

# **Oscillatory Neural Model of Spiking Elements for Memorising of Time-Sequencies**

Roman Borisyuk

*University of Plymouth, UK*

# Introduction

There are two main ideas for designing a memory of sequences:

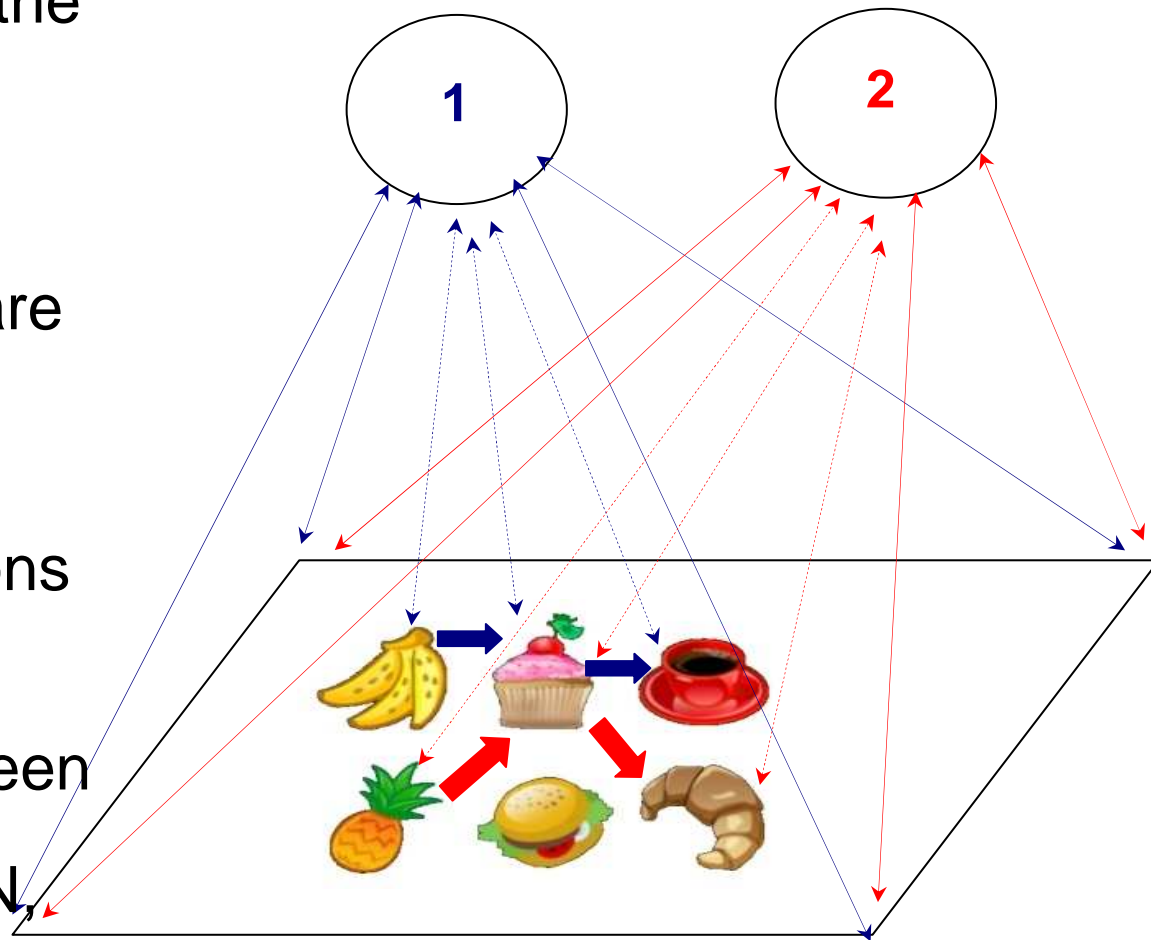
- Chain: To chain consecutive events
- Label: To mark events by ordered labels

# Oscillatory Model of Spiking Elements

- We develop an oscillatory neural network (ONN) model which is designed as a network of **coupled oscillators**.
- Oscillator comprises **excitatory and inhibitory spiking elements of Hodgkin-Huxley** type with all-to-all connections.
- Connections between oscillators are all-to-all type and they are established between excitatory neurons of different oscillators.
- **STDP type learning rule** takes into account activity level of oscillators in two sequential time windows.

# Star-Like Connections

- During memorization the connections between **Central Neuron (CN)** and neurons representing the sequence of objects are adjusted.
- During recall the CN inhibits activities of all neurons except neurons representing the sequence of objects.
- Due to interplay between local connections and global inhibition by CN, **sequences with a common object** (A>B>C, D>B>E) can be recalled.

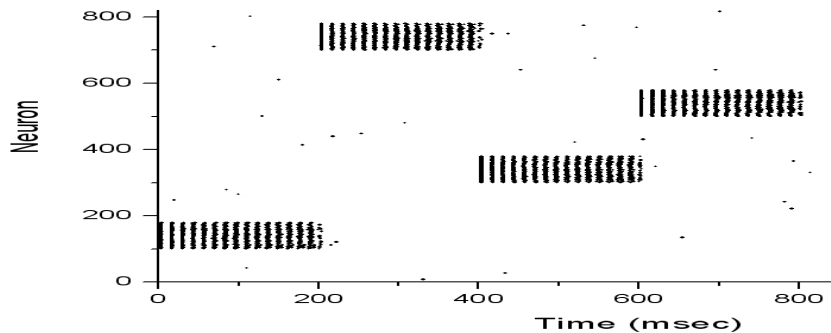


# Memorising a sequence of 6 objects



Each object is coded by a set of 20 neural oscillators corresponding to different object' features.

**An object presentation means stimulation of corresponding oscillators for 200ms. Objects appear sequentially.**

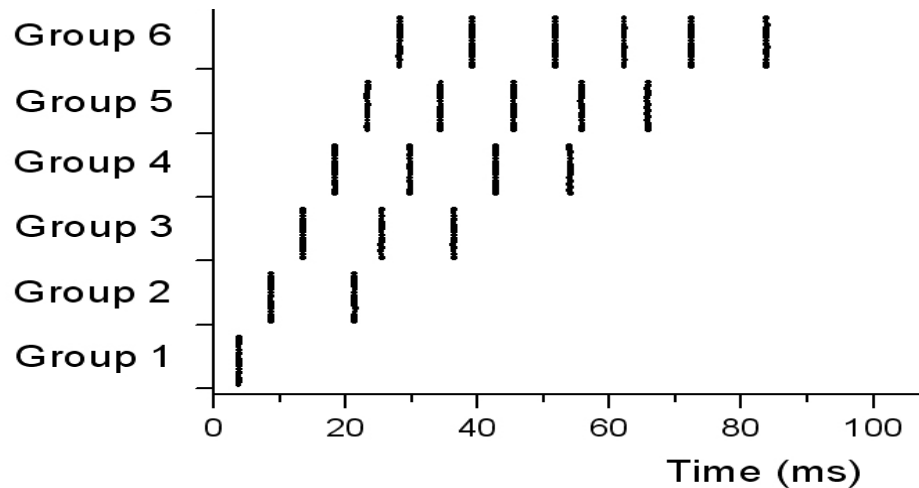


# Replay 1 (arrow shows 1<sup>st</sup> object)

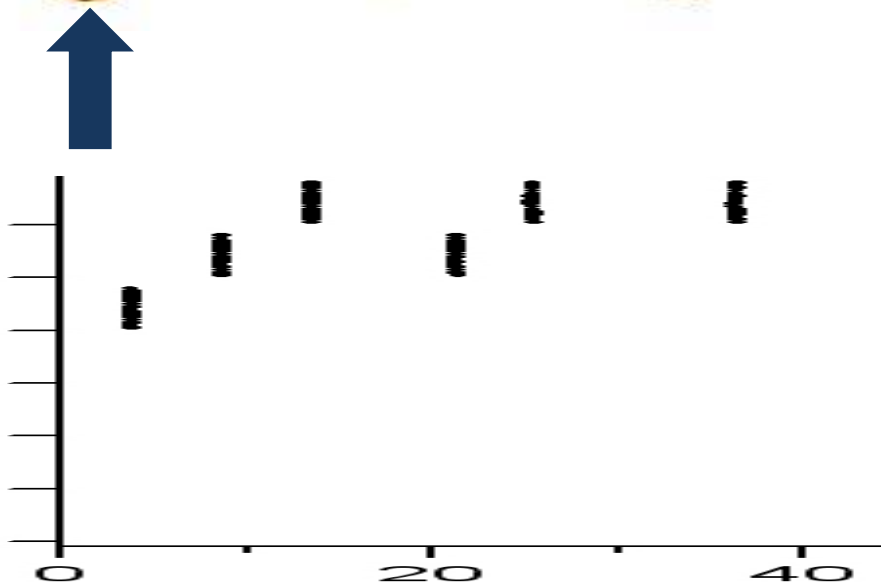


**A total duration of replay is 200ms.**

**Objects appear sequentially with a short delay.**



Replay 2 (arrow shows 1<sup>st</sup> object)



# Memorising of two sequences

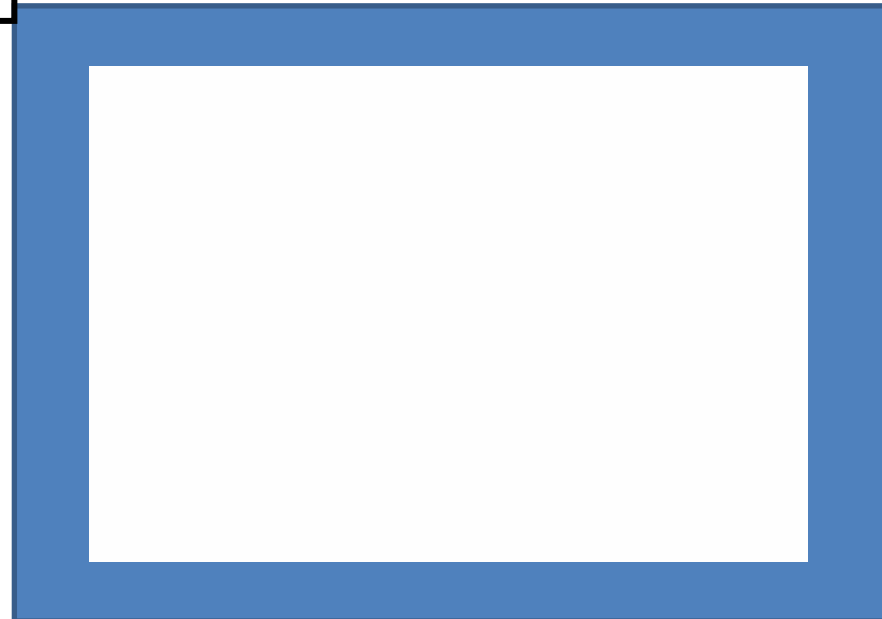


**Blue sequence**

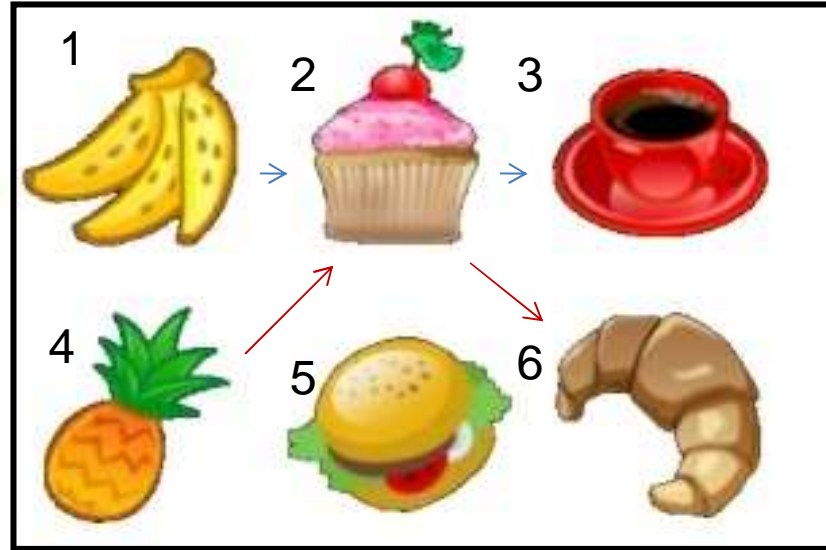
**Two sequences  
with a common  
element:**

**Blue: 1>2>3**

**Red: 4>2>6**



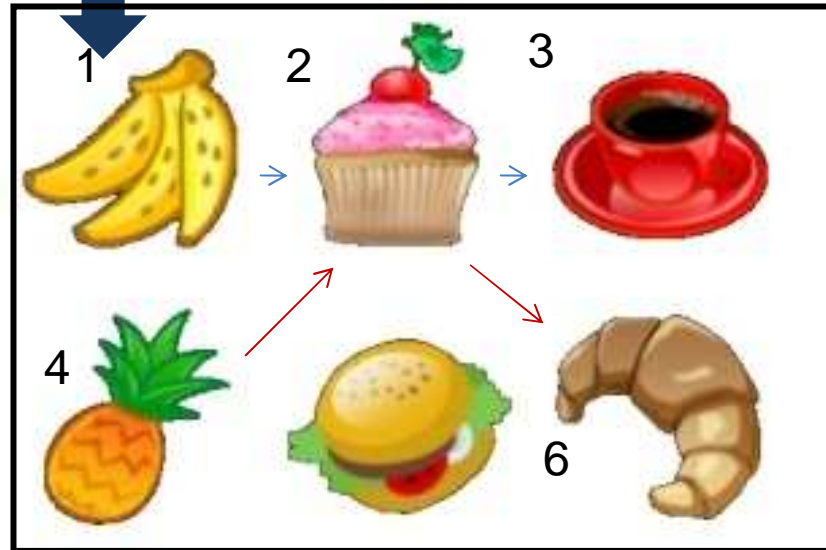
# Memorising of two sequences



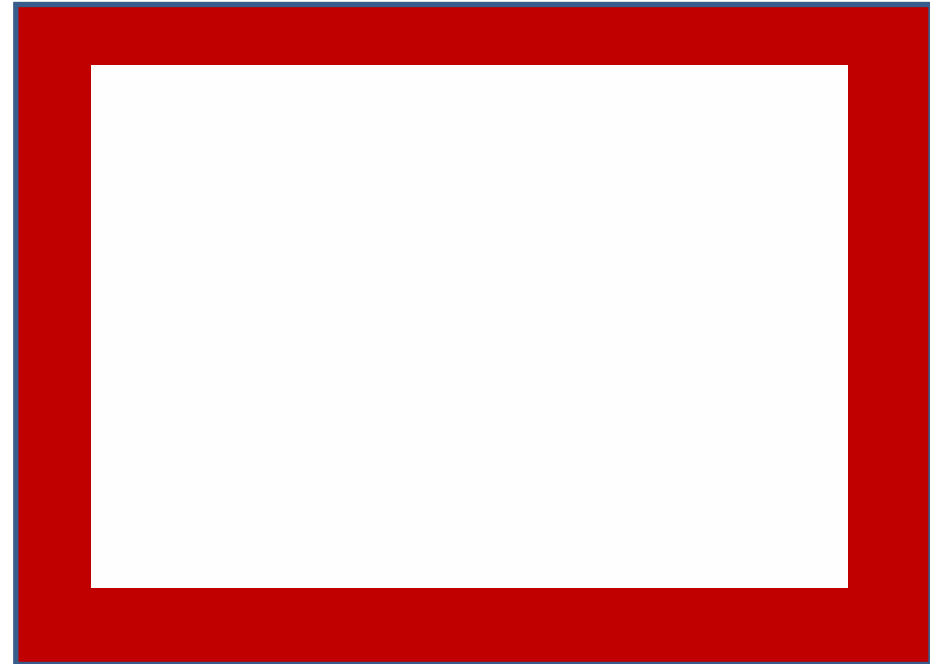
**Red sequence**



# Replay of blue sequence



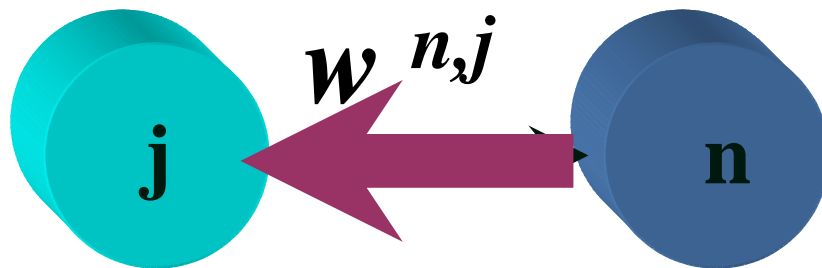
# Replay of red sequence



# Anti STDP and Reverse Replay

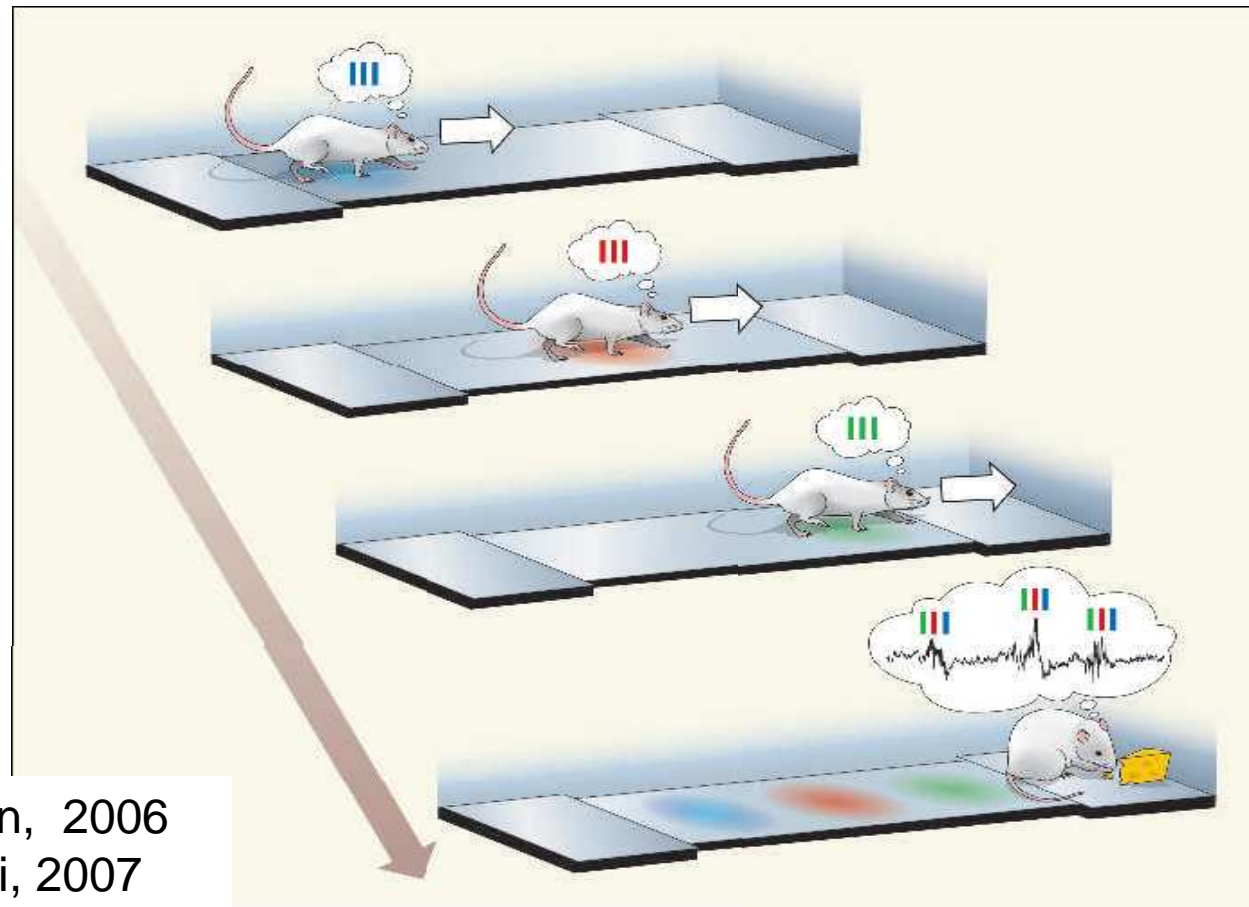


$$w^{n,j}(m+2) = w^{n,j}(m+1) + (\alpha + \beta) \cdot \sigma(E_{\max}^j(m) - h) \cdot \sigma(E_{\max}^n(m+1) - h) - \beta$$



# Application: Preplay and Reverse Replay of Hippocampal Place Cells

Borisyuk R, Chik D. 2009. In preparation



Foster & Wilson, 2006  
Diba & Buzsaki, 2007



**PLYMOUTH**