

# Black-box optimization of cognitive control with electrical stimulation

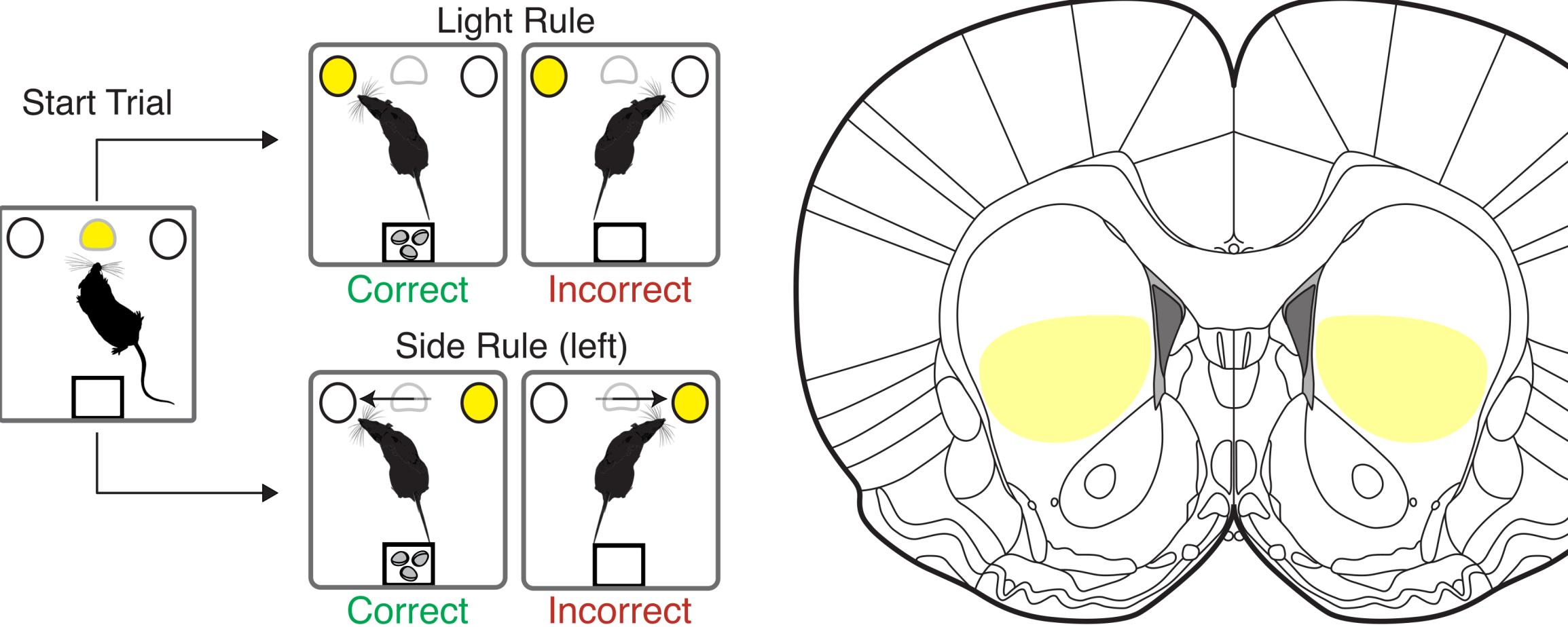
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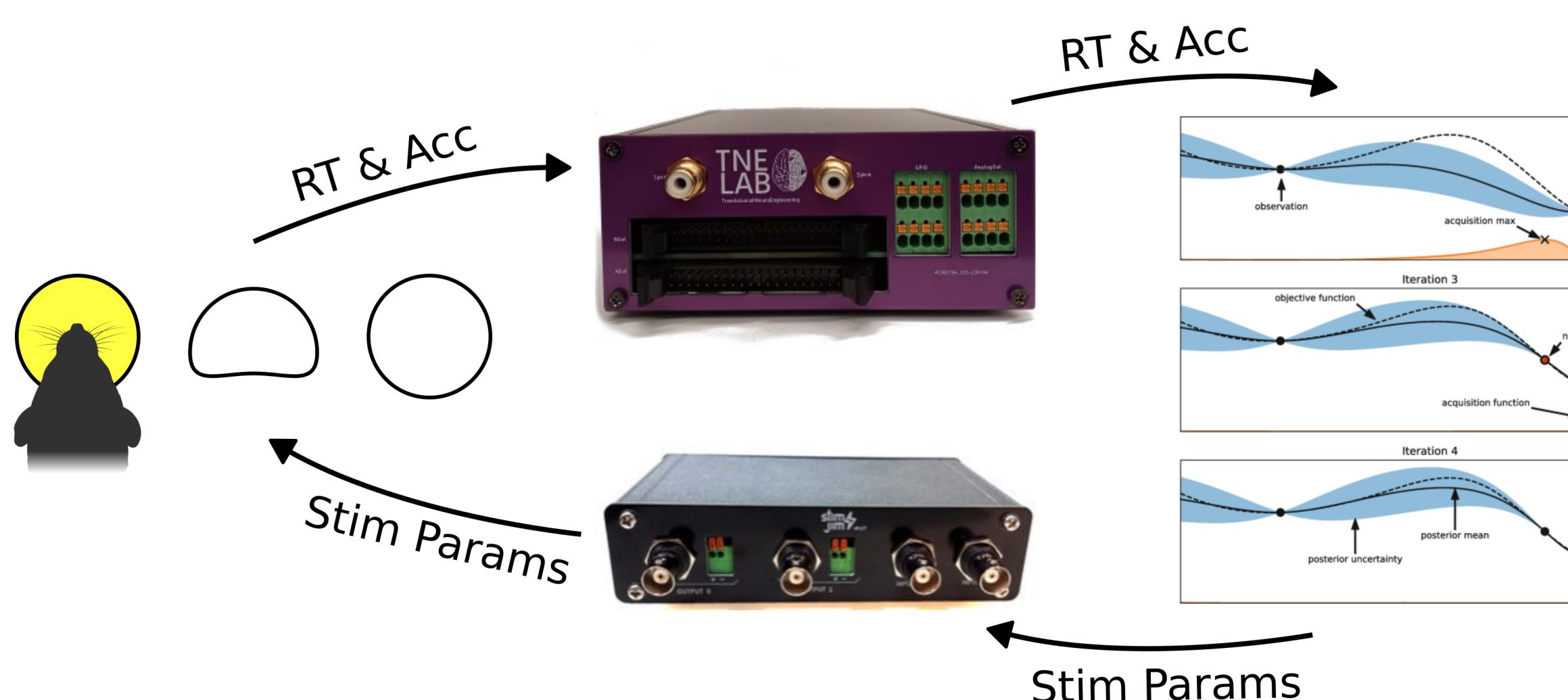
## Intro

- The balance between flexible and rigid thinking is disrupted in psychiatric disorders
- Cognitive control tasks have been used to probe this balance in rats and humans
- Previous work has demonstrated that electrical stimulation can enhance cognitive control in both rats and humans
- Reaction times are a valid trial-to-trial readout of cognitive control that could be used as a guiding signal for identifying clinically effective parameters

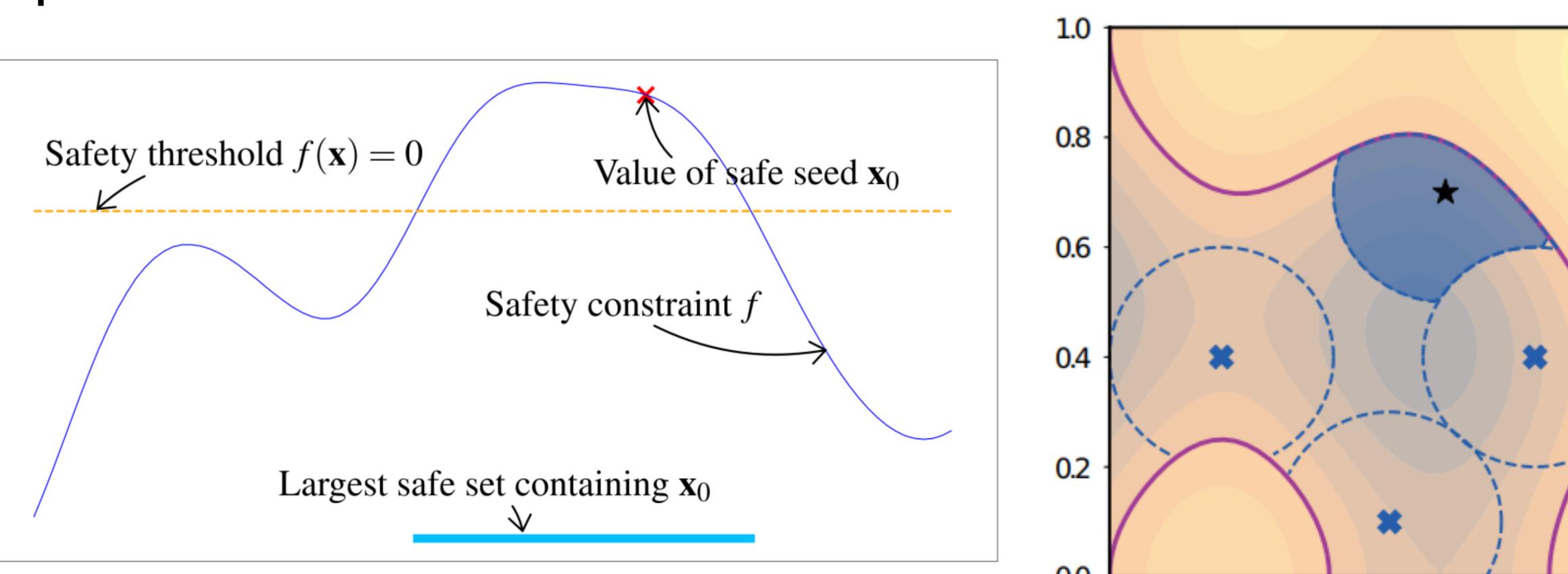
## Methods



- Long-Evans rats were implanted with bipolar, platinum stimulating electrodes in mid-striatum and completed an extradimensional set-shifting task

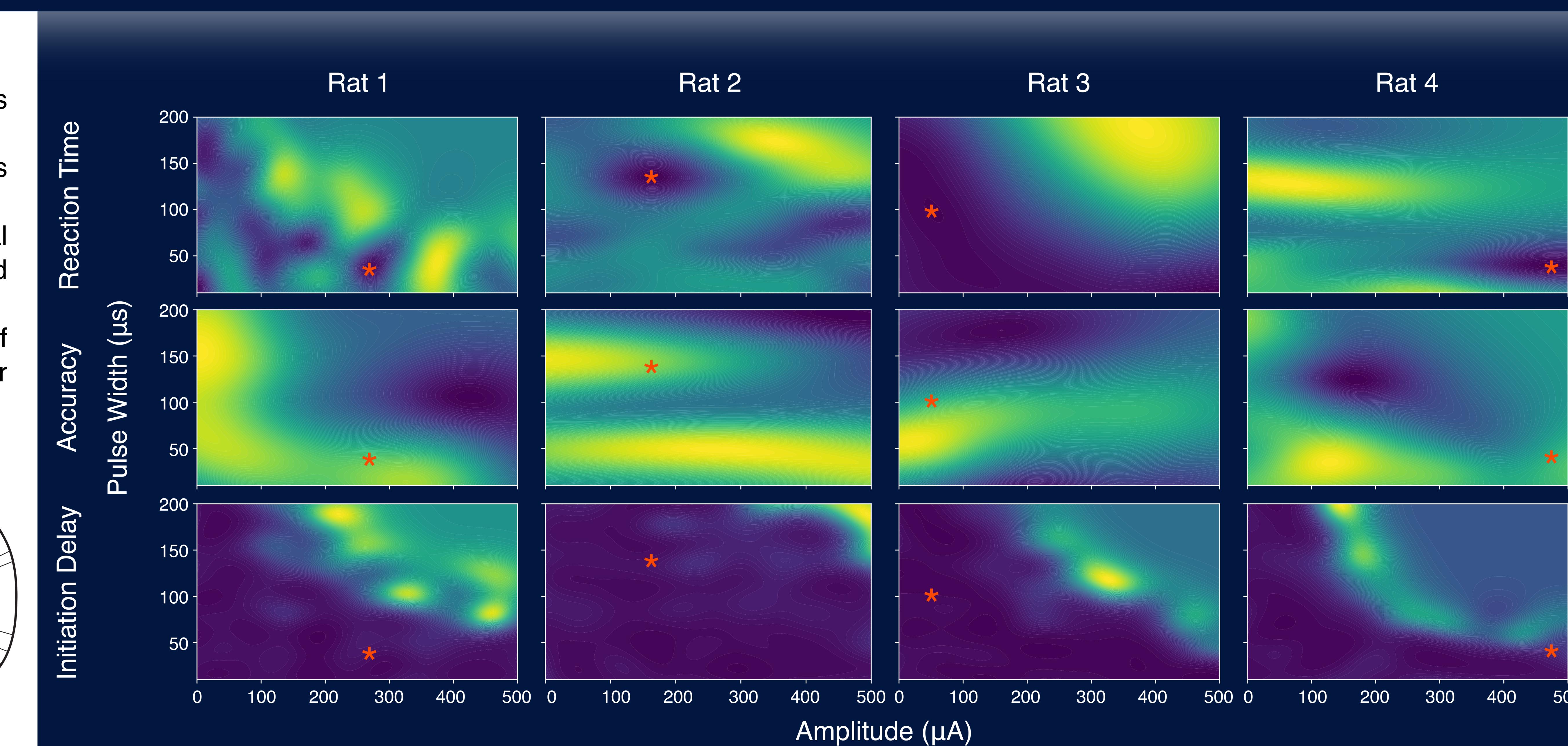


- During each session, reaction times, accuracy, and delays in initiation were sent in real-time to a Bayesian optimizer

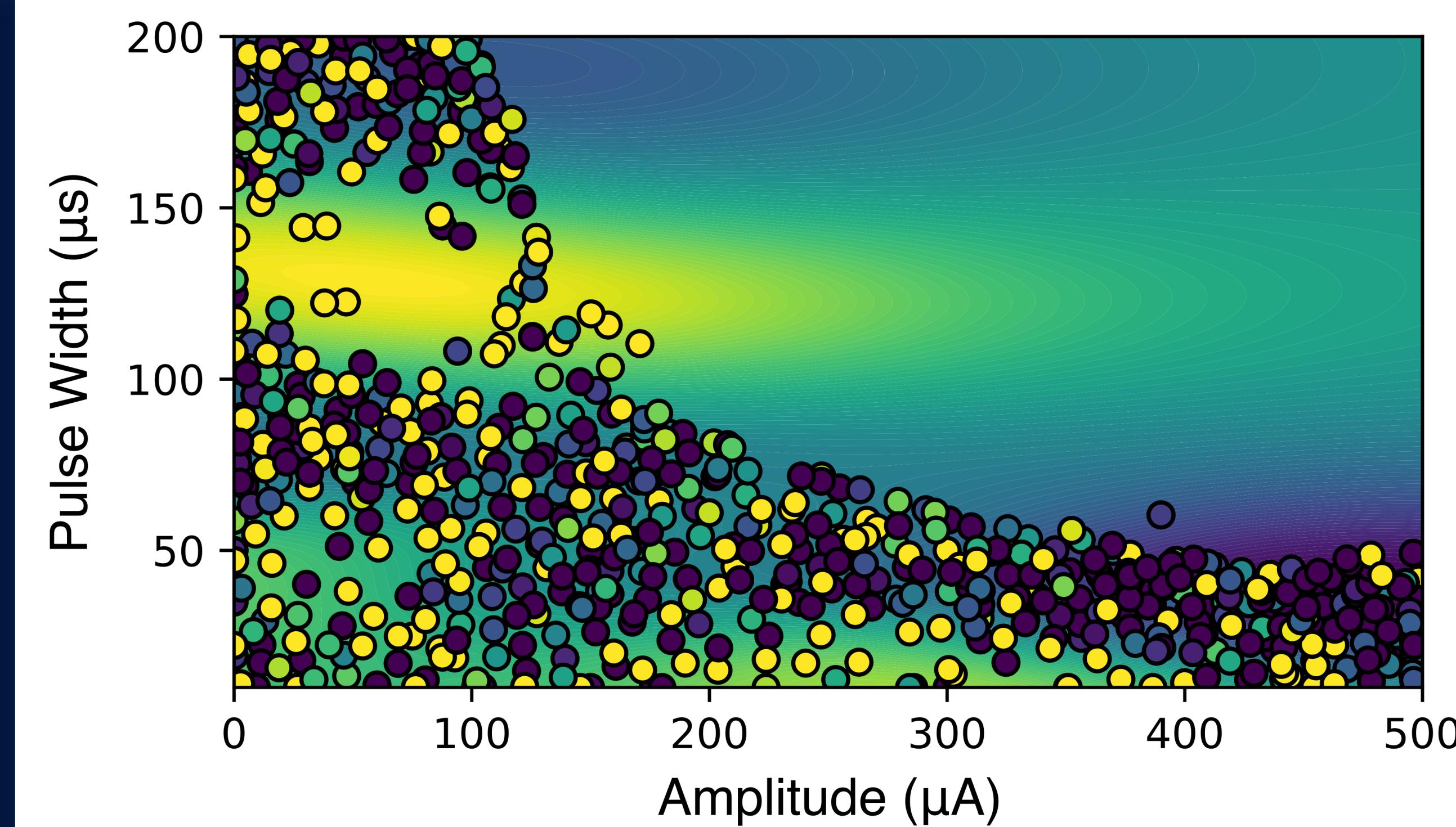


- Information theoretic safe exploration (ISE) was used to define a safe region to sample in based on initiation delay while expected coverage improvement (ECI) was used to robustly sample effective parameters

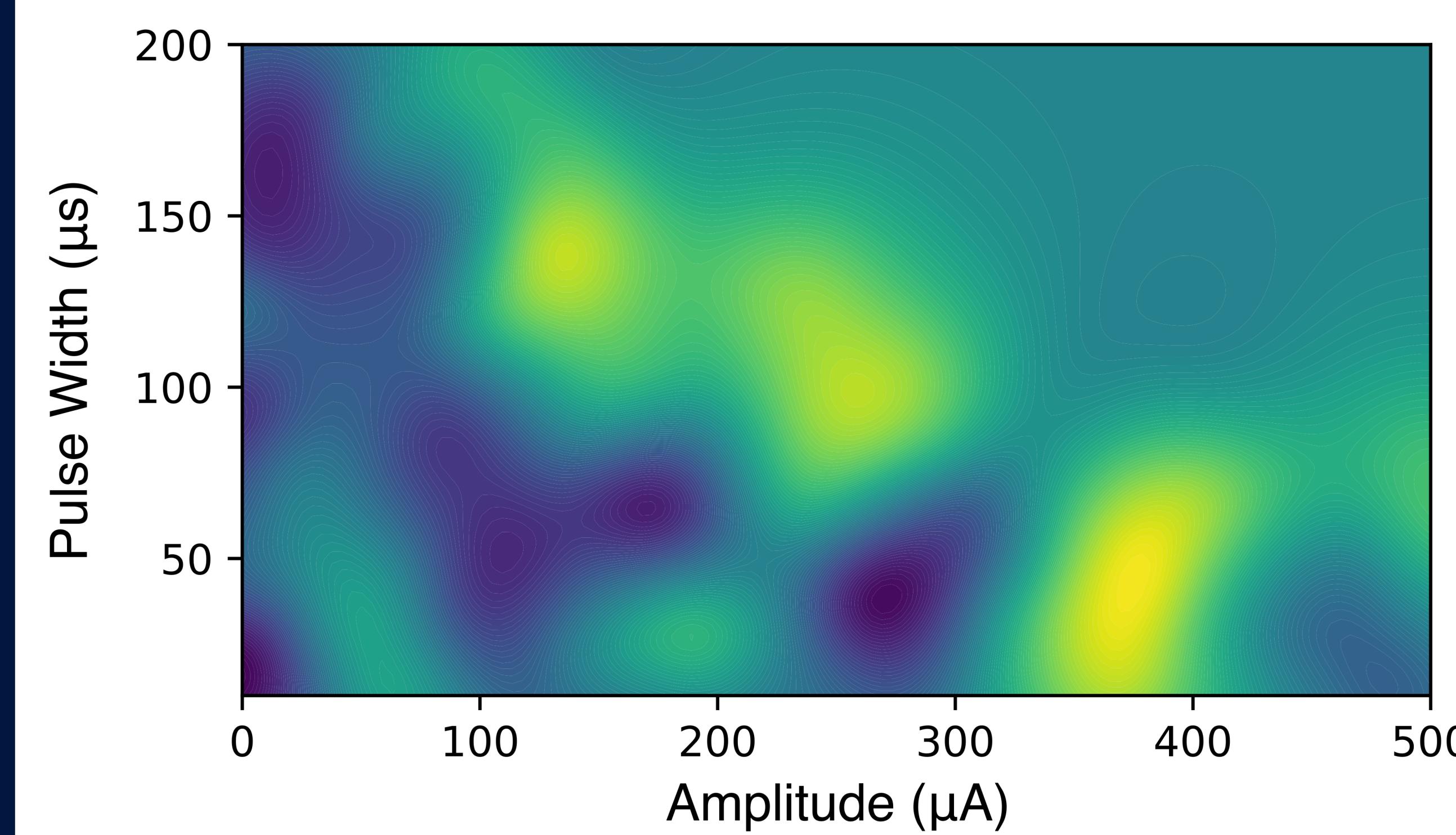
- Following optimization, optimal parameters were compared to sham and standard (300  $\mu$ A, 50  $\mu$ s) settings across sessions.



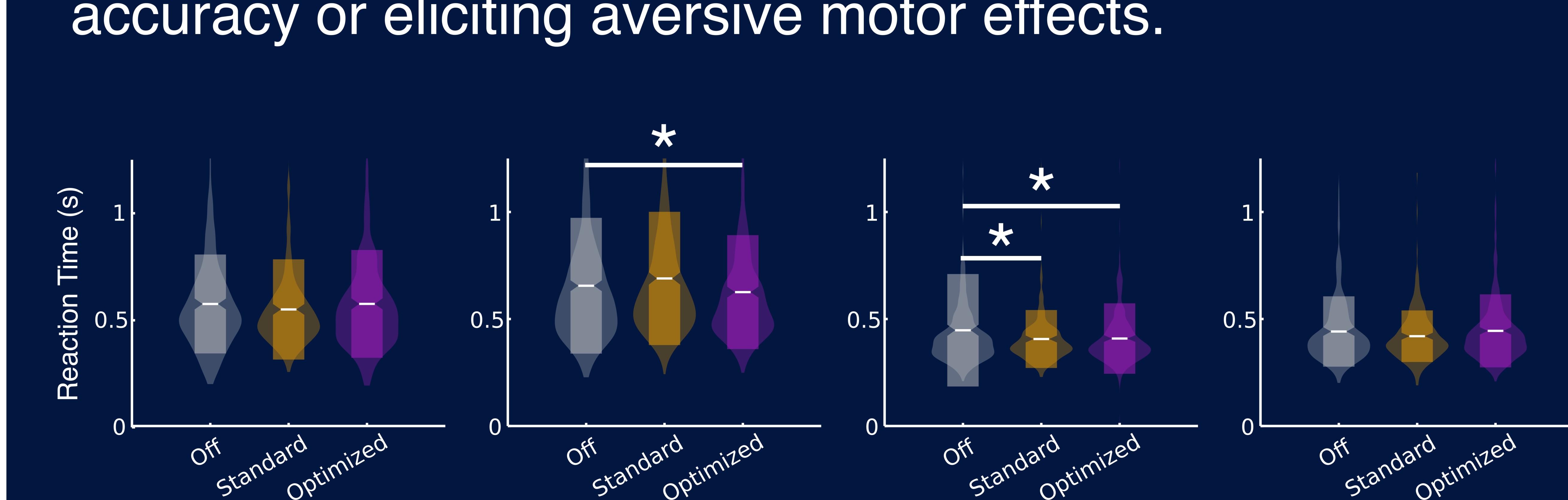
## Future Improvements



- Expected coverage improvement was overly-exploitative when sampling. The model was highly susceptible to a few spurious, neighboring outlier samples dictating parameter regions. Future acquisition functions need a better explore-exploit balance.



- Kernel hyperparameters were refit continuously during optimization. However, for some rats, these parameters became heavily localized and overfit to spurious fluctuations. Hyperparameters could be specified in advance according to simulations from sample data.



2 of the 4 rats showed significant, sustained improvements in reaction times for the parameters identified during optimization.

## Discussion

- The safe range of stimulation parameters varied between rats necessitating rigorous methods like ISE for identifying regions to sample
- The parameters identified during optimization were at least if not more effective than standard settings
- Optimal parameters were ineffective for 2 of the 4 rats requiring further robustness and improvements for the optimization approach

## Acknowledgements

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