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Self-organized criticality of developing artificial neuronal networks and dissociated cell cultures

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Self-organized criticality (SOC) [1] was first described in neuronal cell cultures by Beggs and Plenz [2]. Neuronal networks being in a critical state produce avalanche-like discharges that are power-law distributed. The assessment of avalanches in neuronal networks is a new way of looking at neuronal activities apart from bursts, synchronization etc. The main novelty of our approach is to assess the avalanche distribution at different developmental stages of neuronal networks. For this, we used dissociated postnatal cell culture taken from the rat cortex. Experimental data was provided by the Ulrich Egert group, BCCN Fribourg, Germany. We found that different network states as subcritical, critical or supracritical specify a time and spatial activity profile that is linked but not equivalent to low, moderate or high levels in neuronal activity, respectively. We are the first who show that the activity profile in cell cultures develop from supracritical states over subcritical into critical states. To shed light to the dependency of SOC on network development, we used a self-organizing artificial neuronal network model based on a previous model by Van Ooyen and Abbott [3-5]. An important novelty of our model is that it is more detailed with respect to representing seperate axonal and dendritic fields [6,7]. The model network aims to develop towards a homeostatic equilibrium in neuronal activity that is achieved by growth and retraction of axonal and dendritic fields. This abstract model already reproduces the transient behavior as seen in cell cultures from supracritical over subcritical to critical states. However, we found that some cell cultures remain in a subcritical regime. The model offers a simple explanation as depending on the strength of inhibition, equivalent to the friction in self-organizing systems [8], neuronal networks may or may not reach criticality even though they are homeostatically equilibrated.

References

1. Bak P, Tang C, Wiesenfeld K: **Self-organized criticality: An explanation of 1/f-noise.** *Phys Rev Lett* 1987, **59:**381-384.
2. Beggs J, Plenz D: **Neuronal avalanches in neocortical circuits.** *J Neurosci* 2003, **23:**11167-11177.
3. Van Ooyen A, Van Pelt J: **Activity-dependent outgrowth of neurons and overshoot phenomena in developing neural networks.** *J Theor Biol* 1994, **167:**27-43.
4. Van Ooyen A, Van Pelt J, Corner M: **Implications of activity-dependent neurite outgrowth for neuronal morphology and network development.** *J Theor Biol* 1995, **172:**63-82.
5. Abbott L, Rohrkemper R: **A single growth model constructs critical avalanche networks.** *Prog Brain Res* 2007, **165:**9.
6. Butz M, Teuchert-Noodt G, Grafen K, Van Ooyen A: **Inverse relationship between adult hippocampal cell proliferation and synaptic rewiring in the dentate gyrus.** *Hippocampus* 2008, **18:**879-898.
7. Butz M, Wörgötter F, Van Ooyen A: **Activity-dependent structural plasticity.** *Brain Res Rev* 2009. doi:10.1016/j.brainresrev.2008.12.023
8. Lauritsen K, Zapperi S, Stanley H: **Self-organized branching process: Avalanche models with dissipation.** *Phys Rev E* 1996, **54:**2483-2488.