Efficient coding in auditory cortex determines target detection behavior

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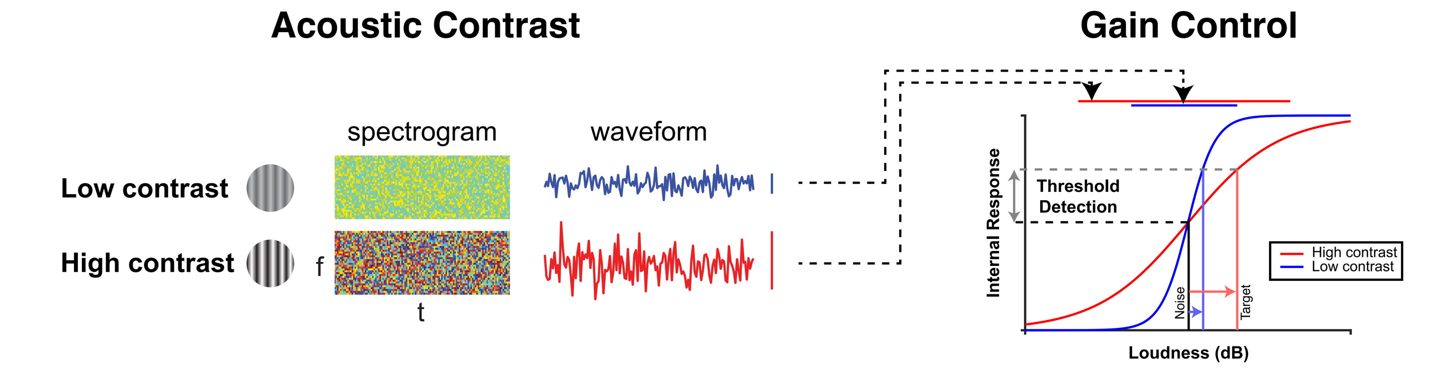
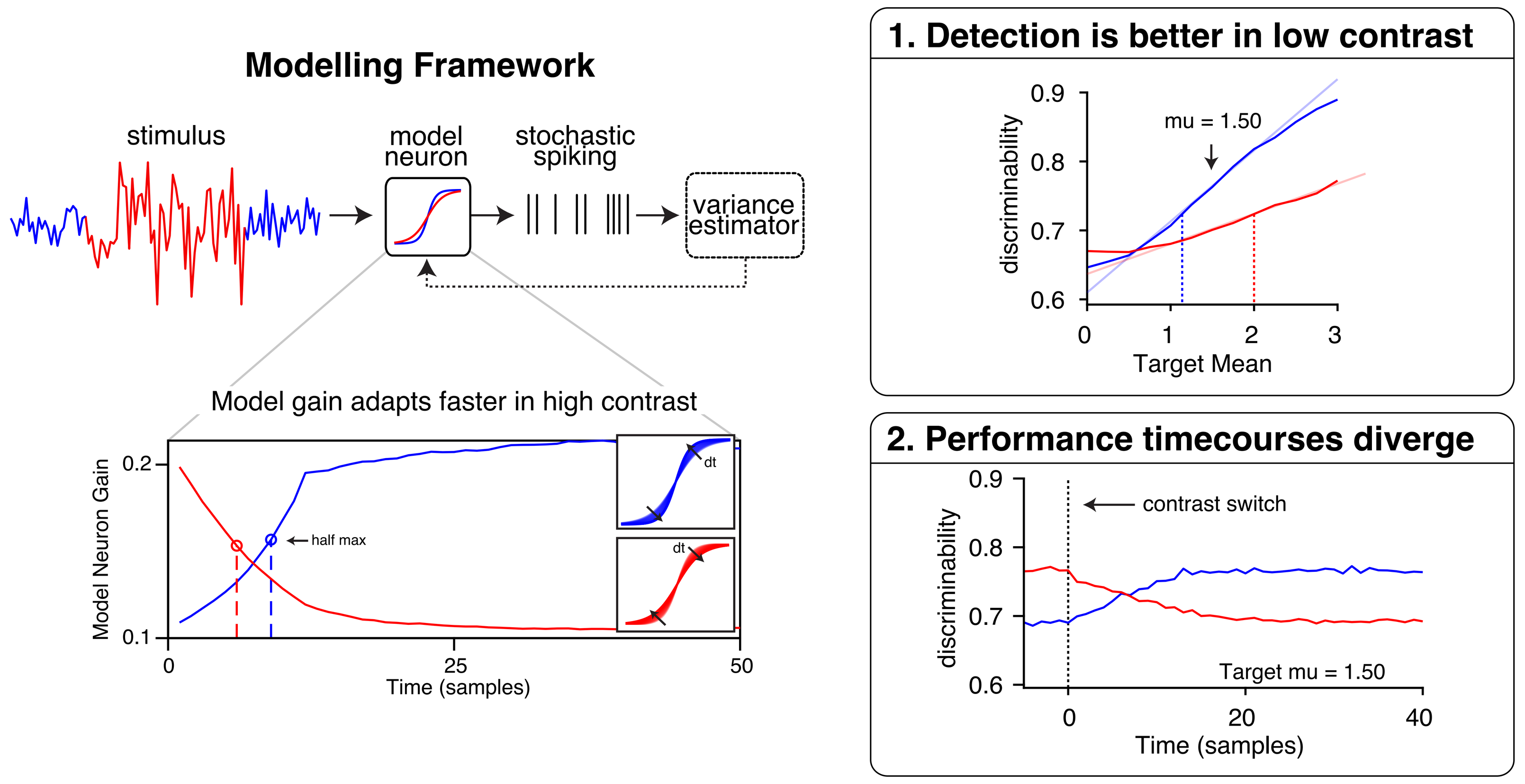
Background

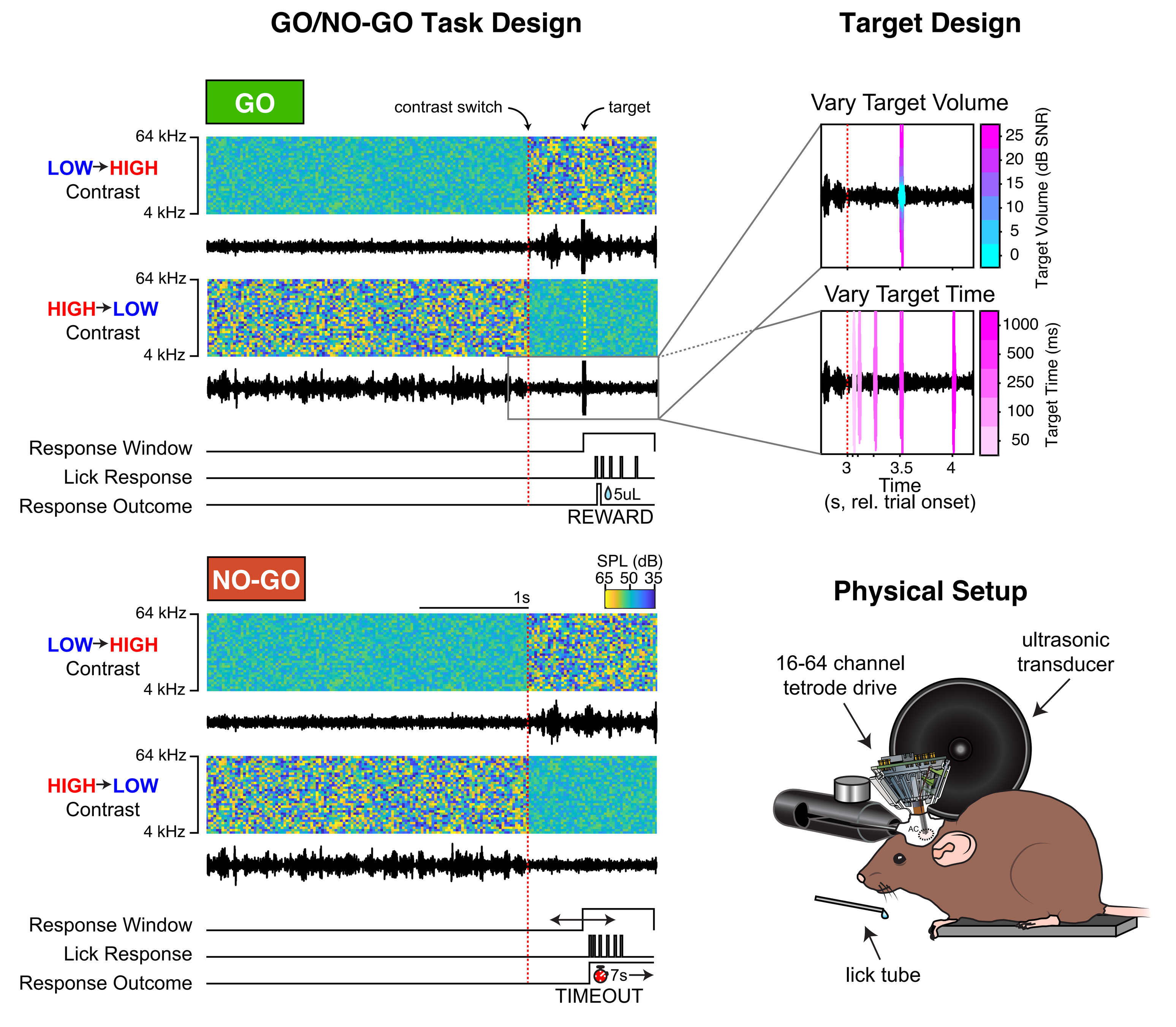
Efficient coding theory hypothesizes that neural systems are optimized to minimize the number of spikes needed to transmit sensory signals (Barlow, 1961). Given this constraint, it is necessary for sensory neurons to adapt their limited dynamic range to encode varying dynamic ranges of incoming information with high fidelity. In the auditory system, **contrast gain control** is a well-documented hallmark of efficient coding in the face of sensory variability. Neurons in auditory cortex (ACtx) adjust their gain to better encode acoustic stimuli with different variability, ie. different contrasts (Rabinowitz et al., 2011; 2013; Cooke et al., 2018; Lohse et al., 2020). However, it is unclear whether gain control in auditory cortex directly contributes to auditory percepts, and there is no current framework linking the neural phenomena to behavioral performance. **Here we chronically record populations of neurons in mice trained to perform a contrast-dependent detection task, and present a theoretical framework of efficient gain control to link our neural and behavioral findings.**



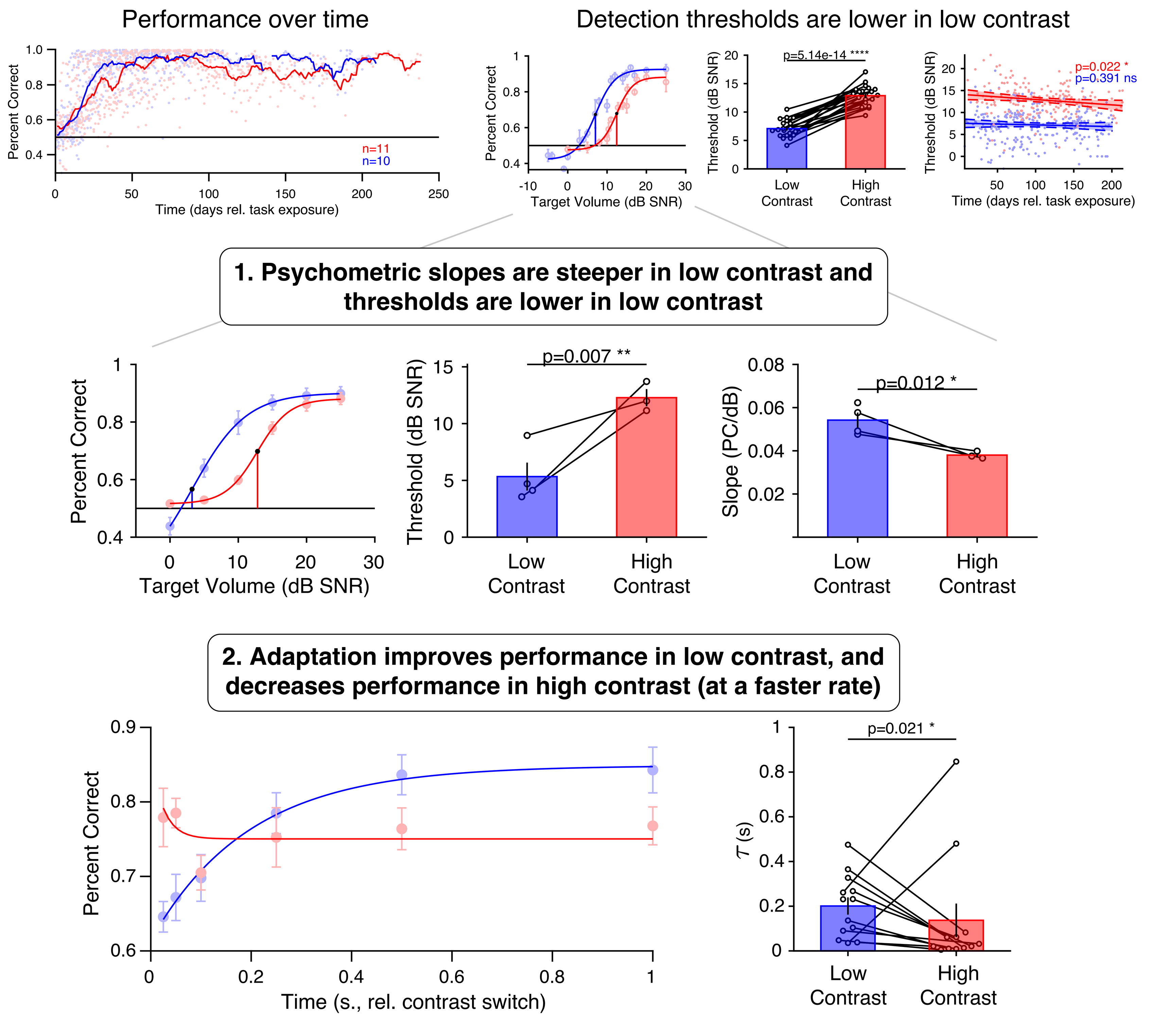
Efficient Coding Model Predictions



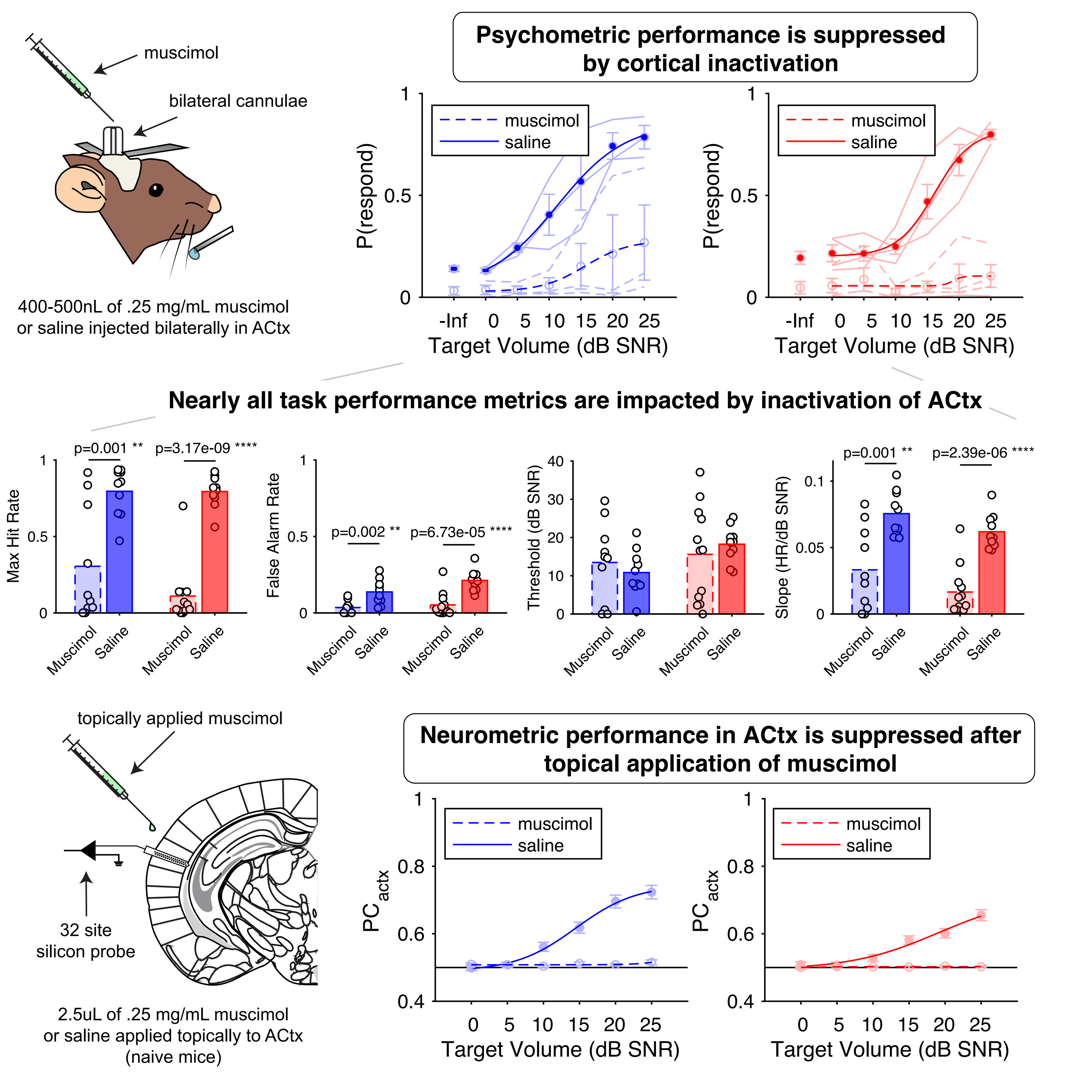
Materials and Methods



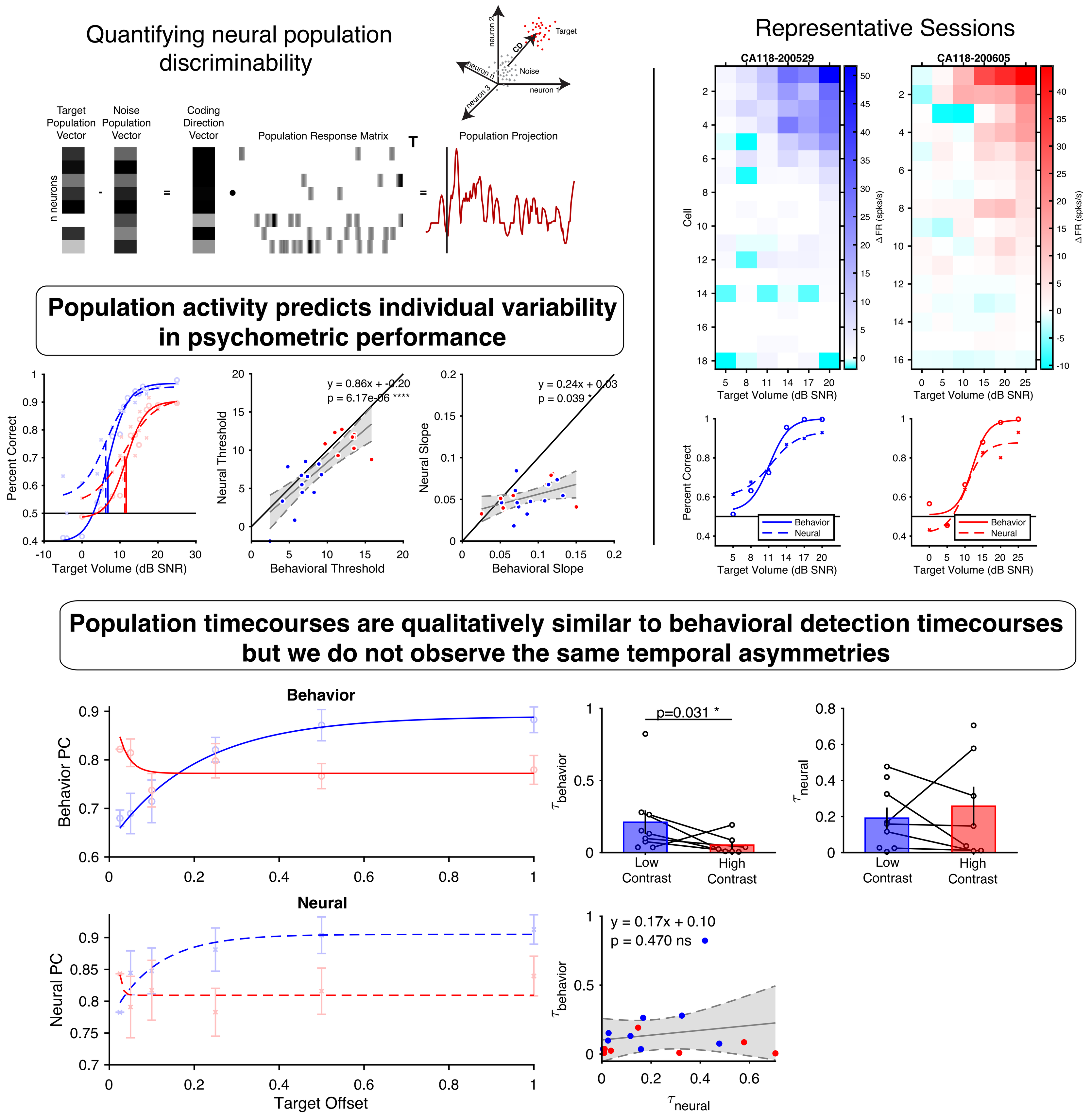
Behavioral performance is consistent with gain control



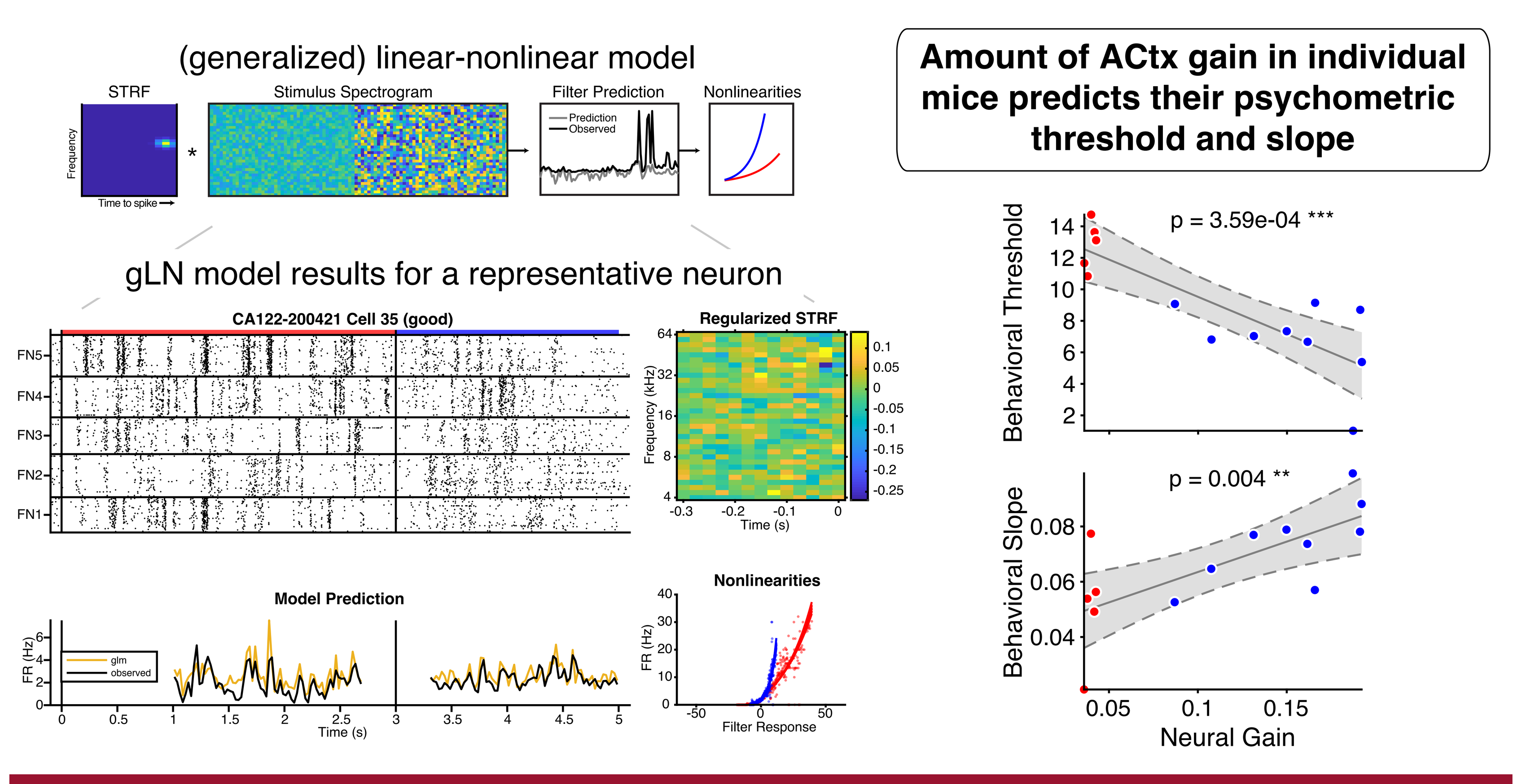
ACtx is necessary for behavioral performance



Population activity in ACtx predicts individual performance



Gain in ACtx also predicts individual performance



Conclusions

1) A normative model of contrast gain control predicts contrast-dependent changes in psychometric performance and specific patterns of behavioral adaptation.

2) We designed a novel target-in-noise detection task to show the model predicts observed contrast-dependent behavioral changes.

3) Muscimol inactivation experiments show necessity of ACtx in performing this task.

4) Chronic recordings of population activity in ACtx show that population representations predict behavioral variability across mice.

5) Estimated amount of cortical gain during the task predicts individual differences in behavior.

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