

## How Gibbs distributions may naturally arise from synaptic adaptation mechanisms

Juan Vasquez, Bruno Cessac, Horacio Rostro-Gonzalez, Thierry Vieville

► **To cite this version:**

Juan Vasquez, Bruno Cessac, Horacio Rostro-Gonzalez, Thierry Vieville. How Gibbs distributions may naturally arise from synaptic adaptation mechanisms. BMC Neuroscience, BioMed Central, 2009, 10 (Suppl 1), pp.P213. <hal-00784452>

**HAL Id: hal-00784452**

**<https://hal.inria.fr/hal-00784452>**

Submitted on 4 Feb 2013

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Poster presentation

Open Access

## How Gibbs distributions may naturally arise from synaptic adaptation mechanisms

Juan C Vasquez\*<sup>1</sup>, Bruno Cessac<sup>1,2</sup>, Horacio Rostro-Gonzalez<sup>1</sup> and Thierry Vieville<sup>3</sup>

Address: <sup>1</sup>NEUROMATHCOMP, INRIA Sophia-Antipolis Méditerranée, 06902, France, <sup>2</sup>LJAD, U. Of Nice-Sophia, France, 06000, France and <sup>3</sup>CORTEX, INRIA-LORIA, France

Email: Juan C Vasquez\* - Juan-Carlos.Vasquez@inria.fr

\* Corresponding author

from Eighteenth Annual Computational Neuroscience Meeting: CNS\*2009 Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P213 doi:10.1186/1471-2202-10-S1-P213

This abstract is available from: <http://www.biomedcentral.com/1471-2202/10/S1/P213>

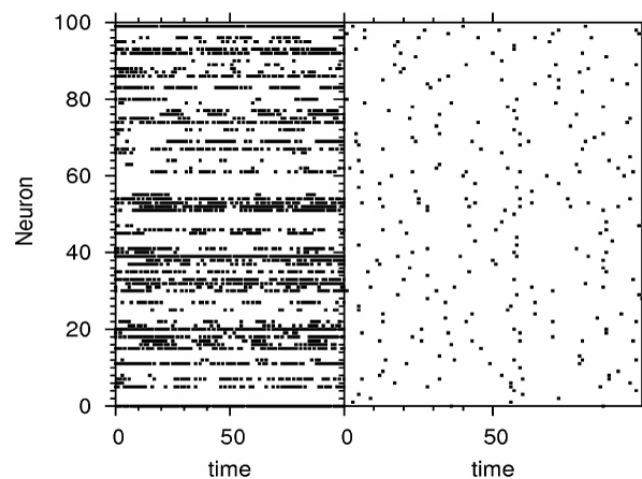
© 2009 Vasquez et al; licensee BioMed Central Ltd.

It is assumed that complex perceptual or sensori-motor tasks are the result of neural network dynamics and are expressed by spike trains containing the neural code. Hence, in this context two main questions are (i) How to characterize the statistical properties of sequences the spikes trains produced by neuronal networks and (ii) What are the effects of synaptic plasticity on these statistics? Using methods from dynamical systems theory and statistical physics, we introduce a framework which applies for very general forms of spike train properties allowing to characterize miscellaneous forms of neural code (rank coding, synchronizations, correlations of different orders, etc.). In this framework, spike trains are associated with a coding of membrane potential trajectories constituting a symbolic coding in important modeling examples. On this basis, we use the thermodynamic formalism from ergodic theory to show how Gibbs distributions are natural probability measures to describe the statistics of spike trains, given the data of known empirical averages. Finally, we show that Gibbs distribution naturally arise when considering slow synaptic plasticity rules, where the only requirement is that characteristic time for synapse adaptation must be quite a bit longer that the characteristic time for neurons dynamics. We include some simulations results applying this framework on recurrent neural network with discrete time current based dynamics under the action of an STDP rule (see Figures 1 and 2). Numerical results are in accord with theory estab-

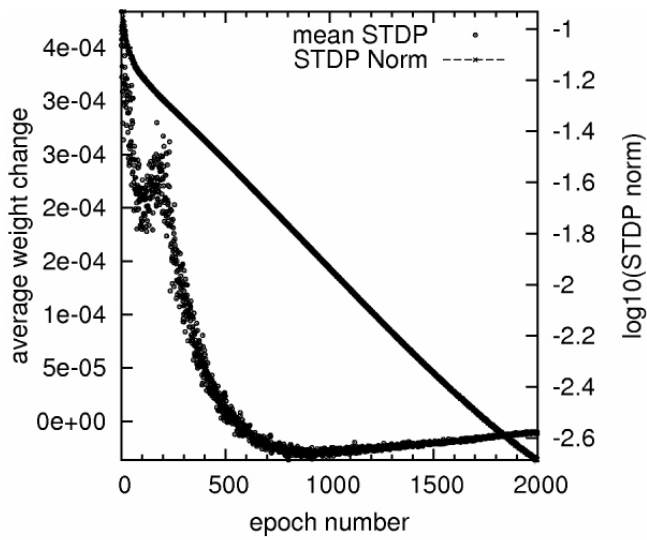
lishing that the topological pressure is a variation quantity with a minimum given by a Gibbs distribution (Figure 3).

### Acknowledgements

Partially supported by the ANR MAPS & the MACCAC ARC projects.



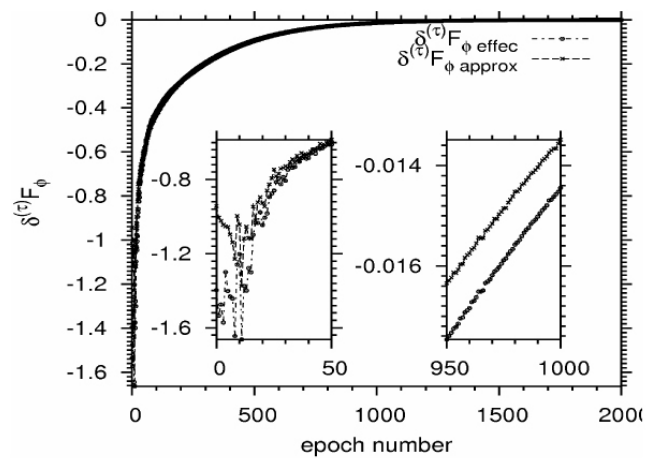
**Figure 1**  
Raster plot for Neurons at start (left) and after 2000 epochs of STDP(right).



**Figure 2**  
**Evolution of the average synaptic modification (mean STDP) and of the Frobenius norm of the total change on the whole synaptic matrix (STDP norm).**

**References**

1. Cessac B, Rostro-Gonzalez H, Vasquez JC, Viéville T: **How Gibbs distribution may naturally arise from synaptic adaptation mechanisms.** *J Stat Phys* in press. arXiv:0812.3899v1



**Figure 3**  
**Evolution of the variation of the topological pressure calculated by two estimation methods.**

Publish with **BioMed Central** and every scientist can read your work free of charge

*"BioMed Central will be the most significant development for disseminating the results of biomedical research in our lifetime."*  
 Sir Paul Nurse, Cancer Research UK

Your research papers will be:

- available free of charge to the entire biomedical community
- peer reviewed and published immediately upon acceptance
- cited in PubMed and archived on PubMed Central
- yours — you keep the copyright

Submit your manuscript here:  
[http://www.biomedcentral.com/info/publishing\\_adv.asp](http://www.biomedcentral.com/info/publishing_adv.asp)