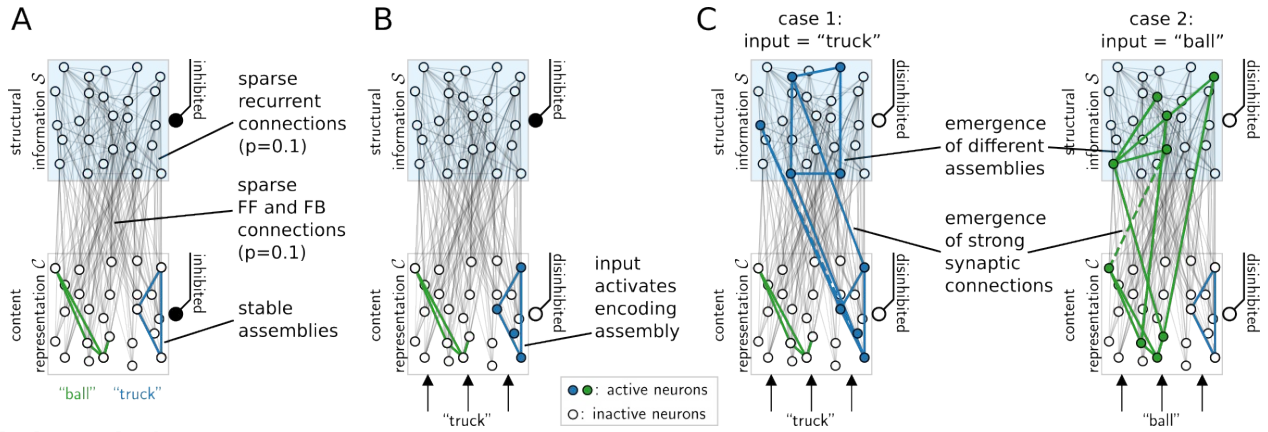
Structured Information Representation with Assemblies of Spiking Neurons

Michael G. Müller[1], Christos H. Papadimitriou[2], Wolfgang Maass[1], Robert Legenstein[1]

[1] Institute of Theoretical Computer Science, Graz University of Technology, Graz 8010, Austria
[2] Computer Science Department, Columbia University, New York, NY 10027

Email: mueller@igi.tugraz.at

High-level cognition requires structured representations of information in which abstract categories are linked to content. Experimental data point to specific subareas of the temporal lobe from which categorical information (like agent or patient in a sentence) can be decoded [1]. We present assembly projections [2], a general mechanism for attaching structural information to content based on assemblies of spiking neurons. We assume that content is encoded by sparse assemblies (similar to the concept cells [3] found in the medial temporal lobe, Fig. A). When activated by input (Fig. B), content can be attached to semantic variables through the formation of a linked assembly in a separate population (Fig. C-D). This link allows structural information to be read out at a later time, leading to the reactivation of the content assembly. Assembly projections emerge through STDP in randomly wired spiking neural networks with divisive inhibition where the different populations are controlled by disinhibition. This models thus provides a very general mechanism for binding (i.e., tying together pieces of information) without relying on assumptions made by many classical models of binding like specific connectivity or special circuitry. As assembly projections also support a number of elementary symbolic computations (e.g., comparing contents linked to different structural categories), they can serve as a building block for models capable of solving more demanding cognitive tasks.



Acknowledgements

This work was supported by the Austrian Science Fund (FWF) projects I 3251-N33 (SASNN) and I 4670-N (SMALL) and by the European Union projects 785907 (HBP) and 824162 (SYNCH).

References

1. Frankland SM and Greene JD (2015) **An architecture for encoding sentence meaning in left mid-superior temporal cortex.** *Proc Natl Acad Sci USA,* 112(37), 11732-11737. doi: 10.1073/pnas.1421236112
2. Müller MG, Papadimitriou CH, Maass W, and Legenstein R (2020). **A model for structured information representation in neural networks of the brain.** *eNeuro*, 7(3). doi: 10.1523/ENEURO.0533-19.2020
3. Quian Quiroga R (2016) **Neuronal codes for visual perception and memory.** *Neuropsychologia,* 83 (2016): 227-241. doi: 10.1016/j.neuropsychologia.2015.12.016