Interplay between synaptic scaling and structural plasticity maintains the robust firing rate homeostasis

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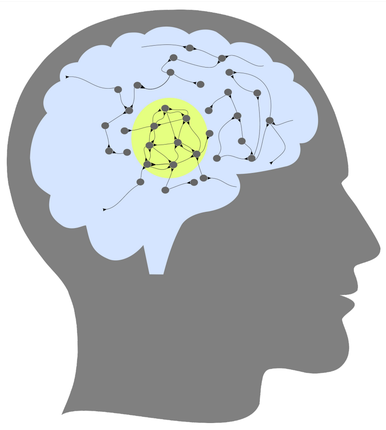
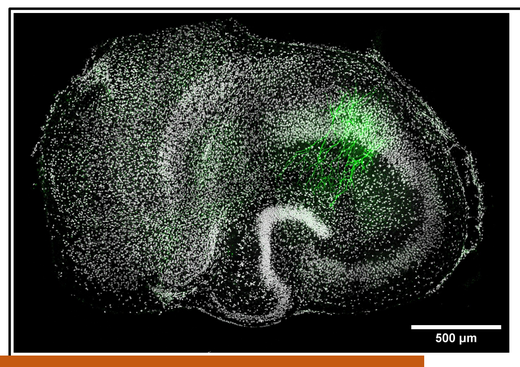
Summary: Homeostatic plasticity is fundamental for neuronal networks to maintain network activity within a dynamic range. In this context, structural synaptic plasticity—including changes in spine sizes, densities, and synapse numbers—is not consistently regulated in a homeostatic manner as seen for the synaptic weights. Increased network activity induces homeostatic down-scaling of excitatory neurotransmission and spine density reduction. Conversely, a decrease in network activity increases excitatory synaptic weights, while either reducing, increasing, or not changing spine densities. To reconcile the rich scenarios of activity-dependent structural plasticity, we explored a homeostatic structural plasticity model with a Gaussian law with two firing activity setpoints. Simulations showed that this model maintains homeostatic properties upon stimulation whereas formation or loss of dendritic spines is observed depending on the extent of deprivation. When dendritic spines are lost due to silencing or denervation, homeostatic synaptic up-scaling or weak external stimulation rescues firing activity and pushes the structural dynamics into regeneration.

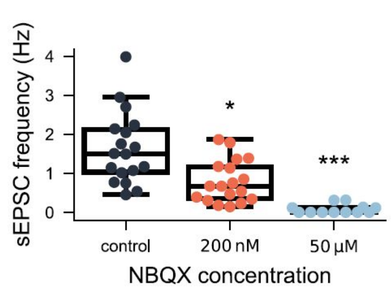
Plasticity & Flexibility

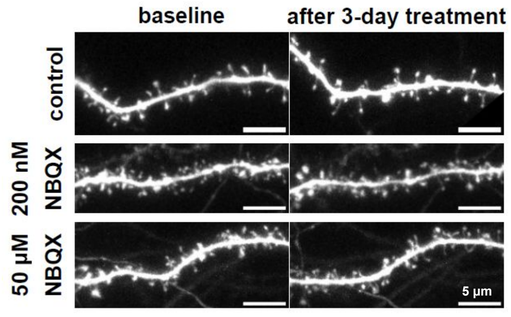


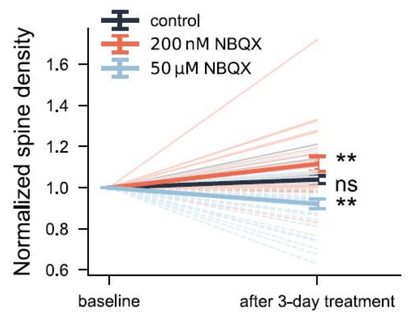
Method 1: *in vitro* experiments



Non-linearity

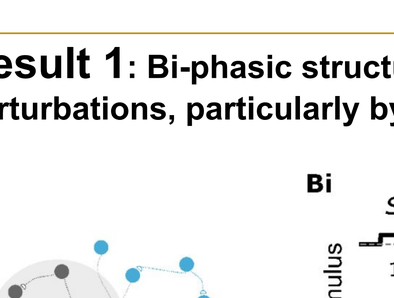






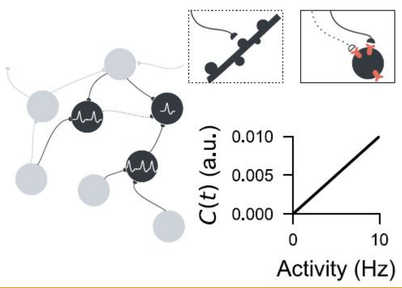
Method 2: computer simulations

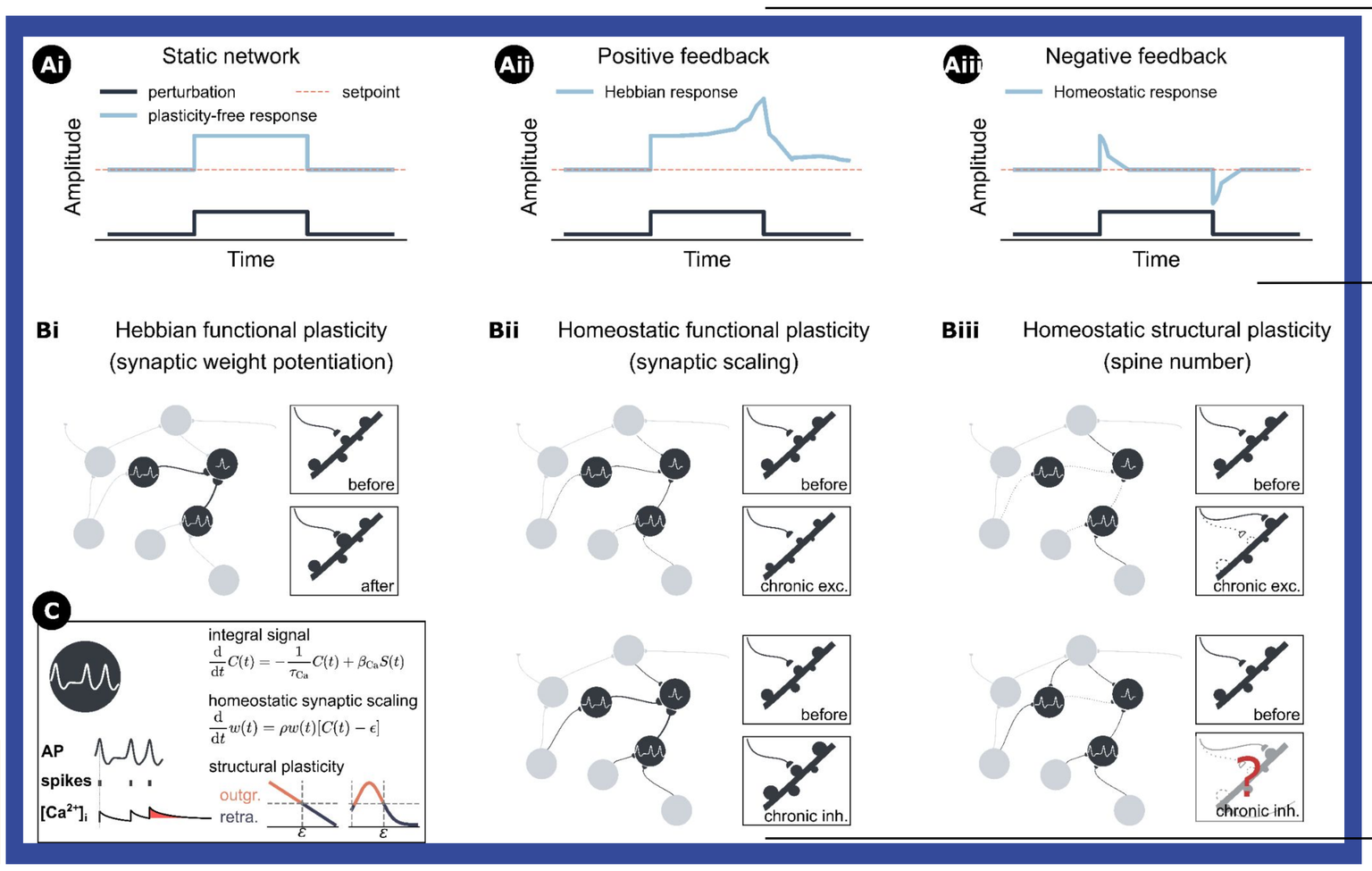
Brunel Network



Homeostatic structural plasticity & homeostatic synaptic scaling

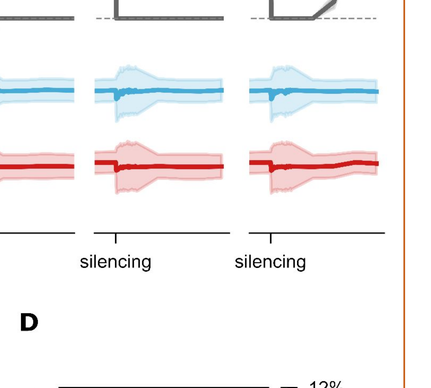
(Ca^{2+} based plasticity rules)





Robustness in complex networks

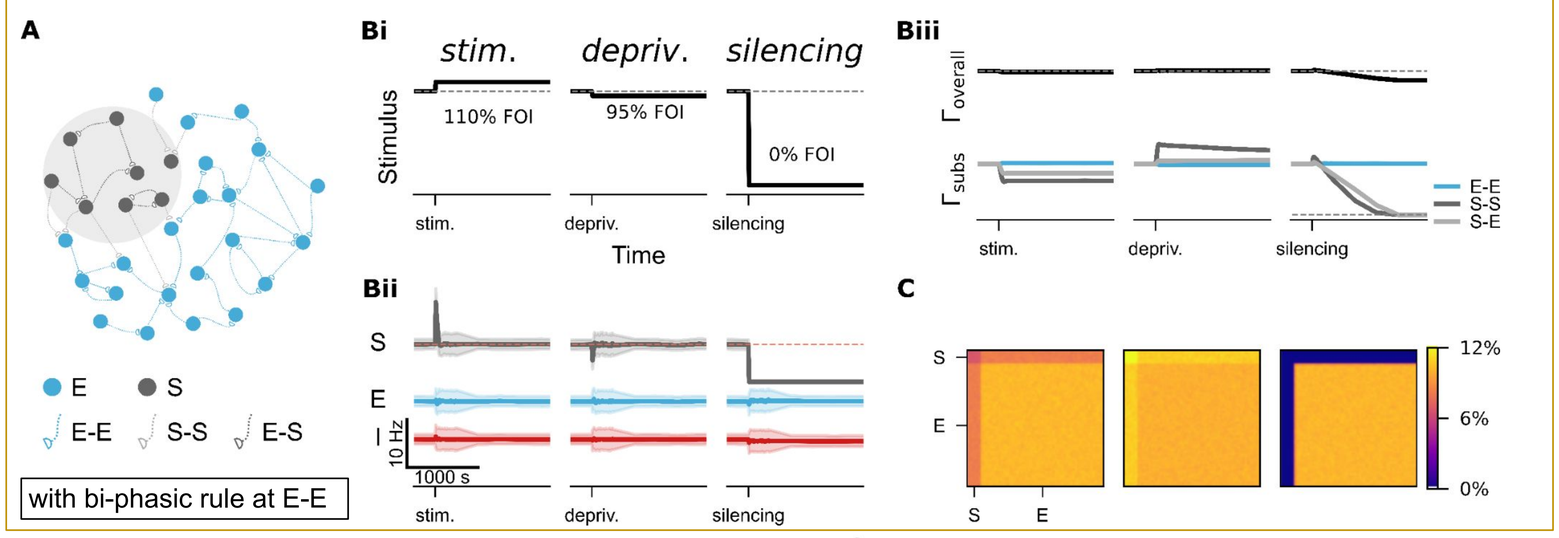
System control



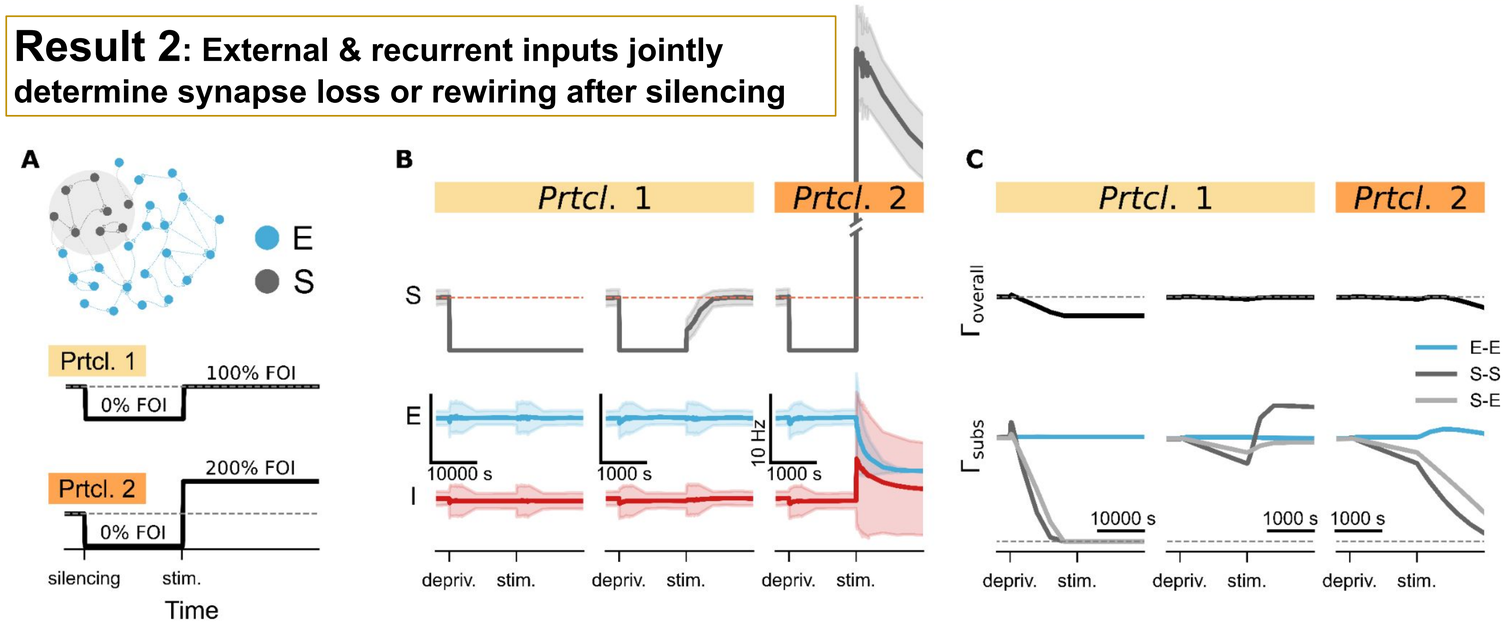
Conclusion:
Homeostatic structural plasticity (HSP) and homeostatic synaptic scaling (SS) are **redundant** and **heterogeneous**

Redundancy & Heterogeneity

Result 1: Bi-phasic structural plasticity rule reconciles rich scenarios triggered by activity perturbations, particularly by activity deprivation



Result 2: External & recurrent inputs jointly determine synapse loss or rewiring after silencing



Result 3: Synaptic scaling sculpts recurrent connectivity and guides the behavior of structural plasticity

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