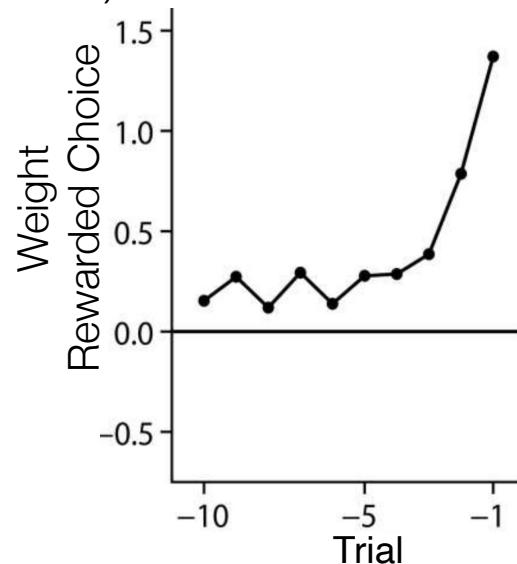


Decisions as a Time Series

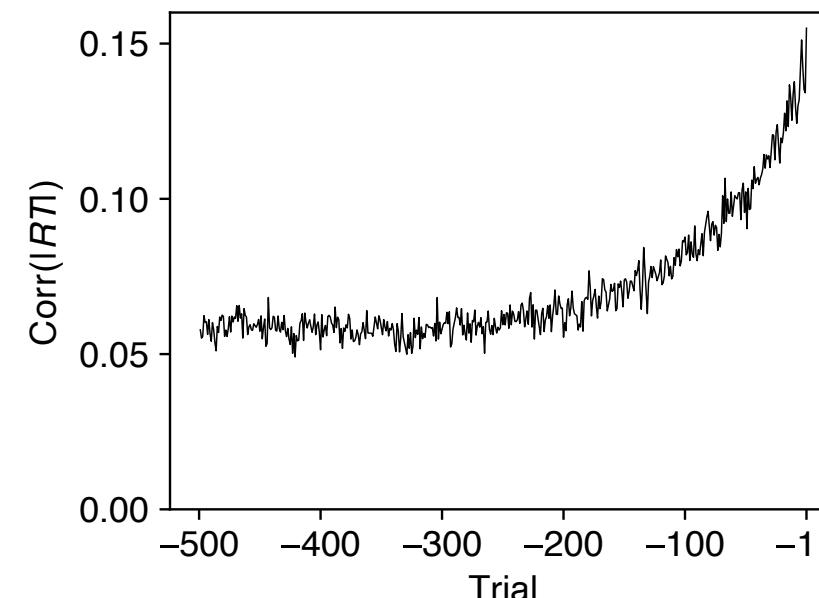
Decision Strategies Change over Time (Ashwood et al. 2022)



Choices Depend on Recent Rewards
(Danskin et al. 2023)

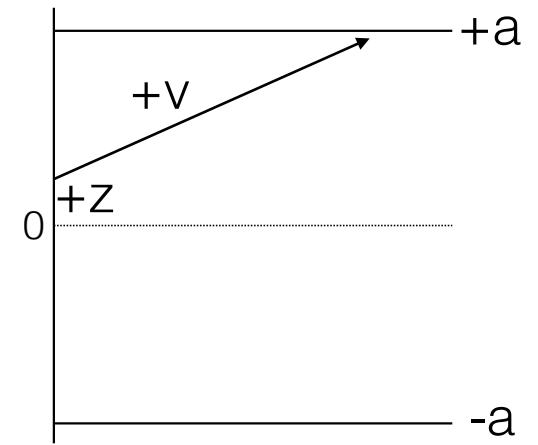
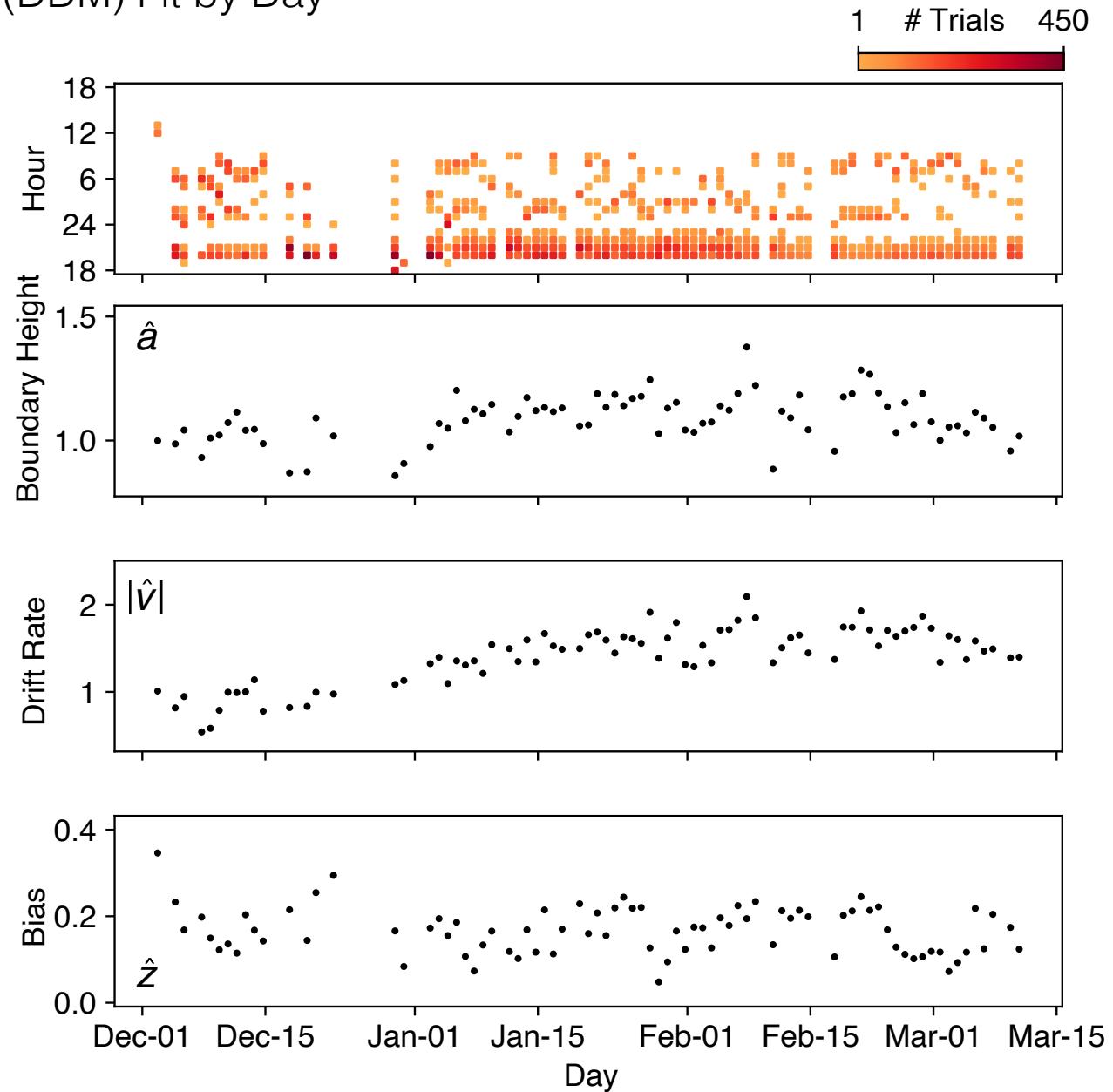


Reaction Times are Autocorrelated



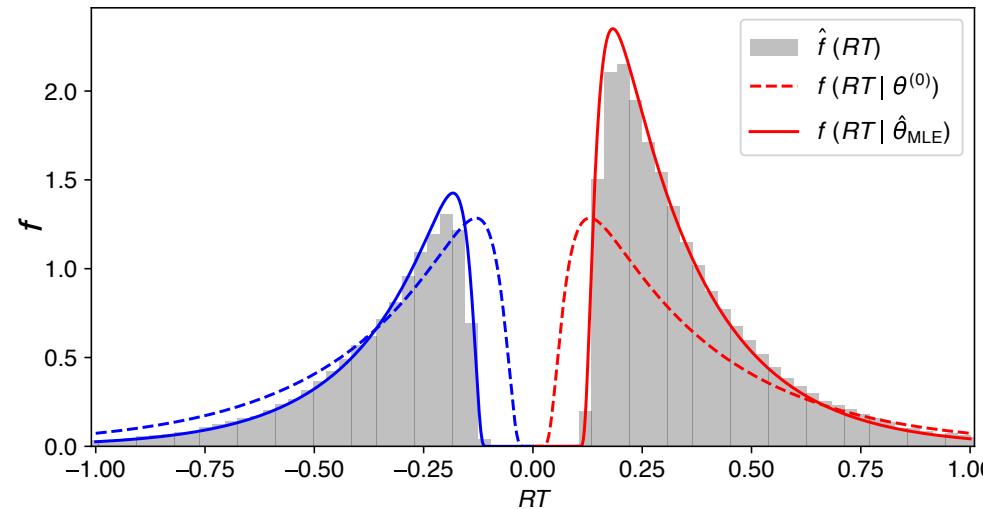
Estimation and Inference

Drift-Diffusion Model (DDM) Fit by Day

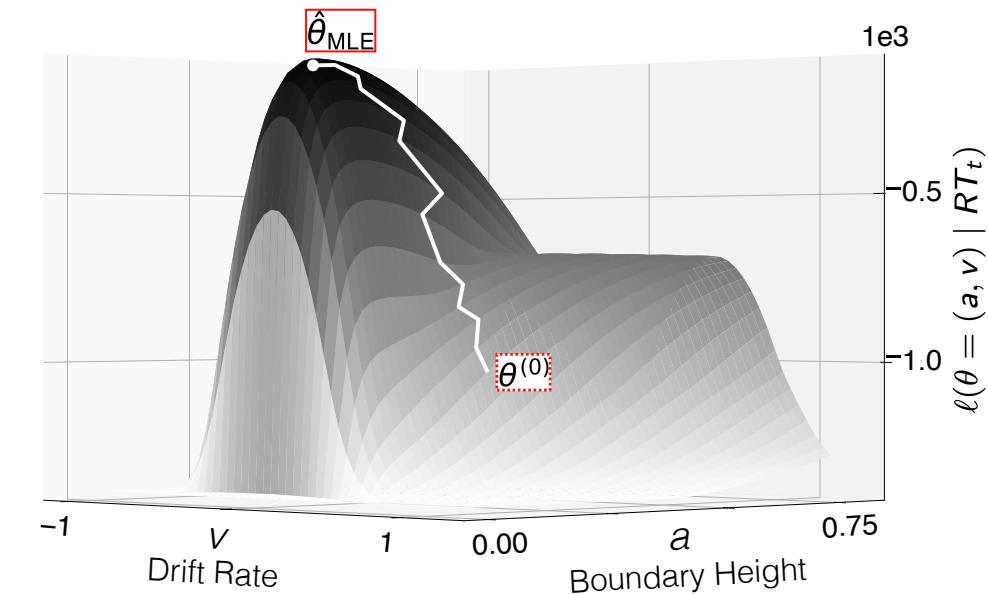


Maximum Likelihood Estimator

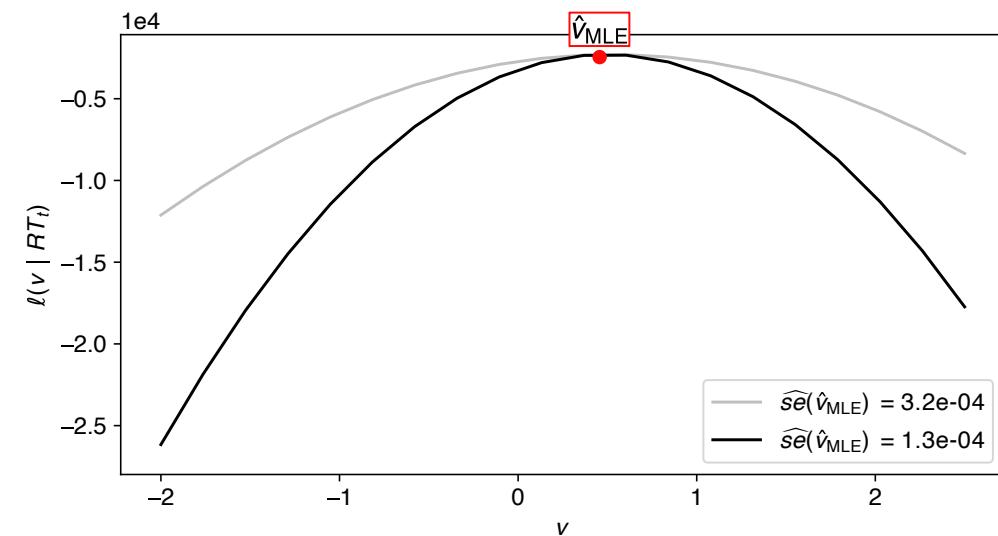
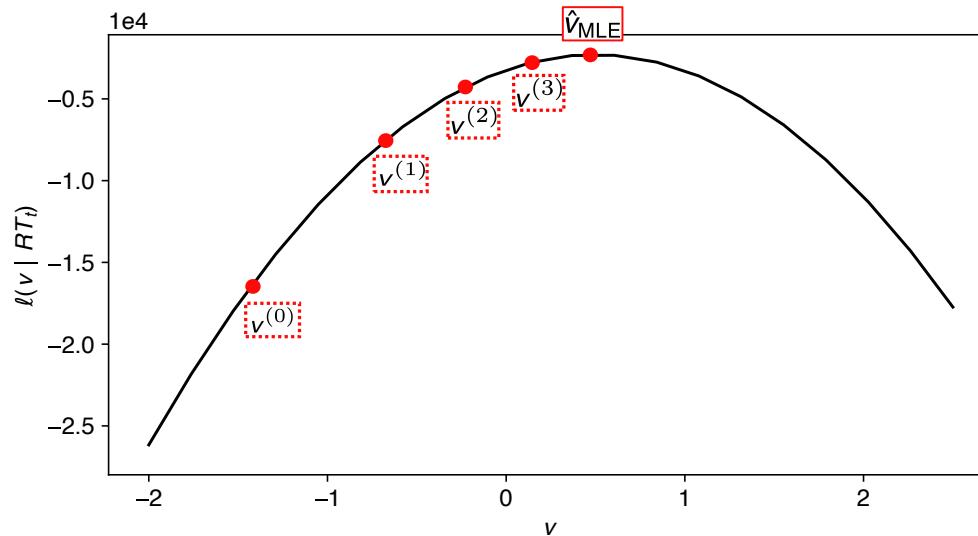
Probability Density Function



Log-Likelihood Function

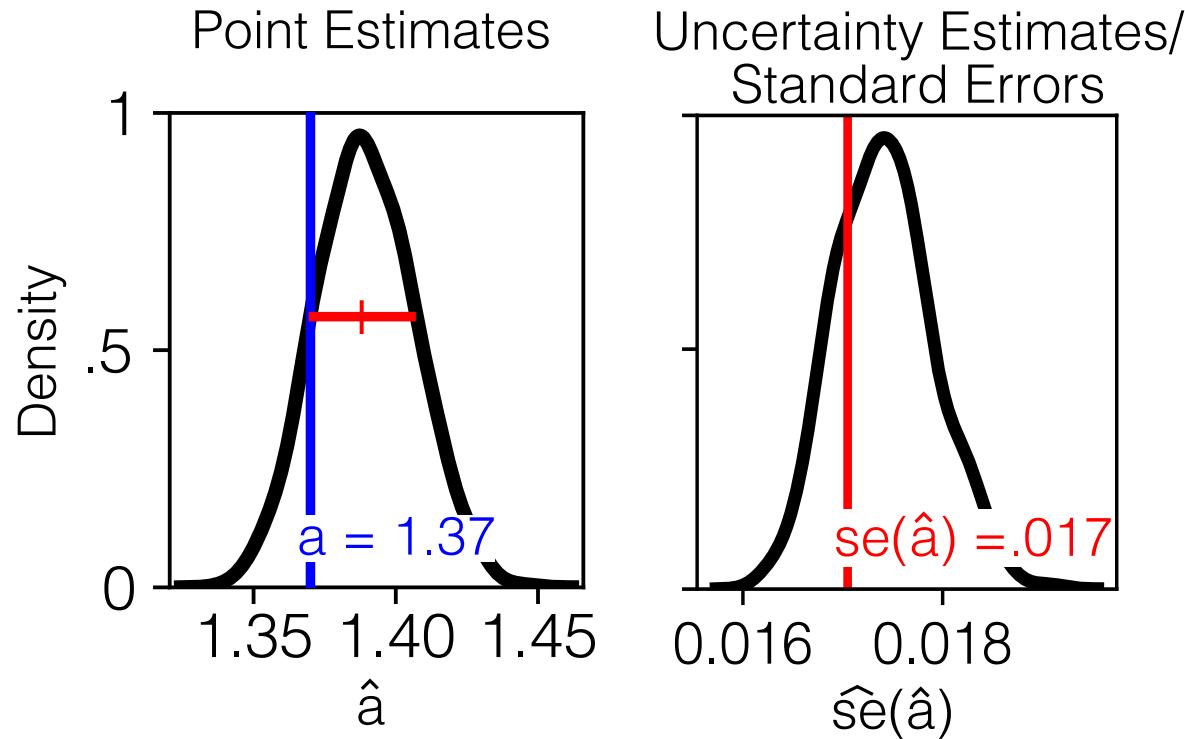


Log-Likelihood Hessian Matrix



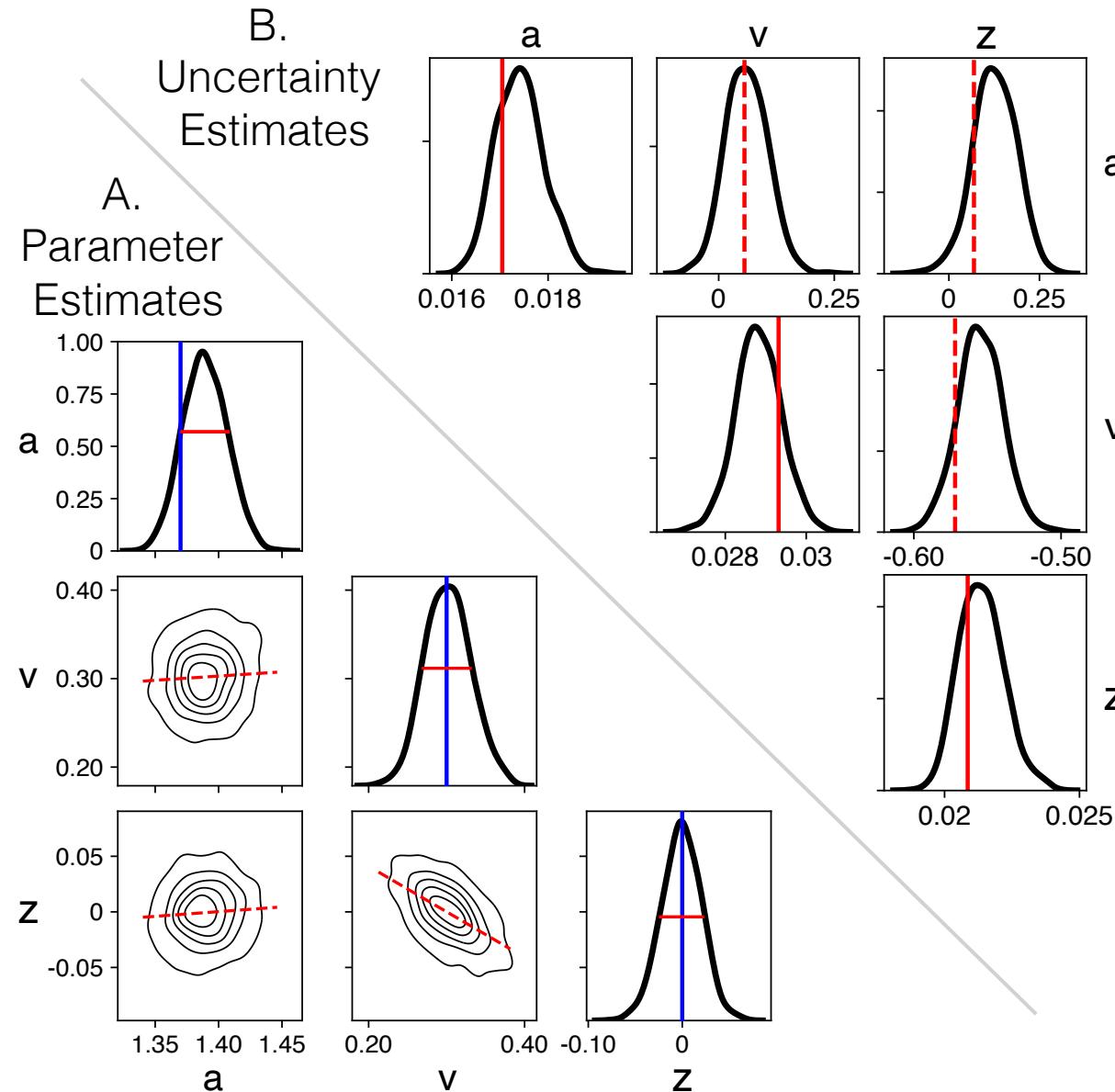
Parameter Recovery Simulations

$a = 1.37$, $v = 0.3$, $z = 0$, $T = 1000$ trials, $B = 900$ repeats



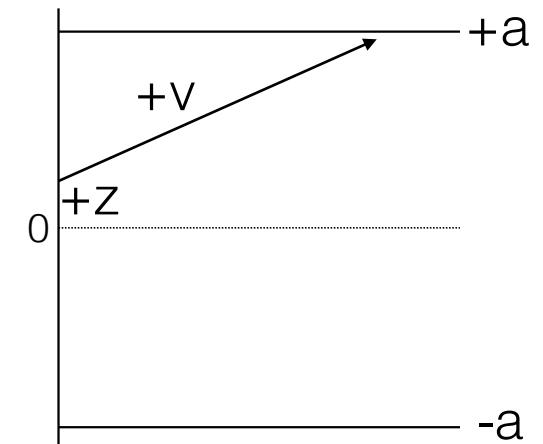
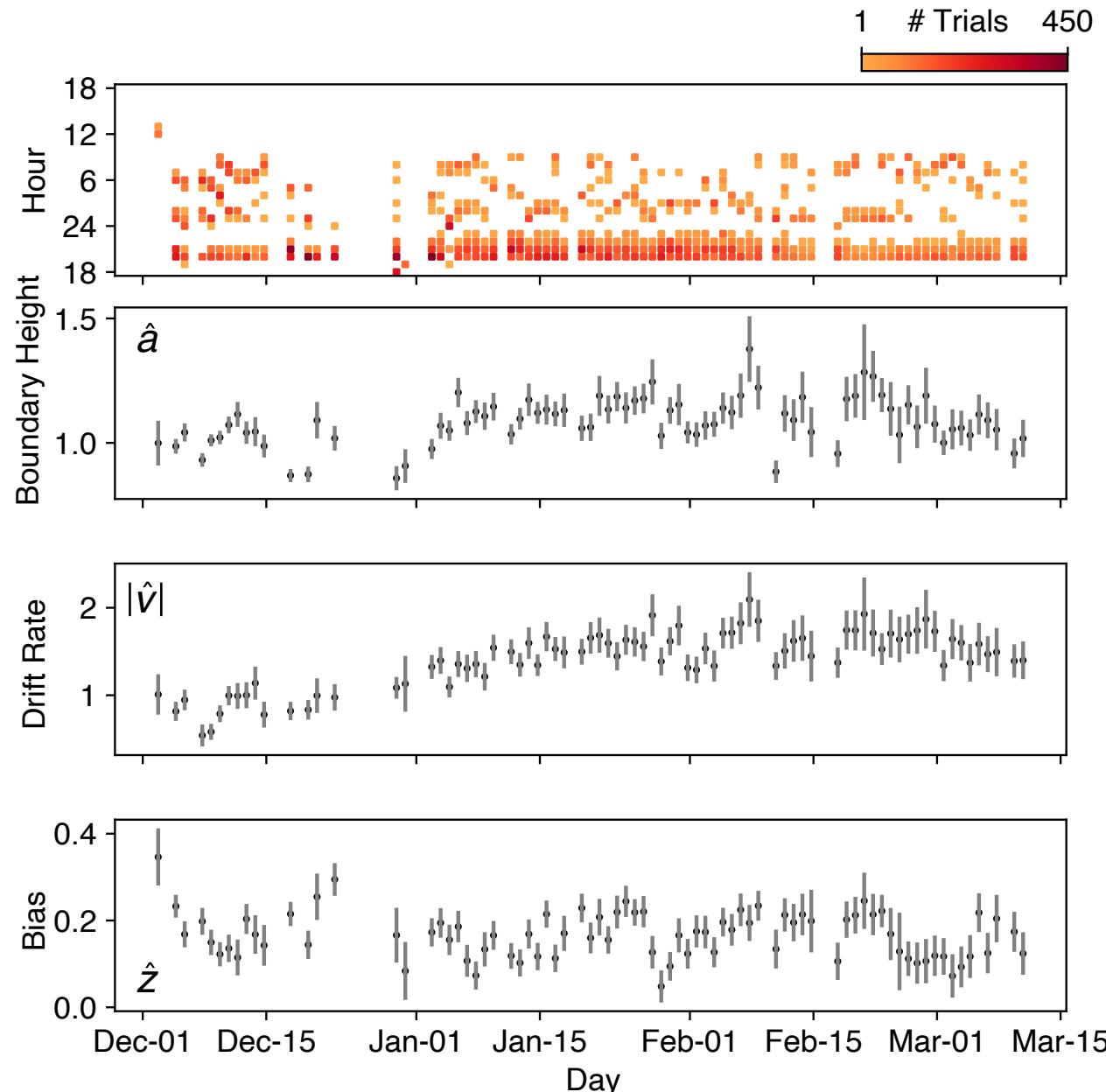
Parameter Recovery Simulations

$a = 1.37$, $v = 0.3$, $z = 0$, $T = 1000$ trials, $B = 900$ repeats



Decision-Making Parameters Change over Time

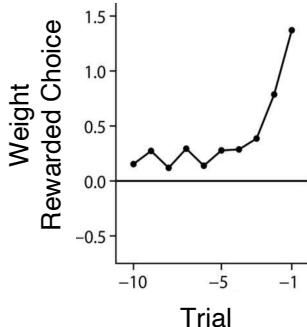
Return to slide 9,
now with the addition of
95% confidence intervals



Conclusions and Future Directions

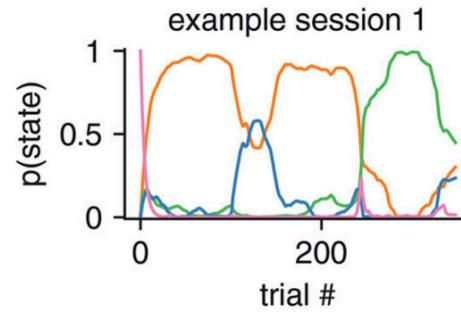
Decision making adapts across many timescales from

10s of trials to...



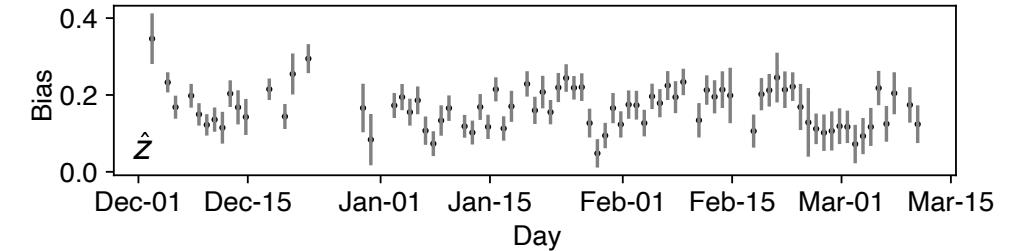
(Danskin et al. 2023)

100s of trials to ...

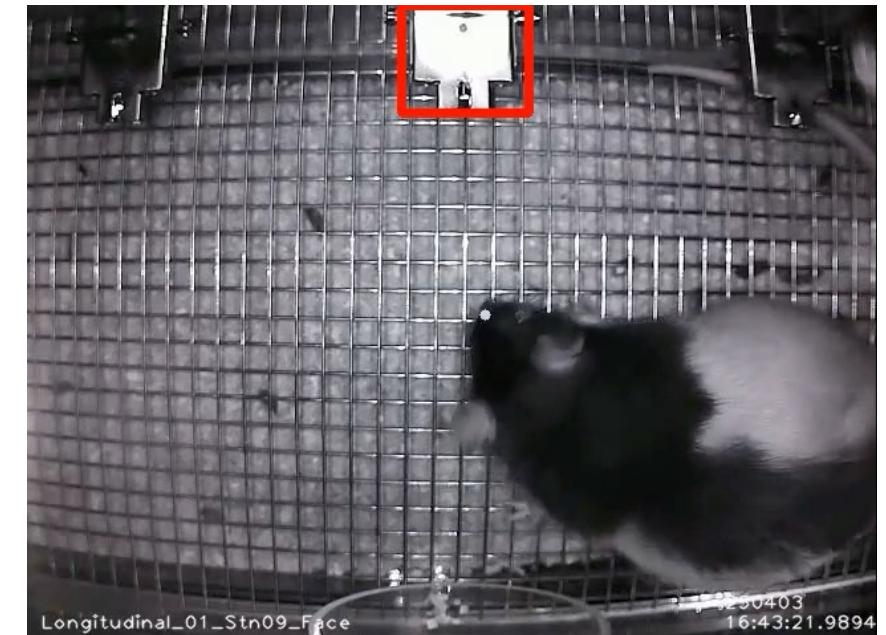


(Ashwood et al. 2023)

1000s of trials



For future directions, we aim to explain how these decision-making parameters covary with trial-by-trial features of rat behavior, such as movement patterns extracted from video.



Acknowledgments

Pamela Reinagel

Armin Schwartzman



Albert Gu



NIH/NINDS



Rat 195

References

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