Simulation-based Bayesian inference of state feedback control model parameters to fit f_o perturbation responses in laryngeal dystonia

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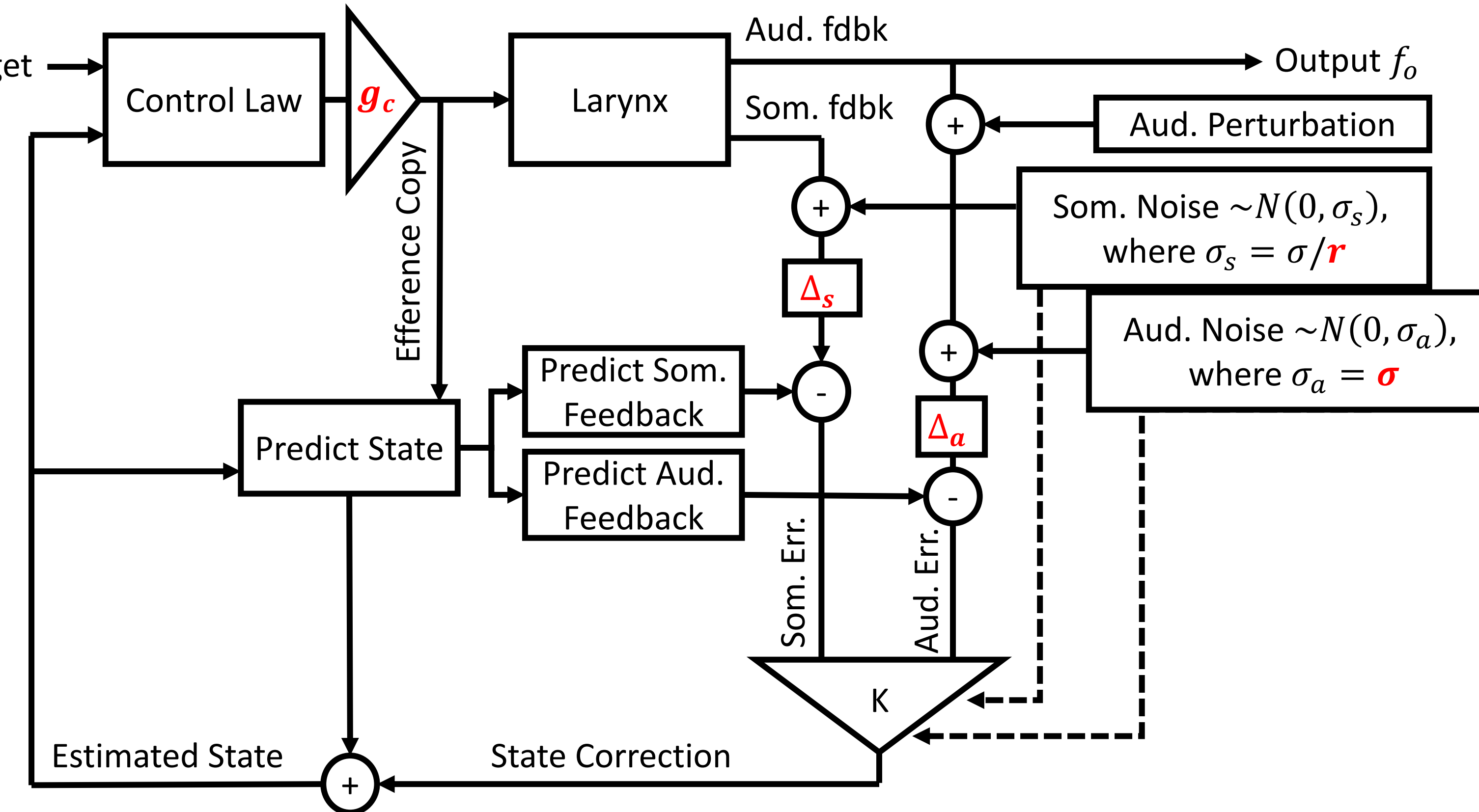[3] Department of Communication Sciences and Disorders, University of Wisconsin–Madison, [4]Department of Otolaryngology, University of California, San Francisco, [5]Modality.AI, San Francisco

Introduction

- Computational modeling was used to explore the neural mechanisms of speech motor control
- A **state feedback control model** was used to simulate a participant's behavioral response to a pitch perturbation experiment
- Bayesian inference was used to determine the set of model parameters **most likely to produce a pitch perturbation response matching that described by existing data**
- The selected model parameters were **compared between patient and control groups**

Simulator

The state feedback control model architecture [1,2] is shown below. The parameters fit are auditory feedback delay (Δ_a), somatosensory feedback delay (Δ_s), overall feedback noise covariance (σ), feedback noise ratio (r), and controller gain (g_c).

Som. Noise $\sim N(0, \sigma_s)$, where $\sigma_s = \sigma / r$

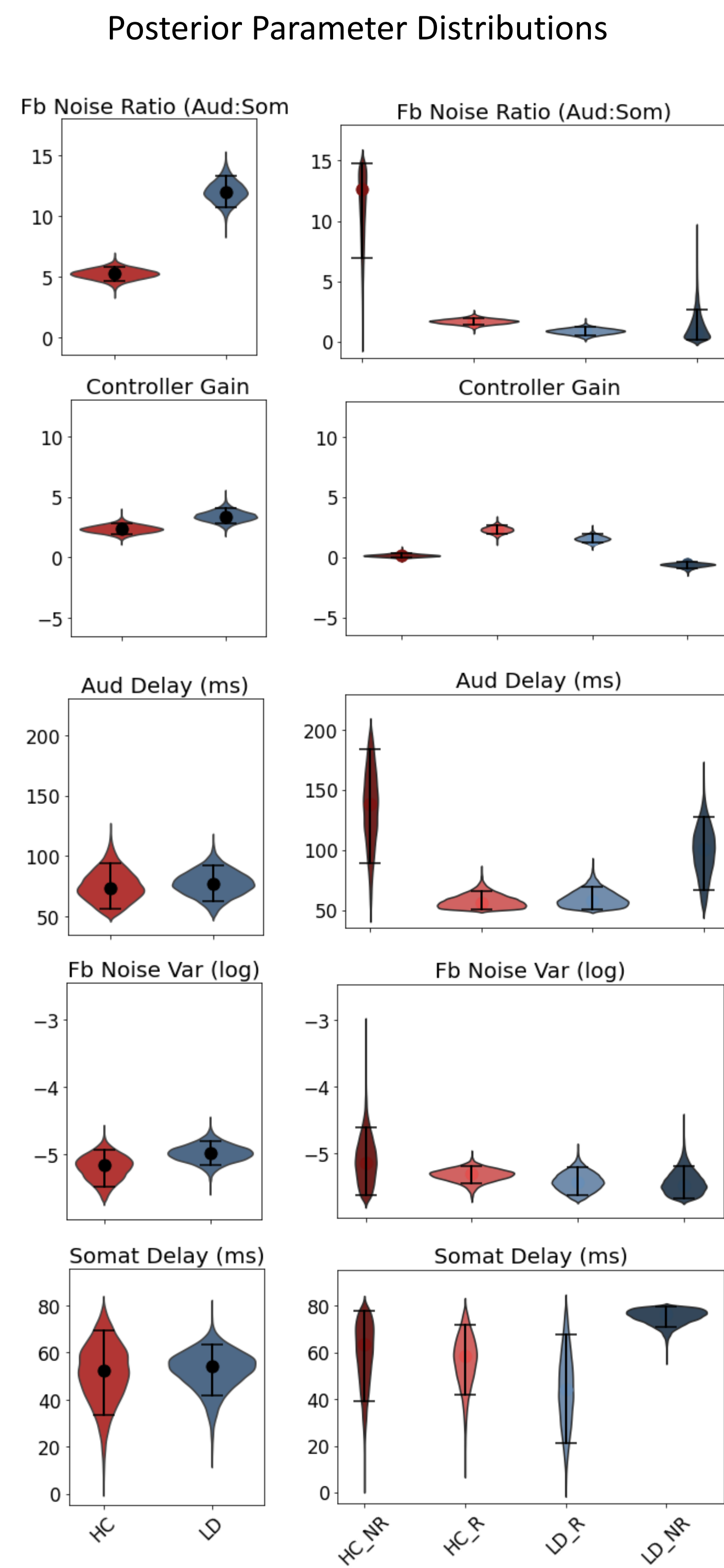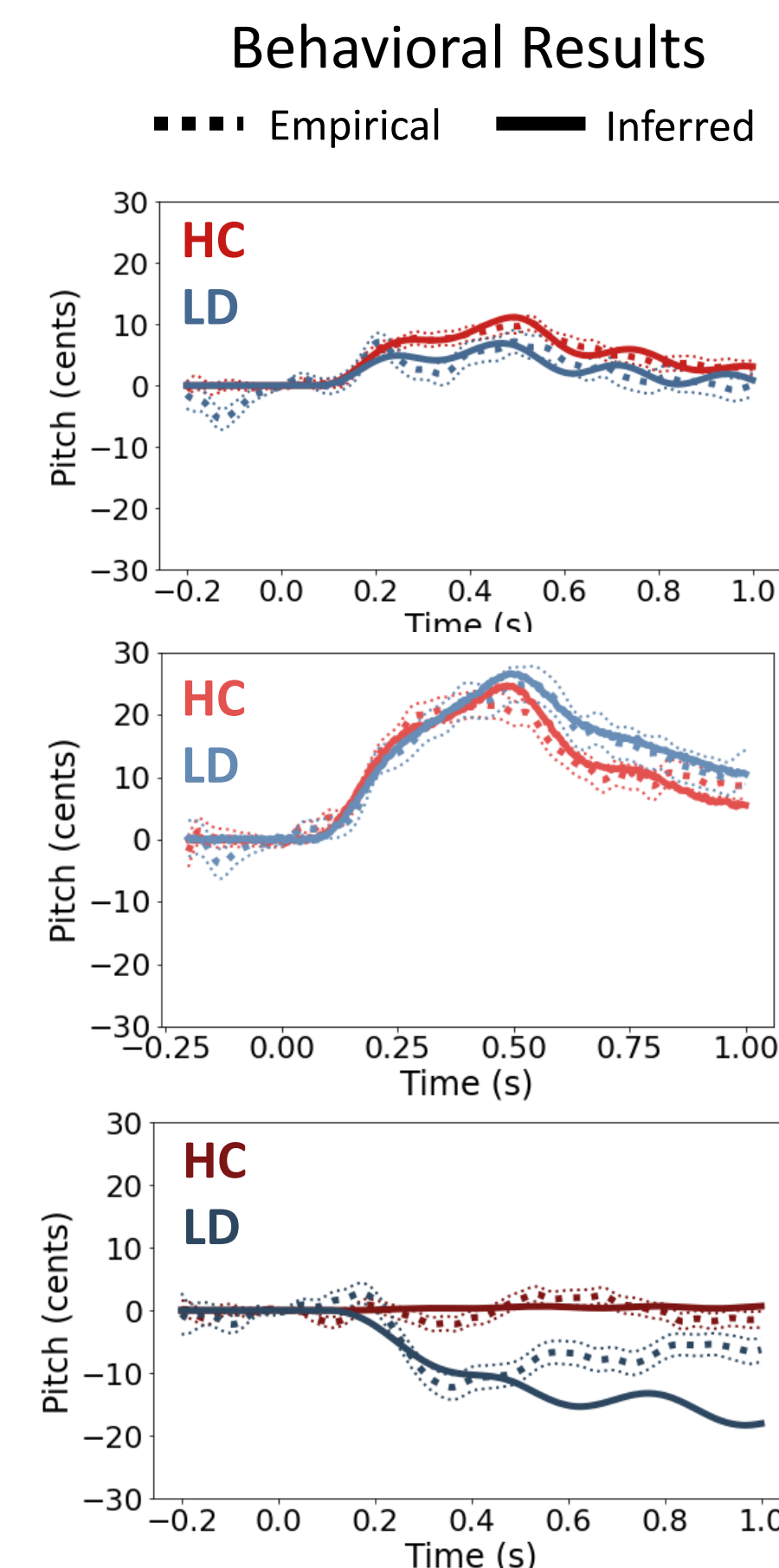Aud. Noise $\sim N(0, \sigma_a)$, where $\sigma_a = \sigma$

Inference

The Python package `sbi` [3,4], a toolbox for simulation-based inference, was used to fit a state feedback control model to pitch perturbation data

A distribution and inferred value for each parameter was determined by sampling the posterior
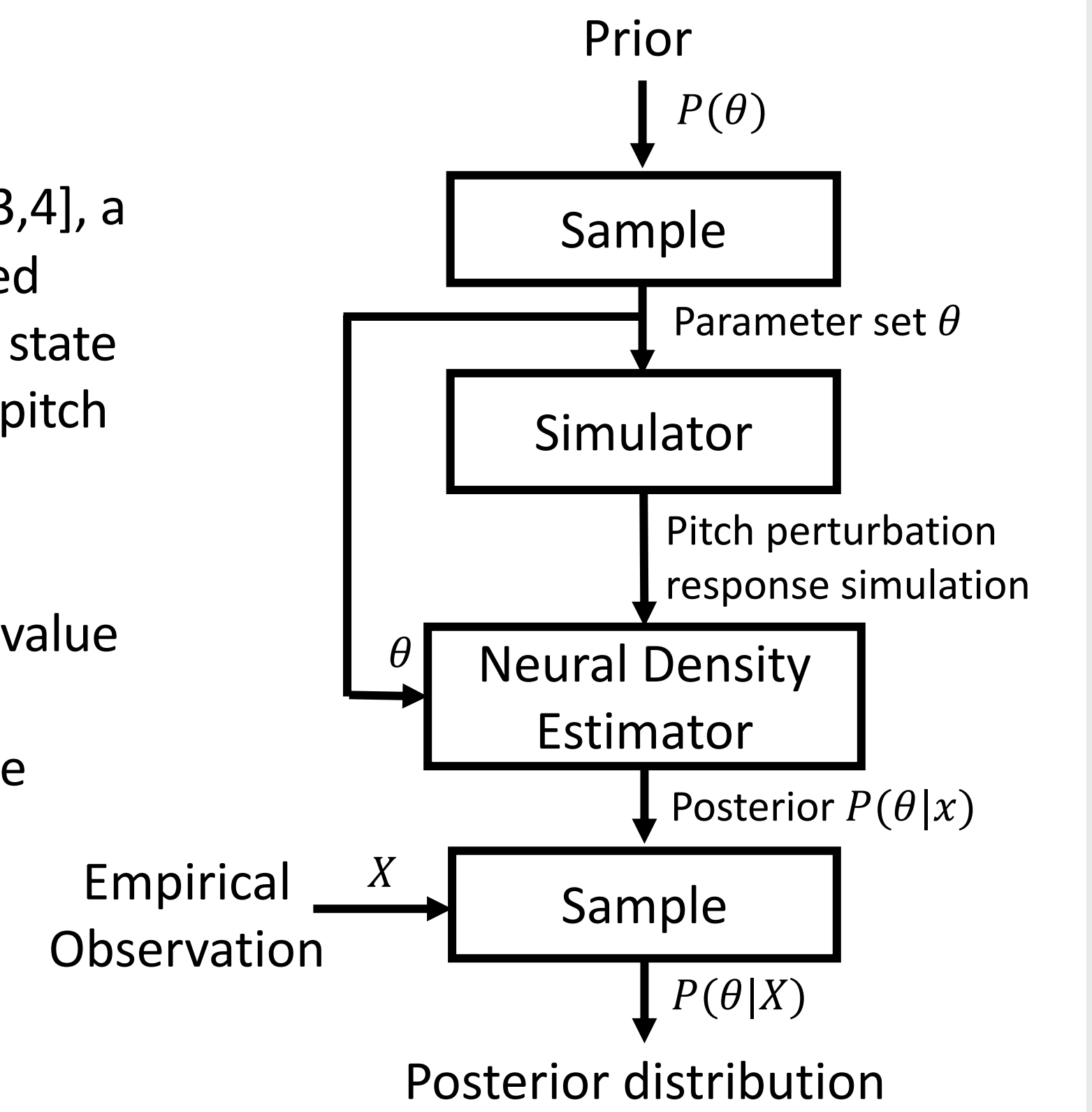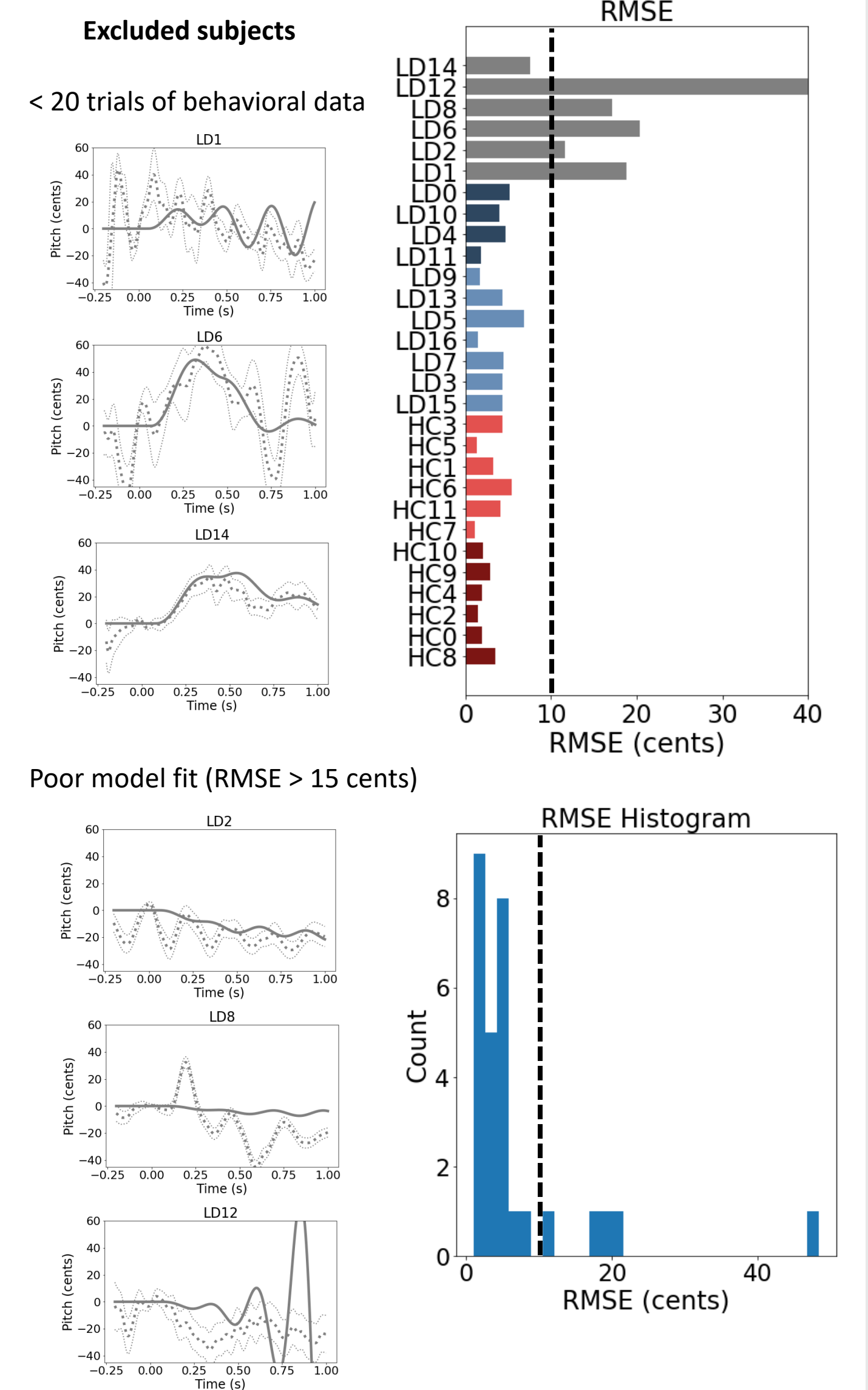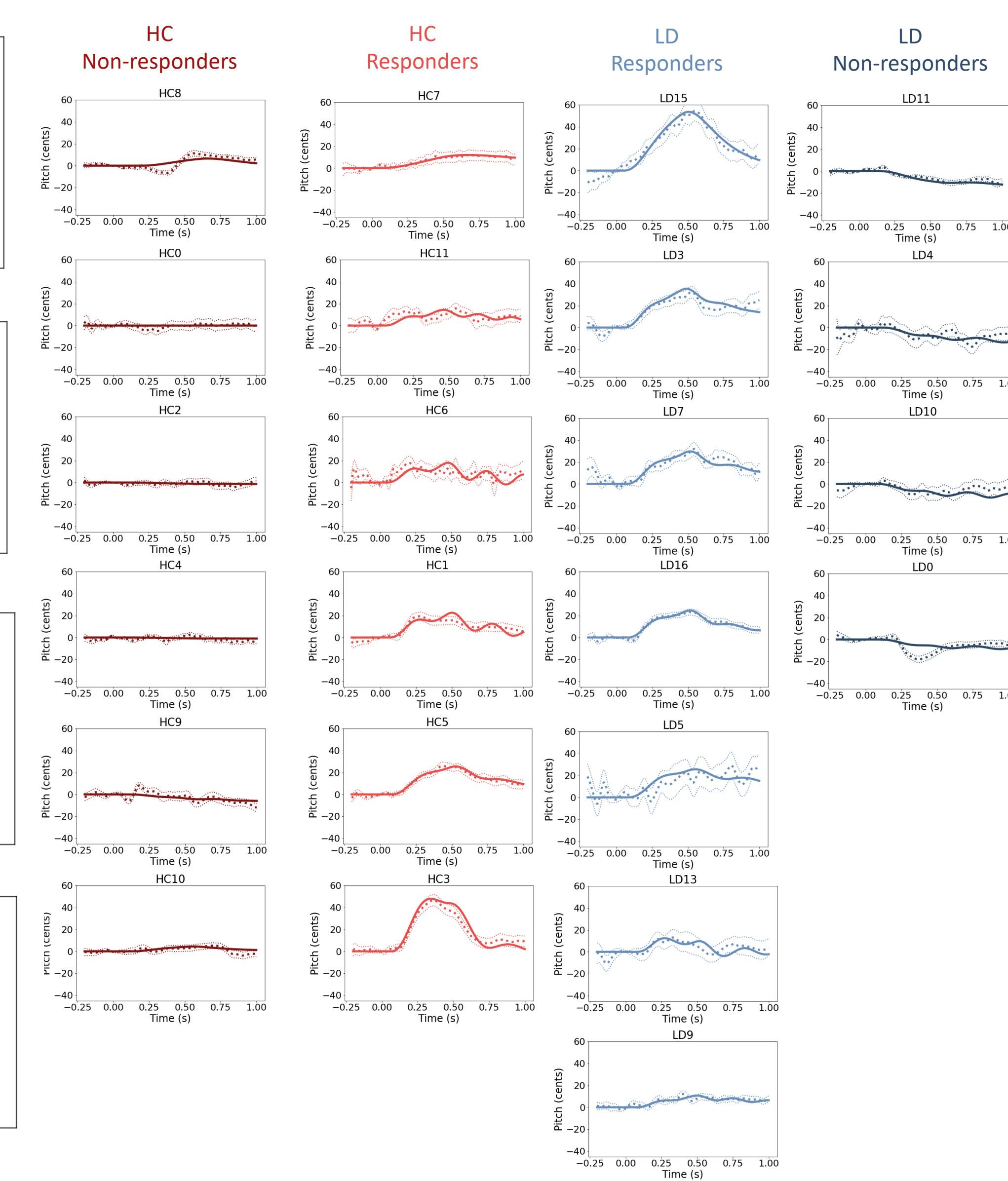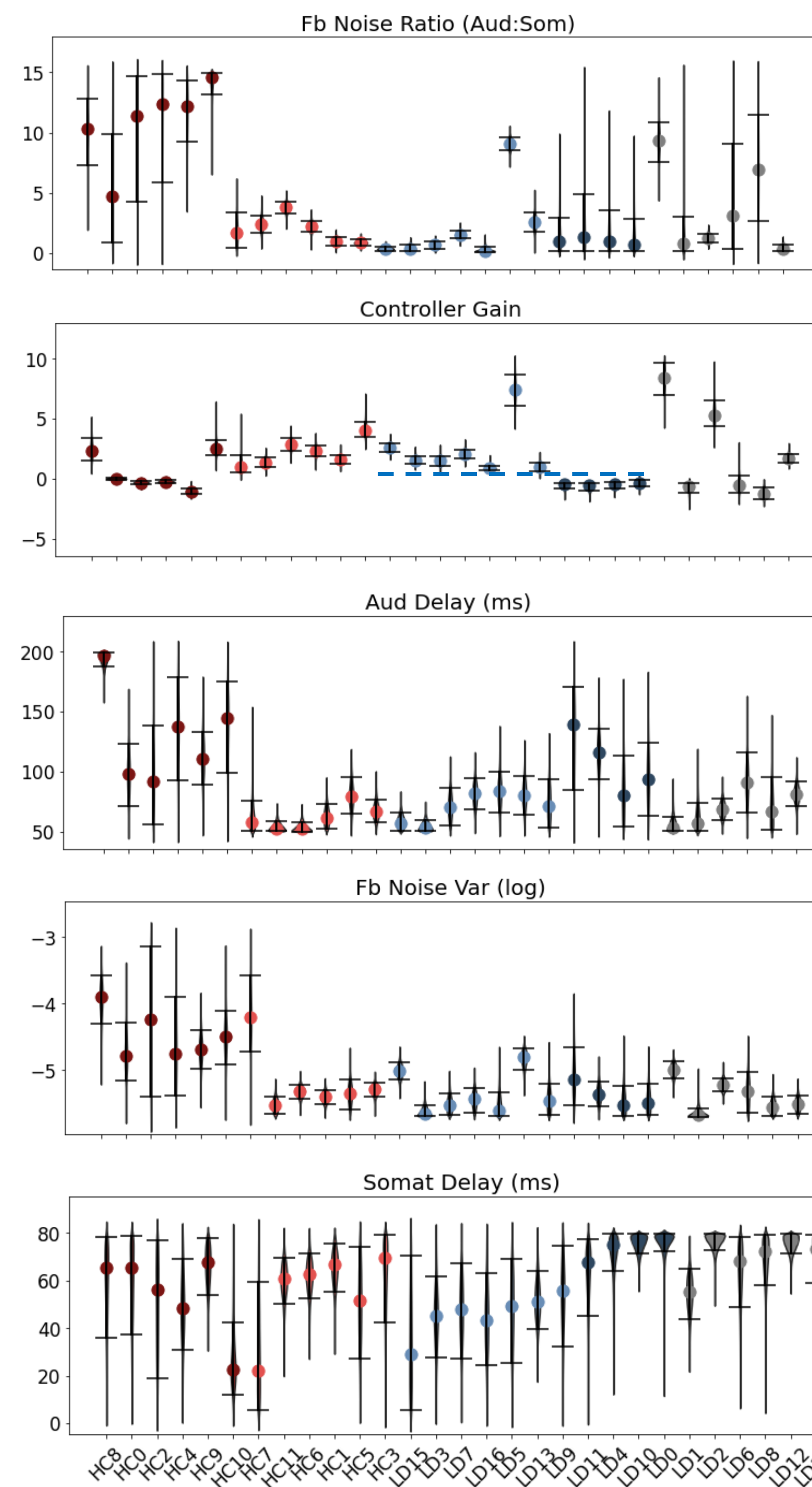

Group Level Model Fit

Preliminary results show a large difference in effect size between the two groups in the relative noise between feedback modalities. In the LD group, responder and non-responder subgroups mainly show a difference in controller gain while in the HC group, several parameters appear to contribute to the differences between subgroups who did and did not oppose the perturbation.

Posterior Parameter Distributions

Behavioral Results

All Participants

Responders (Mean compensation > 3 cents in the time period 0.1 < t < 0.5 s)

Followers/ Non-responders (Mean compensation < 3 cents in the time period 0.1 < t < 0.5 s)

Participant Level Model Fits

References

[1] Houde, J.F., et al. (2014, May 5-8). 10th ISSP, Cologne, Germany; [2] Gaines, J.L. et al. (Submitted).; [3] Tejaro-Cantero, A., et al. (2020). *J Open Source Softw 5*(52), 2505.; [4] Cranmer, K., et al. (2020). *PNAS 117*(48), 30055-30062