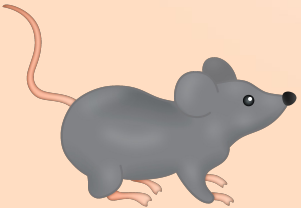
neuromatch academy

From stimulus to choice: Modeling decision-making and feedback effects in mice



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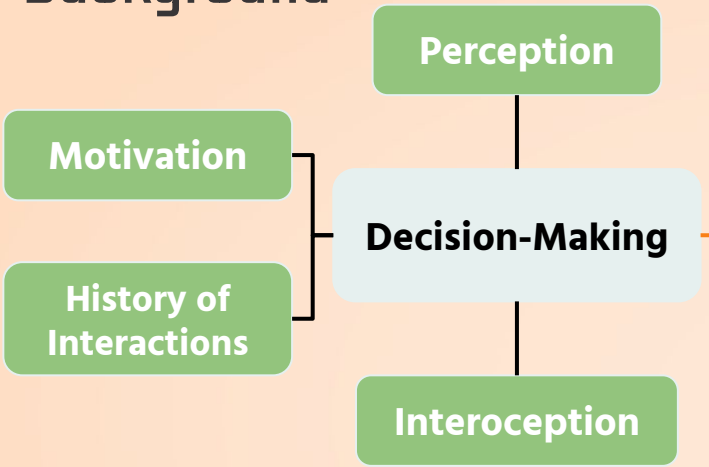
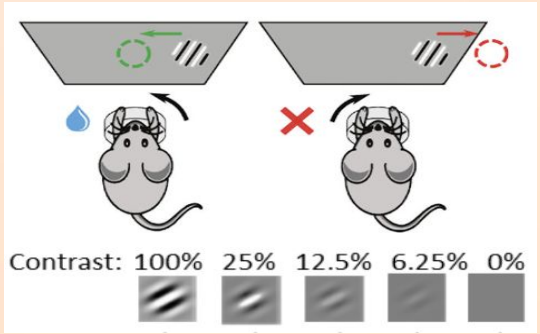
Background



High-order phenomenon present across multiple species

How decision-making integrates low-level sensory input with task-based features that depend on the agent's previous choices?

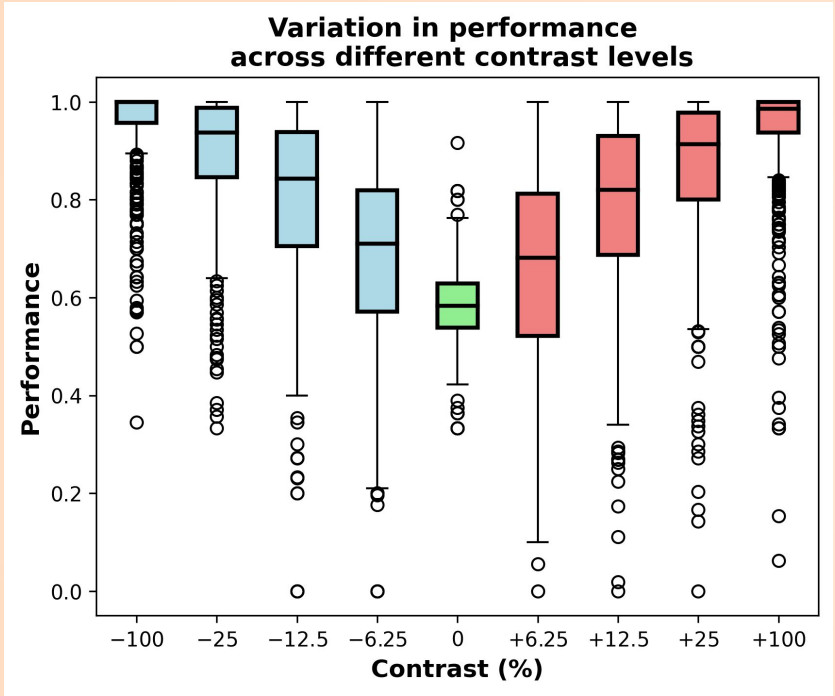


INTERNATIONAL BRAIN LABORATORY

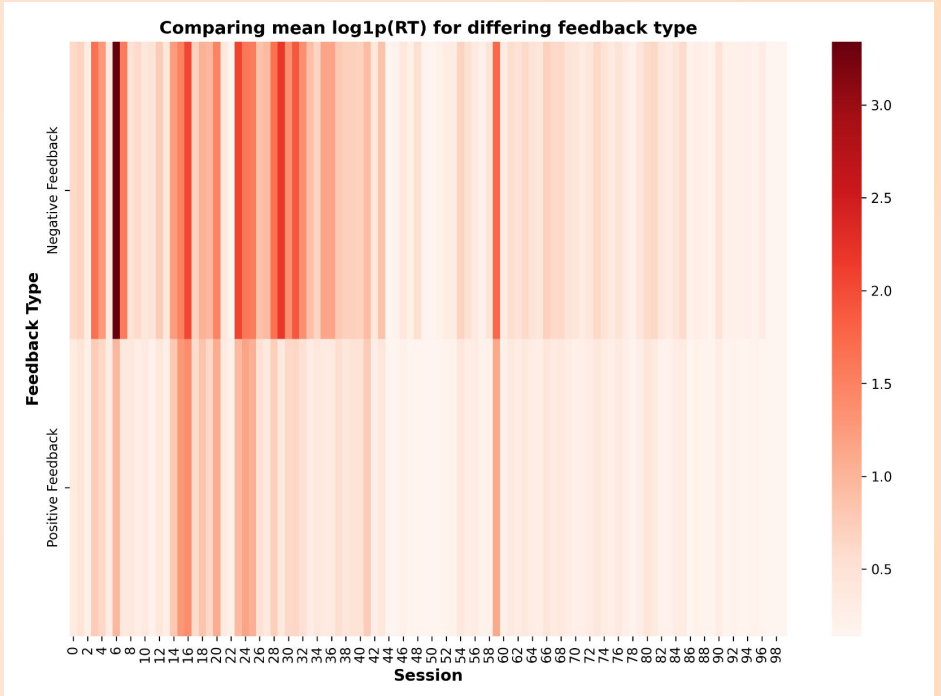
Standardized 2-Alternative Forced Choice Task (2AFC) task with Feedback implemented on mice.

The present project seeks to understand which factors affect/influence the decision-making process in mice trained to perform a 2-Alternative Forced Choice (2AFC) task

Background: Diving into the dataset



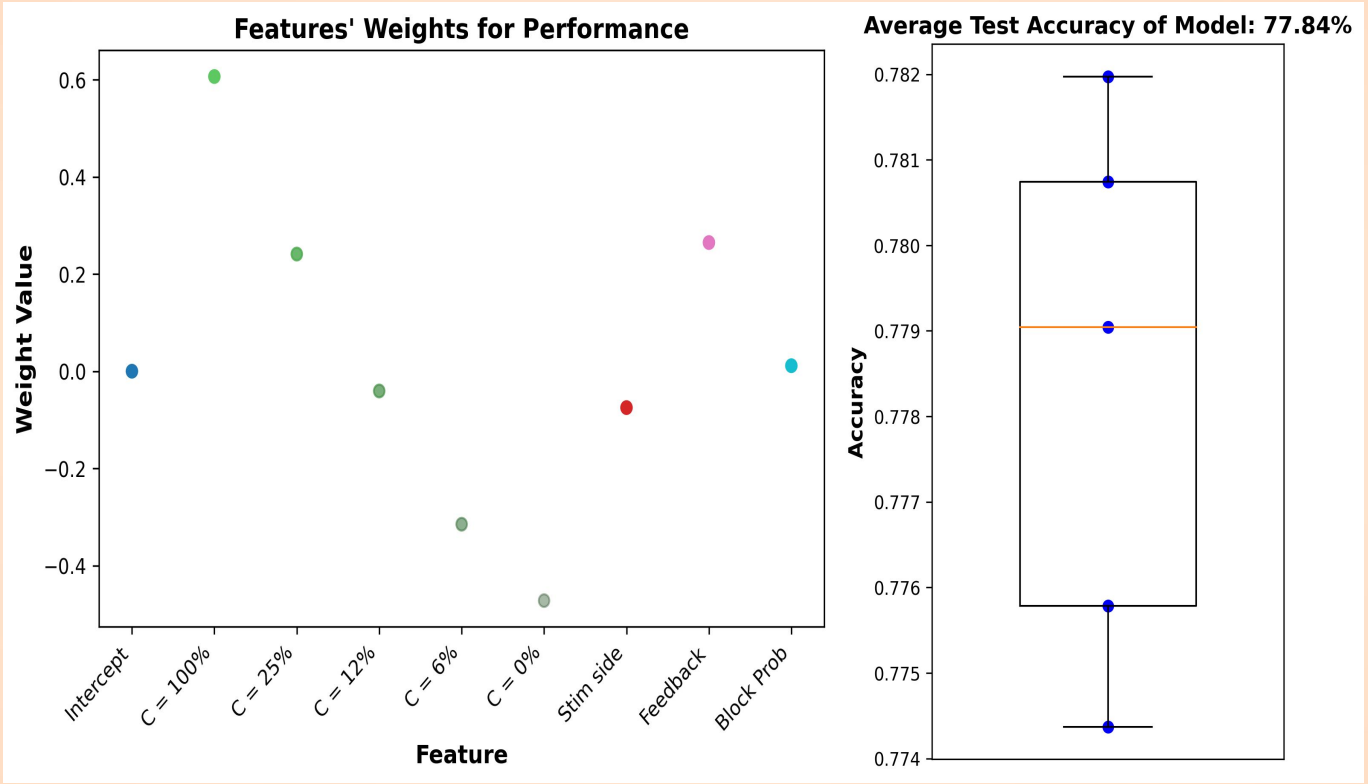
Performance is influenced by the contrast level and the presentation side of the stimulus: **Logistic Regression Model**



Prior history could also influence the decision in the succeeding trial, modifying learning strategies: **General Drift-Diffusion Model**

We aim to apply modeling strategies to show how decision-making integrates low-level sensory input with trial-based features that depend on the agent's previous choices

Analysis 1: Logistic Regression Model



We see that contrast and feedback are the major features used by mice in the decision-making computation

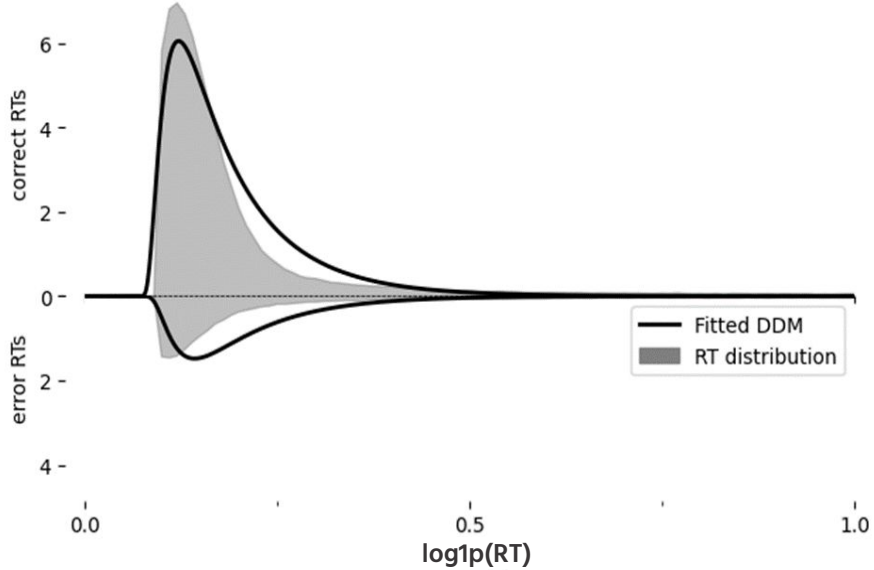
Analysis 2: General Drift-Diffusion Model

Model 1 (static parameters)
Drift = 1.939
Noise = 1, dt = 0.005 (default)
Bound = 0.3759
Starting position = 0.0
Non-decision time = 0.0778
Loss = 83843

Model 2 (varying drift)
Drift = 3.6957*feedbackType
Noise = 1, dt = 0.005
Bound = 0.5173
Starting position = 0.0
Non-decision time = 0.0631
Loss = -13583

Model 3 (varying drift)
Drift = 1.6957*feedbackType
Noise = 0.5, dt = 0.001
Bound = 0.2573
Starting position = 0.1183
Non-decision time = 0.0656
Loss = -17550

Model 4 (varying drift, RT < 60)
Drift = 1.8170*feedbackType
Noise = 0.5, dt = 0.001
Bound = 0.2506
Starting position = 0.1034
Non-decision time = 0.0678
Loss = -36863



We see that a feedback dependence is necessary to capture the dynamics of the decision-making process

Conclusions

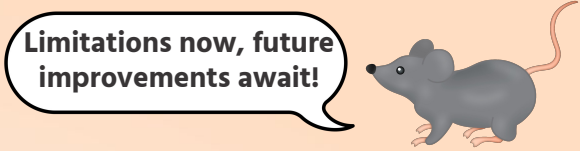
1. Preliminary analysis of the data revealed a variation in mice's performance and response time with stimuli contrast and the previous trials' feedback, respectively.

2. Through a logistic regression model, we concluded that contrast and feedback are the major features used by mice in the decision-making computation.

3. Using the drift-diffusion model, we see that a feedback dependence is necessary to capture the dynamics of the decision-making process.

The project utilized modeling to gain an understanding on how visual contrast and feedback affect the performance of mice, and how feedback affects the dynamics of decision-making

Limitations and Future Work



Limitations		Future Work
LRM and DDM are abstractions Better DDM fit	**Model Design**	Explore non-linear models (neural network, tree based models) Bayesian priors
Excludes internal state, environmental context, long-term effects Not considering non-decision trials	**Feature Set**	Neural recordings Low contrast trials
Species-specific behaviors	**Comparative Studies**	Cross-subject comparisons (individual differences)

Future work should improve models and include more factors to understand decision-making better

References

1. Standardized and reproducible measurement of decision-making in mice *eLife* 2021, **10**, e63711, https://doi.org/10.7554/eLife.63711

2. A practical introduction to using the drift diffusion model of decision-making in cognitive psychology, neuroscience, and health sciences. *Frontiers in Psychology* 2022, **13**, 1039172. https://doi.org/10.3389/fpsyg.2022.1039172