BMC Neuroscience

Poster presentation

Open Access

Random axon outgrowth and synaptic competition generate realistic connection lengths and filling fractions

Marcus Kaiser*[1,2], Claus C Hilgetag[3,4] and Arjen van Ooyen[5]

Address: [1]School of Computing Science, Newcastle University, Claremont Tower, Newcastle upon Tyne, NE1 7RU, UK, [2]Institute of Neuroscience, Newcastle University, Framlington Place, Newcastle upon Tyne, NE2 4HH, UK, [3]Jacobs University Bremen, School of Engineering and Science, 28759 Bremen, Germany, [4]Boston University, Sargent College, Department of Health Sciences, Boston, MA 02215, USA and [5]Department of Integrative Neurophysiology, VU University Amsterdam, 1081 HV Amsterdam, The Netherlands

Email: Marcus Kaiser* - m.kaiser@ncl.ac.uk

* 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):P58 doi:10.1186/1471-2202-10-S1-P58

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P58

Introduction

On various spatial scales, from connectivity between individual neurons in *Caenorhabditis elegans* and rat visual cortex to connectivity between cortical areas in the mouse, macaque [1] and human brain, connection length distributions have very similar shapes, with a long flat tail representing the admixture of long-distance connections to mostly short-distance connections. Furthermore, not all potentially possible synapses are formed and only a fraction of axons (called filling fraction, [2]) establish synapses with spatially neighboring neurons.

Results

Investigating local connectivity between individual neurons [3], we show that simple, random outgrowth of axons can reproduce distance-dependent connectivity as found in many neural systems. Experimentally observed filling fractions can also be generated by competition for free space at the dendritic tree; a model markedly different from previous explanations. In our simple model, which relies on fewer factors than previous approaches, the filling fraction can be determined by the ratio between axon collaterals and free target sites which we call competition factor. The modeled filling fraction decays exponentially with the competition factor. We derive experimentally testable predictions for the relation between filling fraction, average axonal length, and competition. Figure 1.

Conclusion

Simple models that assume a random axonal outgrowth and competition for target space can account for the experimentally found exponential decay in the connection length distribution and the filling fraction.

Acknowledgements

We thank the EPSRC (EP/E002331/1) and the Royal Society (RG/2006/R2) for financial support.

References

1. Kaiser M, Hilgetag CC: **Modelling the Development of Cortical Networks.** *Neurocomp* 2004, **58–60:**297-302.
2. Stepanyants A, Hof PR, Chklovskii DB: **Geometry and structural plasticity of synaptic connectivity.** *Neuron* 2002, **34:**275-88.
3. van Ooyen A: *Modeling Neural Development MIT Press*; 2003.

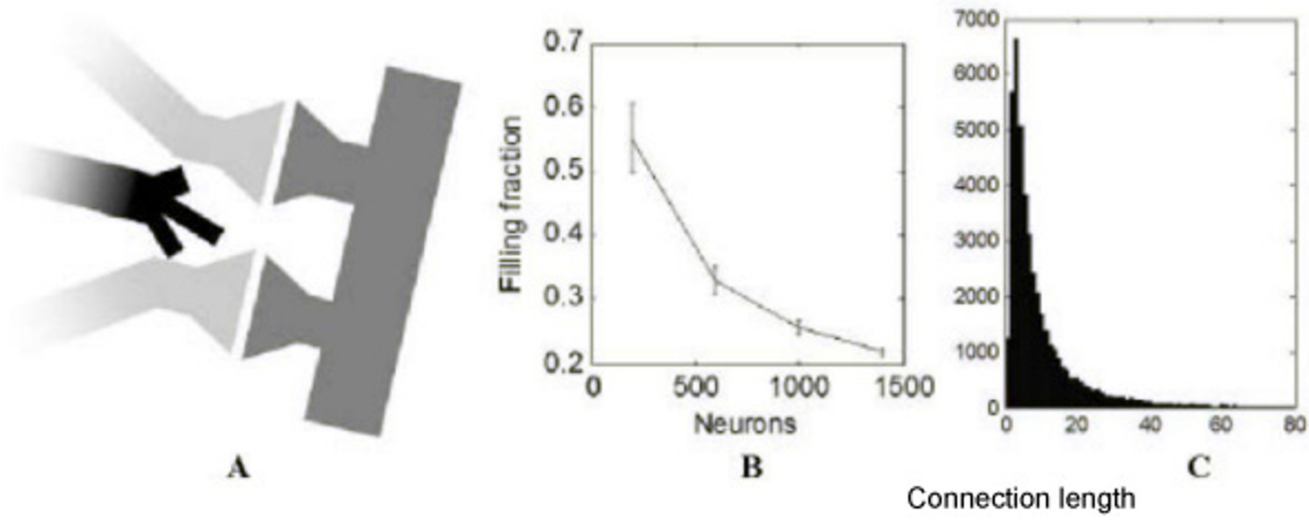

Figure 1
Synaptic competition for dendritic space (A) leads to a decay in filling fraction with neuron density (B). Both with and without competition the connection length distribution (**C**) is similar to experimental studies.