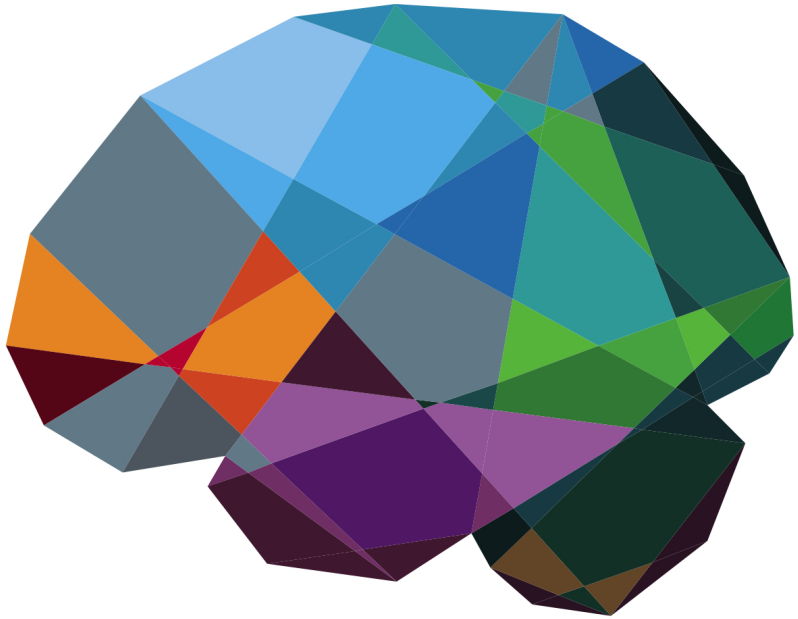


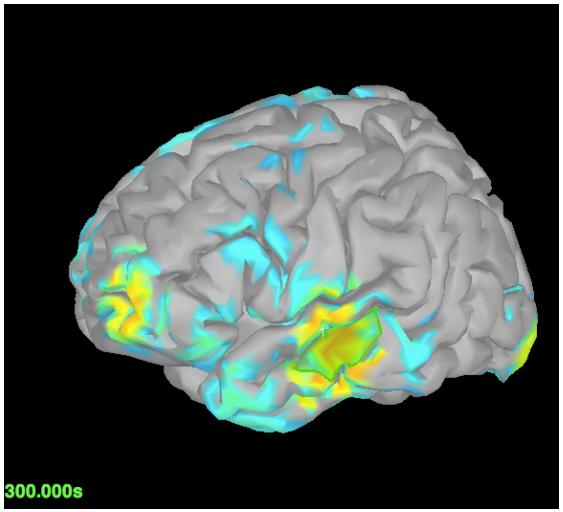
Framework for Collective Multimodal Reverse Engineering the Brain

Petra Ritter

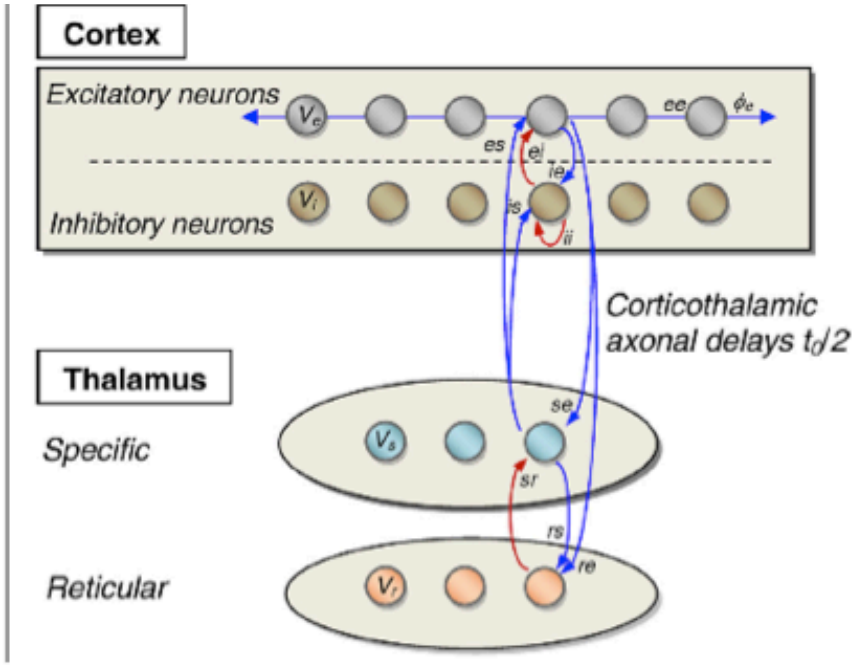
CHARITÉ
UNIVERSITÄTSMEDIZIN BERLIN

Brain Scales

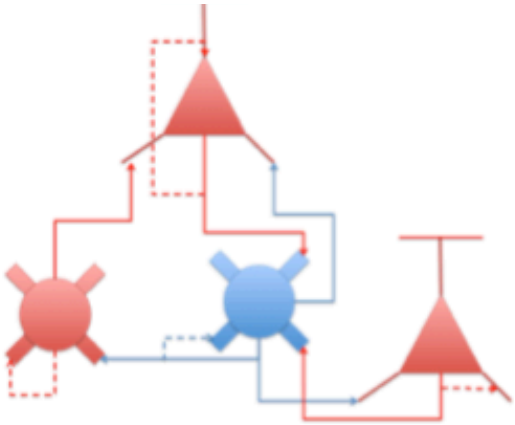
Macroscopic



Mesoscopic



Microscopic



Multimodal Data Pipeline

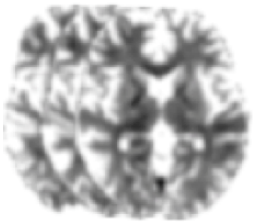
Human

Animal

BOLD

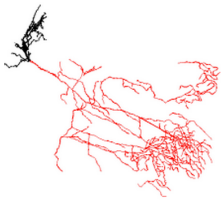
T1,2

EEG

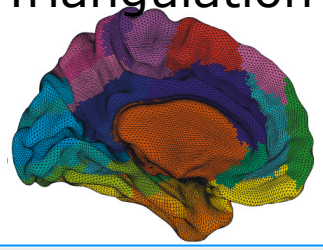


DTI

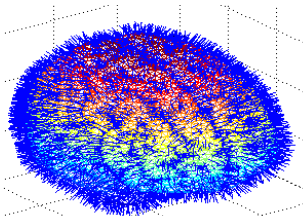
Axon tracing



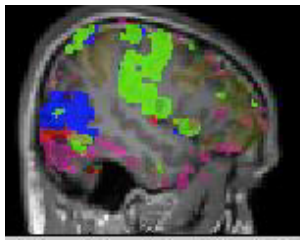
Parcellation
Triangulation



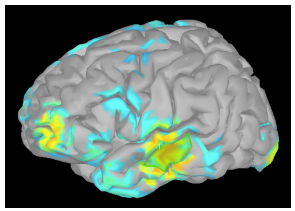
Lead field
matrix



Tractography

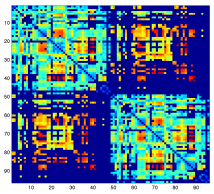


ROI
BOLD
time
courses

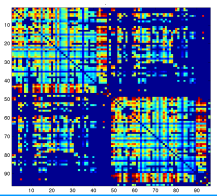


Electric
source
activity

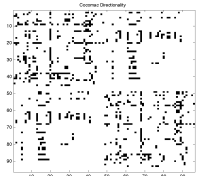
Distances



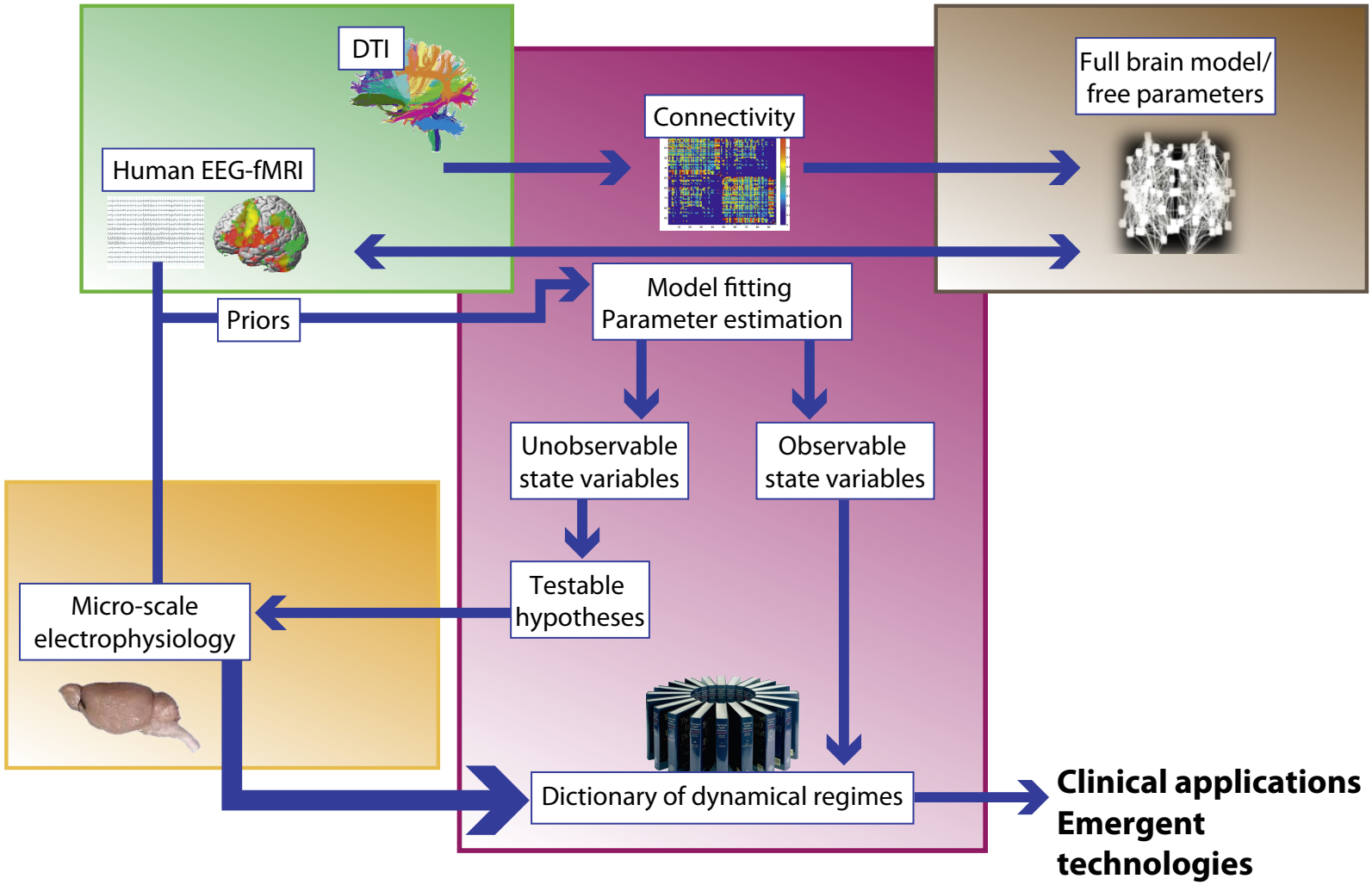
Capacities



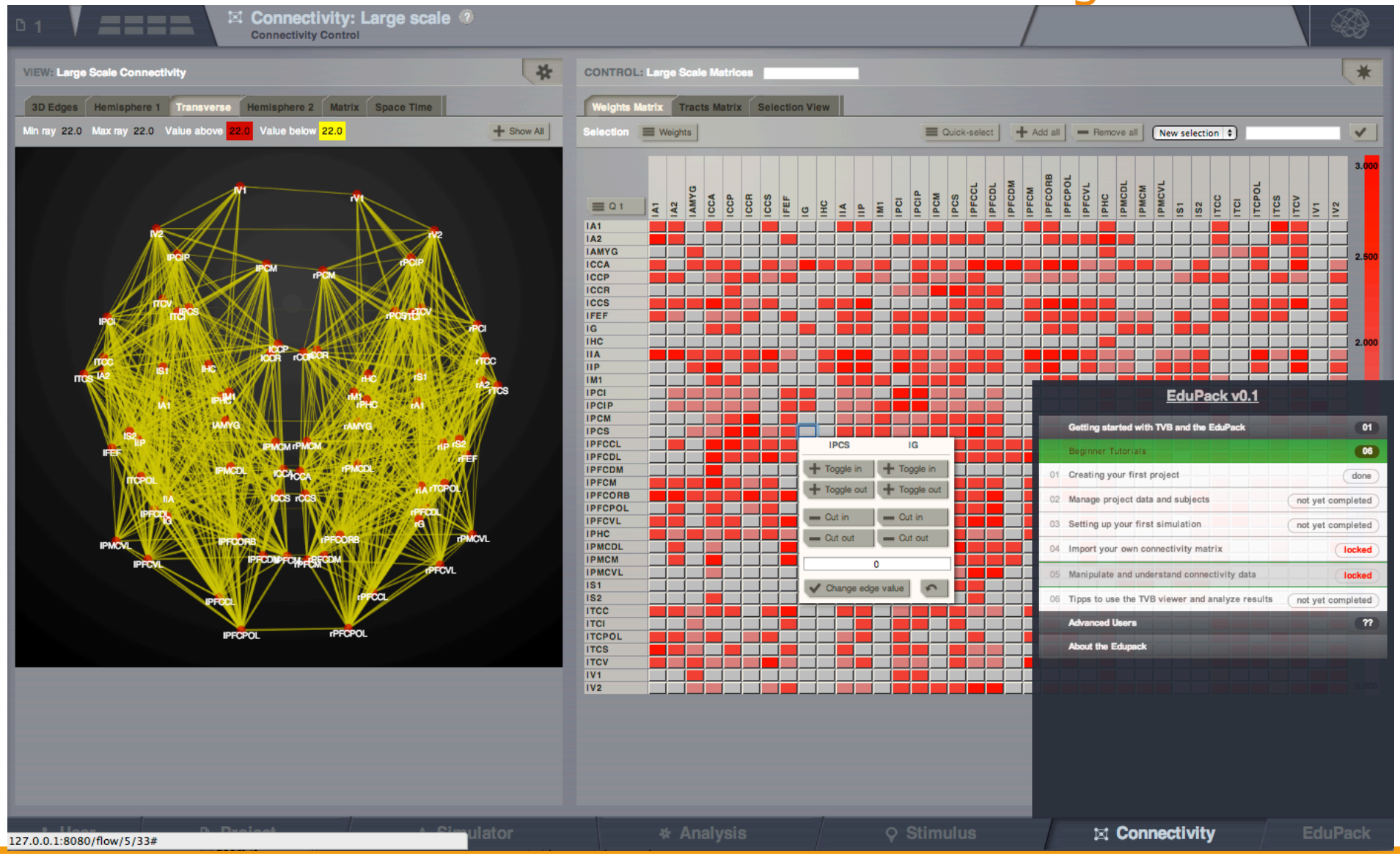
Directionality



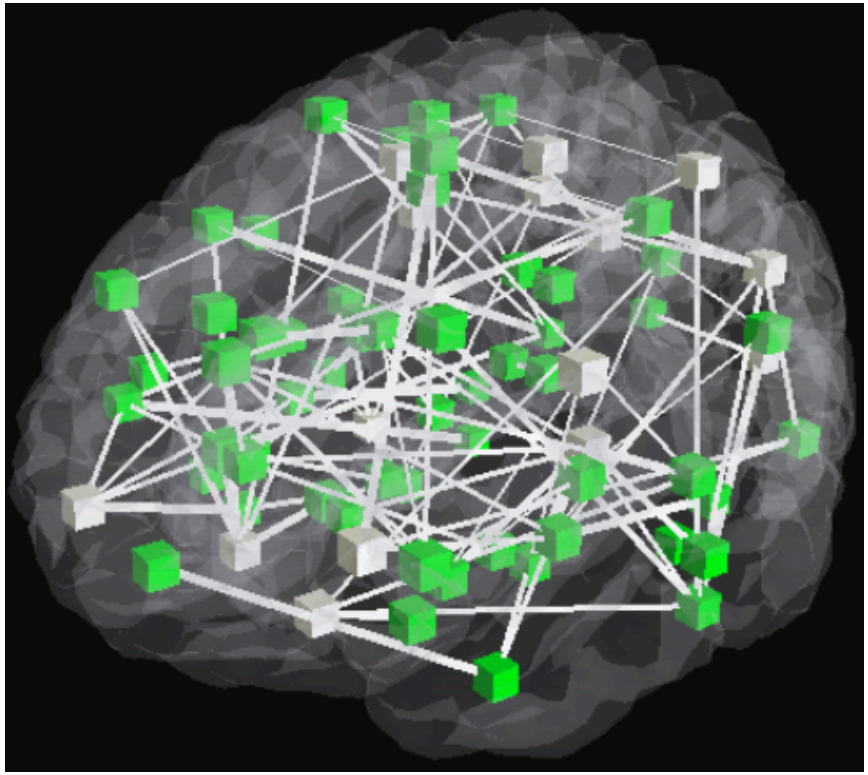
Knowledge Inference with The Virtual Brain



The Virtual Brain Software Package



Full Brain Model



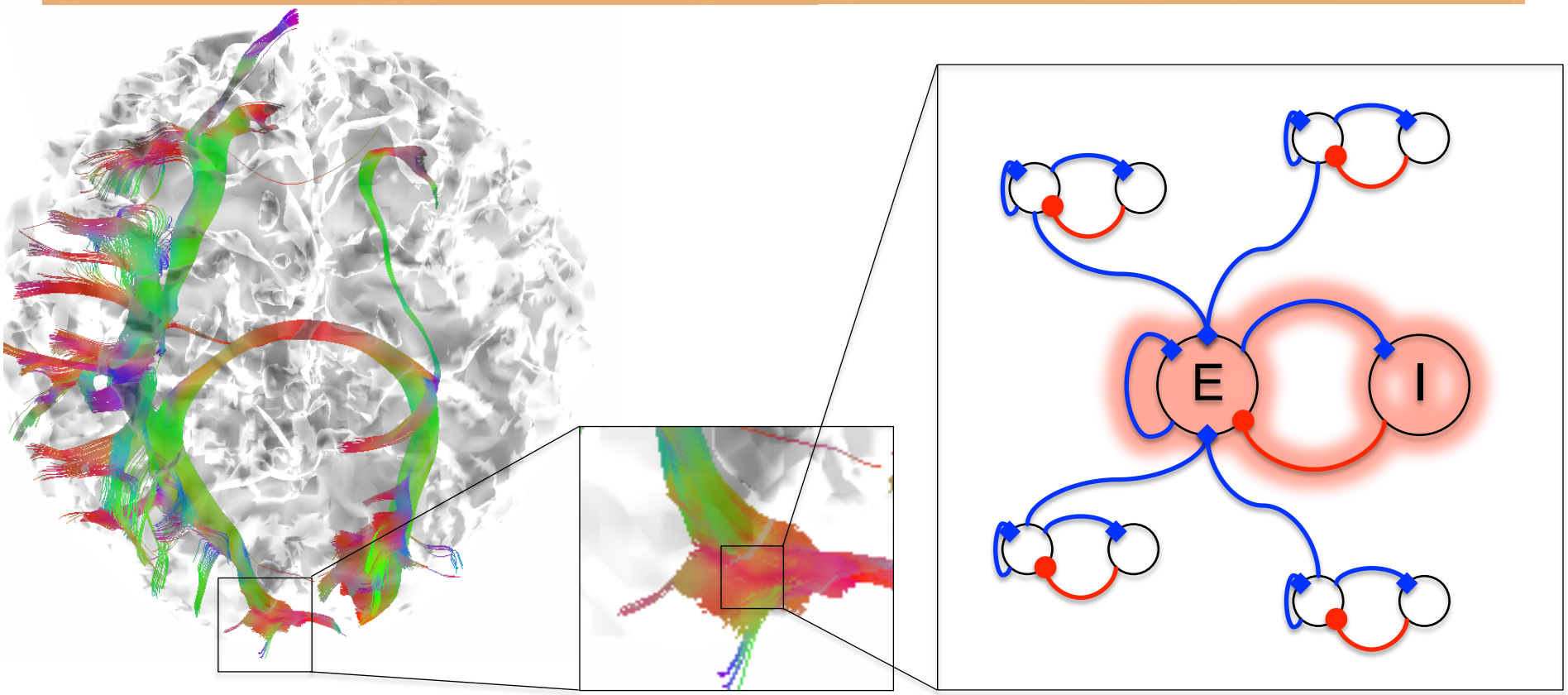
Large scale equation of The Virtual Brain

Population activity

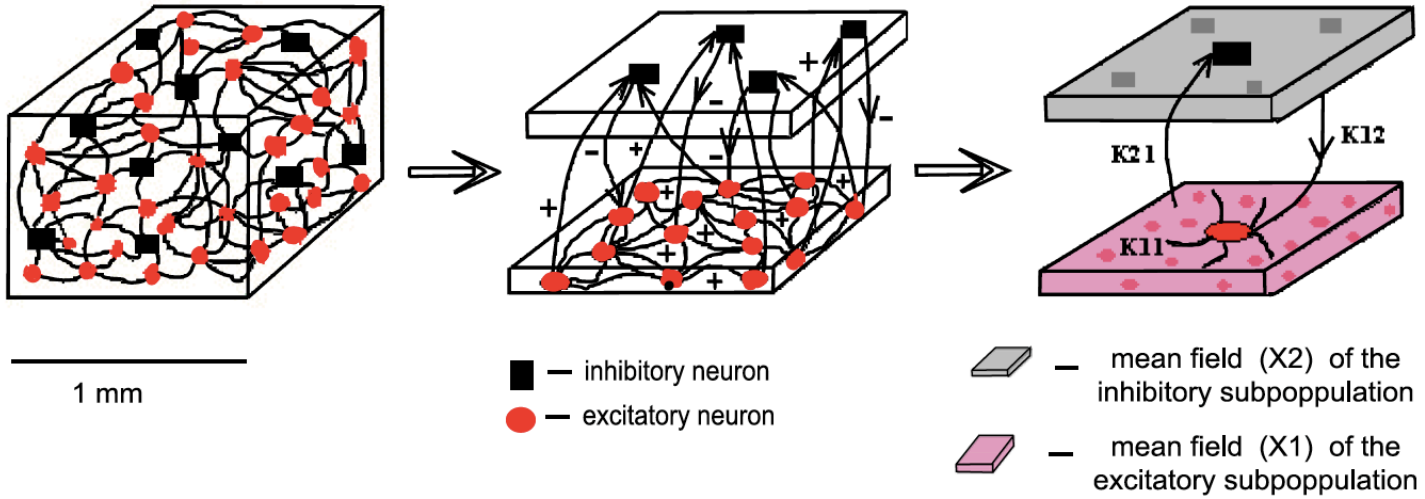
Short range input

Long range input

$$\dot{\Psi}(x,t) = N(\Psi(x,t)) + \int_\Gamma g_{local}(x,x\prime)S(\Psi(x\prime,t))dx\prime + \int_\Gamma g_{global}S(\Psi(x\prime,t-\frac{|x-x\prime|}{\nu}))dx\prime + I(x,t) + \xi(x,t)$$



Choice of population models

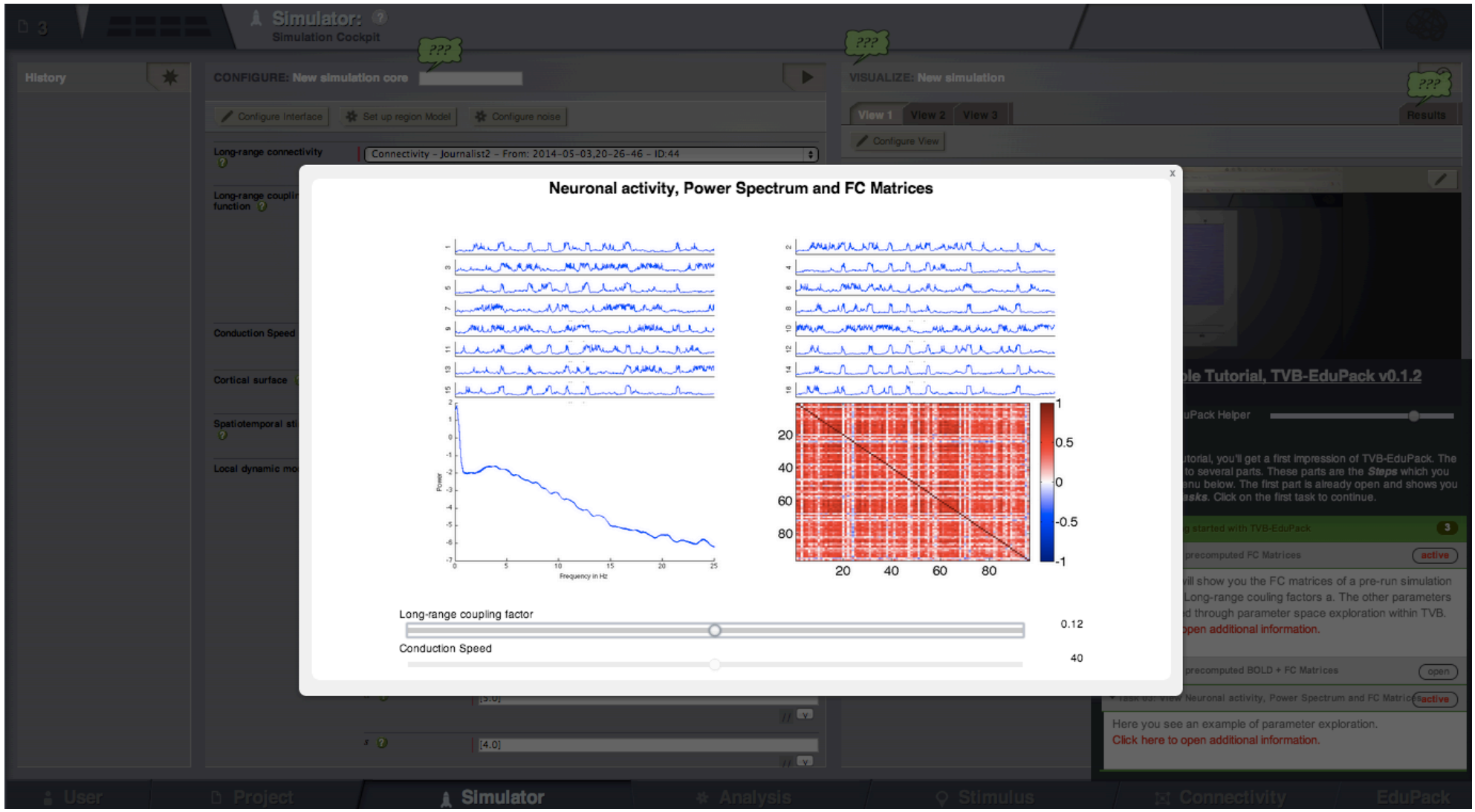


$$\dot{x}_i = y_i - ax_i^3 + bx_i^2 - z_i + [K_{11}(X_1 - x_i) - K_{12}(X_2 - x_i)] + IE_i$$
$$\dot{y}_i = c_i - dx_i^2 - y_i$$
$$\dot{z}_i = rsx_i - rz_i - m_i$$
$$\dot{w}_i = v_i - aw_i^3 + bw_i^2 - u_i + K_{21}(X_1 - w_i) + II_i$$
$$\dot{v}_i = h_i - p_i w_i^2 - v_i$$
$$\dot{u}_i = rsw_i - ru_i - n_i$$

Stefanescu & Jirsa 2008 PloS CB

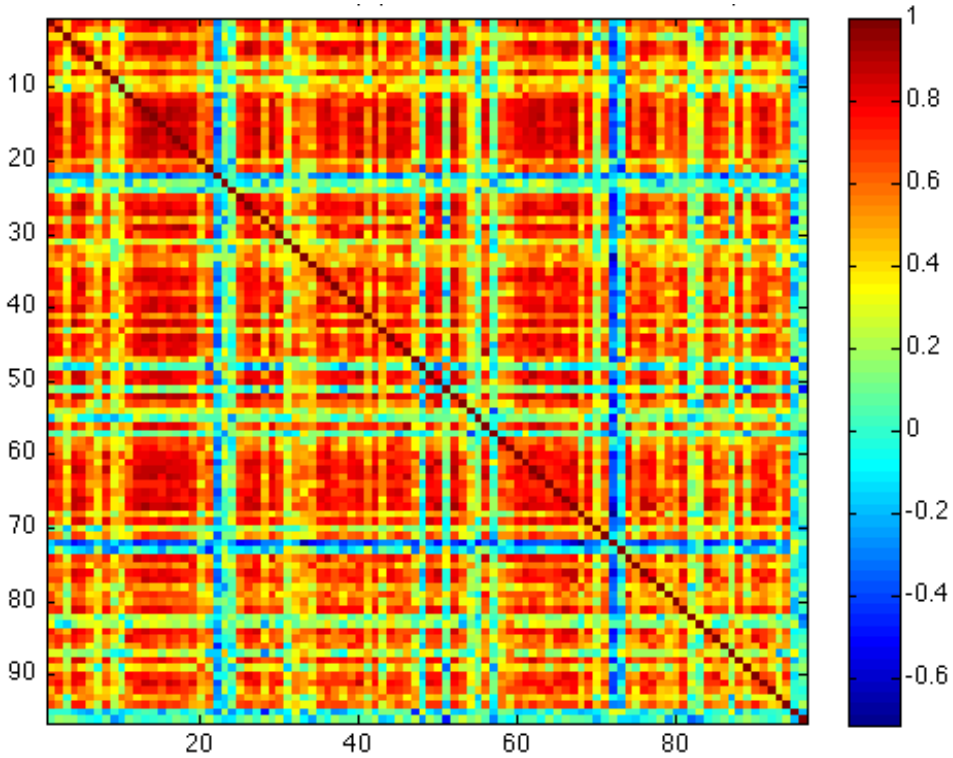
Ritter, Schirner, McIntosh, Jirsa 2013 Brain Connectivity

Dictionary of dynamical regimes

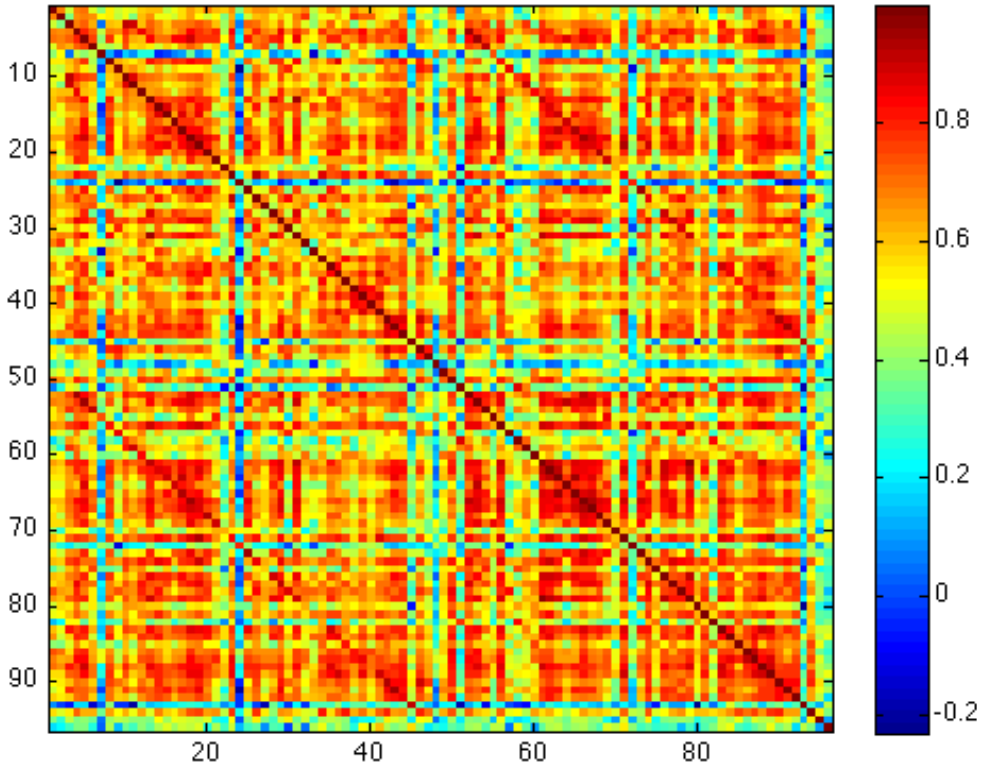


Functional connectivity based model tuning

Simulated

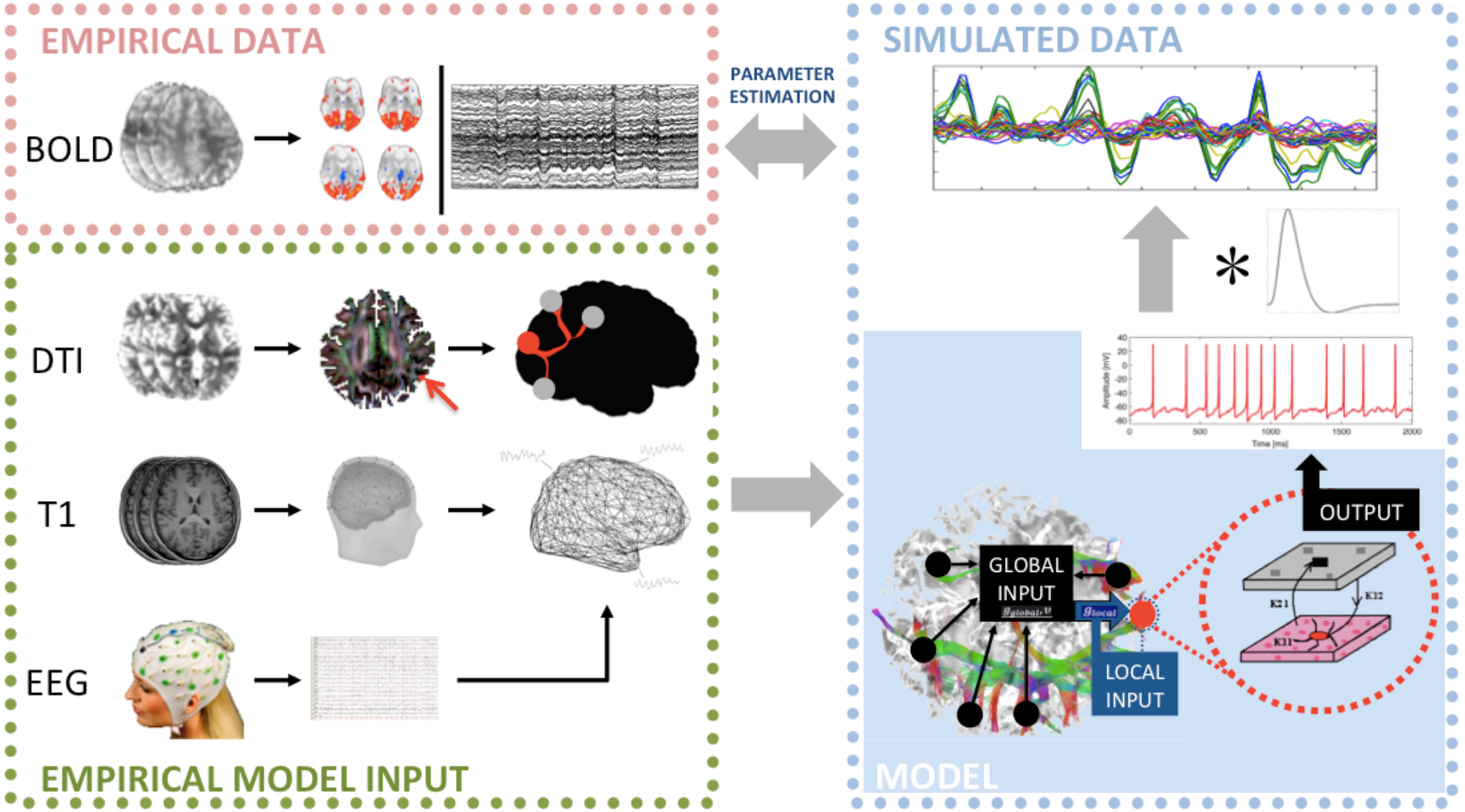


Empirical

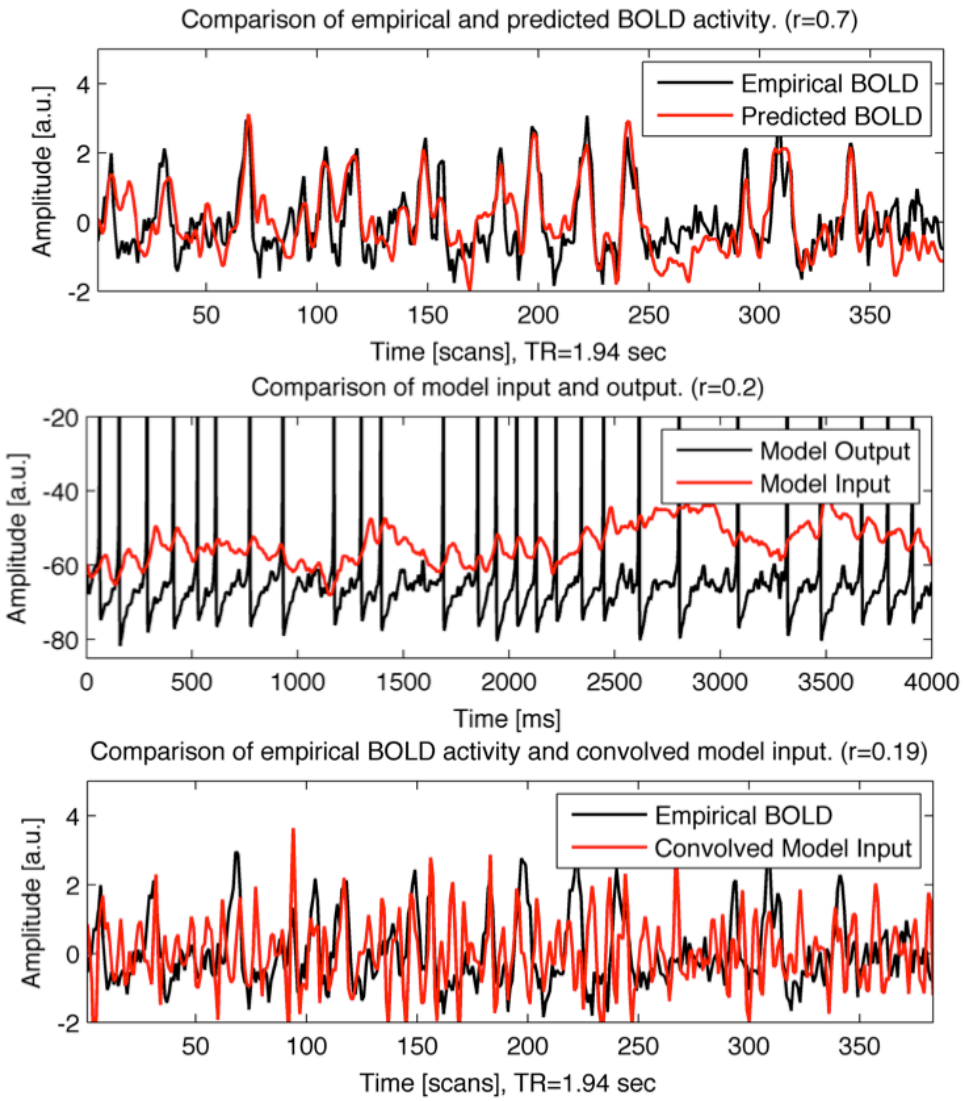


Ritter et al. 2013 Brain Connectivity

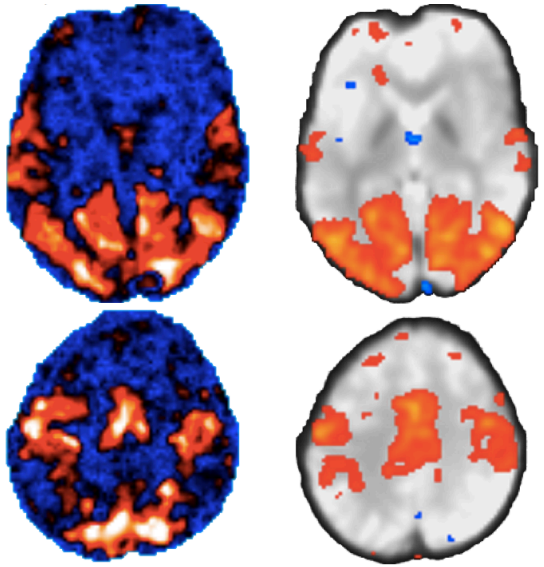
Multimodal reverse engineering the brain



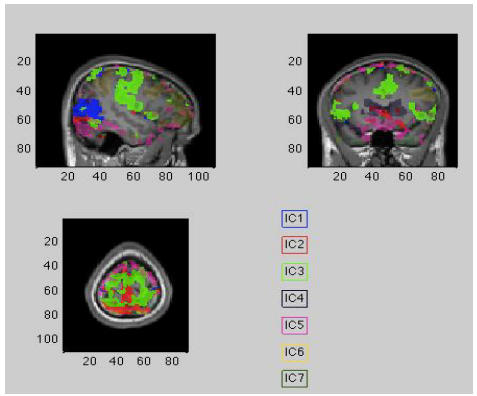
Simulating dynamical regimes

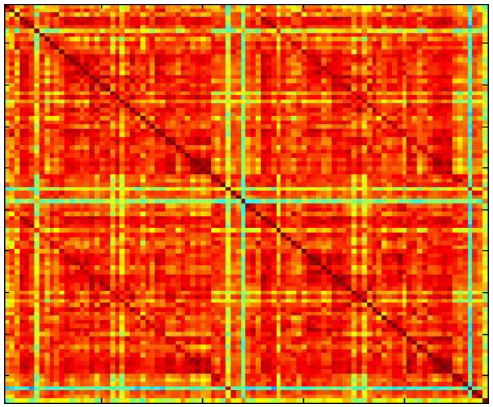


Mutual Information predicted vs. empirical

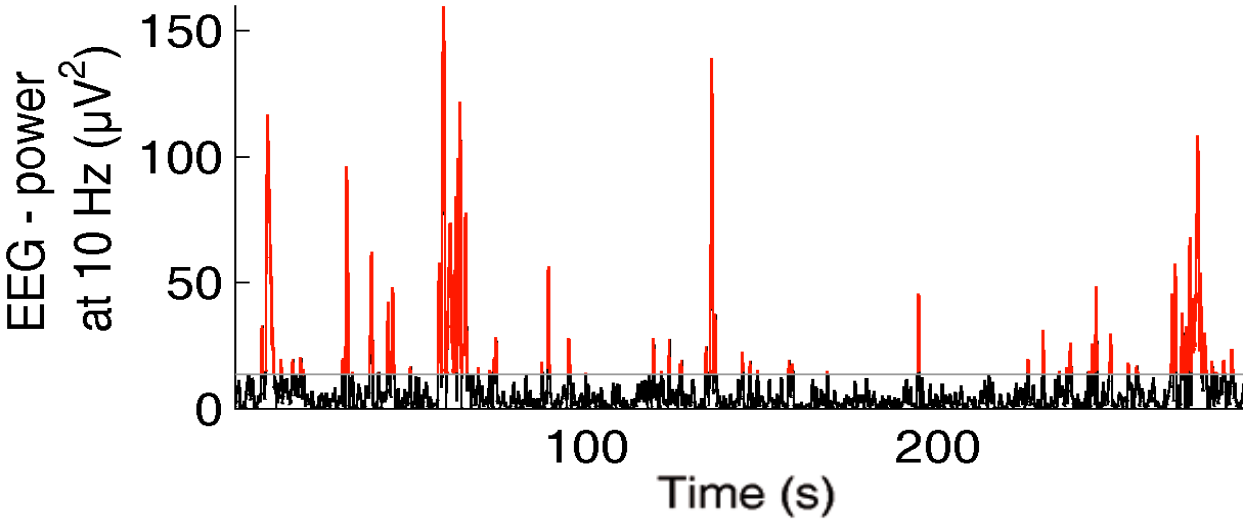


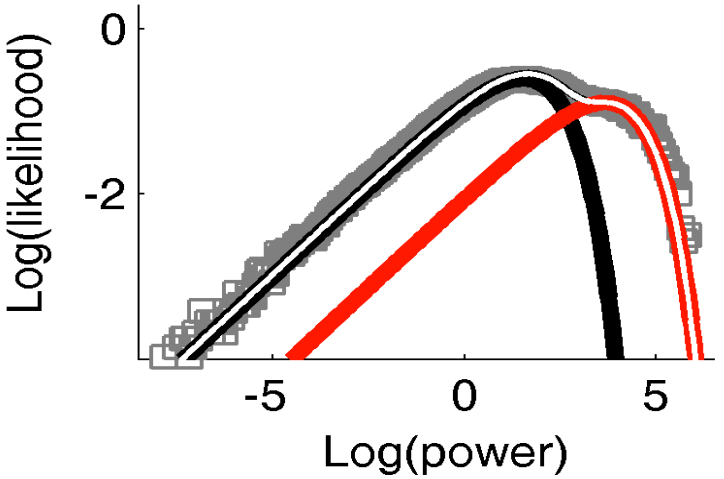
RSN's



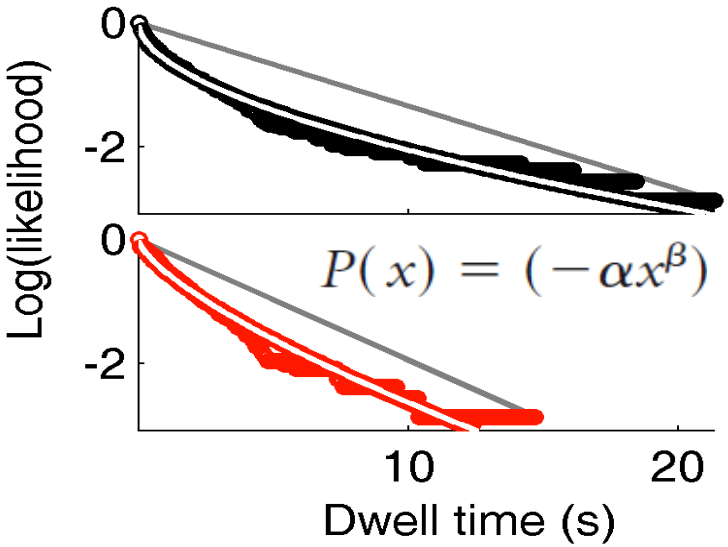


Multistabe EEG regimes



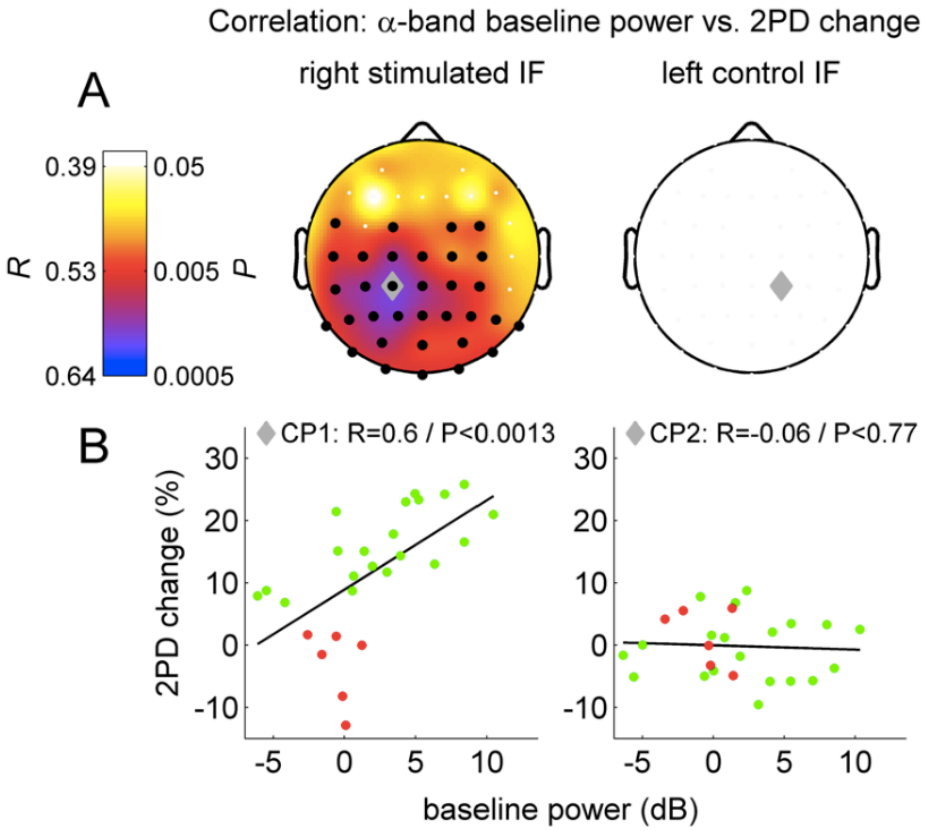


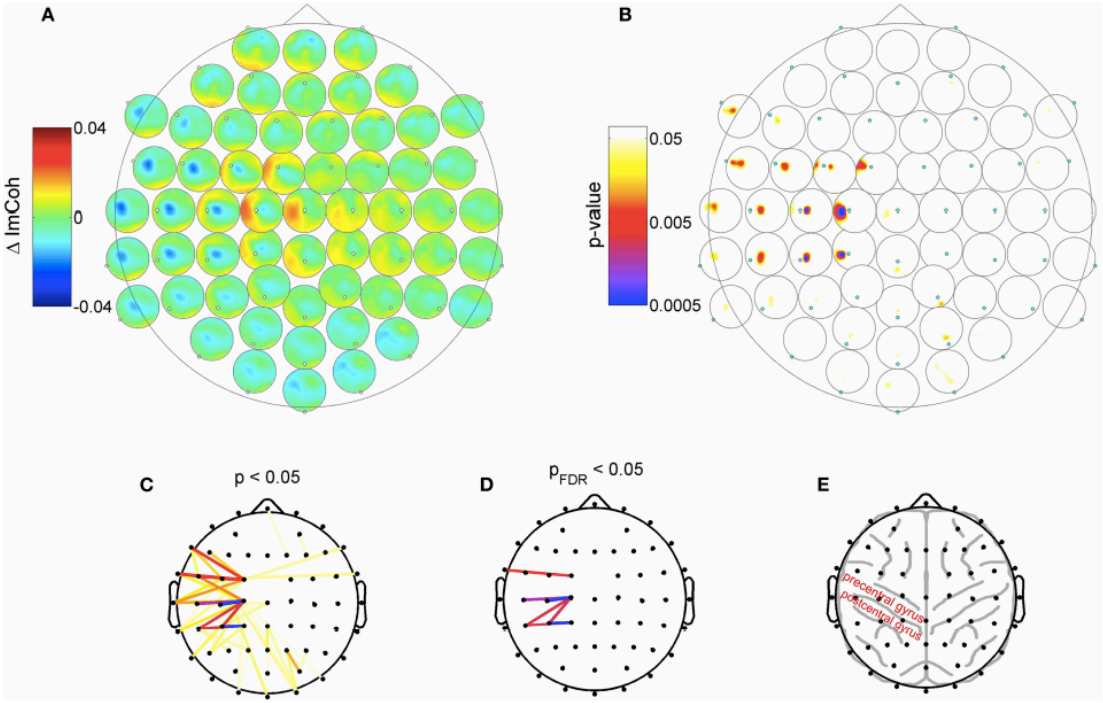
1. Multistability
2. Scale invariance
3. Dwell times: stretched exponentials



Freyer et al. 2009 J. Neuroscience

Linking plasticity & dynamical regimes

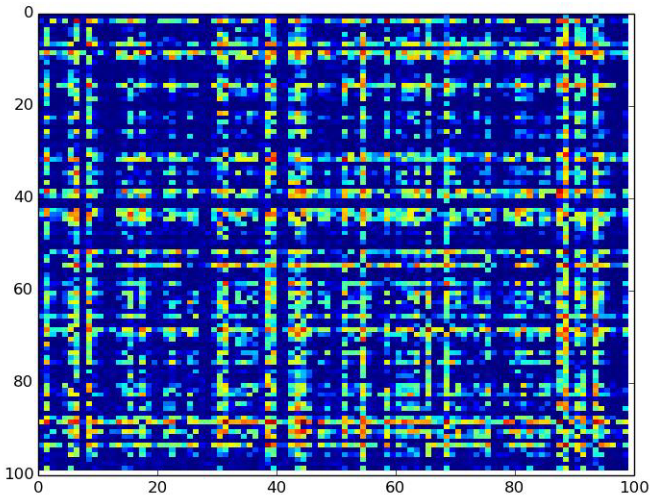




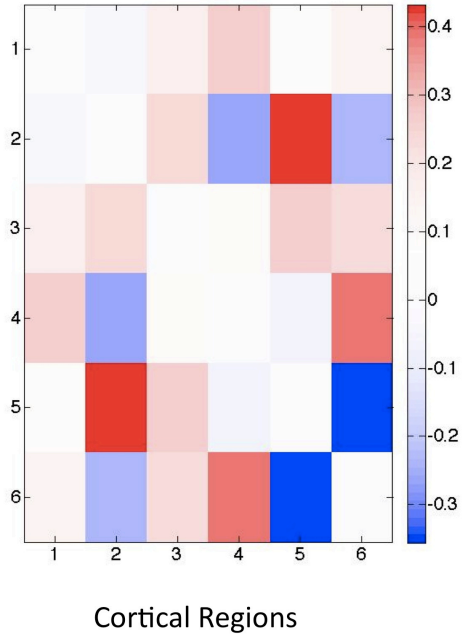
Freyer, Becker, Dinse, Ritter 2012 J. Neuroscience
Freyer, Reinacher, Becker, Dinse, Ritter 2013 Frontiers Hum Neuroscience
Sigala, Haufe, Roy, Dinse, Ritter 2014 Frontiers Computational Neuroscience

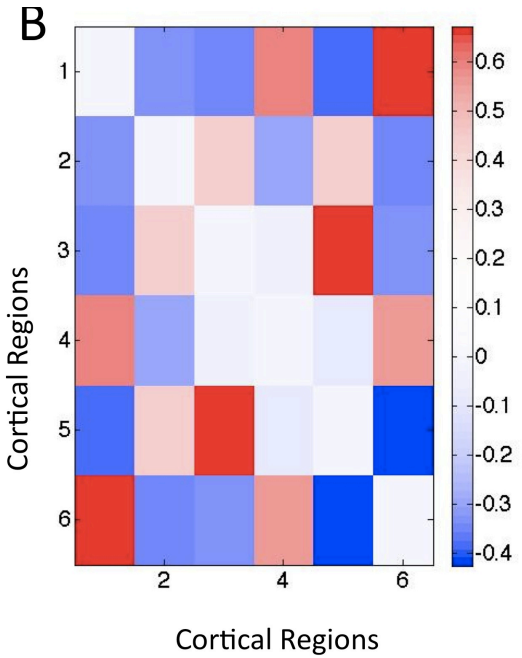
Plasticity in full brain simulations: local plasticity shapes global brain dynamics

Local structural connectivity change



Global functional connectivity change





Roy, Sigala, Breakspear, McIntosh, Jirsa, Deco, Ritter (under review)

Over the past five years, this consortium of 15 distinguished neuro-scientists joined their efforts to solve humankind's biggest mystery: understanding the human brain functions and dysfunctions – and create a way to simulate and predict its behaviour.

Spanning three continents and 10 sites, the team members combine extensive knowledge and experience from computational, cognitive and clinical neuroscience.

Now, as solid and tested theoretical frameworks emerge through peer-reviewed research, this team makes its move towards a realistic and openly accessible virtual brain.

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Petra Ritter [TVB Applications Leader]
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Ana Solodkin
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Stephen Strother
Toronto
computational and cognitive neuroscience

Giulio Tononi
Madison
computational, cognitive and clinical neuroscience

questions:

info@thevirtualbrain.org

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James S. McDonnell Foundation (grant **Brain NRG [JSMF22002082])**

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Ontario Innovation Trust

Ontario Innovation Trust

Baycrest

Baycrest Foundation

CREDITS

We also would like to thank our partners for technology and design:

codeBOX

CodeBox: implementation of brain virtualization, software architecture & development, server setup & hosting

two tribes: project design strategy, logo, website, copywriting, user interfaces