Peterson et al. BMC Neuroscience 2013, 14(Suppl 1):P47
http://www.biomedcentral.com/1471-2202/14/S1/P47

BMC Neuroscience

POSTER PRESENTATION Open Access

# The Neurodynamics of Epilepsy: Synaptic regulation and reversal potential modulation during seizures in a neural field model with conductance-based synapses

Andre D H Peterson[1,2,3*], Iven MY Mareels[2], Hamish Meffin[2,4], David B Grayden[1,2,5], Mark J Cook[2,3], Anthony N Burkitt[1,2,5]

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

Recent experimental results have shown that during the initiation and termination of epileptic seizures there is a significant change in the micro-ionic environment of cortical neurons [1] that affects network balance between excitation and inhibition. This is evident through non-synaptic changes in the micro-ionic environment such as the excitatory and inhibitory reversal potentials and conductances that have been measured over the course of a seizure in an *in vitro* mouse model [2]. Although this phenomenon of a change in reversal potentials during seizures has recently been simulated numerically using a relatively small number of detailed multi-compartmental spiking models [3], it has not yet been modelled using larger scale mesoscopic neural field models within an analytical framework. This is because the majority of these models use current-based synapses, which do not take the reversal potentials into account [4] as they are more difficult to incorporate in mesoscopic models of brain dynamics.

We present an analysis of a neural field model with conductance-based synapses that takes into account the reversal potentials and the nonlinear multiplicative effect that they have on the associated conductance. The conductance-based synapses model is derived, analysed and juxtaposed with the current-based synapses model and the results interpreted physiologically.

A comparative bifurcation analysis of both models reveals that there are significant differences in the oscillatory behaviours that correspond to epileptic seizures [4]. In the conductance-based synapses model, there are endogenous anti-epileptic regulatory or control mechanisms that operate on the synaptic scale, whereas previously these were thought to be mainly on the network level; for example, in terms of feedback, feedforward and surround inhibition [5]. Further, upon modulation of the reversal potentials, the new model exhibits seizure behaviour that initiates and terminates due to non-synaptic ionic mechanisms, similar to that measured in recent experiments [1].

Seizure dynamics in the brain are modulated by both synaptic regulatory mechanisms and non-synaptic homeostatic mechanisms, which play key roles during seizure initiation, spread and termination [5]. These mechanisms have been investigated using a novel analytical neural field model which has provided insights into understanding epileptic brain dynamics that are not currently observable in electrophysiological experiments and numerical simulations alone.

**Acknowledgements**
This work was supported by ARC Linkage Project #LP0560684 and an SVHM REF grant.

**Author details**
[1]NeuroEngineering Lab, Dept. of Electrical & Electronic Engineering, University of Melbourne, Australia. [2]Centre for Neural Engineering, University of Melbourne, Australia. [3]Centre for Clinical Neurosciences, St. Vincent's Hospital, Melbourne, Australia. [4]NICTA Victoria Research Lab, Melbourne, Australia. [5]Bionics Institute, East Melbourne, Australia.

Published: 8 July 2013

* Correspondence: peterson@unimelb.edu.au
[1]NeuroEngineering Lab, Dept. of Electrical & Electronic Engineering, University of Melbourne, Australia
Full list of author information is available at the end of the article

**References**

1. Barmashenko G, Hefft S, Aertsen A, Kirschstein T, Köhling R: **Positive shifts of the GABA-A receptor reversal potential due to altered chloride homeostasis is widespread after status epilepticus.** *Epilepsia* 2011, **52(9)**:1570-1578.
2. Ziburkus J, Cressman JR, Schiff S: **Seizures as imbalanced up states: Excitatory and inhibitory conductances during seizure like events.** *J Neurophysiol* 2012, doi:10.1152/jn.00232.2012.
3. Krishnan GP, Bazhenov M: **Ionic dynamics mediate spontaneous termination of seizures and postictal depression state.** *J Neurosci* 2011, **31(24)**:8870-8882.
4. Breakspear M, Roberts JA, Terry JR, Rodrigues S, Mahant N, Robinson PA: **A unifying explanation of primary generalized seizures through nonlinear brain modeling and bifurcation analysis.** *Cerebral Cortex* 2006, **16(9)**:1296-1313.
5. Milton J, Jung P: **Epilepsy as a Dynamic Disease.** 2003, Springer.

doi:10.1186/1471-2202-14-S1-P47
**Cite this article as:** Peterson *et al.*: The Neurodynamics of Epilepsy: Synaptic regulation and reversal potential modulation during seizures in a neural field model with conductance-based synapses. *BMC Neuroscience* 2013 **14**(Suppl 1):P47.