Analysis of population activity in balanced spiking neural networks after neuron loss

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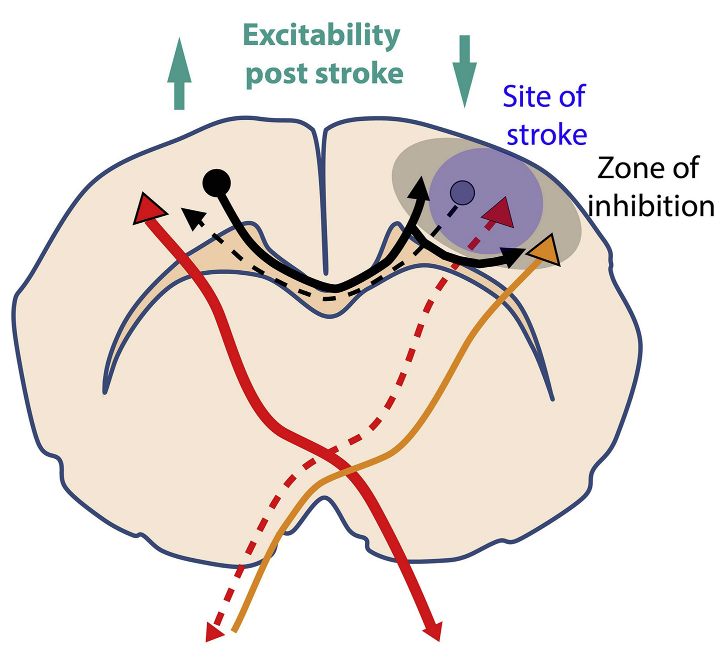
Stroke Circuitry and Rehabilitation

Yearly, more than **795,000** people in the U.S. have a stroke. **80%** will experience some degree of motor impairment and **33%** of those have neuron-loss-related residual disability that is unresolveable by current rehabilitation methods.

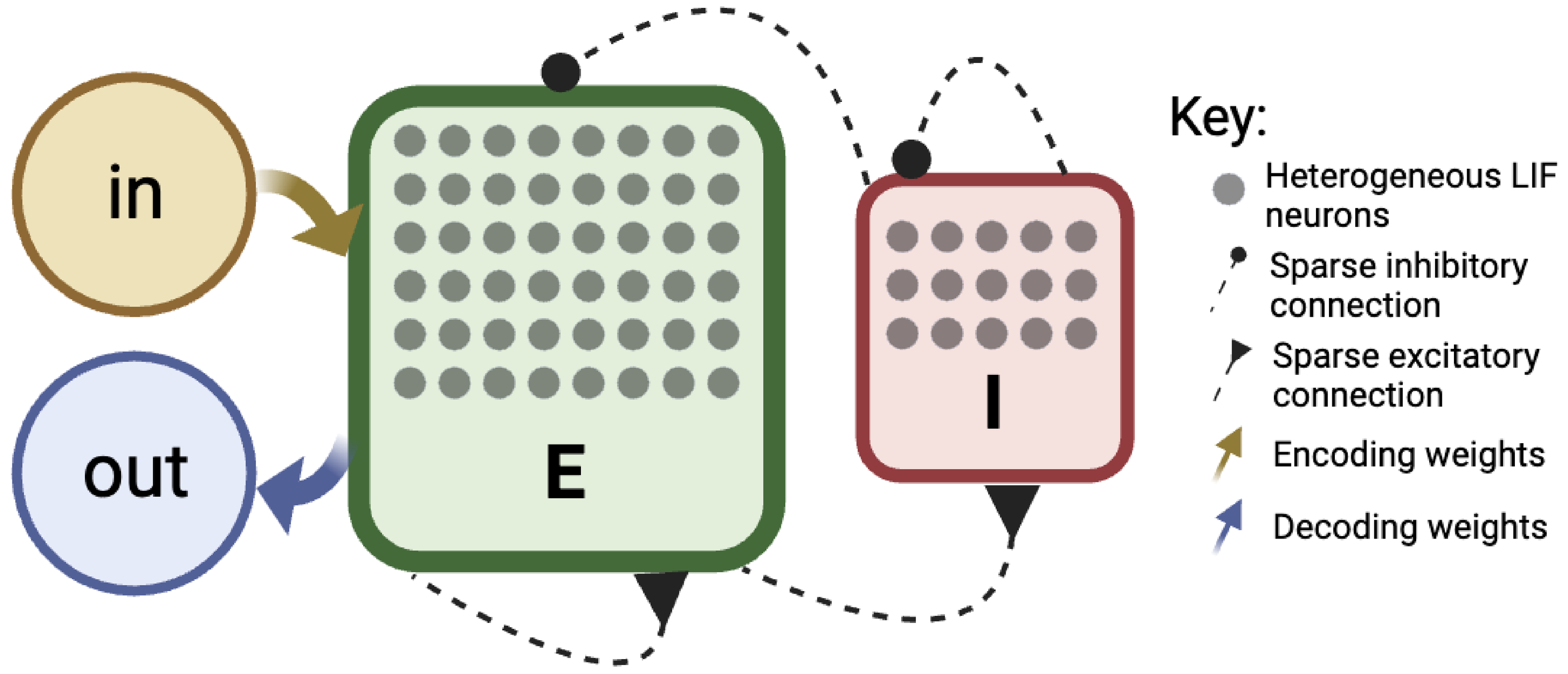
- In homeostasis, excitatory (**E**) and inhibitory (**I**) neural populations are balanced
- Allows for high fidelity outputs via **interhemispheric** and **local** shaping
- Understanding disruption of this balance could enable tailored deficit recovery



Boddington and Reynolds, 2017

Experimental Design

Spiking neural networks (SNN) were developed in Python using the Neural Engineering Framework Nengo

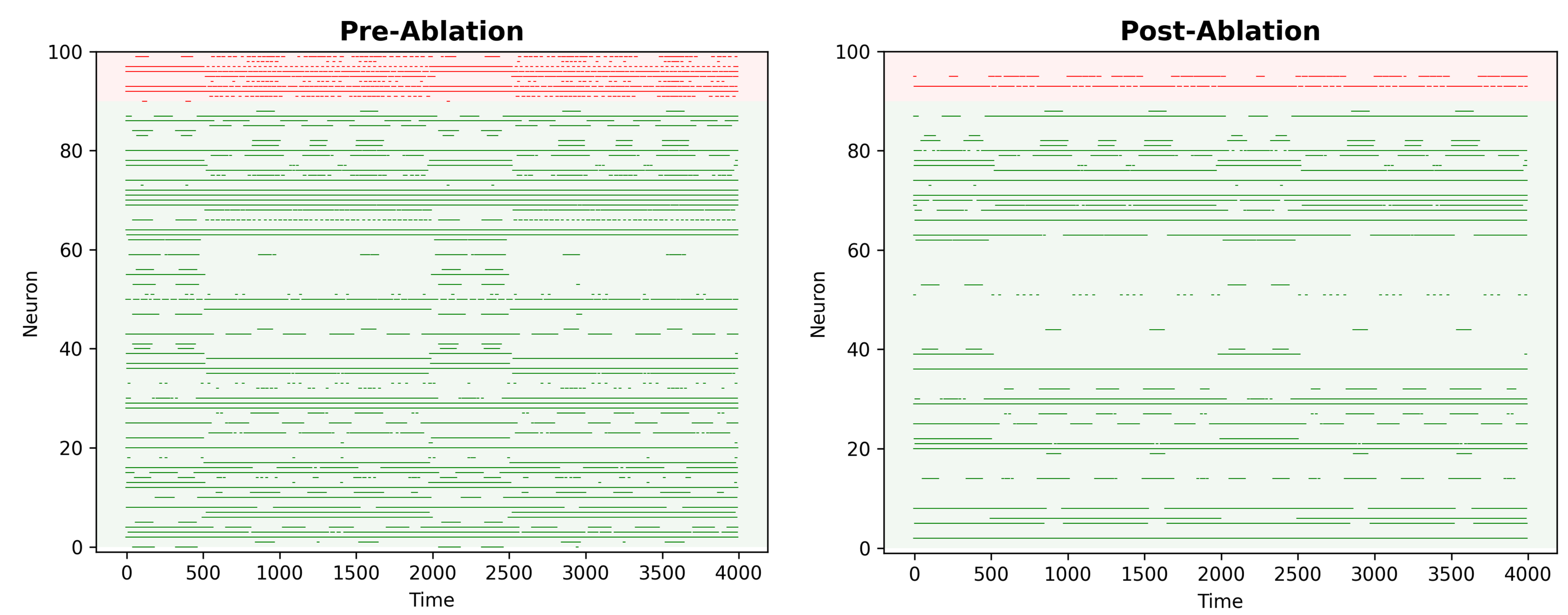


Inter-ensemble connection weights were determined under conditions of "sparse balance" using:

$$\sum_j a_{ij} = 0 \quad \text{for every } i^{th} \text{ neuron}$$

To simulate neuron loss, an ablation framework was designed that randomly annihilates neurons at the population level

Main Results

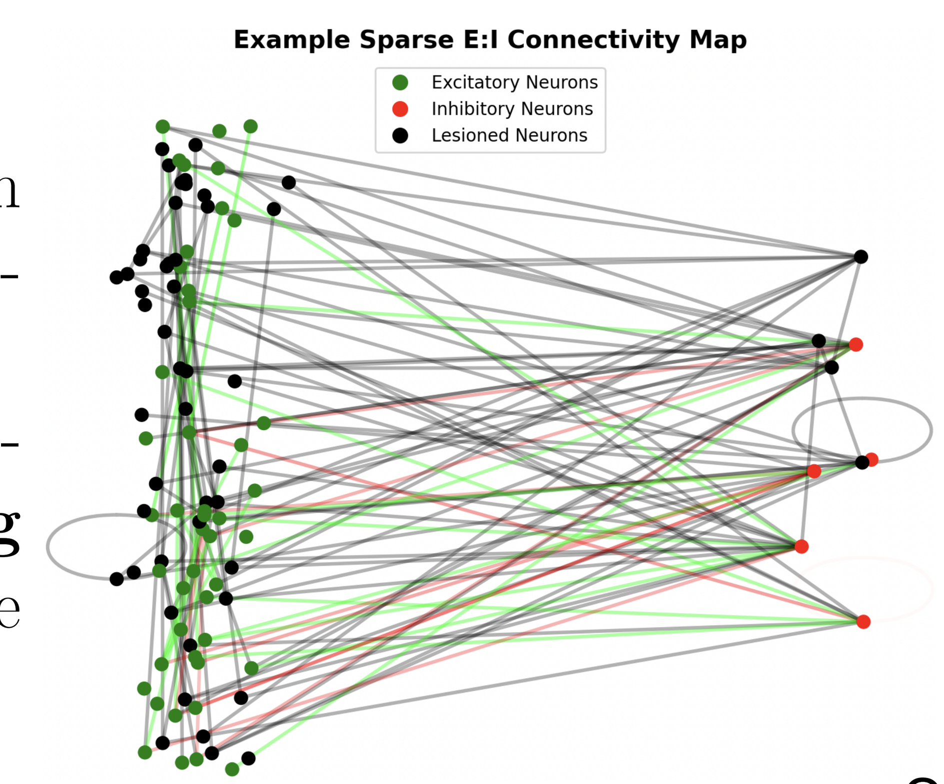


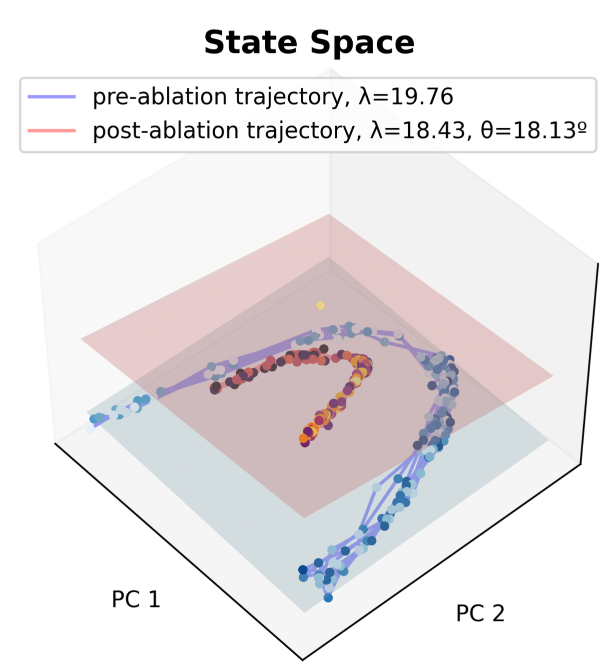
Neural rasters indicate:

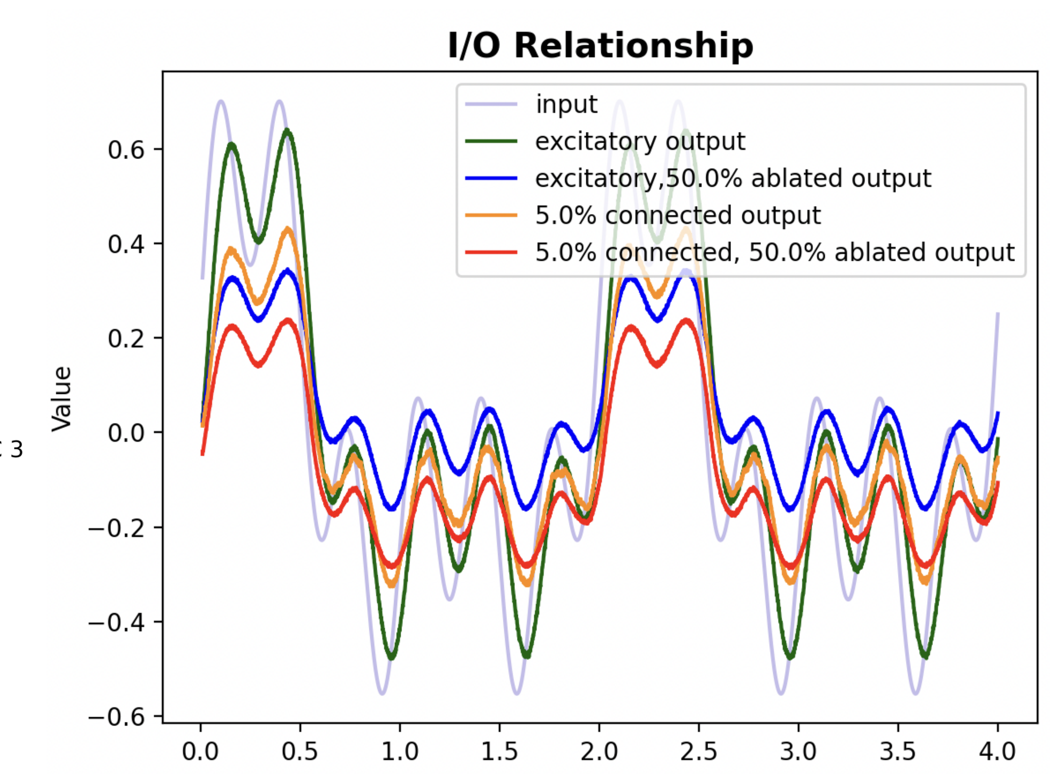
- conserved **periodicity** between input and spike encodings
- post-lesion **rate adaptation** in non-adaptive neuron types

Ablation:

- **reduces** input fidelity in both unconnected and connected populations
- **preserves** trajectory geometry while **translating** starting position in PC-space

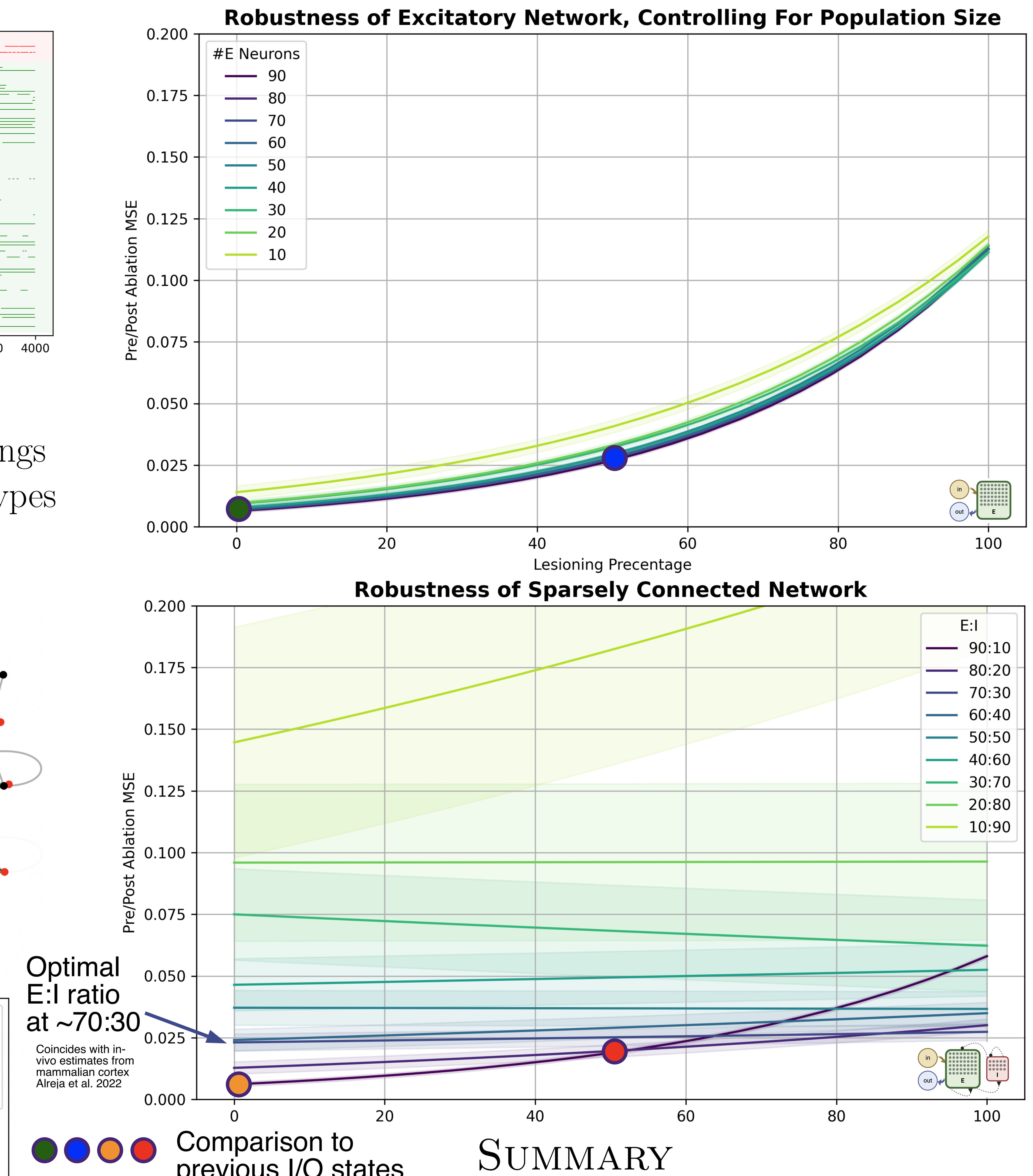






mean square error calculated for g/b (top) and o/r (bottom) on next panel

Parameter Sweeps



Summary

At the cost of reduced amplitude-matching, balanced E:I neural circuits exhibit intrinsic dynamics that facilitate **robustness to population-level ablation**. Characterizing this balance is a first step for future work on restoring functionality in damaged populations.