Emergence of binding capabilities in generic spiking neural networks
Michael G. Müller1, Robert Legenstein1, Christos H. Papadimitriou2, Wolfgang Maass1

1 Institute for Theoretical Computer Science, Graz University of Technology, Graz, Austria
2 EECS, UC Berkeley, CA 94720, USA

Summary
- Spiking networks with random connectivity support binding through STDP
- Values are encoded by emerging assemblies
- Variable activity is shaped by the content, consistent with fMRI data [1]
- This binding mechanism allows performing elementary cognitive operations
- Preprint available: https://arxiv.org/abs/1611.03698

Model architecture
- Linked populations of spiking neurons controlled by disinhibition
- Sparse random connectivity with STDP
- Content space: stable assemblies for concepts (like concept cells, [2])
- Variable spaces: encode variables
- Disinhibition of variable space while content assembly is active: emergence of assembly linked with content representation

Recalling variables
- Disinhibition of variable space after delay: previously active assembly activates content representation
- Neurons driven to fire by transiently increased excitability
- Simulation results: robust recall for different network wirings and content assemblies (success rate 100%, success criterion: > 80% assembly overlap)

Content-shaped activity
- fMRI data from Frankland and Greene [1]: areas in lmSTC encode specific semantic variables
- Example: can read out agent (“truck”) and patient (“ball”) in a sentence (“The truck hit the ball.”)
- Simulation results: robust readout (> 97% accuracy) from subsampled activity under severe noise conditions

Symbolic operations
- Elementary cognitive computations supported by this model:
  - Copying contents between variables
  - Comparing variable contents

References