

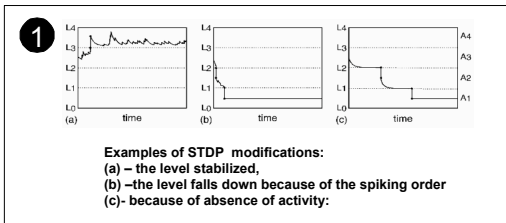
STRUCTURE AND DYNAMICS OF PRECISE FIRING SEQUENCES DETECTED IN COUPLED NEURAL NETWORKS

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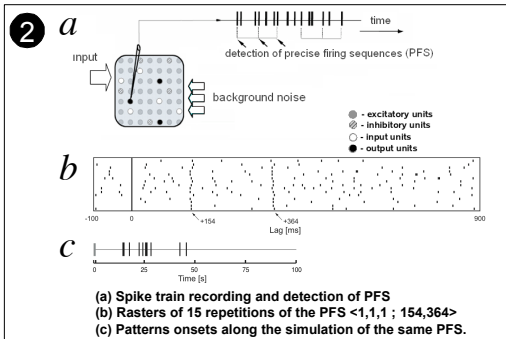
NEURAL NETWORK MODEL

- The network is initially created with 8000 excitatory and 2000 inhibitory units following Sobol quasi random distribution on a 100x100 lattice with connections established following a 2D Gaussian probability densities.
- STDP rule: synapses are characterized by 4 activation levels. Each post- or presynaptic spike modifies a real valued function: postsynaptic spike coming shortly after the postsynaptic one increments the function, spiking in the opposite order decrements the function. Then the function crosses a boundary the synapse change the activation level. Then the activation falls down to the lowest level the synapse is definitively excluded from the network (Fig.1).



PRECISE FIRING PATTERNS

Spike trains of units being active by the end of simulation were scanned for occurrences of preferred firing sequences (PFS) by means of the PGA [TV] (Figure 2).



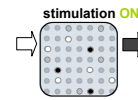
EXTERNAL STIMULATION

The duration of each stimuli is 100 ms, at 0.5 Hz rate. 800 excitatory units are arbitrary selected as input units and divided into two groups, A and B. Sequences AB and BA are random and equiprobable. Each group (A or B) is subdivided into 10 subgroups and receives a depolarization each ms of the stimulus in the following order:

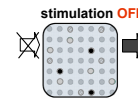
$$AB: \underbrace{[A_1, A_2, \dots, A_{10}]}_{5 \text{ times}}; \underbrace{[B_1, B_2, \dots, B_{10}]}_{5 \text{ times}}; \quad BA: \underbrace{[B_1, B_2, \dots, B_{10}]}_{5 \text{ times}}; \underbrace{[A_1, A_2, \dots, A_{10}]}_{5 \text{ times}}$$

SIMULATIONS

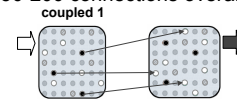
Stimulation ON: keeping the same rules and parameters the simulation was repeated 30 times with different random generator seeds.



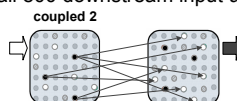
Stimulation OFF: the seeds were reused to reproduce 30 simulations in absence of stimulation.



Coupled Networks 1: excitatory units keeping at least 5 active connections by the end of simulation formed the output layer of the upstream network (~150-200 units). The spike train of one output unit is being sent to one input unit of the downstream network instead of stimulus (~ 150-200 connections overall).

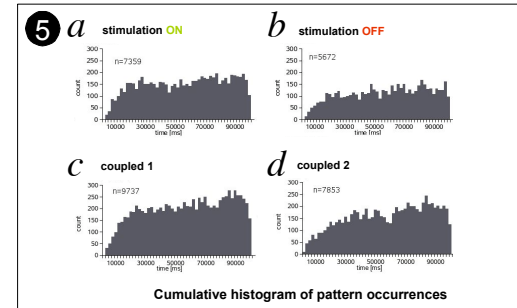
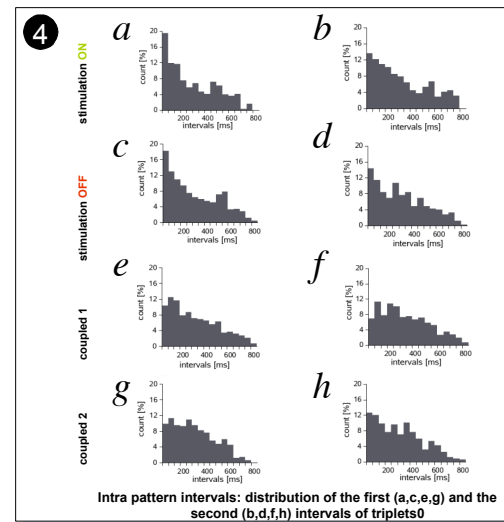
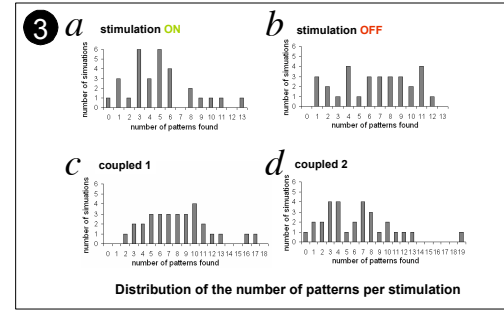


Coupled Networks 2: the output units of the upstream network are connected to several input units in order to project to all 800 downstream input units.



RESULTS

	Stim ON	Stim OFF	Coupled 1	Coupled 2
Active cells	5352	4240	4860	3763
Detected Patterns	197 (3.7%)	147 (3.5%)	241 (5%)	168 (5%)
Pattern Occurrences	7359 (38.5)	5672 (37.4)	9373 (39.9)	7853 (46.8)
Triplets/Quadruplets	59/138=0.4	54/93=0.6	107/134=0.8	89/99=0.9
Multi-unit Patterns	6	5	8	12



DISCUSSION

The results show that the downstream network activity was characterized by fewer surviving units at the end of the simulation run although the active cells to detected pattern ratio is greater as well as the mean number of single pattern repetitions.

In presence of the external stimulus precise firing patterns observed in the upstream network were relatively more frequent than in the absence of stimulation.

The intrapattern structure of precise firing sequences and ratio triplet-quadruplet are different for coupled networks which may signify that a stimulation or input from coupling makes networks be organizing differently than in absence of stimulation.

As a common feature of precise firing for all four series the tendency of patterns to be formed by the network during first 20 seconds and the quasi invariant level of number of pattern occurrences after first 20 seconds until the end of simulation which may correspond to the periods of self organization and stability of the network.

REFERENCES

[TV] Tetko IV, Villa AEP (2001) A pattern grouping algorithm for analysis of spatiotemporal patterns in neuronal spike trains. 1. detection of repeated patterns, Journal of Neuroscience Methods 105: 1-14.