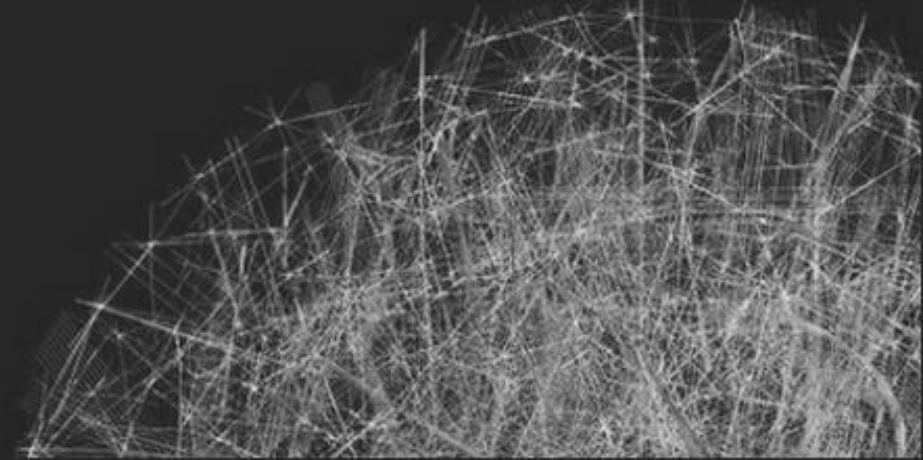


# NeuroMat



## Synaptic plasticity in a cortical microcircuit model: different scenarios



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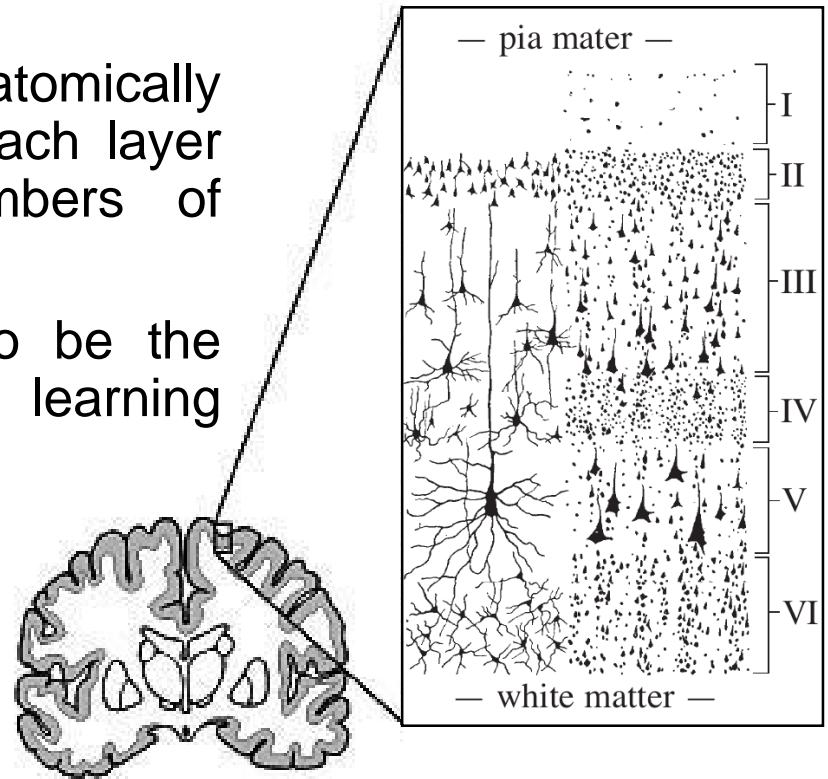
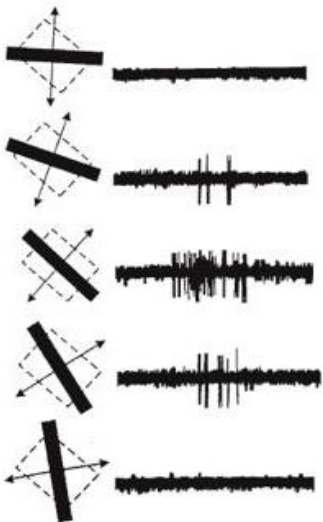




# Introduction

# Primary visual cortex

- As the entire neocortex, V1 is anatomically divided into six layers, where each layer has different types and numbers of neurons.
- Synaptic plasticity is thought to be the underlying mechanism behind learning and memory.



- There are neurons in V1 which its response is selective to angular orientation.

# Goal

- How does the synaptic plasticity affect the orientation selectivity of the network?

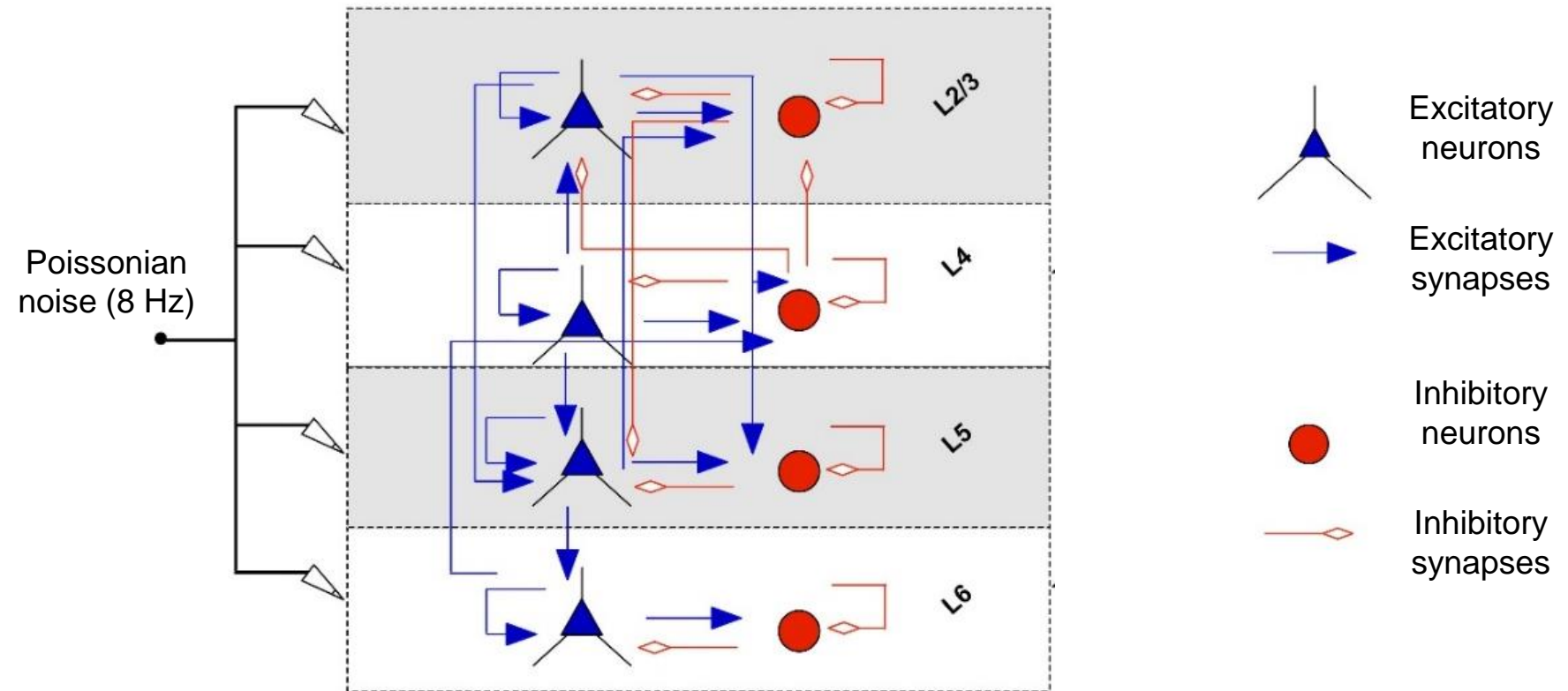




# Methods

# The network

10,000 neurons  
~ 5 million synapses

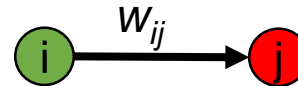


Excitatory/inhibitory ratio = 4:1

# Stochastic neuron model (GL model)

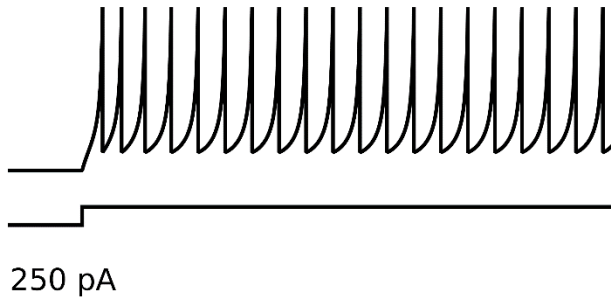
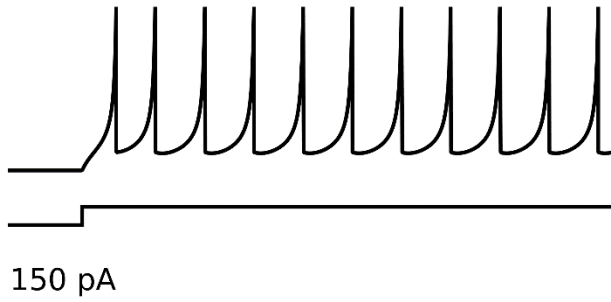
$$V_i(t + 1) = \begin{cases} V_r & \text{if } X_i(t) = 1 \\ \mu(V_i(t) - V_r) + V_r + RI_i(t) + \sum_{j=1}^N w_{ij} X_j(t); & \text{if } X_i(t) = 0 \end{cases}$$

Synaptic increment

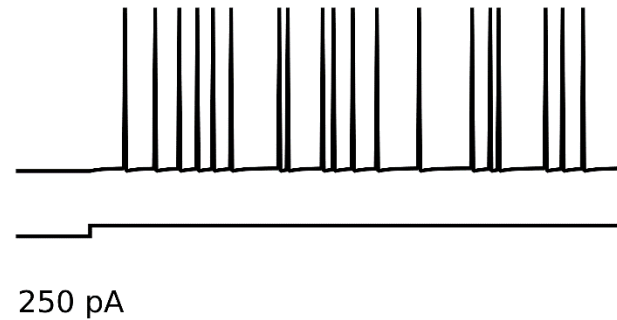
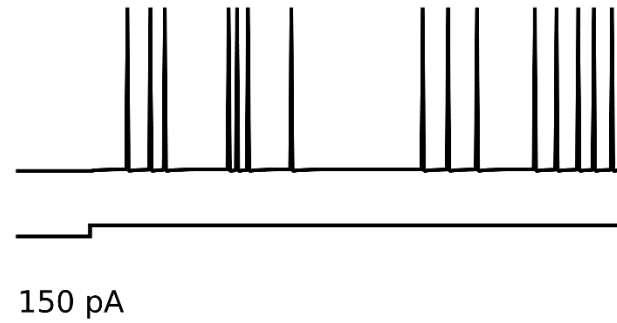
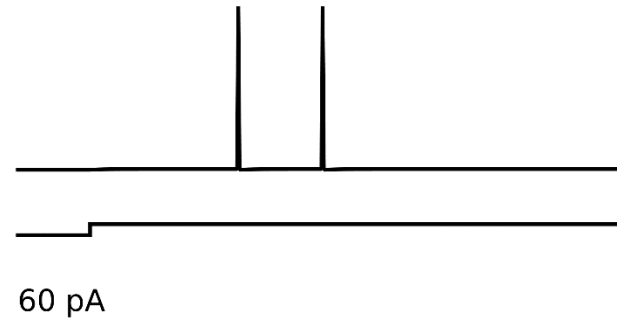


$$\Phi(V) = \begin{cases} 0 & \text{if } V \leq V_t \\ [\gamma(V - V_r)]^r & \text{if } V_t < V < V_S \\ 1 & \text{if } V \geq V_S \end{cases}$$

### Izhikevich Model - RS

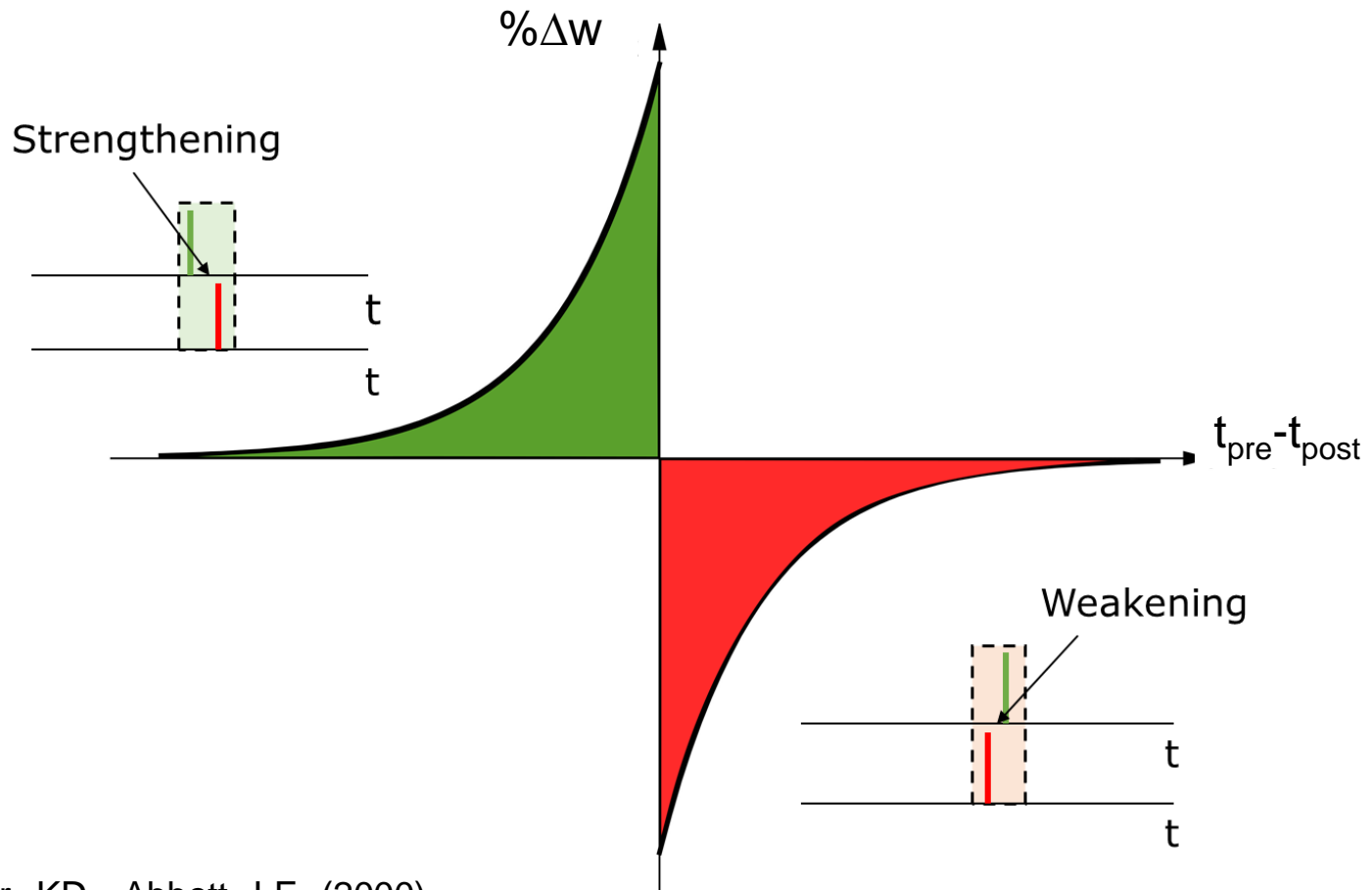


### GL Model - RS





# Asymmetric spike-timing-dependent plasticity (STDP) rule



\* Song S, Miller KD, Abbott LF (2000). Competitive Hebbian learning through spike-timing-dependent synaptic plasticity.

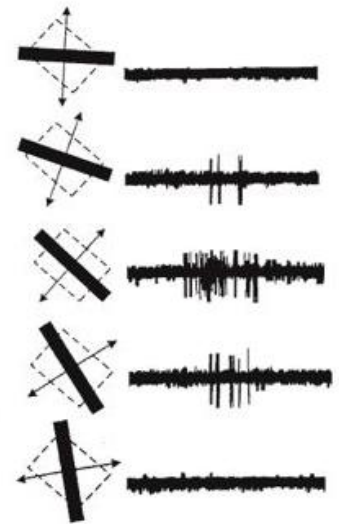
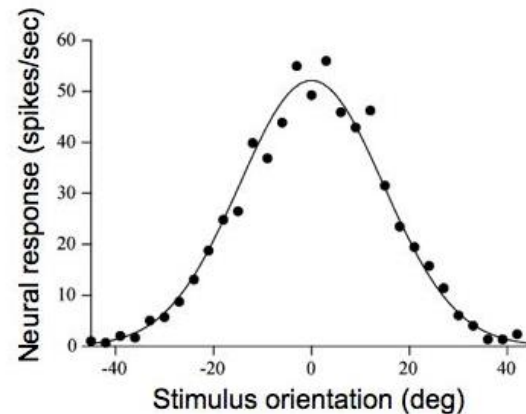
# Simulations

- Duration of simulation: 10000 ms;
- 1st: Poissonian spike trains applied as background with 8 Hz;
- 2nd: visual stimuli applied at L4 as angular oriented pulses;

$$I_{ext,i} = I \cdot \cos(\theta_I - \theta_i^*)$$

Orientation selectivity index (OSI):

$$OSI_i = \frac{\sqrt{(\sum_{\theta} f_i(\theta) \cos(2\theta))^2 + (\sum_{\theta} f_i(\theta) \sin(2\theta))^2}}{\sum_{\theta} f_i(\theta)}$$



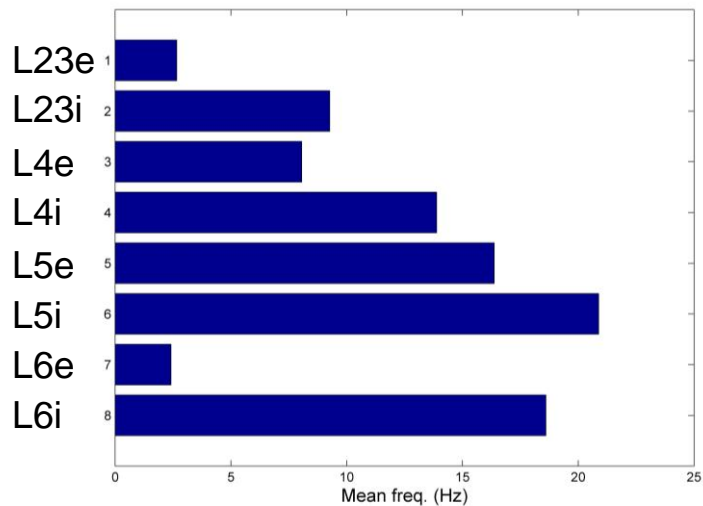
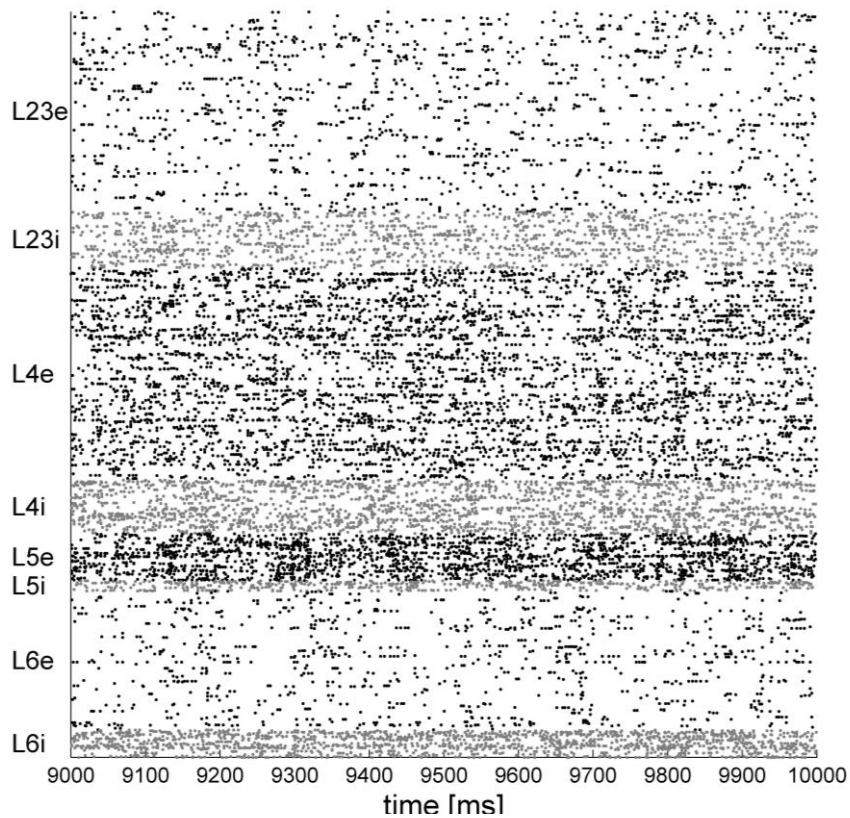
OSI = 0 → The neuron fires for any stimuli.

OSI = 1 → The neuron fires preferentially to one angle.

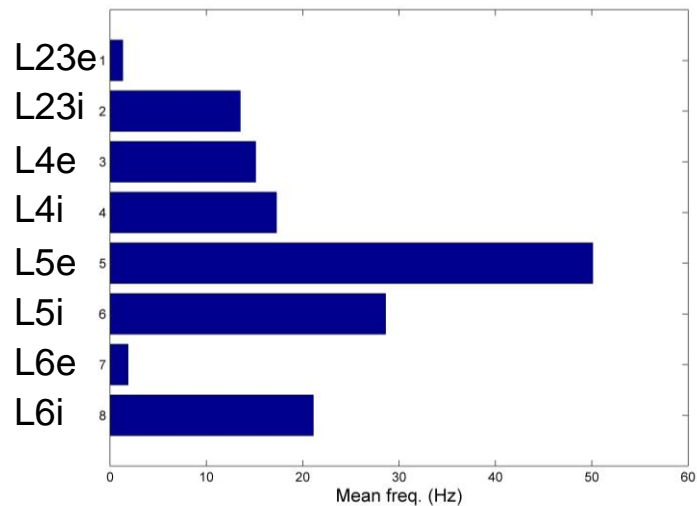
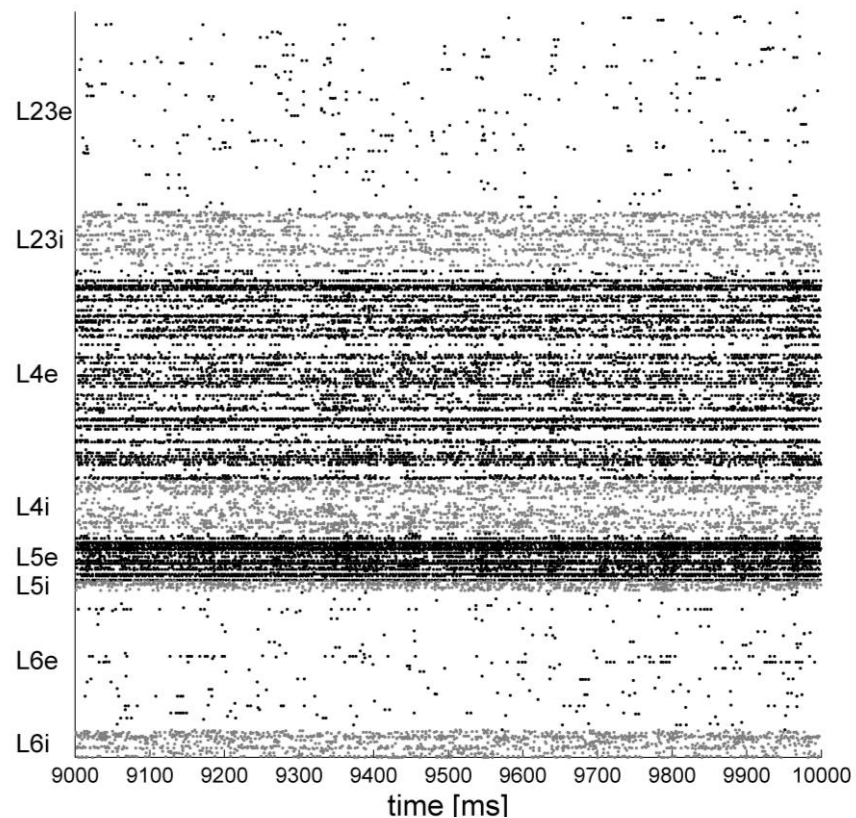


# Preliminary results

# Control (no STDP)



# With STDP

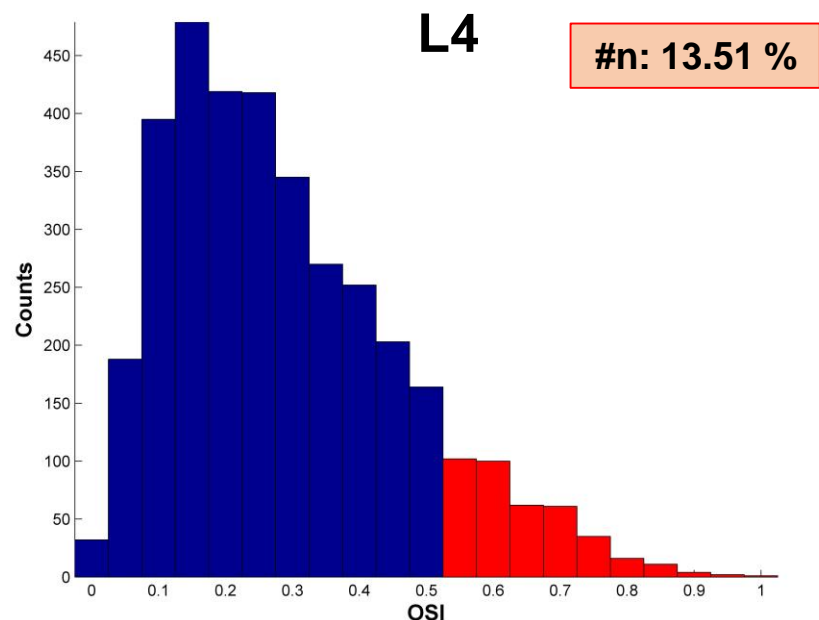
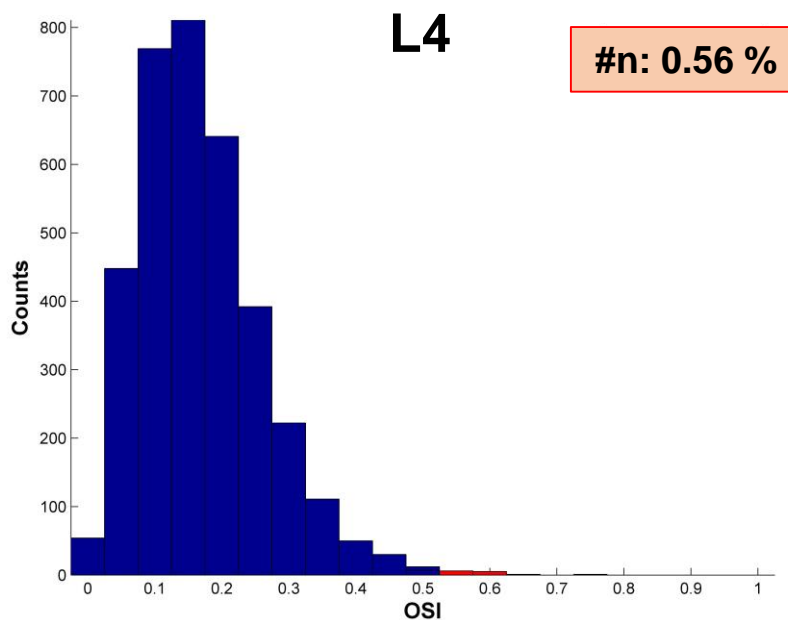
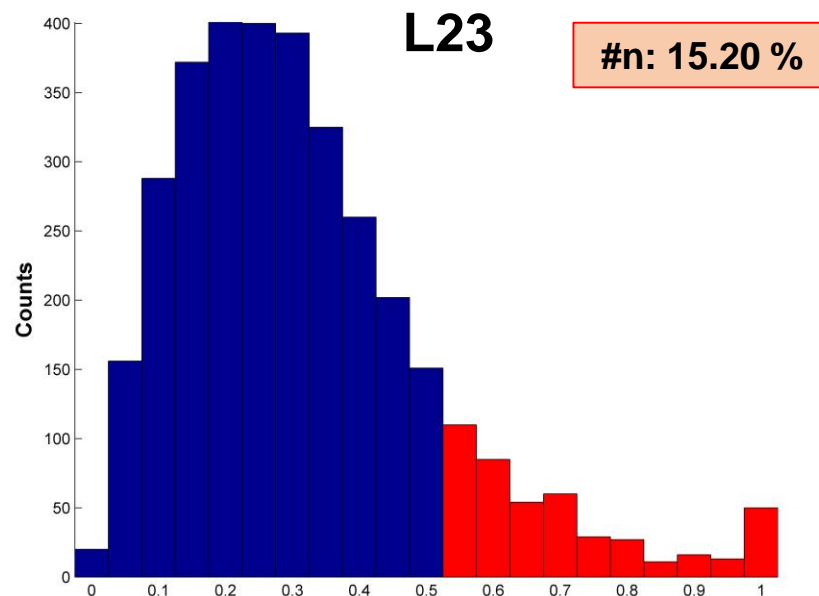
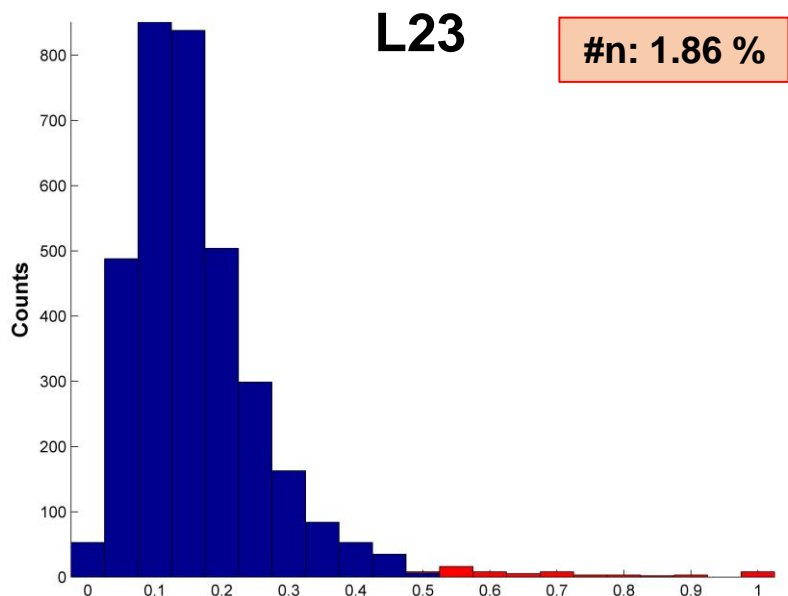




# Orientation Selectivity Index (OSI)

## Control

## STDP

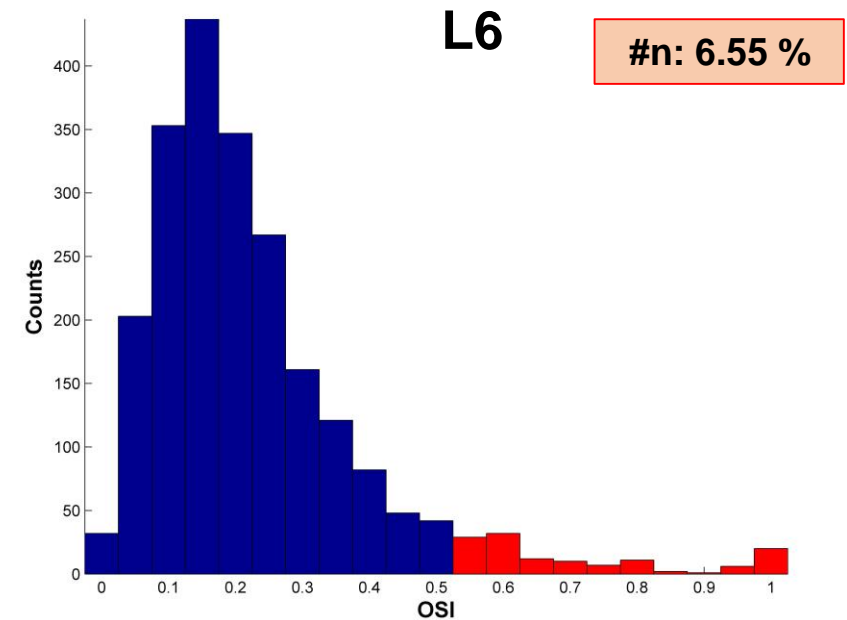
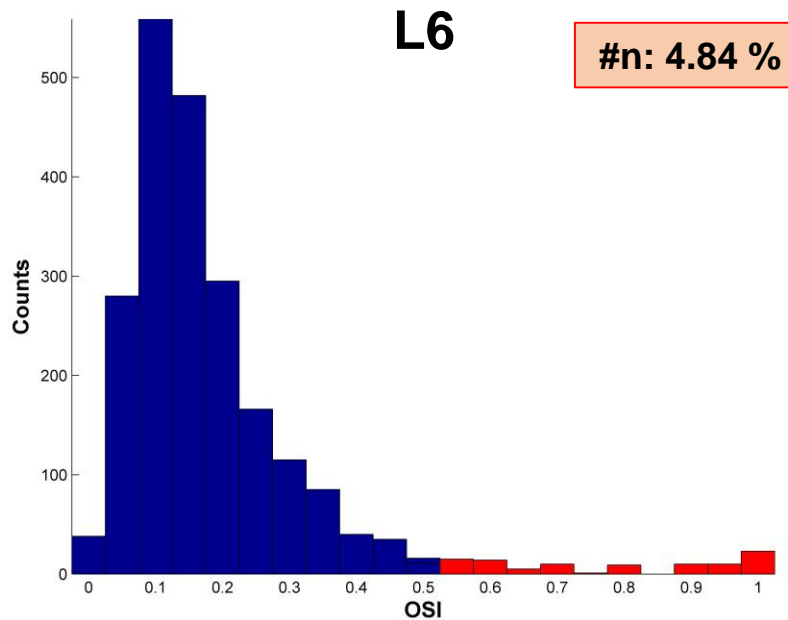
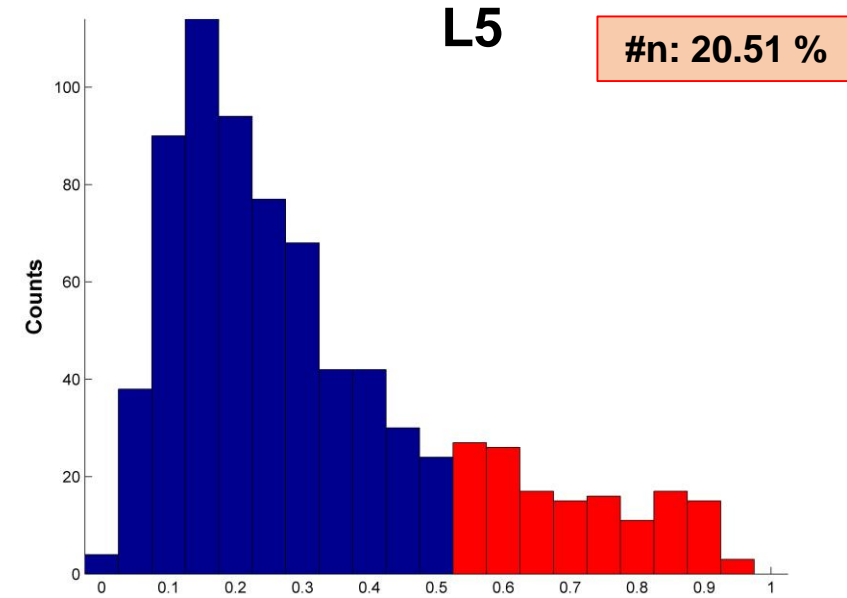
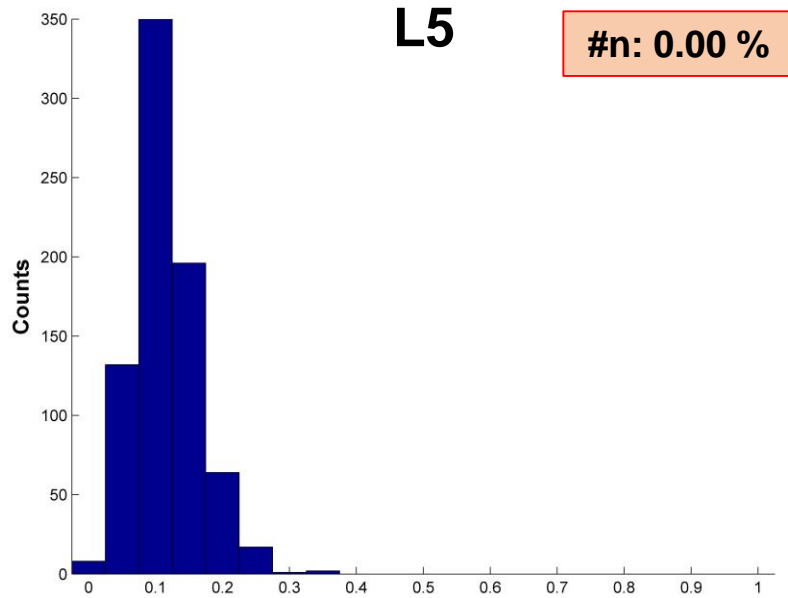




# Orientation Selectivity Index (OSI)

## Control

## STDP



# Partial conclusion

- In the first case, the network with STDP higher average frequency;
- STDP can improve the orientation selectivity in this network.

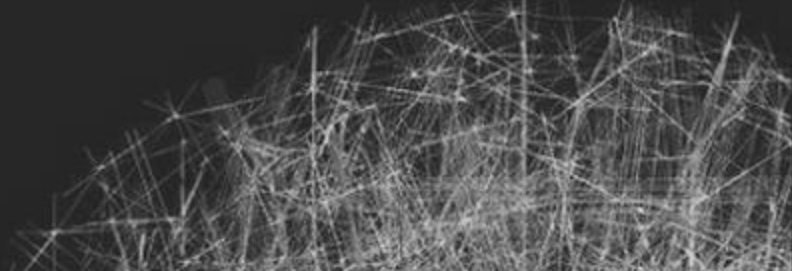


# References

# References

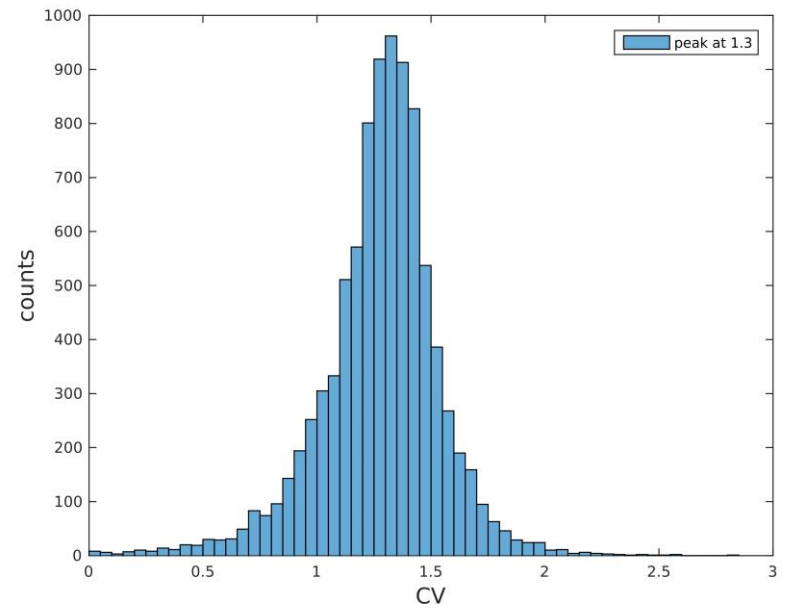
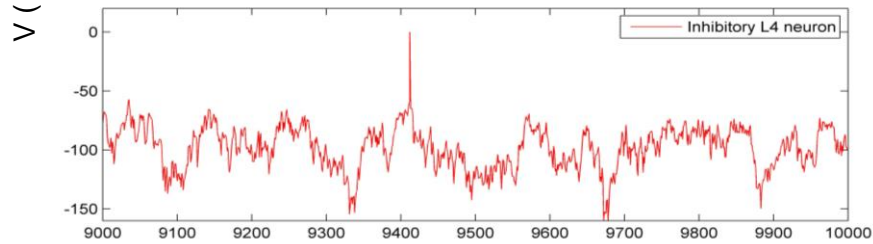
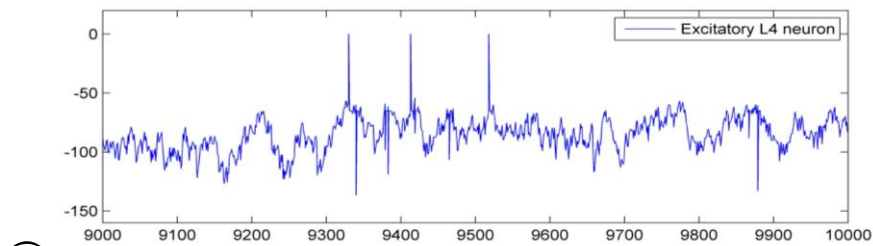
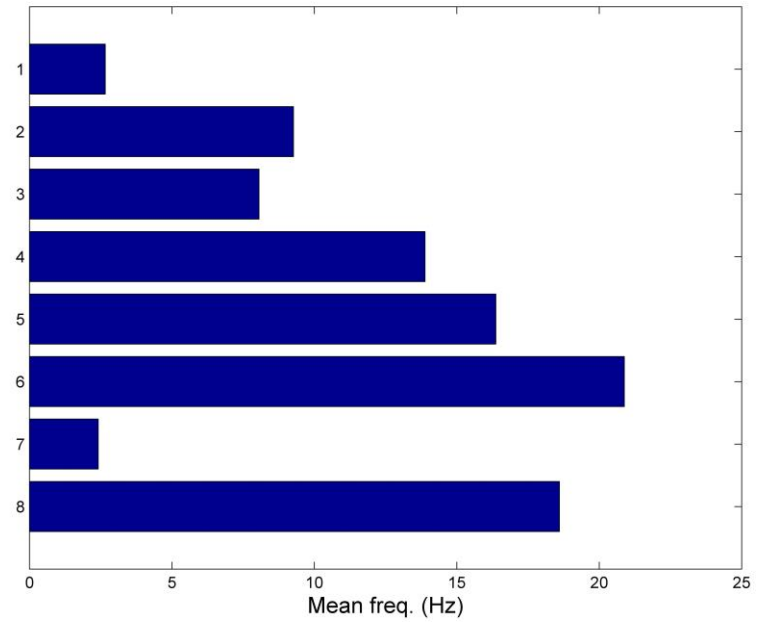
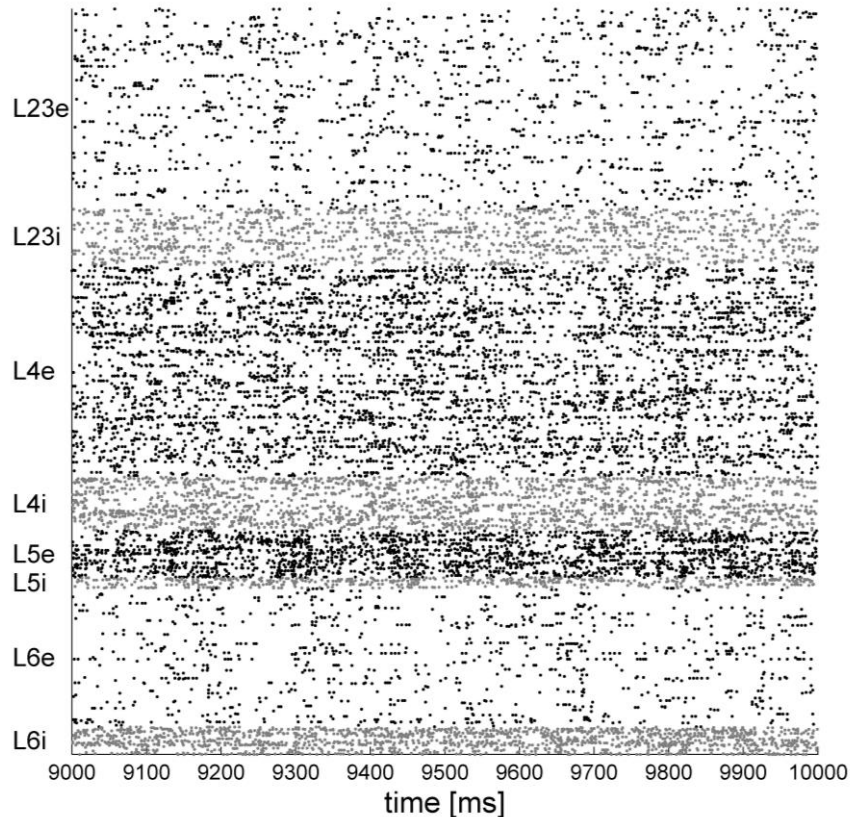
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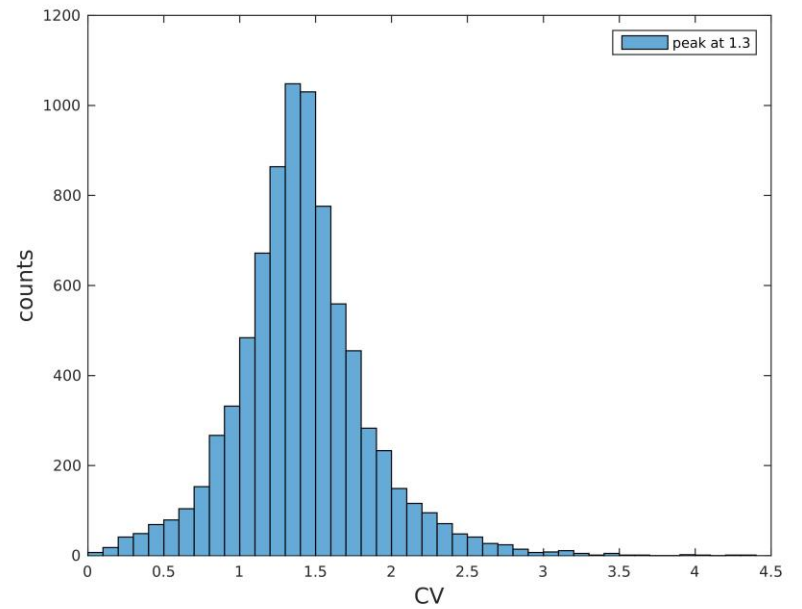
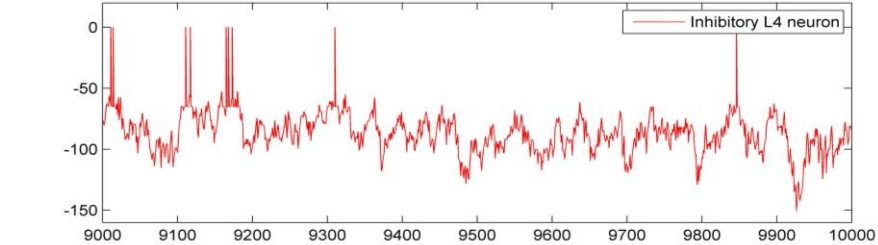
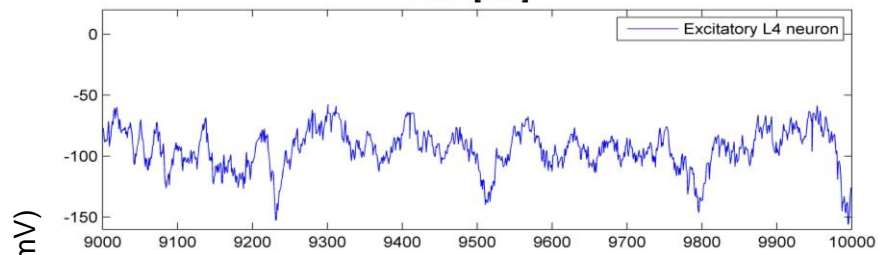
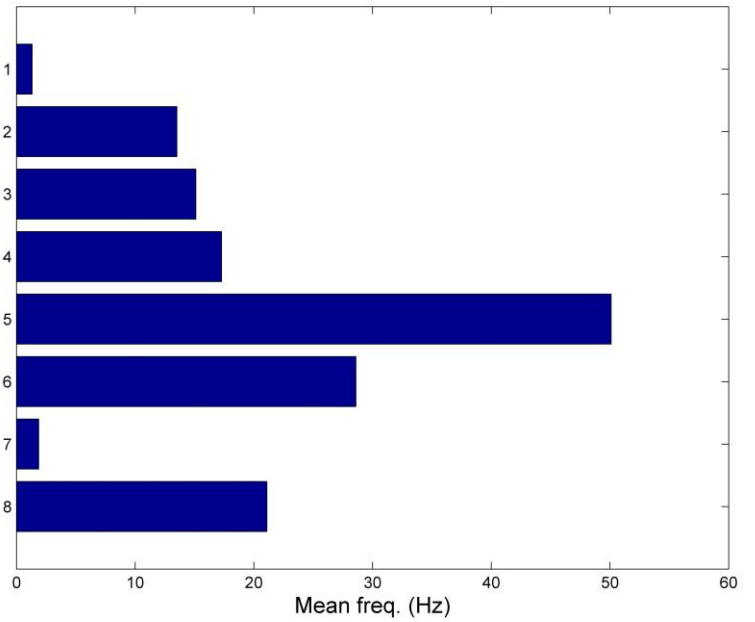
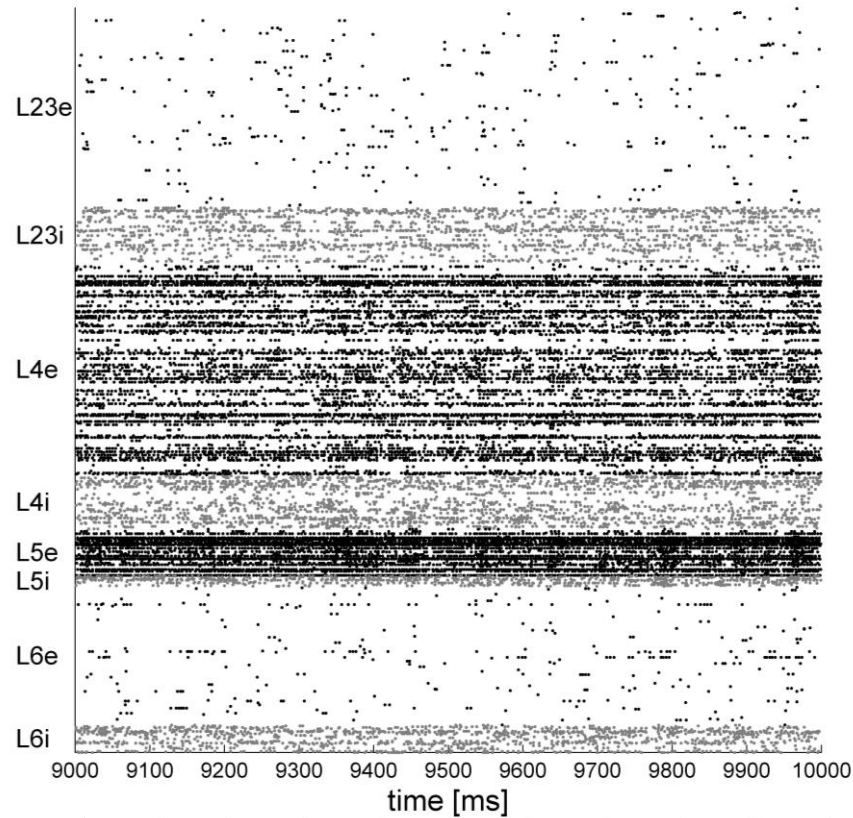




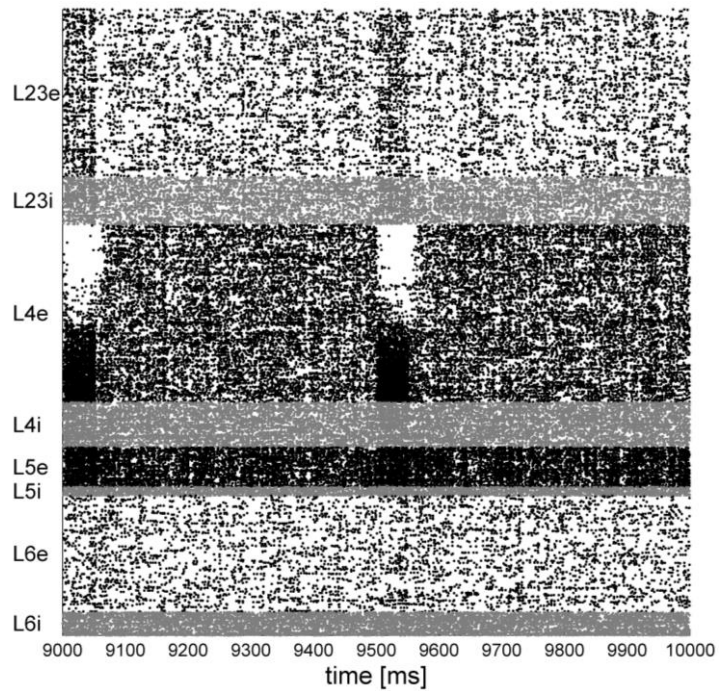
# Control (no STDP)



# With STDP



# Control



# STDP

