

Computer models of claustrum subnetworks

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Introduction

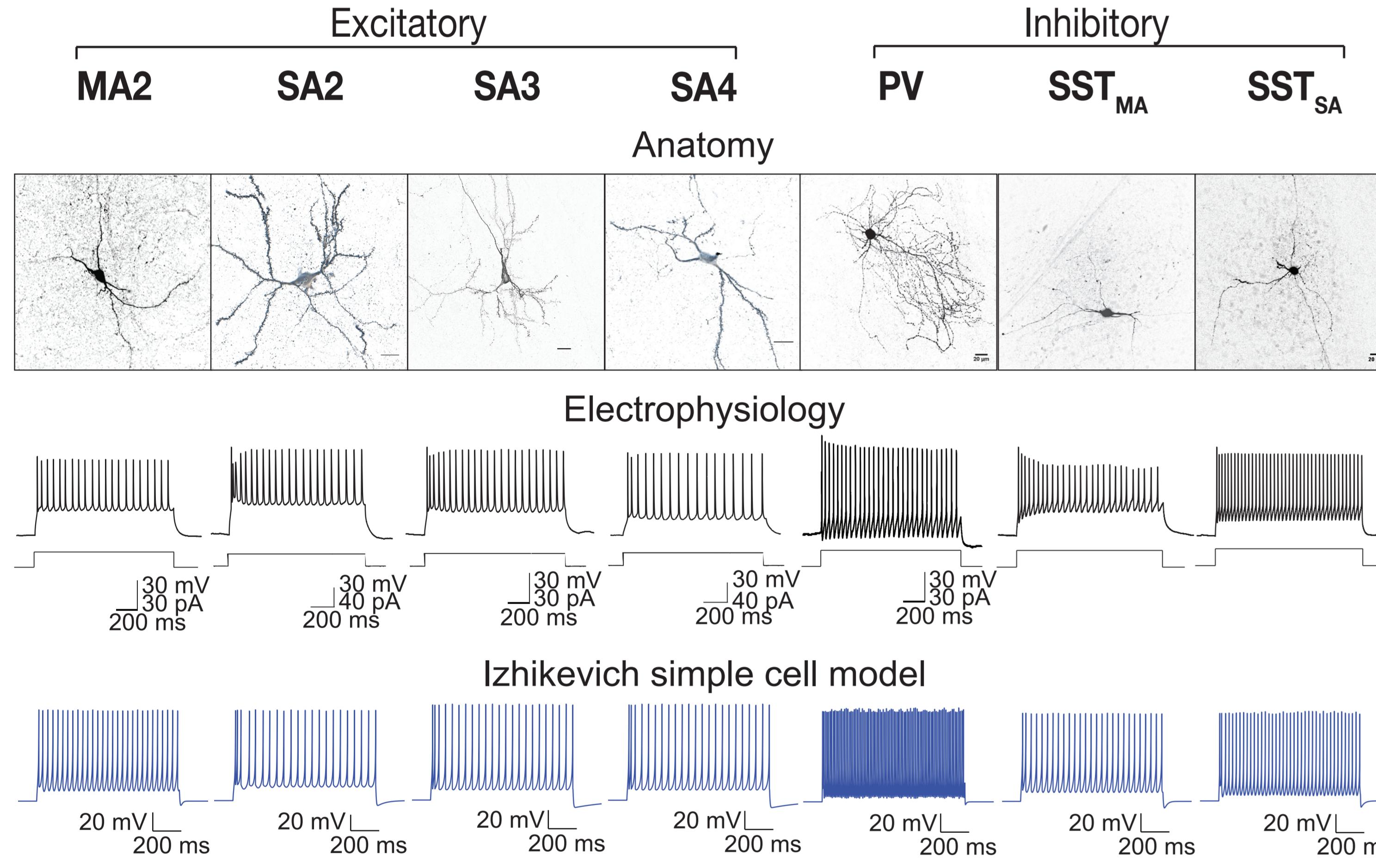
Brain dynamics underlies the mechanisms of information flow and brain computation. We constructed a network model of simplified (integrate-and-fire) spiking neurons fitted to current clamp measures of different classes of claustrum neurons from mouse. Approximate connectivity was based on optogenetic mapping data. We probed the network's dynamical behaviour with stimulation into different cell groups.

Methods

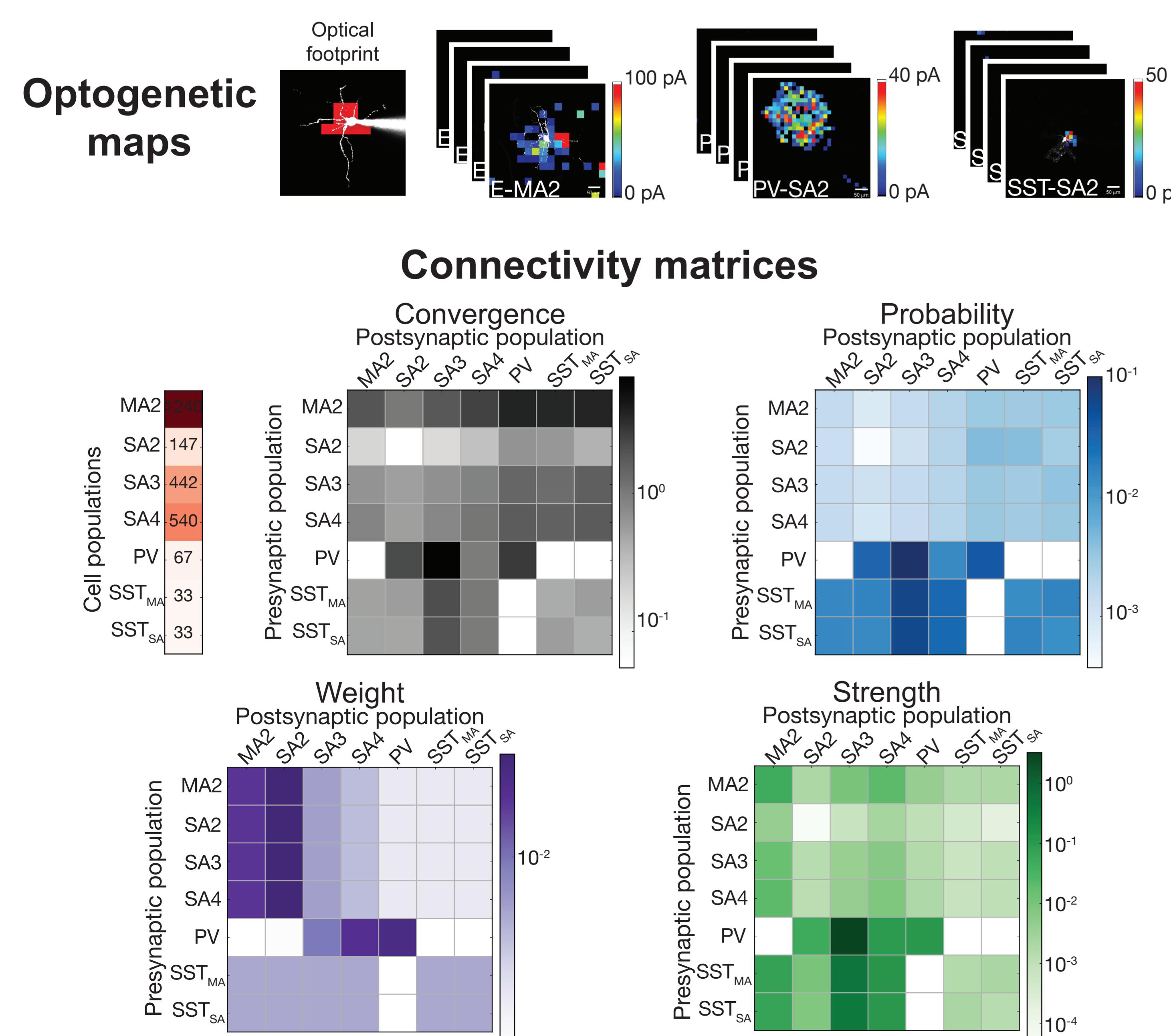
What we know?	What we don't know
• Single cell firing properties that can be classified into numerous cell types	Don't have presynaptic identities of excitatory cells and therefore:
• Relative cell counts by type	Assumptions
• Strength of excitatory (E) and inhibitory (I) inputs into each cell type (but not necessarily their presynaptic identities)	• All E → E and E → I weights are equalized across the same postsynaptic cell type
• I → E and I → I weights and convergence	• All E → E and E → I convergence densities are based our values on relative cell counts

We utilized data obtained from electrophysiological characterisation of single cell responses to current clamp in mouse. Cells were classified as either mildly adapting (MA) or strongly adapting (SA). I cells were additionally classified by peptide markers: somatostatin (SST) and parvalbumin (PV).

Clastral cell types

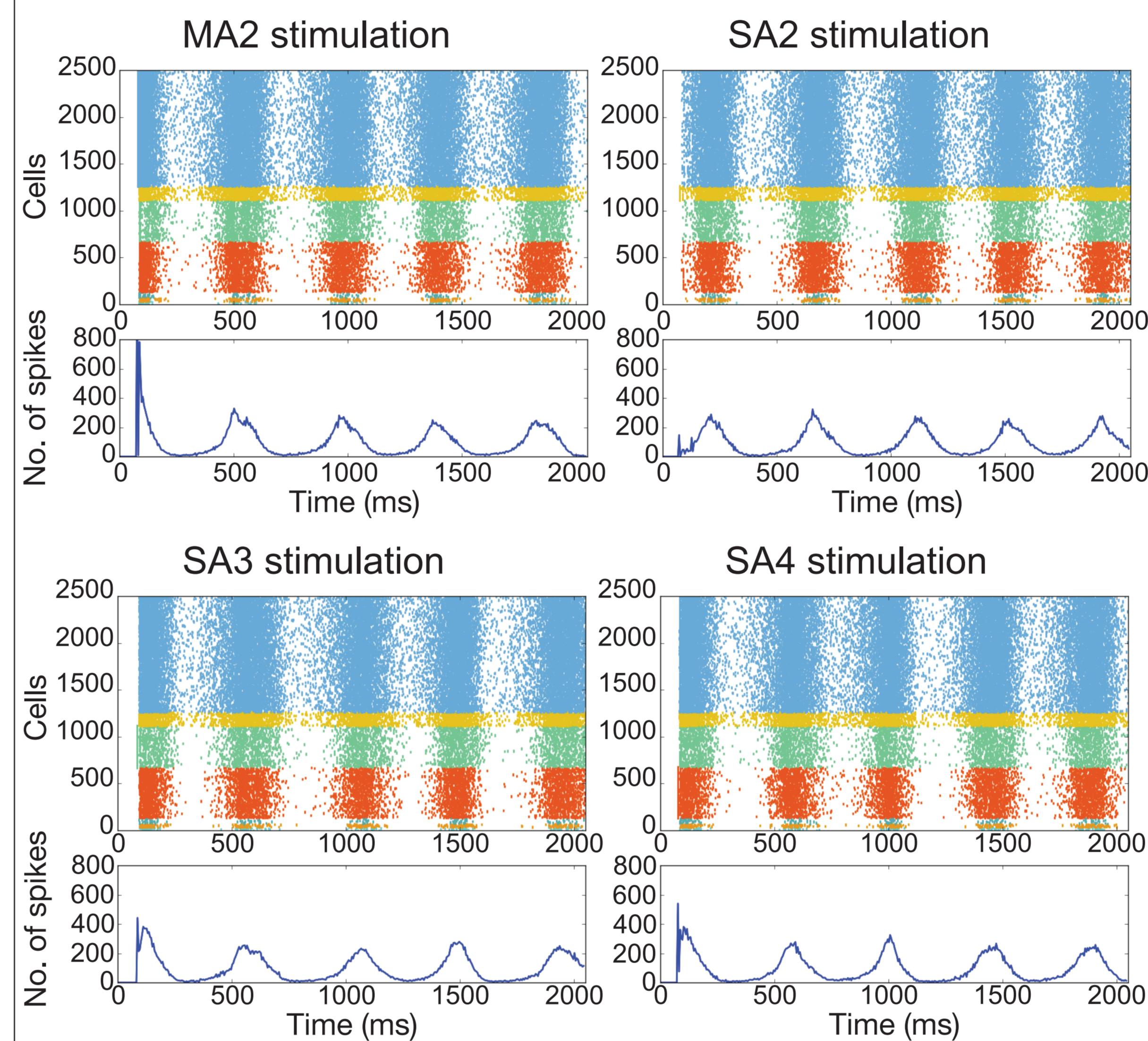


Approximate connectivity parameters — convergence and weights — were derived from optogenetic maps, which, except for inhibitory neurons, defined locations but not identity of neurons presynaptic to a recorded neuron of known identity. I-E and I-I gains were then tuned concurrently until reasonable firing rates were observed in all populations.

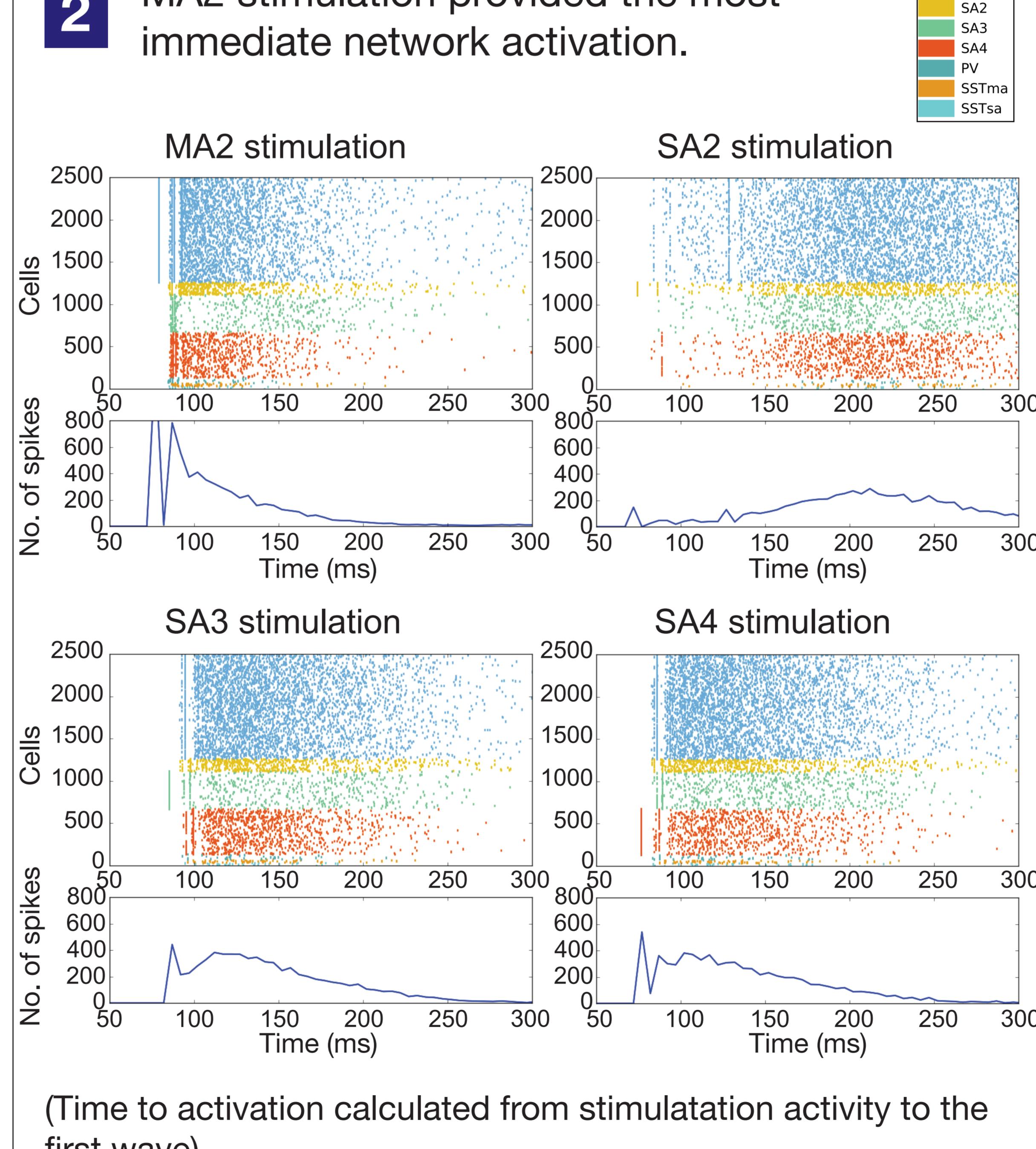


Activation of the network via any of the excitatory cell populations induces oscillations

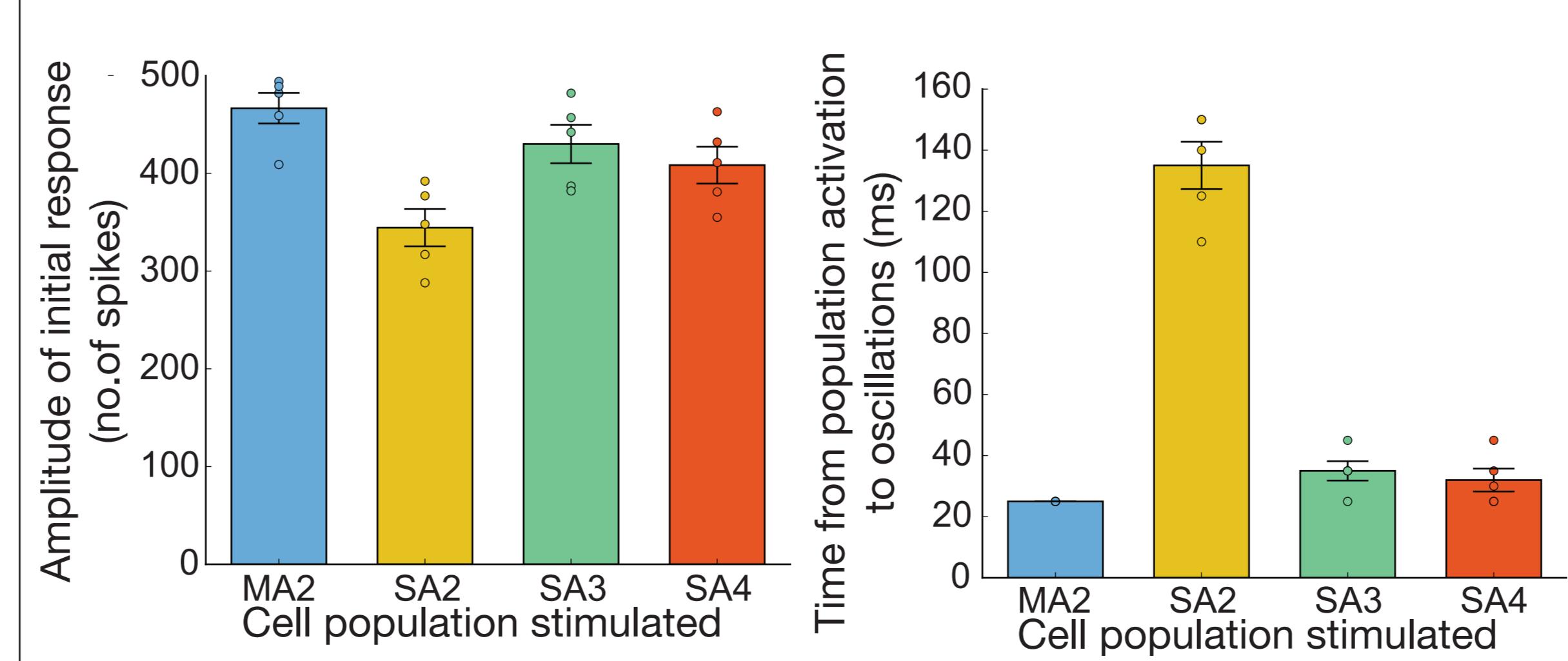
1 Synchronised input to all cells of any of the four excitatory cell populations was sufficient to set off persistent oscillatory activity in the network



2 MA2 stimulation provided the most immediate network activation.



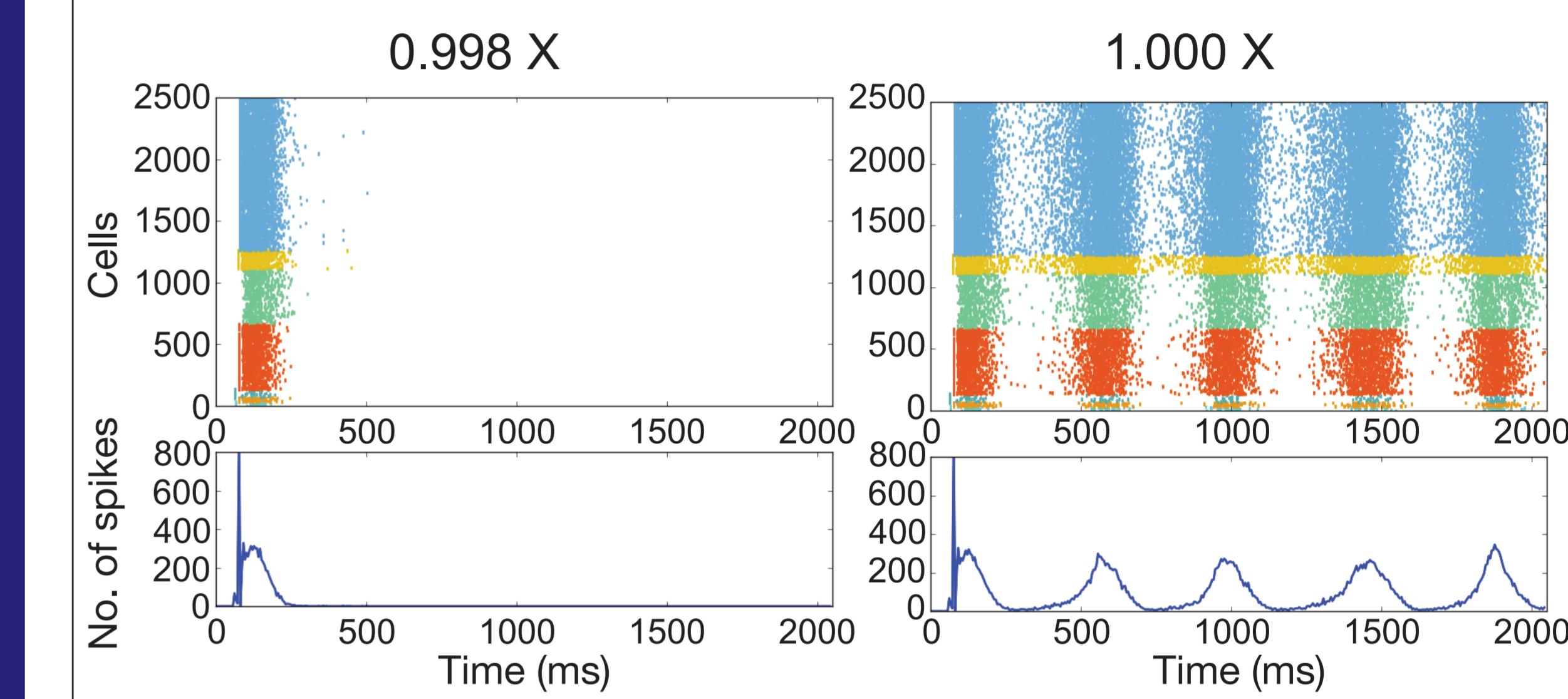
(Time to activation calculated from stimulation activity to the first wave)



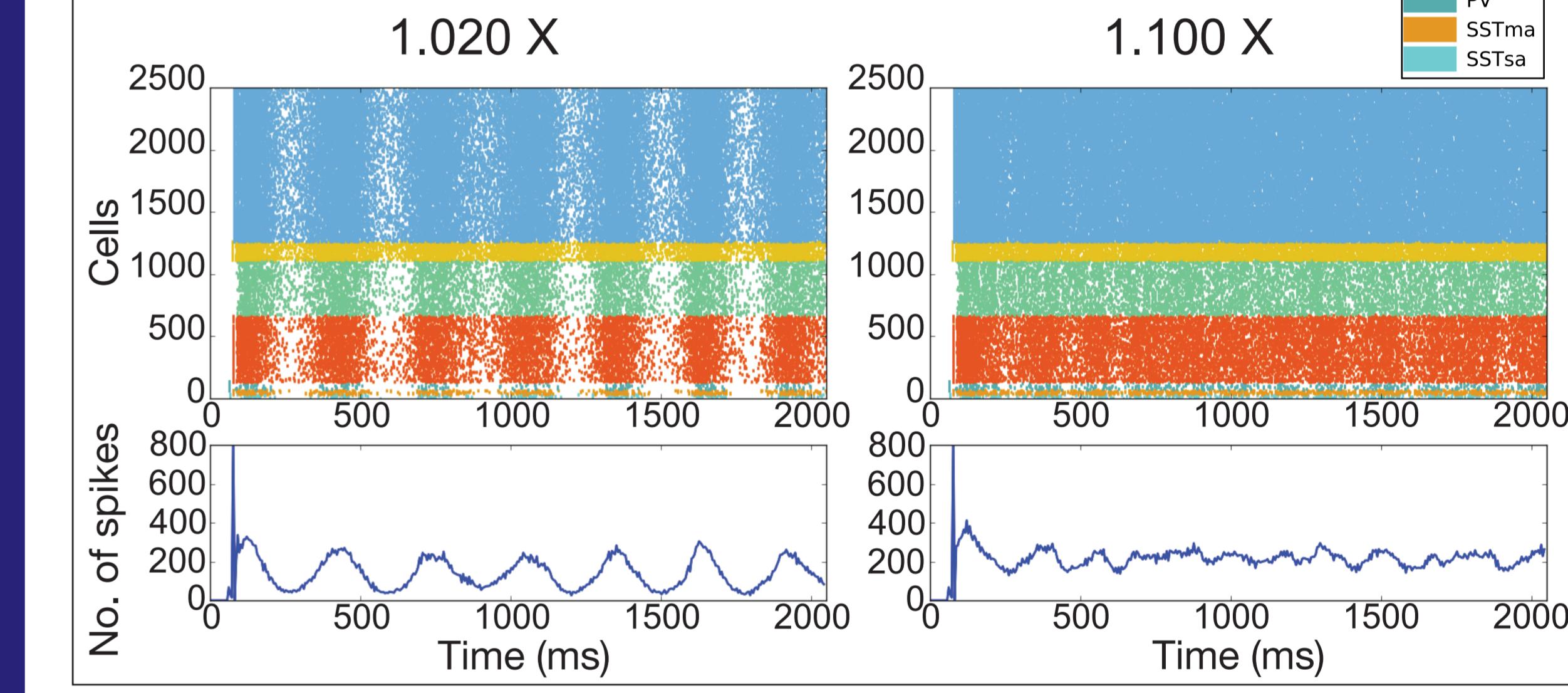
Ongoing network activity depends on reciprocal connections and recurrent activity within the MA2 population

3 Sufficient MA2-MA2 strength is required for persistent activity

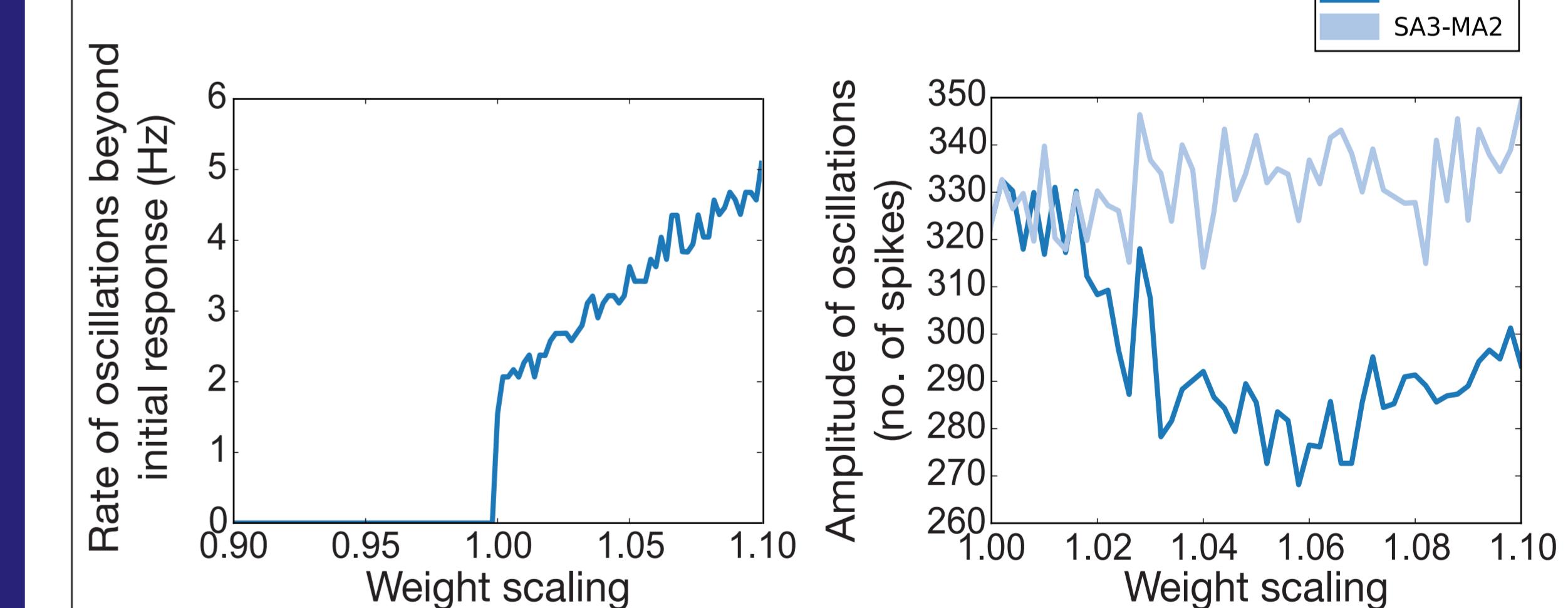
(Synchronised input given to all cells in the network.)



4 MA2-MA2 strength controls frequency of oscillations



5 Frequency of oscillations increases with MA2-MA2 weight, accompanied by a downward trend in oscillation amplitude.



Conclusion

- Oscillations emerged after activation of network regardless of cell type population stimulated.
- MA2, the largest population, may play a role in maintaining oscillatory activity.
- The model offers a means to study both complex dynamics and information flow in the claustrum network.

References

Yanxia Tang, Martin Graf and George J. Augustine (2017). Functional properties and local synaptic circuits of mouse claustrum neurons. Manuscript in preparation.
Dura-Bernal S, Suter BA, Neymotin SA, Kerr CC, Quintana A, Gleeson P, Shepherd GMG, Lytton WW. NetPyNE: a Python package for NEURON to facilitate development and parallel simulation of biological neuronal networks. Computational Neuroscience (CNS'16). Web: neurosimlab.org/netpyne

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