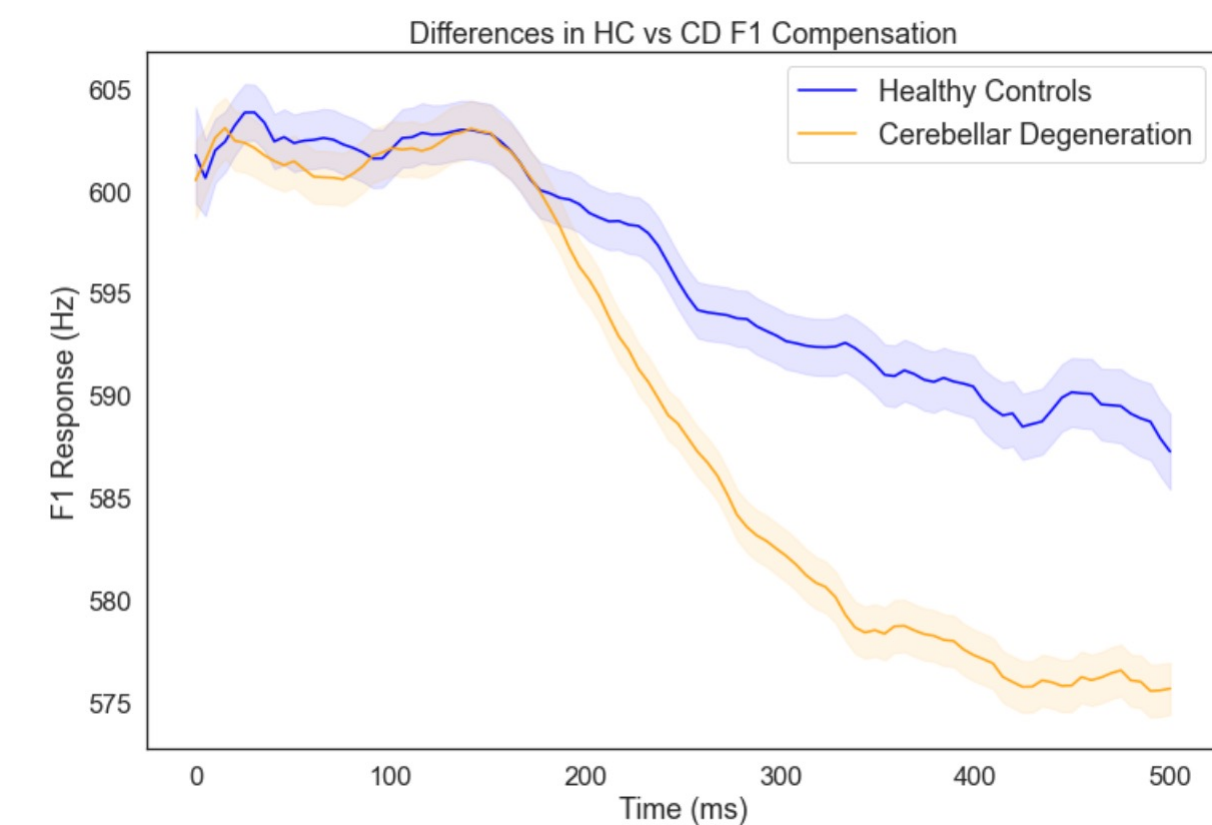


# Validating Simulation Based Inference on Feedback Aware Control of Tasks in Speech (FACTS)

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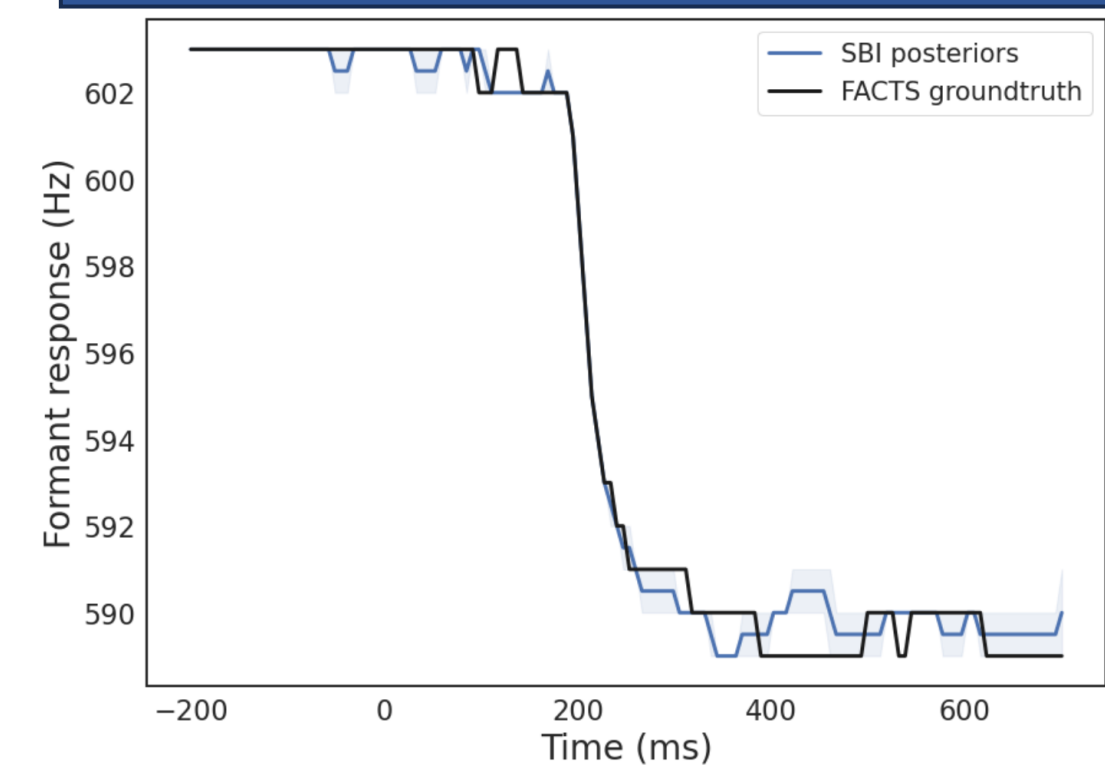
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## Introduction and Motivation

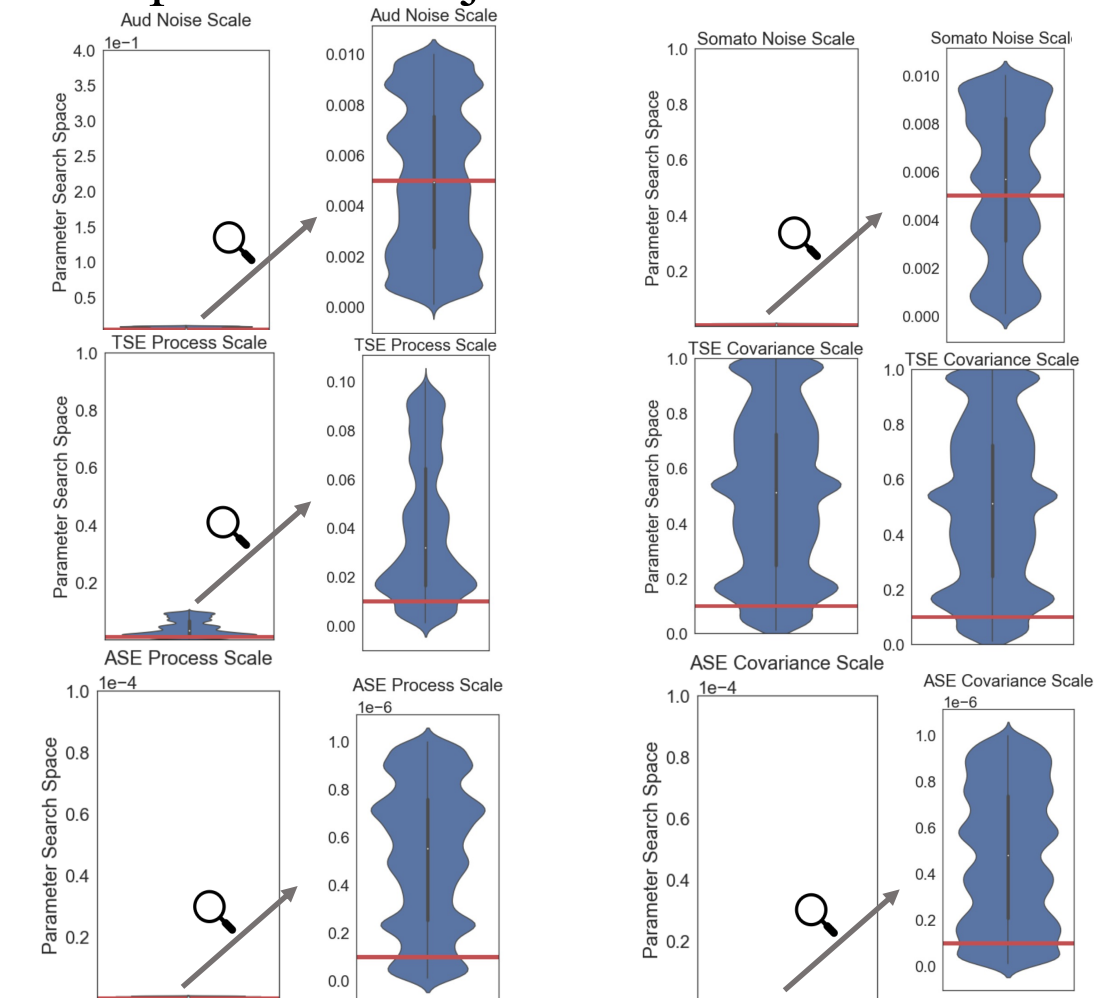


- It is unknown what neurocomputational mechanisms lead to speech differences between healthy controls (HC) and disordered populations [1].
- Simulation based inference (SBI) [2] quantifies parameter certainty over mechanistic models, thereby estimating mechanistic hypotheses that explain differences.

## Validation

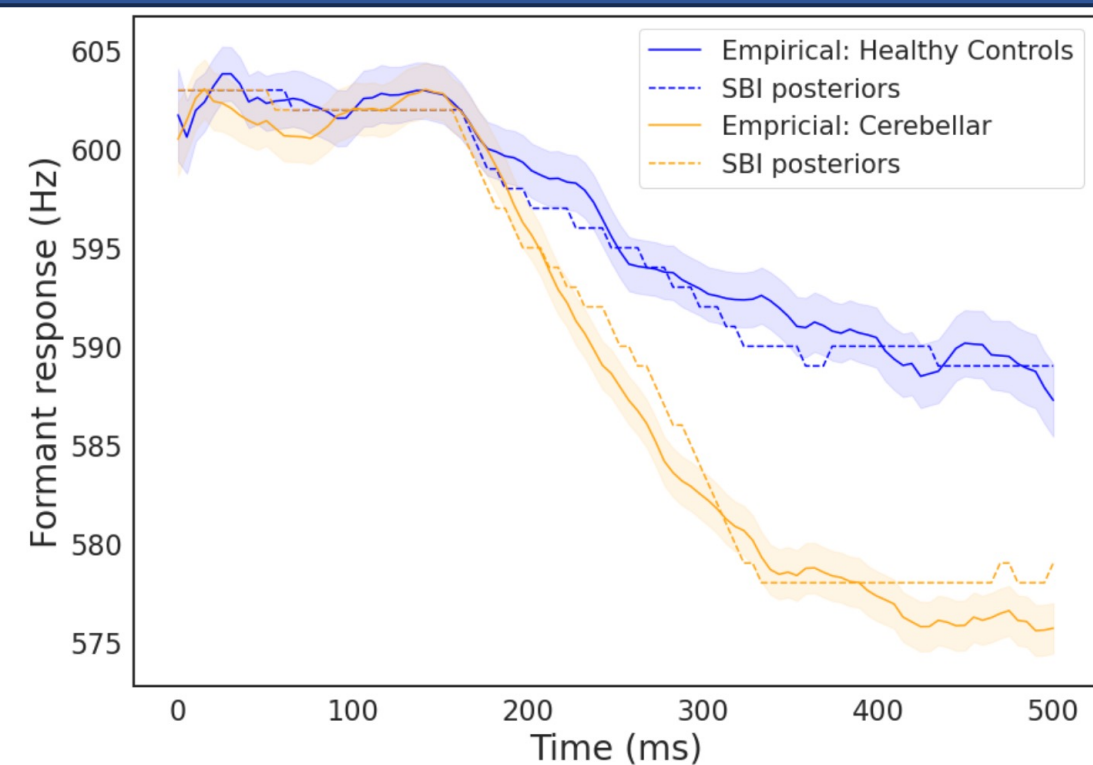


SBI posteriors recover parameter values that lead to closely matched F1 compensation trajectories in FACTS.

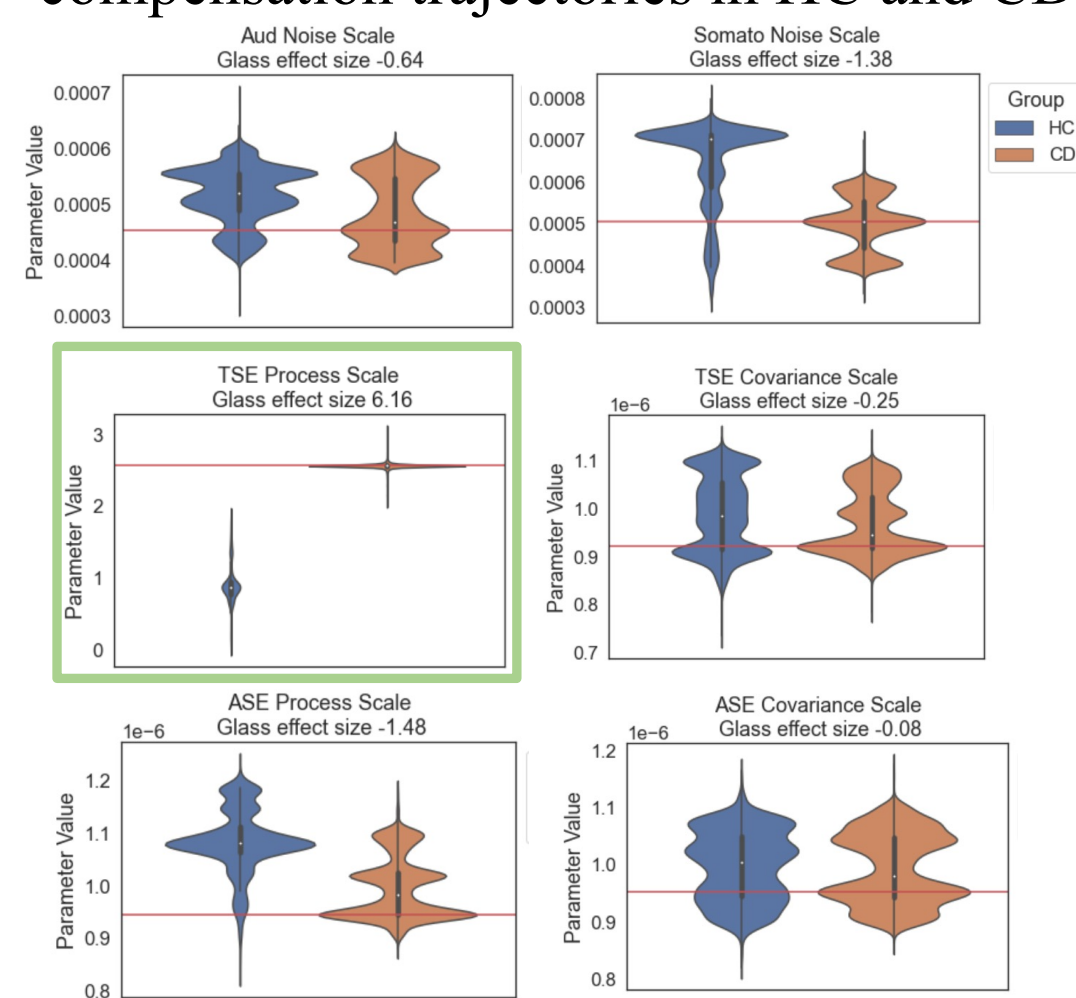


Red lines represent ground truth. The blue violin plots show SBI posterior means are close to ground-truth. Left figure of a pair shows search space, right figure zooms in.

## Result

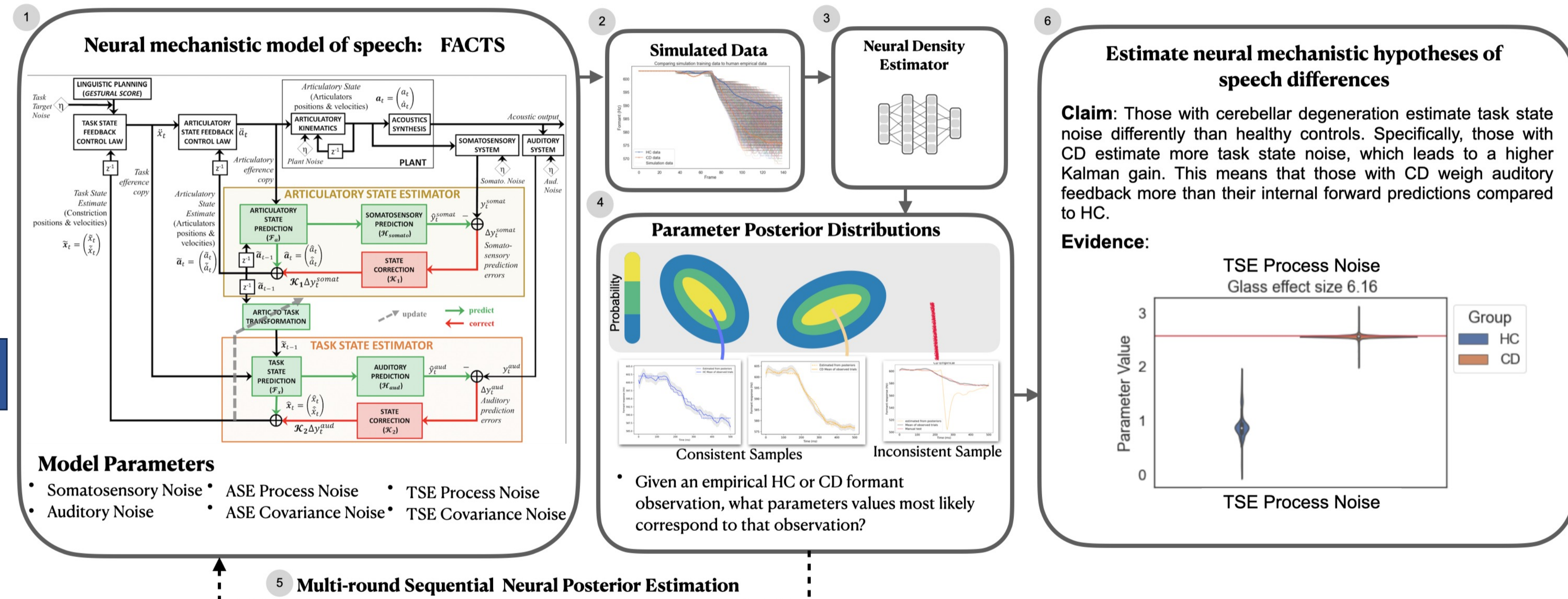


SBI posteriors recover parameter values that lead to closely matched F1 compensation trajectories in HC and CD.



Comparing HC to CD posteriors, TSE Process Scale shows the largest effect size (green box). Red line represents CD mode.

## Method



- FACTS from [3], architecture C, was used. Uniform priors are used for first round of SBI.
- 10,000 simulations of FACTS (input, output) pairs were generated for training.
- SBI trains a neural density estimator of FACTS parameter probabilities conditioned on F1 compensation observations.
- Given an HC or CD F1 observation, posterior distributions are drawn over FACTS parameter space. The peaks of the posteriors tend towards more consistent samples.
- Use posteriors as the prior for the next round of multi-round SNPE training. Sample 250 simulations per round.
- When SBI has converged, compare HC and CD posteriors.

## Discussion

- This work validates the ability of SBI to recover a known parameter set in the FACTS model, which is a necessary first step towards estimating changes in control in speakers with neurogenic speech disorders.
- We additionally showed that SBI-derived model parameters can provide a good qualitative fit to human behavioral data from neurobiologically healthy speakers and those with cerebellar degeneration.
- SBI with FACTS estimates that those with CD have more task state noise, leading to a higher Kalman gain, and thereby a higher reliance on auditory feedback. Thus, theories about the cerebellum's neural computations should include the cerebellum's role in estimating task state noise.
- Potential rehabilitative therapies of CD may consider stimulating functional regions that reduce task state noise, stimulating upstream brain regions that result in increased task state noise, or multi-modal feedback devices that give users better estimates of task state[4].

## References

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