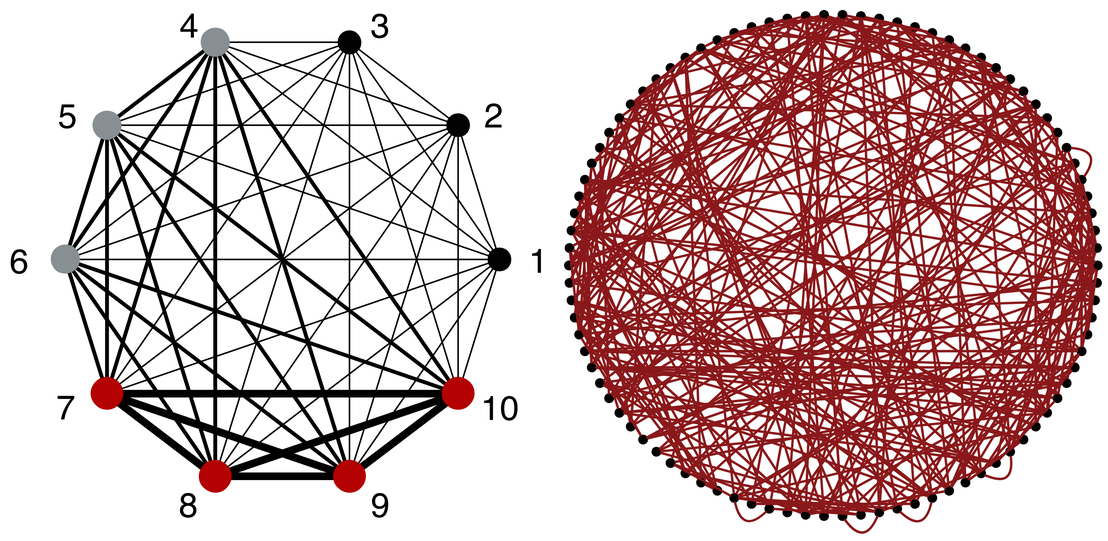
Neurons don’t get along

Miguel Escobar Mendoza, Javier Cubillos Cornejo, Ignacio Bordeu
Facultad de Ciencias Físicas y Matemáticas - Universidad de Chile

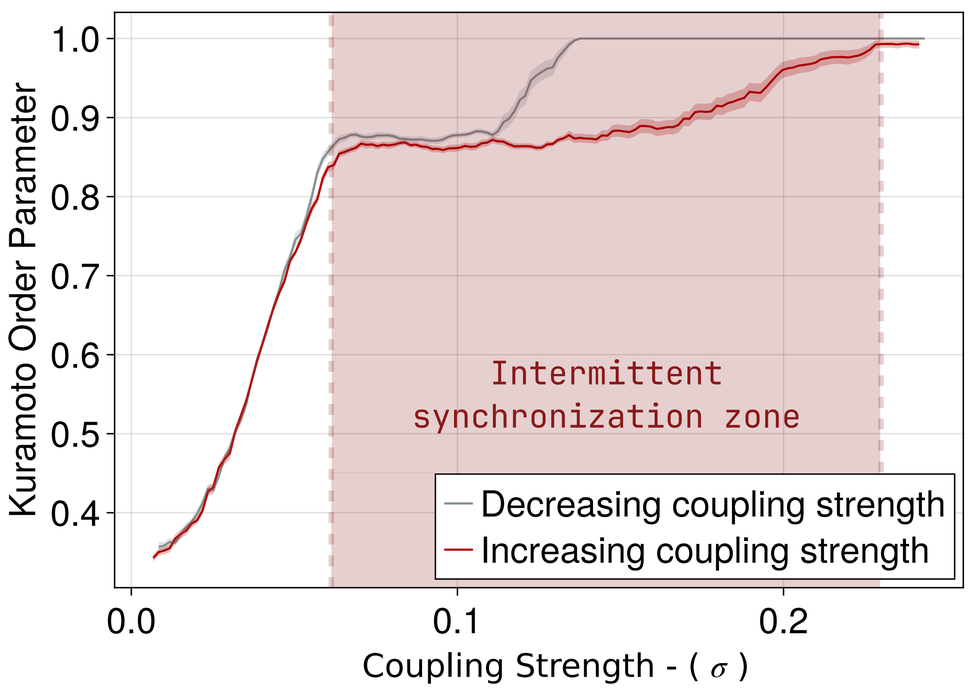
Neurons and synchronization:

Synchronization regulation in neuronal activity within the brain is essential for maintaining optimal functionality. Its dysregulation is linked to pathologies such as epilepsy and Parkinson's disease [1, 2], characterized by **intermittent episodes of strong synchronization**.

This work focuses on investigating the causes of intermittent synchronization in networks of coupled FitzHugh-Nagumo (FHN) oscillators, a paradigmatic model of neuronal activity [3].



$$\frac{d}{dt}\begin{bmatrix}\varepsilon u_i \\ v_i\end{bmatrix} = \begin{bmatrix}u_i - u_i^3/3 - v_i \\ u_i + a\end{bmatrix} - \sigma \sum_{j\in G} L_{ij} B(\phi) \begin{bmatrix}u_j \\ v_j\end{bmatrix}$$

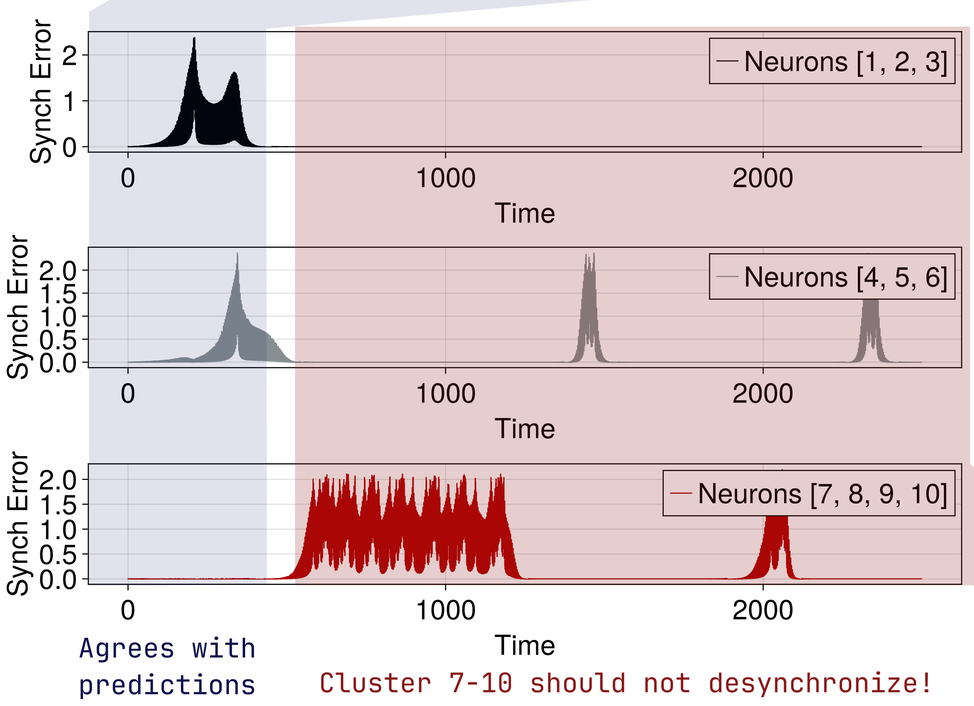


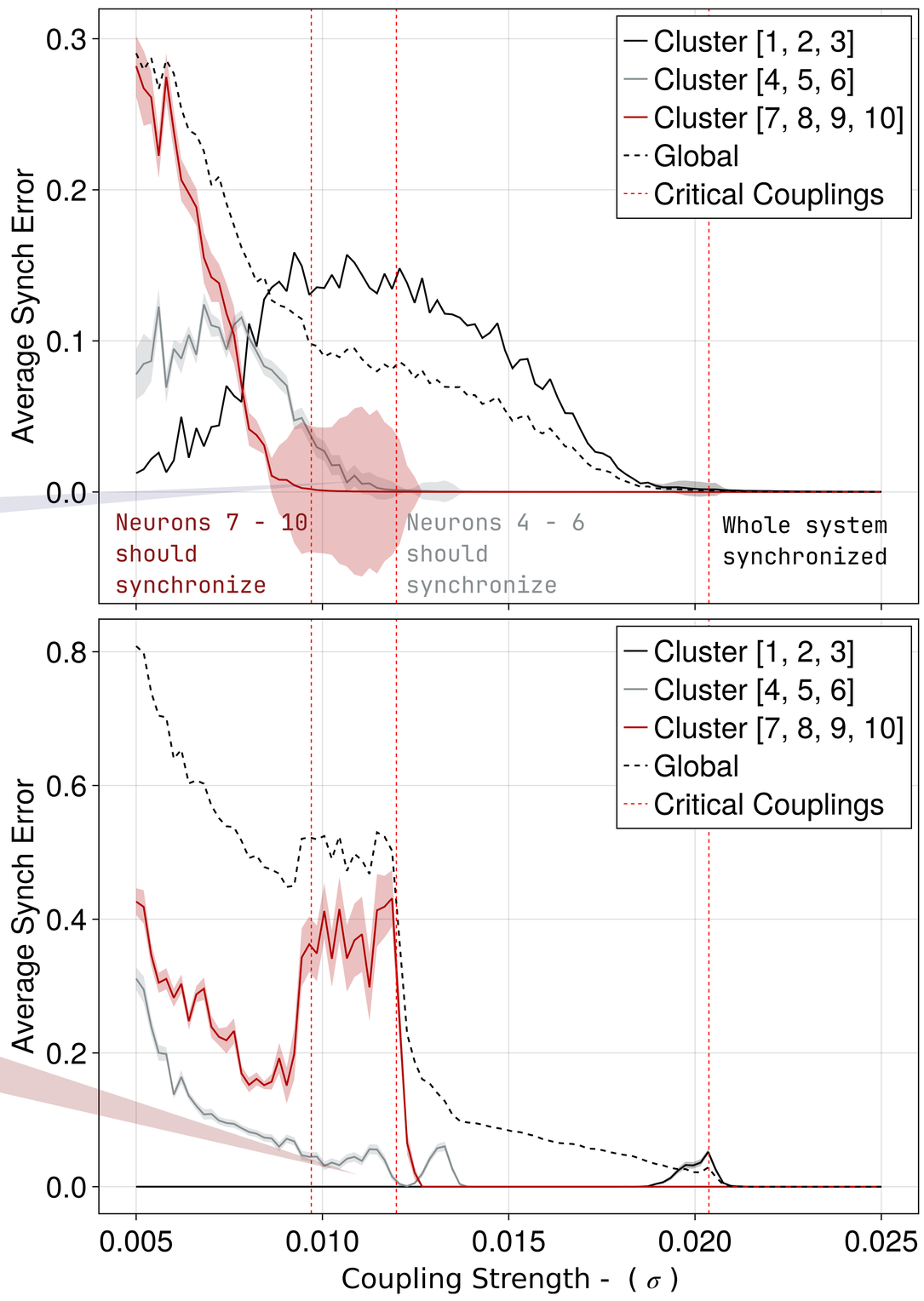
Intermittent synchronization

We explored the relationship between the Kuramoto order parameter and the coupling strength σ on a **90-neuron Watts-Strogatz network**. We found **intermittency is associated with a plateau in the Kuramoto order parameter** on the way to full synchrony. To investigate this phenomenon we studied a smaller **10-neuron highly clustered network.**

Clustering and disagreement:

Following a method proposed by Bayani et. al. (2024) we studied synchronization thresholds for each cluster. **Smaller timescales gave good agreement with the theory, but in longer timescales the clusters desynchronize. The neurons don’t seem to agree!**





Supplementary Material and acknowledgements