

POSTER PRESENTATION

Open Access

Dendritic nonlinearities enable PFC microcircuits to serve as predictive modules of persistent activity

Athanasia Papoutsis^{1,2*}, Panagiotis C Petrantonakis¹, Panayiota Poirazi¹

From Twenty Second Annual Computational Neuroscience Meeting: CNS*2013
Paris, France. 13-18 July 2013

The ability to monitor and probe the activity of large neuronal networks both *in vivo* and *in vitro* has recently established that neurons of various brain regions are organized into spatially restricted clusters (or small assemblies) that are bi-directionally connected, share common inputs and are co-activated during behavioral tasks [1,2]. Investigations regarding the functional implications of such neuronal clustering have proposed that this modularity may underlie the spiking irregularities seen in cortical activity *in vivo* [3] or code for the execution of a voluntary movement [4]. In the prefrontal cortex (PFC), such microcircuits are proposed to support the spontaneous emergence of Up and Down states [5], a phenomenon linked to persistent activity, which is the cellular correlate of working memory.

In this work we investigate the functional role of PFC microcircuits in the expression of persistent activity, focusing on the contribution of nonlinear dendritic properties to the induction, termination, and coding of upcoming state transitions.

Towards this goal we developed a layer V PFC microcircuit consisting of 7 pyramidal neurons and 2 interneurons implemented in the NEURON simulation environment. Modelling equations for the biophysical mechanisms used have been reported in [6,7]. All neuron models were biophysically detailed but morphologically simplified and were validated regarding their intrinsic, synaptic and connectivity properties (e.g. number of synapses, latencies etc). Our results show that the non-linear integration of synaptic inputs at the basal dendrites of pyramidal neurons, mediated by the

induction of NMDA-spikes, is imperative for the emergence of the persistent state in the microcircuit, but this necessity disappears when increasing the network size. Moreover dendritic versus somatic specific alterations of ionic currents (such as the R type VGCCs) differentially modulate persistent activity induction, substantiating the critical role of location specific effects of various neuromodulators. Finally, we find that several features of the network activity *prior* to the induction and/or termination of persistent firing contain predictive information of the upcoming state-transition(s), which is readily available to downstream neurons. These findings suggest that PFC microcircuits may serve as tunable and predictive modules of persistent activity and subsequently working memory.

Author details

¹Institute of Molecular Biology and Biotechnology, Foundation for Research and Technology, Heraklion, Crete, 70013, Greece. ²Department of Biology, University of Crete, Heraklion, Crete, 71409, Greece.

Published: 8 July 2013

References

1. Ko H, Hofer SB, Pichler B, Buchanan Ka, Sjöström PJ, Mrcic-Flogel TD: **Functional specificity of local synaptic connections in neocortical networks.** *Nature* 2011, **473**:87-91.
2. Song S, Sjöström PJ, Reigl M, Nelson S, Chklovskii DB: **Highly nonrandom features of synaptic connectivity in local cortical circuits.** *PLoS biology* 2005, **3**:e68.
3. Litwin-Kumar A, Doiron B: **Slow dynamics and high variability in balanced cortical networks with clustered connections.** *Nature neuroscience* 2012, **15**:1498-505.
4. Hira R, Ohkubo F, Ozawa K, Isomura Y, Kitamura K, Kano M, Kasai H, Matsuzaki M: **Spatiotemporal Dynamics of Functional Clusters of Neurons in the Mouse Motor Cortex during a Voluntary Movement.** *The Journal of neuroscience: the official journal of the Society for Neuroscience* 2013, **33**:1377-1390.

* Correspondence: papoutsis@imbb.forth.gr

¹Institute of Molecular Biology and Biotechnology, Foundation for Research and Technology, Heraklion, Crete, 70013, Greece

Full list of author information is available at the end of the article

5. Shu Y, Hasenstaub AR, McCormick DA: **Turning on and off recurrent balanced cortical activity.** *Nature* 2003, **423**:288-293.
6. Sidiropoulou K, Poirazi P: **Predictive Features of Persistent Activity Emergence in Regular Spiking and Intrinsic Bursting Model Neurons.** *PLoS Computational Biology* 2012, **8**:e1002489.
7. Durstewitz D, Gabriel T: **Dynamical basis of irregular spiking in NMDA-driven prefrontal cortex neurons.** *Cerebral cortex* 2007, **17**:894-908.

doi:10.1186/1471-2202-14-S1-P319

Cite this article as: Papoutsi *et al.*: Dendritic nonlinearities enable PFC microcircuits to serve as predictive modules of persistent activity. *BMC Neuroscience* 2013 **14**(Suppl 1):P319.

**Submit your next manuscript to BioMed Central
and take full advantage of:**

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

