SP4

SP4 – highlights of results in 2017

Discovery of new cell type-specific network topological structures in neocortex (Gal et al. **Nature Neurosci.** 2017)

ARTICLES

nature neuroscience

Rich cell-type-specific network topology in neocortical microcircuitry

Eyal Gal[1,2], Michael London[1,2], Amir Globerson[3,4], Srikanth Ramaswamy[5], Michael W Reimann[5], Eilif Muller[5], Henry Markram[5] & Idan Segev[1,2]

Uncovering structural regularities and architectural topologies of cortical circuitry is vital for understanding neural computations. Recently, an experimentally constrained algorithm generated a dense network reconstruction of a ~0.3-mm^3 volume from juvenile rat somatosensory neocortex, comprising ~31,000 cells and ~36 million synapses. Using this reconstruction, we found a small-world topology with an average of 2.5 synapses separating any two cells and multiple cell-type-specific wiring features. Amounts of excitatory and inhibitory innervations varied across cells, yet pyramidal neurons maintained relatively constant excitation/inhibition ratios. The circuit contained highly connected hub neurons belonging to a small subset of cell types and forming an interconnected cell-type-specific rich club. Certain three-neuron motifs were overrepresented, matching recent experimental results. Cell-type-specific network properties were even more striking when synaptic strength and sign were considered in generating a functional topology. Our systematic approach enables interpretation of microconnectomics 'big data' and provides several experimentally testable predictions.

SP4

SP4 – highlights of results in 2017

Measurement of the relation between neuronal activity and local field potentials in human cortex (Telenczuk et al., **Nature Sci. Reports** 2017)

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Local field potentials primarily reflect inhibitory neuron activity in human and monkey cortex

Received: 23 May 2016
Accepted: 05 December 2016
Published: 11 January 2017

Bartosz Teleńczuk[1], Nima Dehghani[2,3], Michel Le Van Quyen[4], Sydney S. Cash[5], Eric Halgren[6], Nicholas G. Hatsopoulos[7] & Alain Destexhe[1]

The local field potential (LFP) is generated by large populations of neurons, but unitary contribution of spiking neurons to LFP is not well characterised. We investigated this contribution in multi-electrode array recordings from human and monkey neocortex by examining the spike-triggered LFP average (st-LFP). The resulting st-LFPs were dominated by broad spatio-temporal components due to ongoing activity, synaptic inputs and recurrent connectivity. To reduce the spatial reach of the st-LFP and observe the local field related to a single spike we applied a spatial filter, whose weights were adapted to the covariance of ongoing LFP. The filtered st-LFPs were limited to the perimeter of 800 μm around the neuron, and propagated at axonal speed, which is consistent with their unitary nature. In addition, we discriminated between putative inhibitory and excitatory neurons and found that the inhibitory st-LFP peaked at shorter latencies, consistently with previous findings in hippocampal slices. Thus, in human and monkey neocortex, the LFP reflects primarily inhibitory neuron activity.

SP4 – highlights of results in 2017

Study of the links between functional and effective connectivity (Schueker et al. **PLoS Comp. Biol.** 2017)

PLOS | COMPUTATIONAL BIOLOGY

RESEARCH ARTICLE

Fundamental Activity Constraints Lead to Specific Interpretations of the Connectome

Jannis Schuecker[1☯]*, **Maximilian Schmidt**[1☯], **Sacha J. van Albada**[1], **Markus Diesmann**[1,2,3], **Moritz Helias**[1,3]

1 Institute of Neuroscience and Medicine (INM-6) and Institute for Advanced Simulation (IAS-6) and JARA BRAIN Institute I, Jülich Research Centre, Jülich, Germany, **2** Department of Psychiatry, Psychotherapy and Psychosomatics, Medical Faculty, RWTH Aachen University, Aachen, Germany, **3** Department of Physics, Faculty 1, RWTH Aachen University, Aachen, Germany

☯ These authors contributed equally to this work.
* j.schuecker@fz-juelich.de

CrossMark
click for updates

OPEN ACCESS

Citation: Schuecker J, Schmidt M, van Albada SJ, Diesmann M, Helias M (2017) Fundamental Activity Constraints Lead to Specific Interpretations of the Connectome. PLoS Comput Biol 13(2): e1005179. doi:10.1371/journal.pcbi.1005179

Editor: Jörn Diedrichsen, University College London, UNITED KINGDOM

Received: April 1, 2016

Accepted: October 3, 2016

Published: February 1, 2017

Abstract

The continuous integration of experimental data into coherent models of the brain is an increasing challenge of modern neuroscience. Such models provide a bridge between structure and activity, and identify the mechanisms giving rise to experimental observations. Nevertheless, structurally realistic network models of spiking neurons are necessarily underconstrained even if experimental data on brain connectivity are incorporated to the best of our knowledge. Guided by physiological observations, any model must therefore explore the parameter ranges within the uncertainty of the data. Based on simulation results alone, however, the mechanisms underlying stable and physiologically realistic activity often remain obscure. We here employ a mean-field reduction of the dynamics, which allows us to include activity constraints into the process of model construction. We shape the phase space of a multi-scale network model of the vision-related areas of macaque cortex by systematically refining its connectivity. Fundamental constraints on the activity, i.e., pro-

Co-funded by the European Union

SP4 – highlights of results in 2017

Model of propagating activity during irregular states in cortex (Zerlaut and Destexhe, **Neuron** 2017)

CellPress

Neuron
Perspective

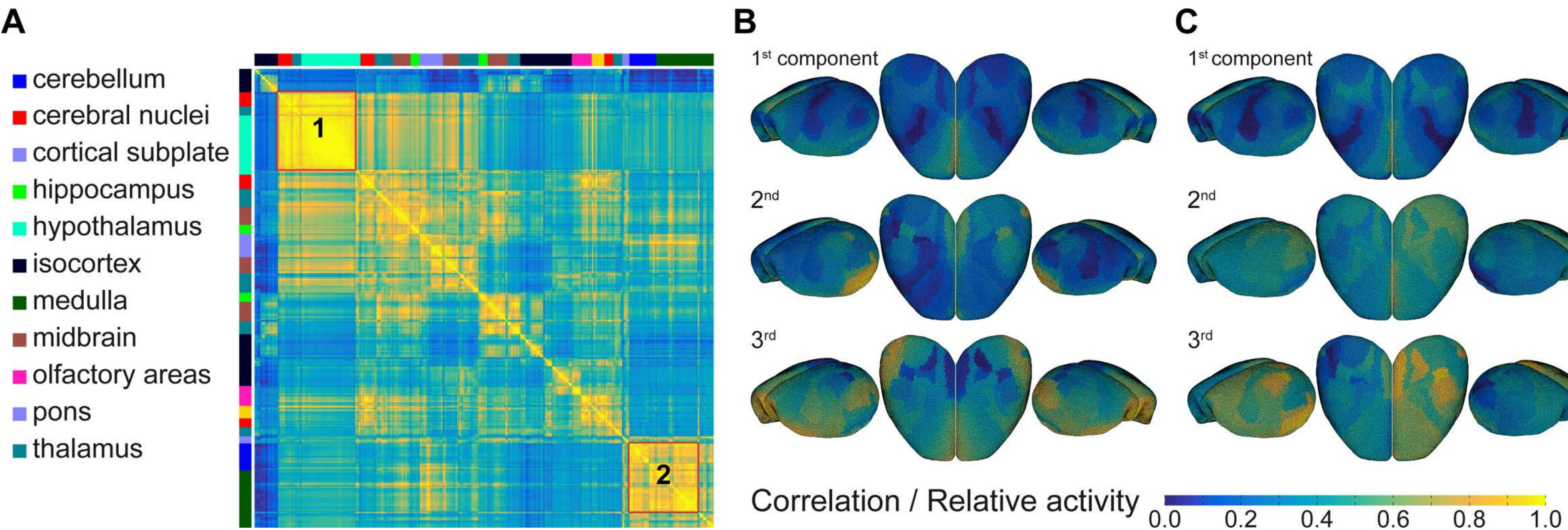
Enhanced Responsiveness and Low-Level Awareness in Stochastic Network States

Yann Zerlaut[1,3] and Alain Destexhe[1,2,*]
[1]Unit for Neurosciences, Information and Complexity (UNIC), CNRS, 91198 Gif sur Yvette, France
[2]The European Institute for Theoretical Neuroscience (EITN), 75012 Paris, France
[3]Present address: Neural Coding Laboratory, Istituto Italiano di Tecnologia, 38068 Rovereto, Italy
*Correspondence: destexhe@unic.cnrs-gif.fr
http://dx.doi.org/10.1016/j.neuron.2017.04.001

Desynchronized brain states are known to be associated with arousal and increased awareness, but the exact mechanisms are unknown. Here, we show that neuronal networks displaying asynchronous irregular (AI) activity can implement a low-level form of awareness, due to their specific responsiveness properties. We emphasize the importance of the conductance state and stochasticity to explain these properties. We suggest that the purpose of cortical structures is to generate AI states with optimal responsiveness, to be globally aware of external stimuli.

SP4 – highlights of results in 2017

First simulations of mice resting state (Jirsa et al., 2017)



Co-funded by the European Union