

Introduction

We tested the hypothesis that a dynamical systems approach with varying initial conditions and inputs provides a mechanistic understanding of neural population activity underlying a reach decision

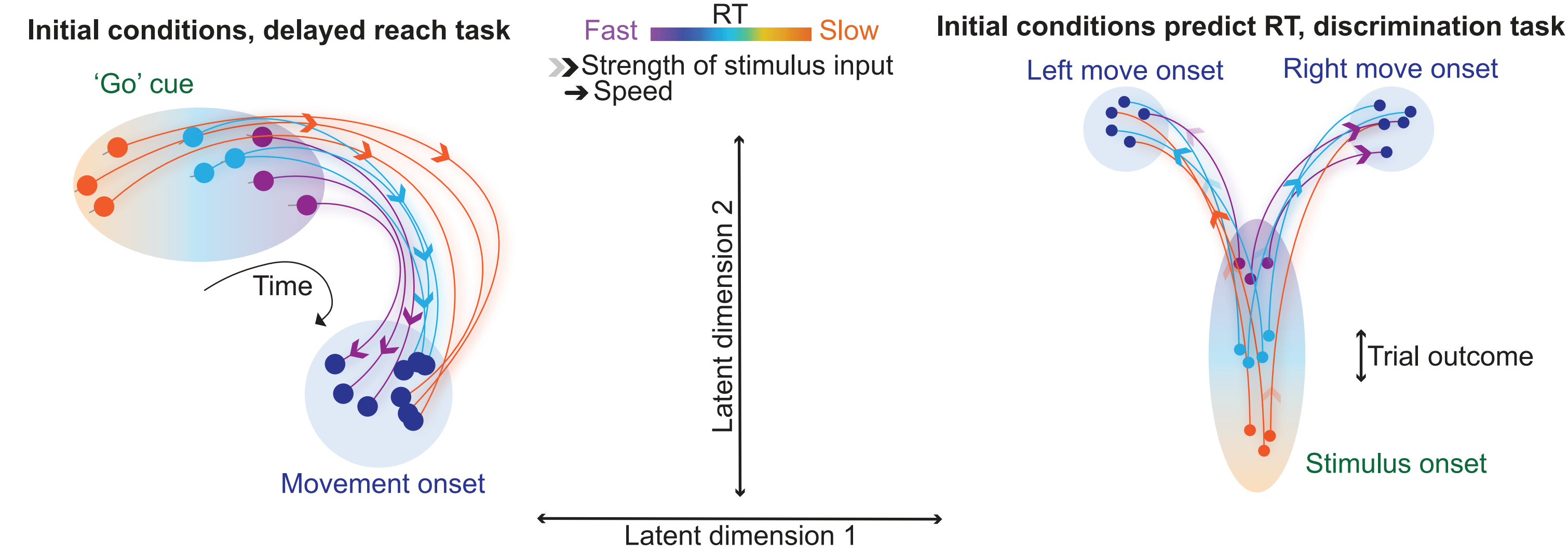
$$dX/dt = F(X) + U$$

F - recurrent dynamics in region of interest (ROI); U - input to the system outside ROI; X_0 - Initial condition in ROI

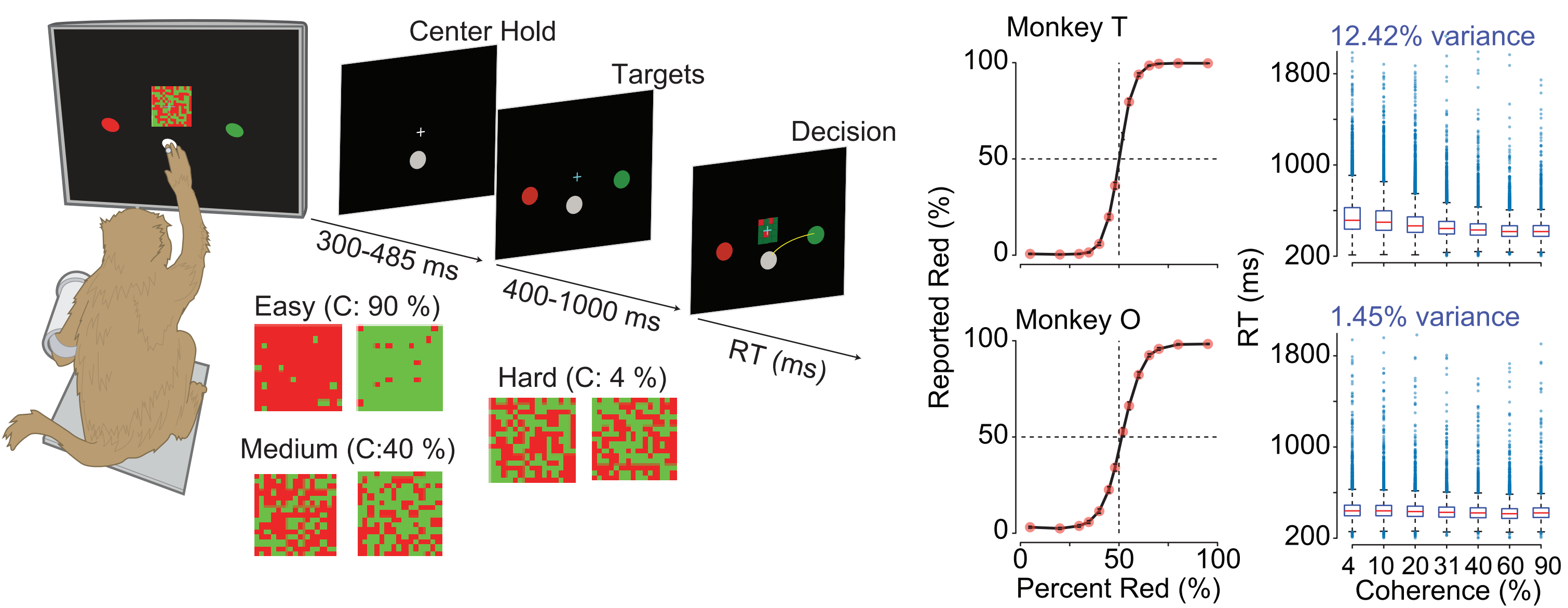
Prediction 1: the initial condition, as indexed by the prestimulus neural population state, predicts poststimulus decision-related neural dynamics and behavior (i.e., reaction time (RT))

Prediction 2: the speed of choice-selective dynamics after stimulus onset depends on initial conditions and stimulus strength

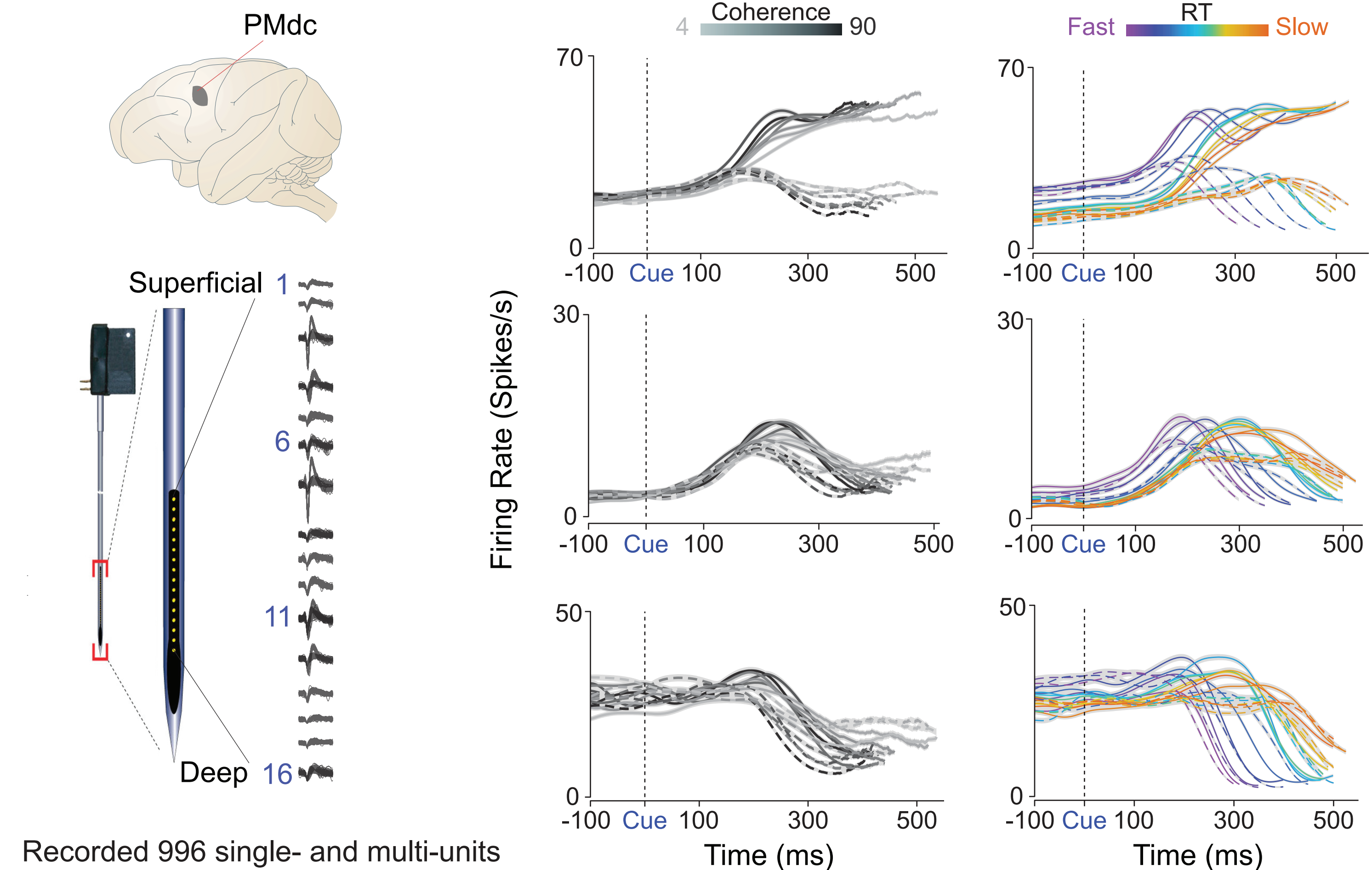
Hypotheses



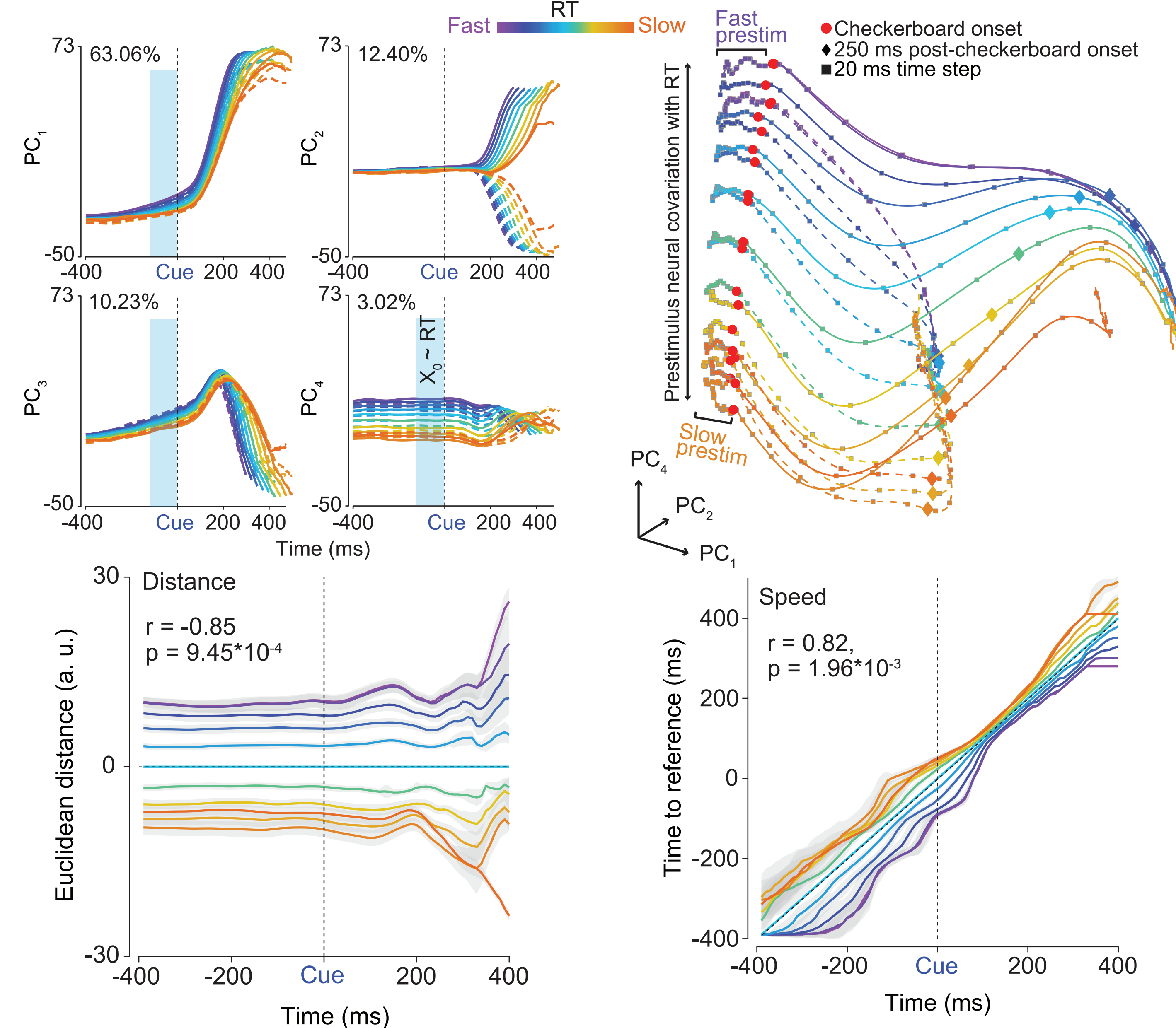
Decision-making is dependent on sensory evidence and internal state



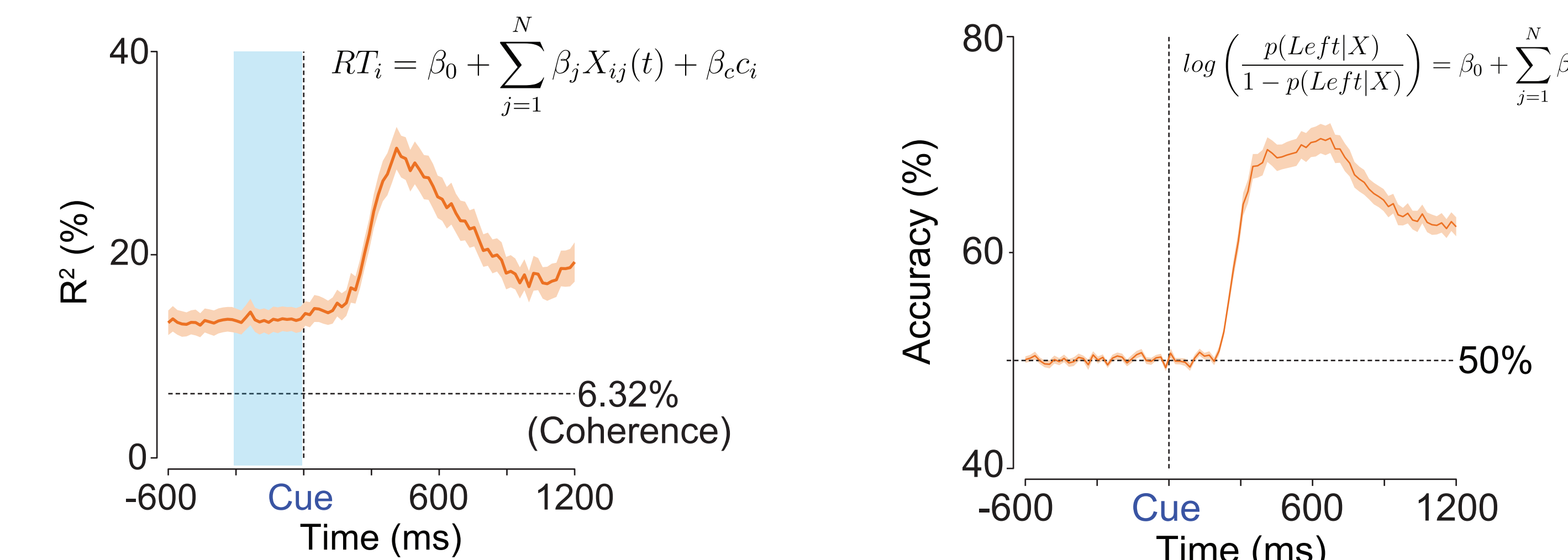
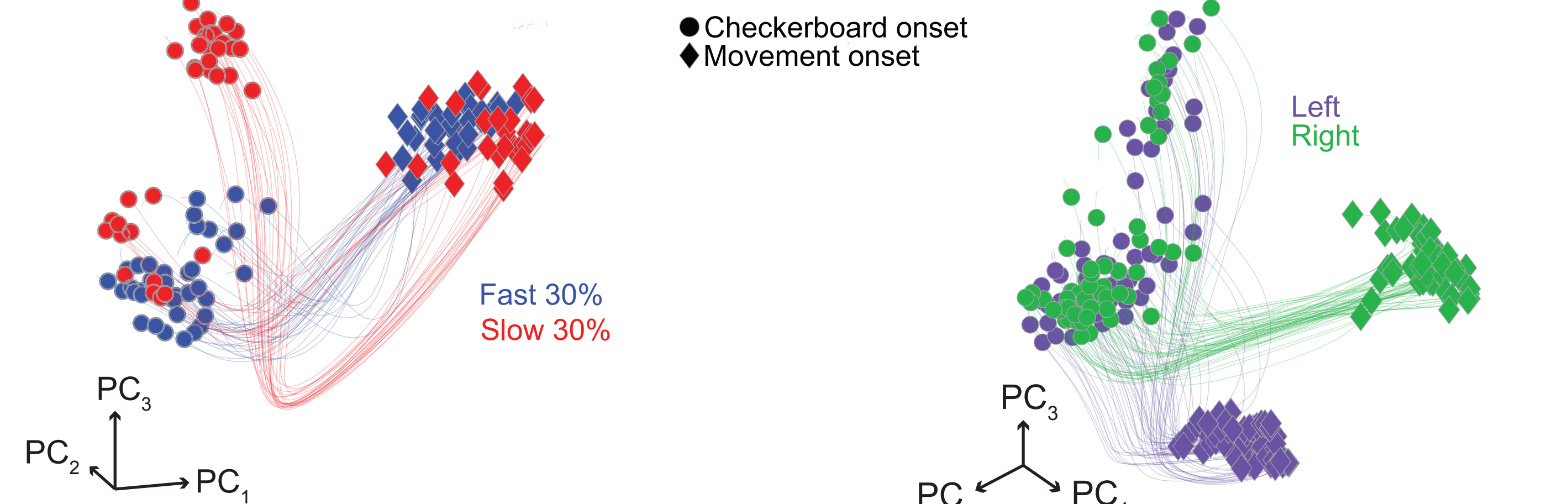
Single-unit prestimulus firing rates covary with RT and poststimulus activity is input dependent



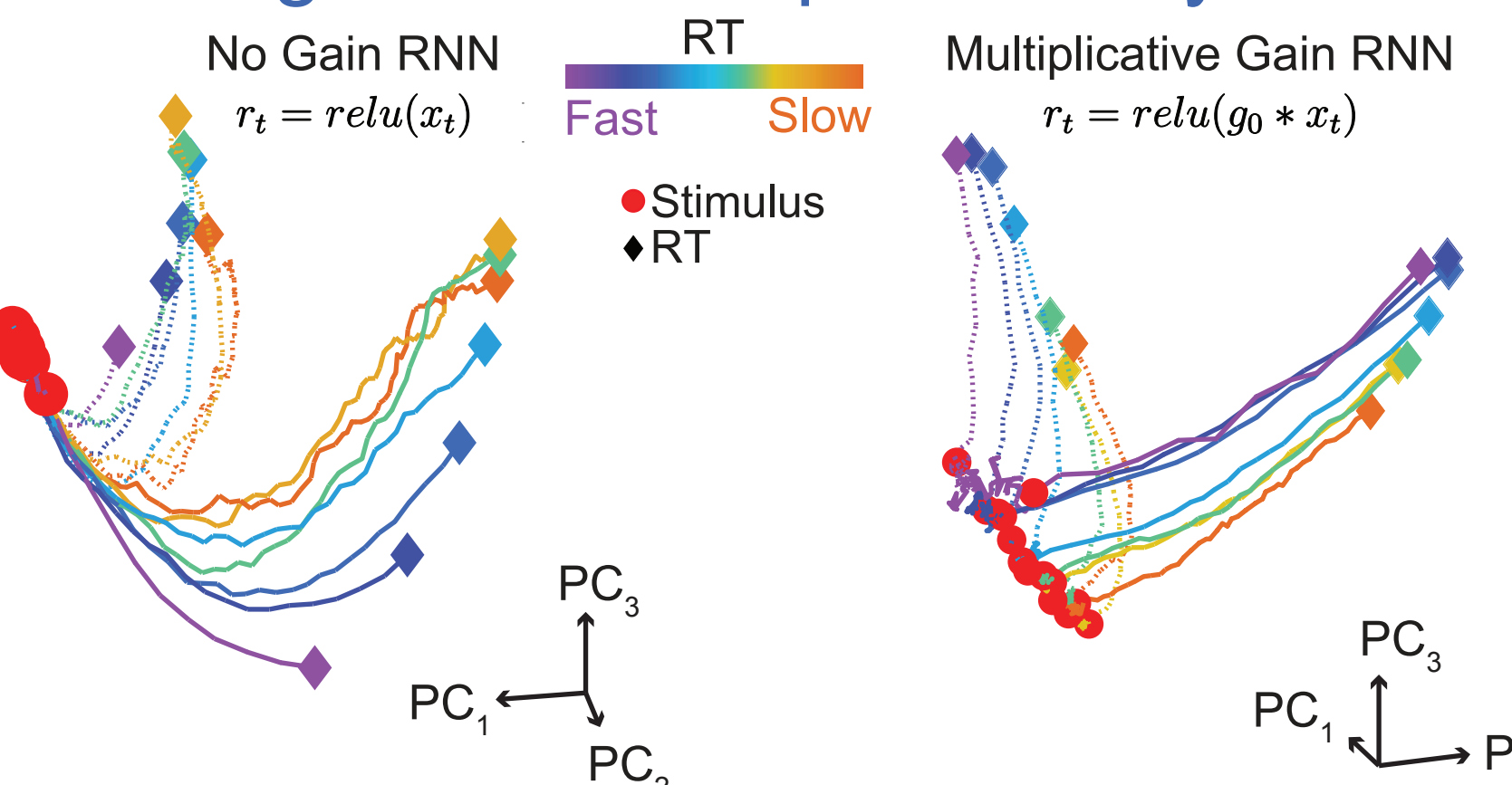
Position and "velocity" of initial condition correlate with poststimulus dynamics and RT



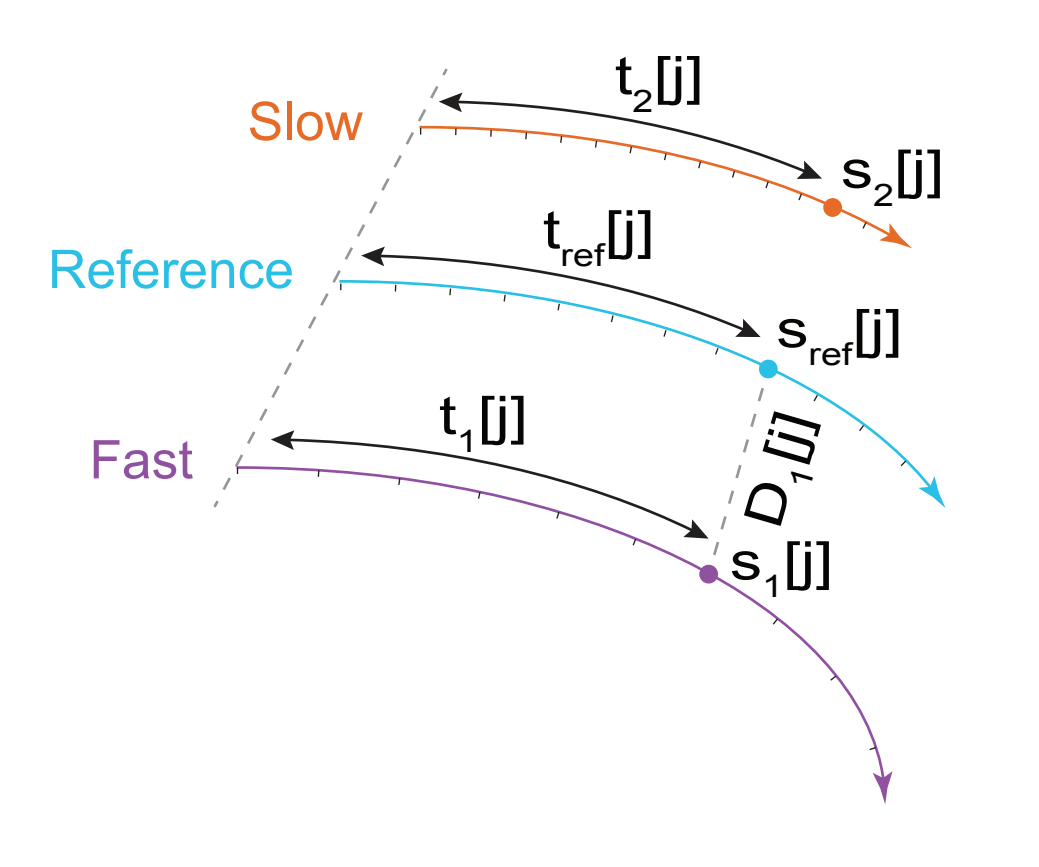
Initial conditions predict RT but do not predict eventual choice



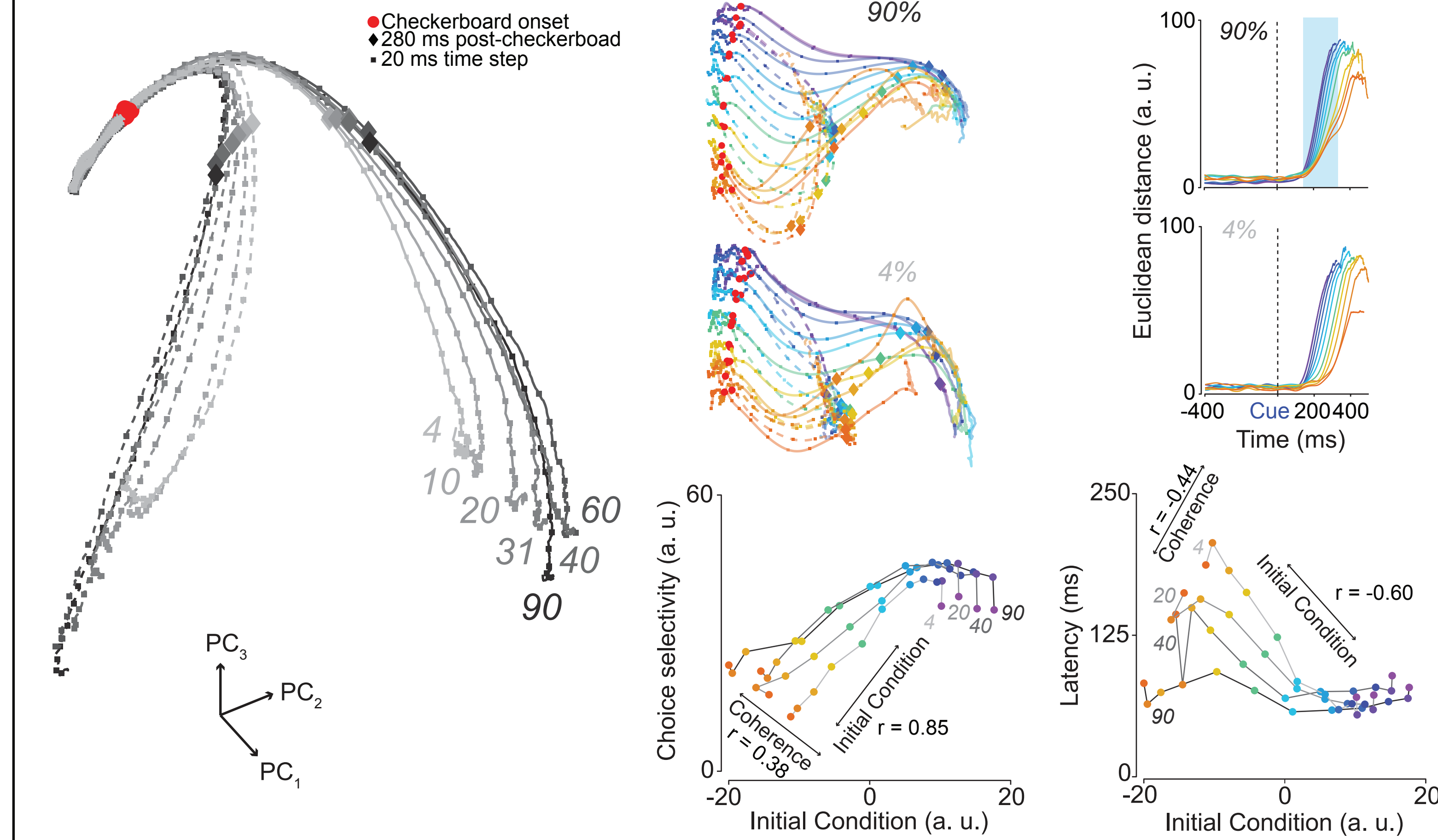
Gain signal RNNs reproduce dynamics



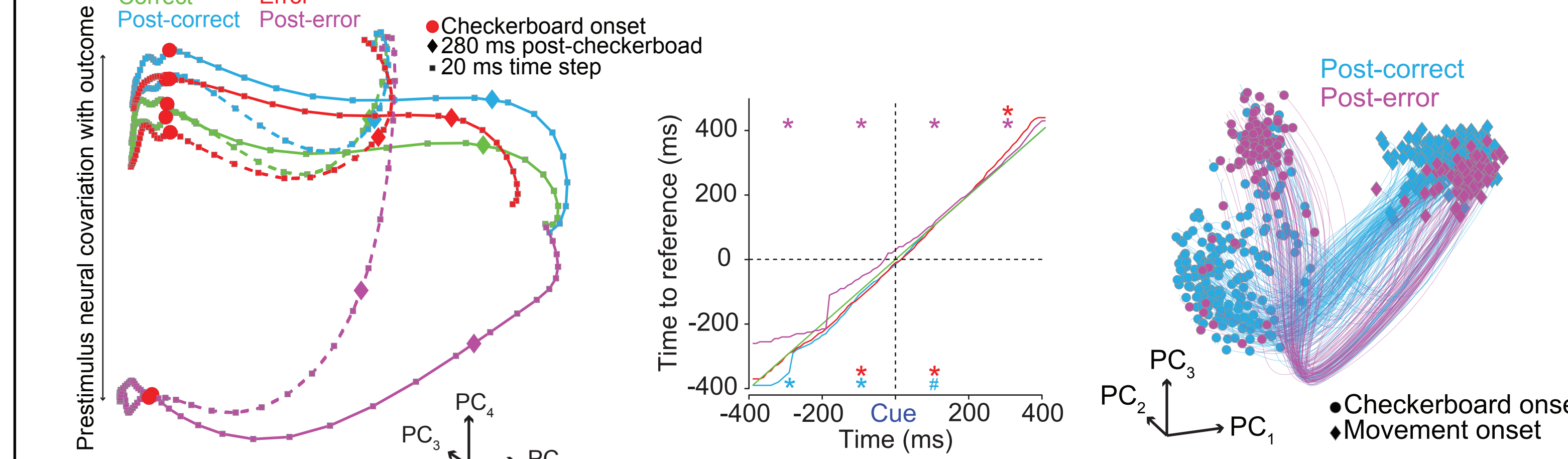
Methods - KiNeT



Inputs and initial conditions both contribute to the speed of poststimulus decision-related dynamics



The outcome of the previous trial influences the initial condition



Conclusions

- Lawful relationships between low-dimensional neural activity and task variables such as choice, RT, stimulus difficulty, and past outcomes
- Initial conditions have as strong or stronger impact, as compared to inputs, in determining timing of decision-related dynamics and behavior
- Bridges previously disparate findings from SAT, PES, and motor planning providing a framework for deriving decision-making models

References

1. Afshar, A., Santhanam, G., Yu, B. M., Ryu, S. I., Sahani, M., and Shenoy, K. V. (2011). Single-trial neural correlates of arm movement preparation. *Neuron*, 71:555-564.
2. Remington, E. D., Narain, D., Hosseini, E. A., and Jazayeri, M. (2018). Flexible sensorimotor computations through rapid reconfiguration of cortical dynamics. *Neuron*, 98:1005-1019.e5.
3. Pandarinath, C., O'Shea, D. J., Collins, J., Jozefowicz, R., Stavisky, S. D., Kao, J. C., Trautmann, E. M., Kaufman, M. T., Ryu, S. I., Hochberg, L. R., Henderson, J. M., Shenoy, K. V., Abbott, L. F., and Sussillo, D. (2018). Inferring single-trial neural population dynamics using sequential auto-encoders. *Nature Methods*, 15:805-815.

Acknowledgements

