Analyzing Big Data from Big Brains
Terrence Sejnowski
Salk Institute
UCSD
HHMI

NIPS 2016

BARCELONA · SPAIN · DECEMBER 5 - 10 | http://nips.cc

TUTORIALS

Deep Reinforcement Learning Through Policy Optimization
Pieter Abbeel (OpenAI, UC Berkeley) and John Schulman (OpenAI)

Large-scale Optimization: Beyond Stochastic Gradient Descent and Convexity
Francis Bach (INRIA, ENS) and Suvrit Sra (MIT)

Variational Inference: Foundations and Modern Methods
David Blei (Columbia), Shakir Mohamed (Google Deepmind) and Rajesh Ranganath (Princeton)

Natural Language Processing for Computational Social Science
Cristian Danescu-Niculescu-Mizil (Cornell) and Lillian Lee (Cornell)

Generative Adversarial Networks
Ian Goodfellow (OpenAI)

Theory and Algorithms for Forecasting Non-stationary Time Series
Vitaly Kuznetsov (Google) and Mehryar Mohri (Courant Institute, Google Research)

Deep Learning for Building AI Systems
Andrew Ng (Baidu, Stanford University)

ML Foundations and Methods for Precision Medicine and Healthcare
Suchi Saria (Johns Hopkins) and Peter Schulam (Johns Hopkins)

Crowdsourcing: Beyond Label Generation
Jenn Wortman Vaughan (Microsoft Research)

INVITED SPEAKERS

Reproducible Research: the Case of the Human Microbiome
Susan Holmes (Stanford University)

Dynamic Legged Robots
Marc Raibert (Boston Dynamics)

Intelligent Biosphere
Drew Purves (Google DeepMind)

Predictive Learning
Yann LeCun (Facebook and New York University)

Machine Learning and Likelihood-Free Inference in Particle Physics
Kyle Cranmer (New York University)

Learning About the Brain: Neuroimaging and Beyond
Irina Rish (IBM T.J. Watson Research Center)

Engineering Principles From Stable And Developing Brains
Saket Navlakha (The Salk Institute for Biological Studies)

SYMPOSIA

Recurrent Neural Networks and other Machines that Learn Algorithms
Alex Graves (Google DeepMind)
Juergen Schmidhuber (IDSIA)
Rupesh Srivastava (IDSIA)
Sepp Hochreiter (Johannes Kepler University)

Deep Learning
Navdeep Jaitly (Google)
Roger Grosse (University of Toronto)
Yann LeCun (New York University & Facebook)

Machine Learning and the Law
Adrian Weller (Cambridge, Alan Turing Inst.)
Conrad McDonnell (Gray's Inn Tax Chambers)
Jatinder Singh (University of Cambridge)
Thomas Grant (University of Cambridge)

ORGANIZING COMMITTEE

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BRAIN Initiative

Brain Research through Advancing Innovative Neurotechnologies

Advisory Committee to the NIH Director

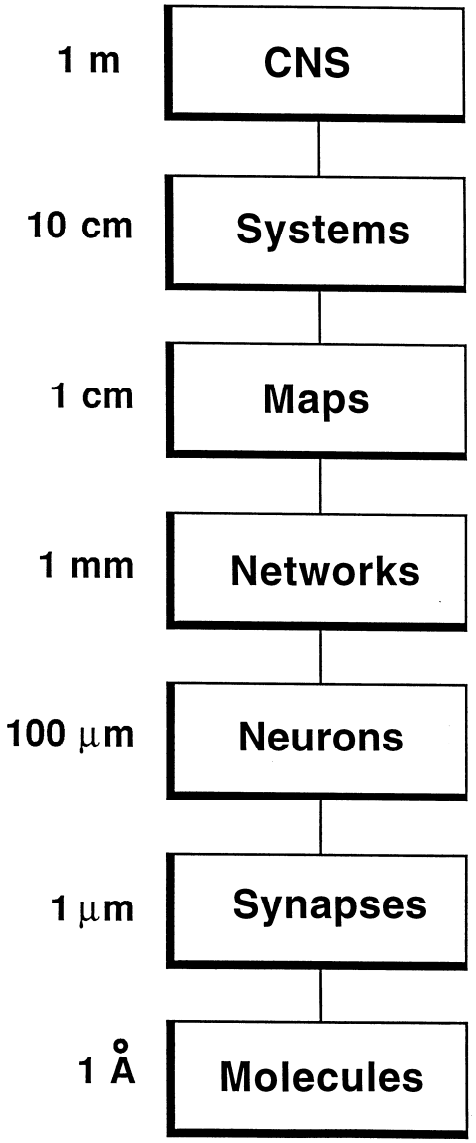
BRAIN 2025

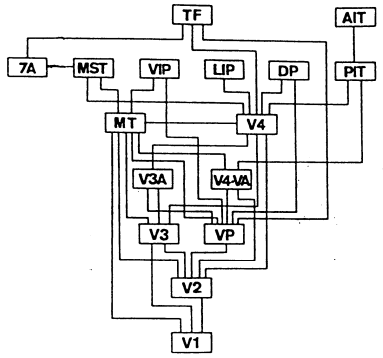
Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Working Group

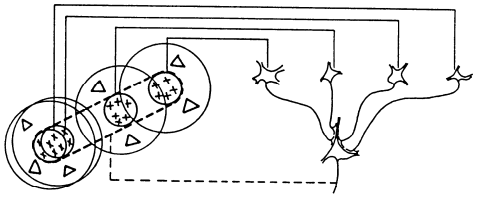
JUNE 05, 2014

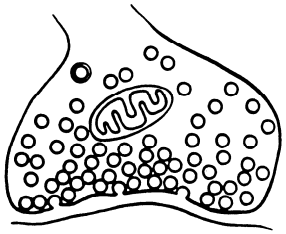
National Institutes of Health
Turning Discovery Into Health

Levels of Investigation

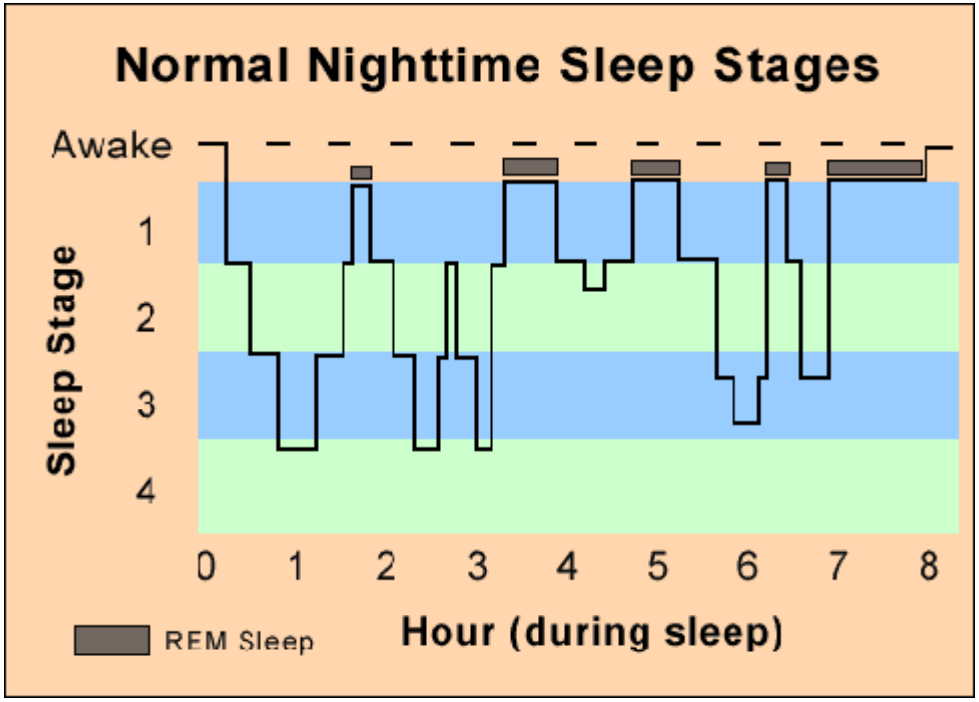


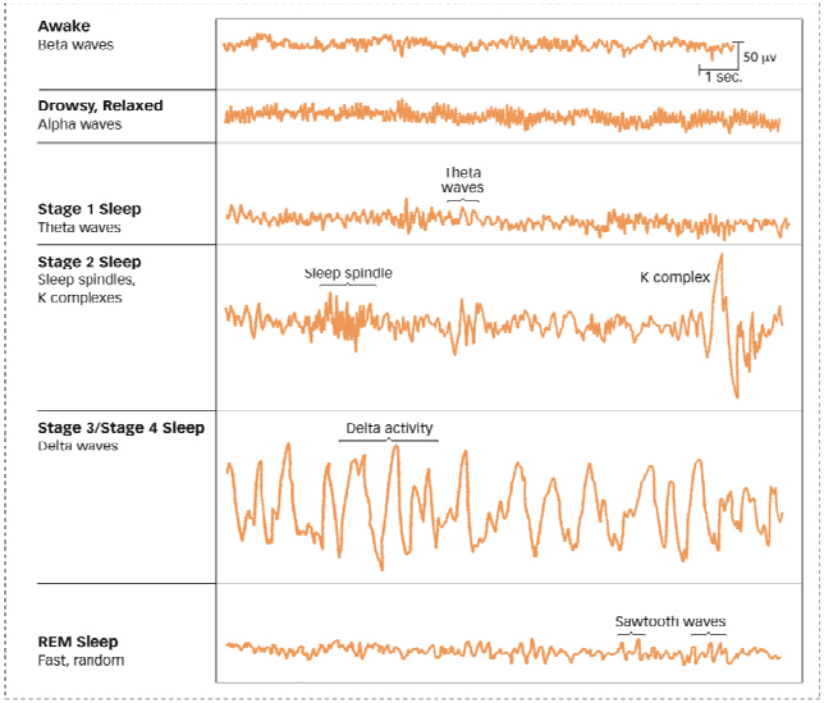




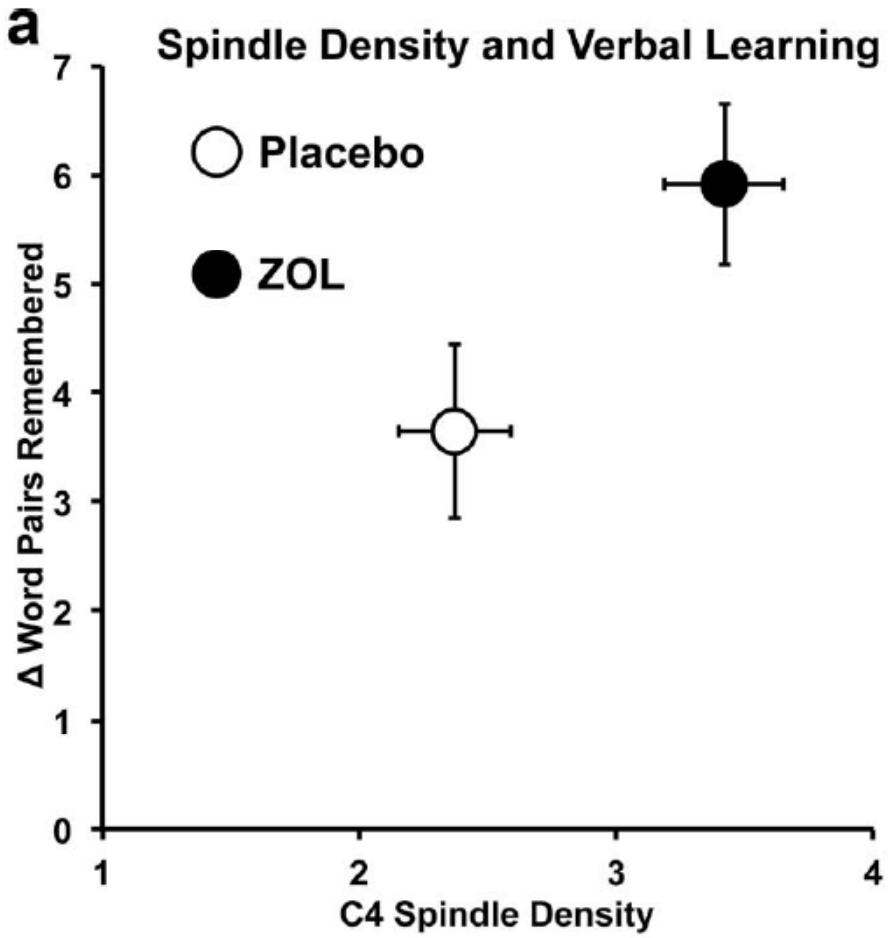


Sleep Stages



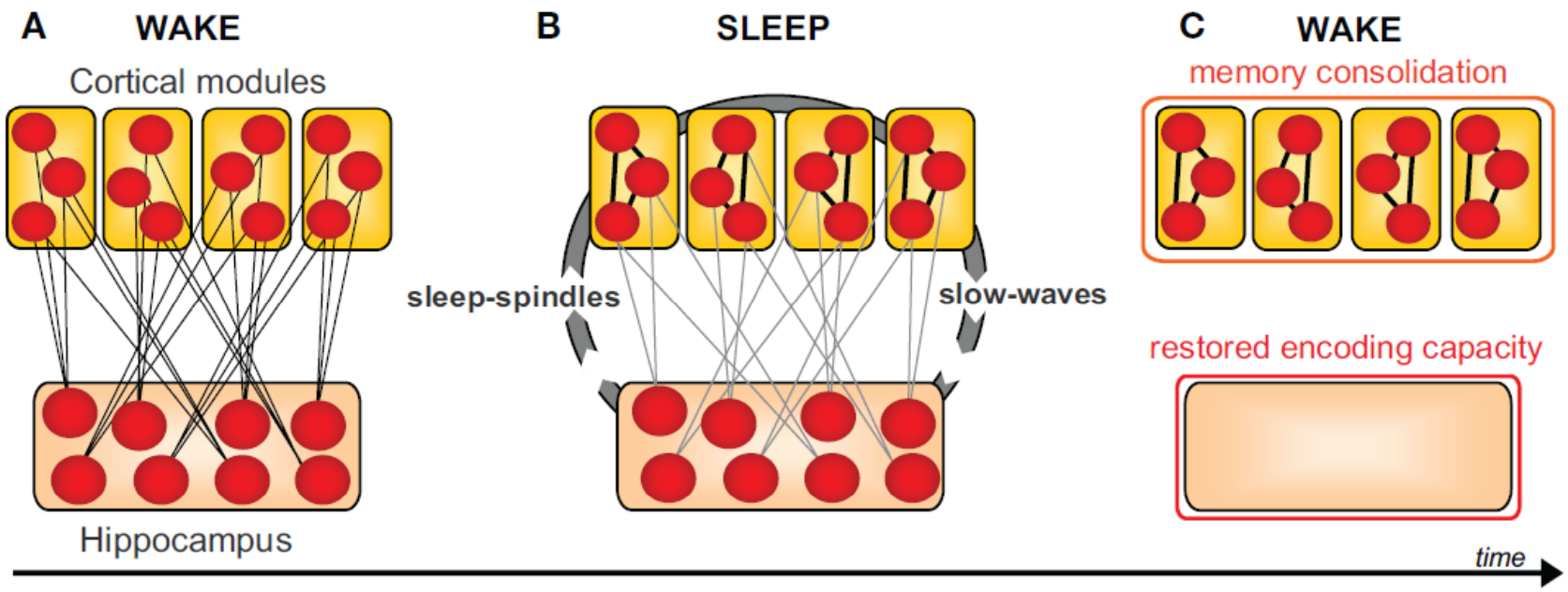


Sleep and Consolidation

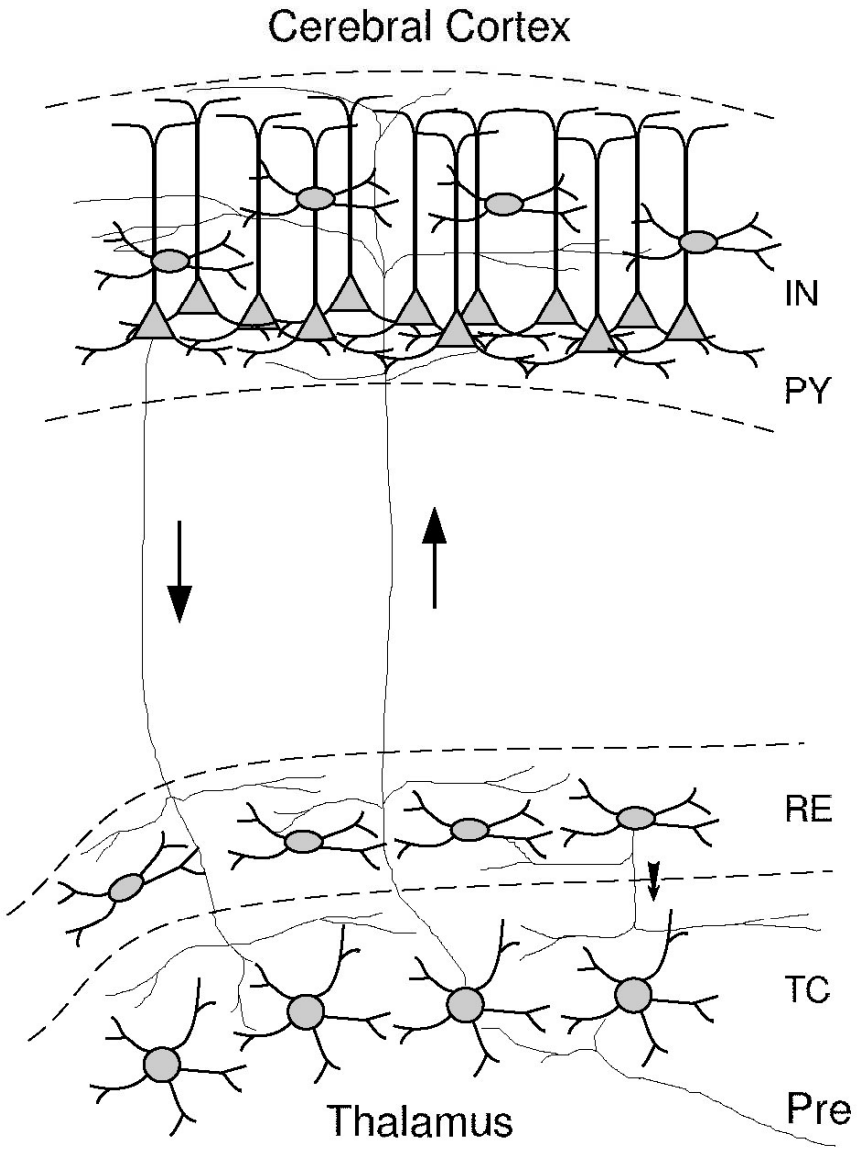


Mednick, et al (2013)

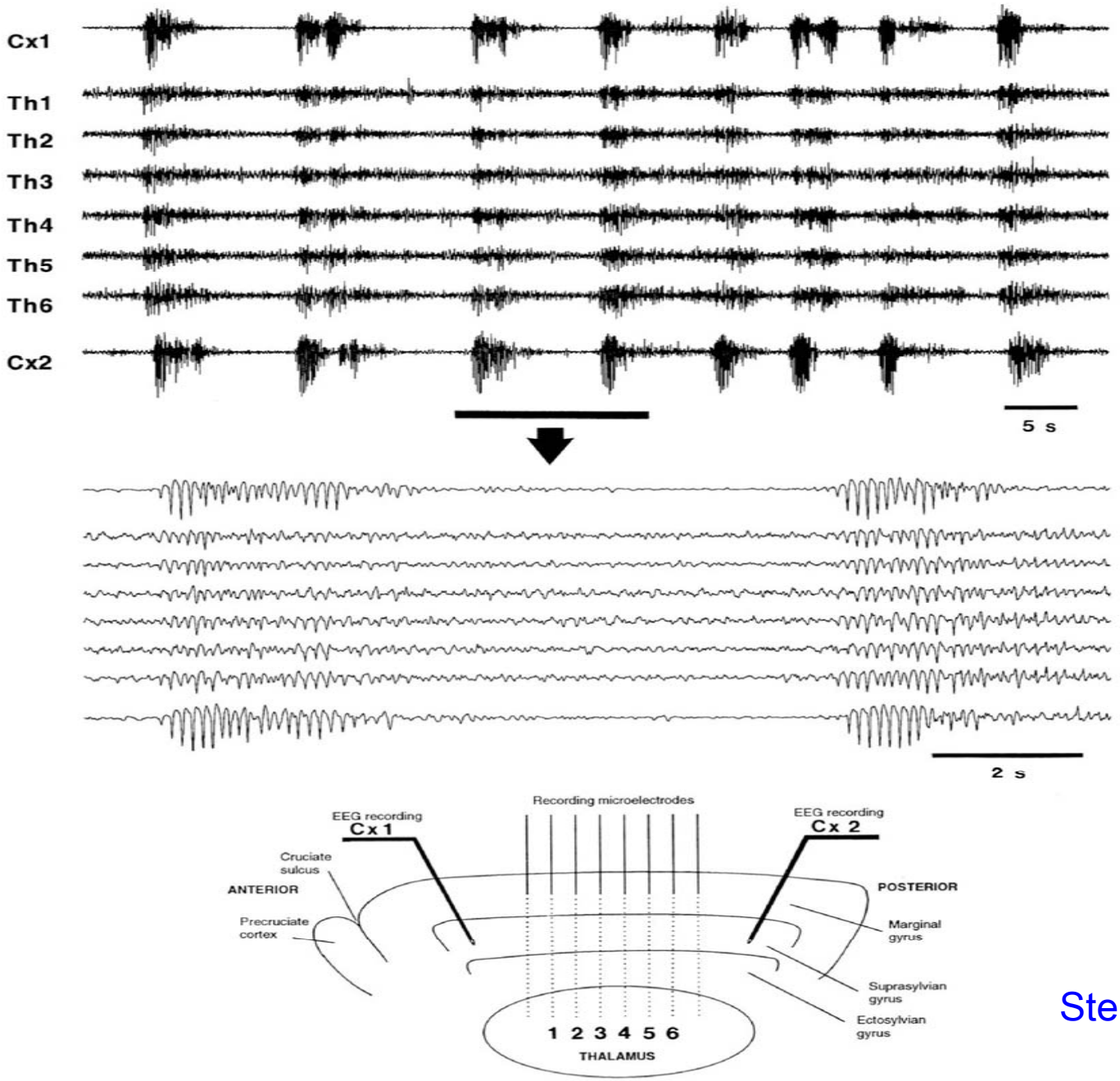
Memory Consolidation



Gyorgi Buzsaki

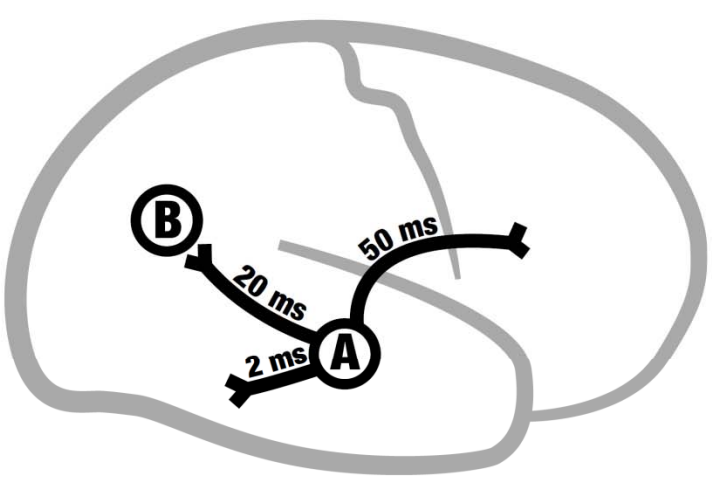


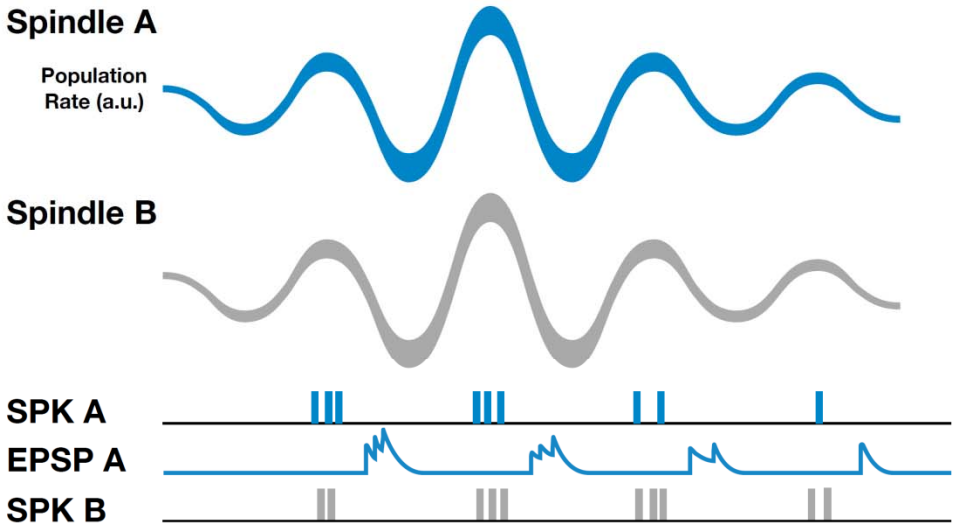
Destexhe and Sejnowski, 1993



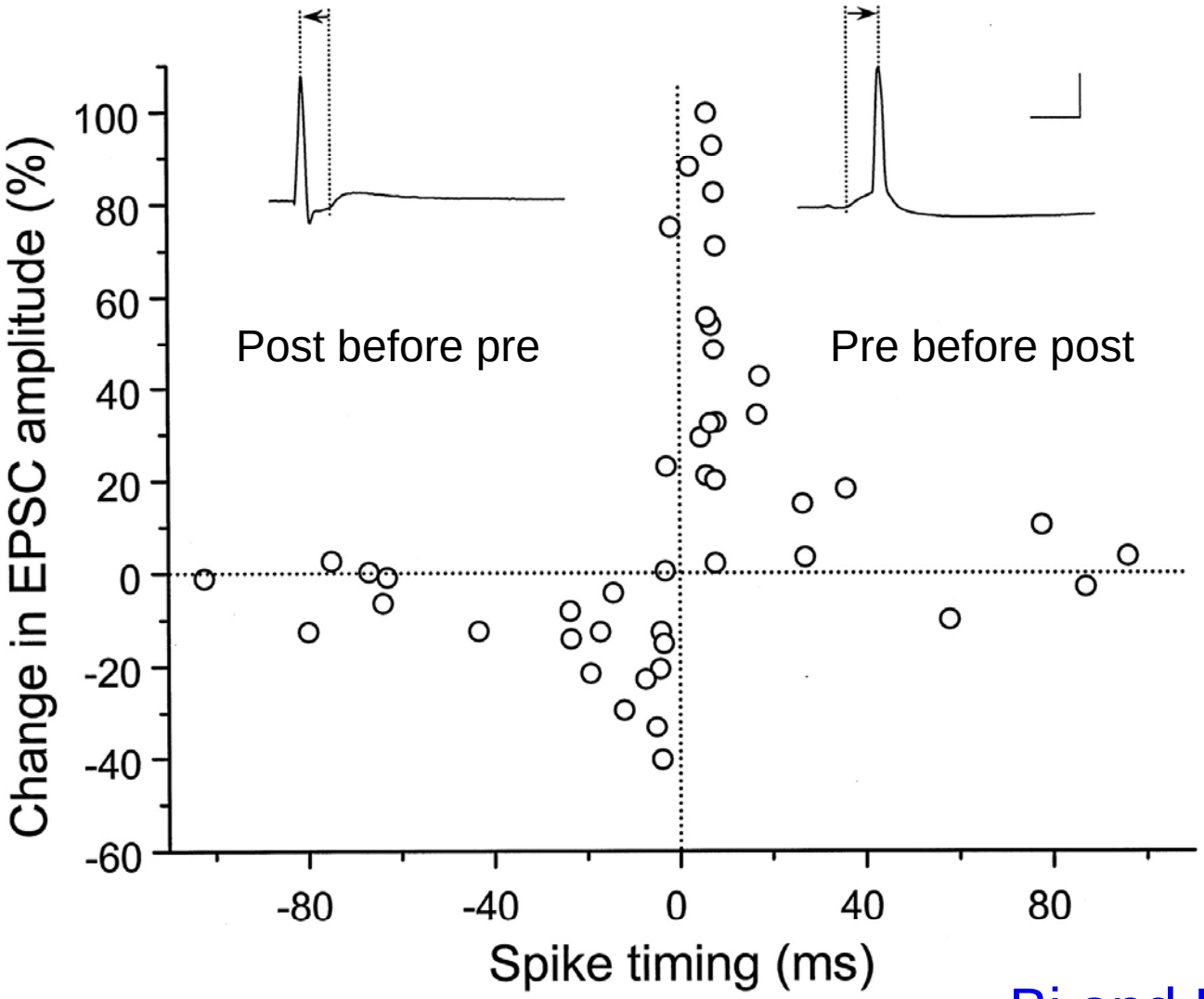
Steriade, 1990

STDP and Sleep Spindles



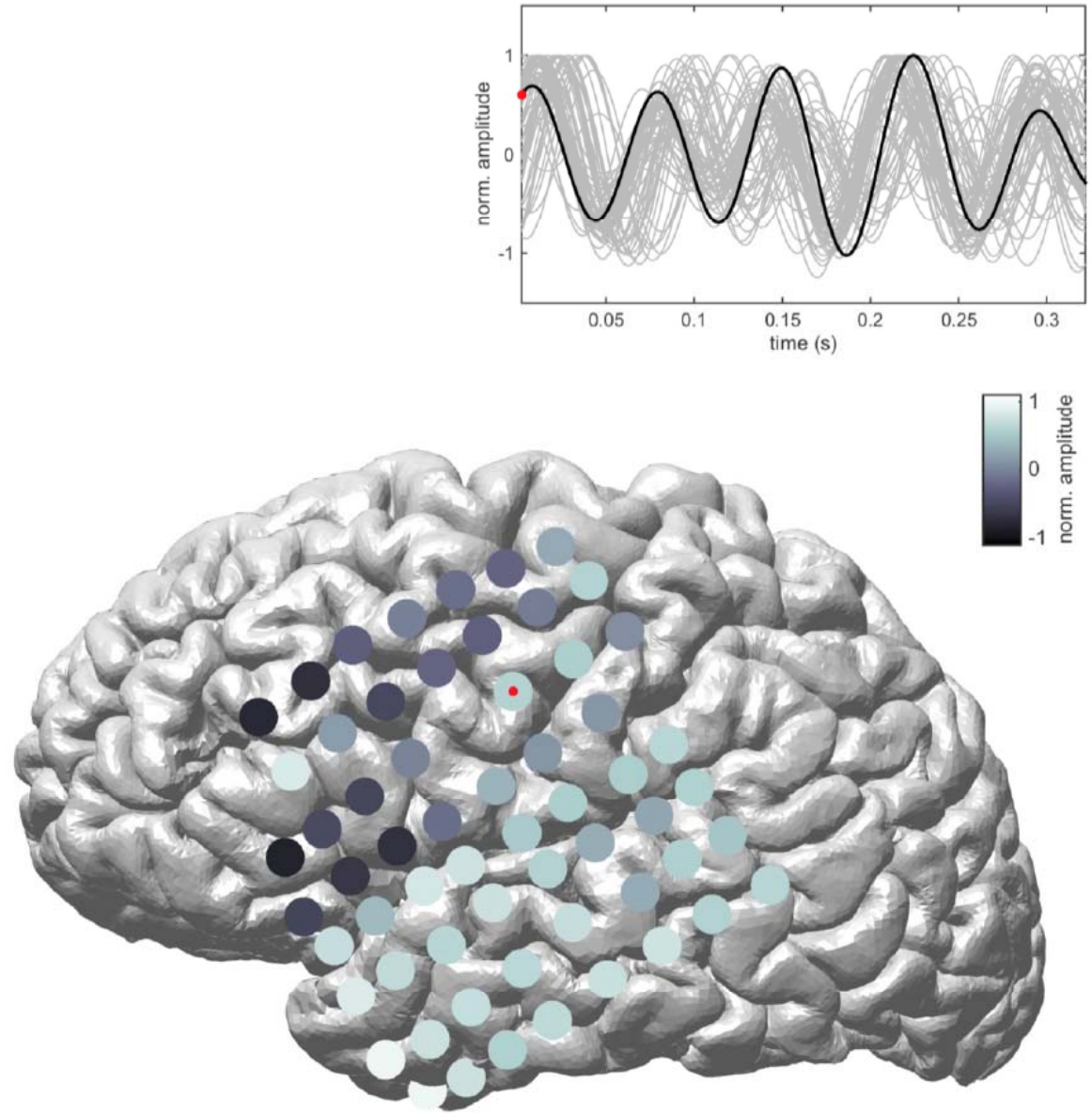


Spike-Time Dependent Synaptic Plasticity



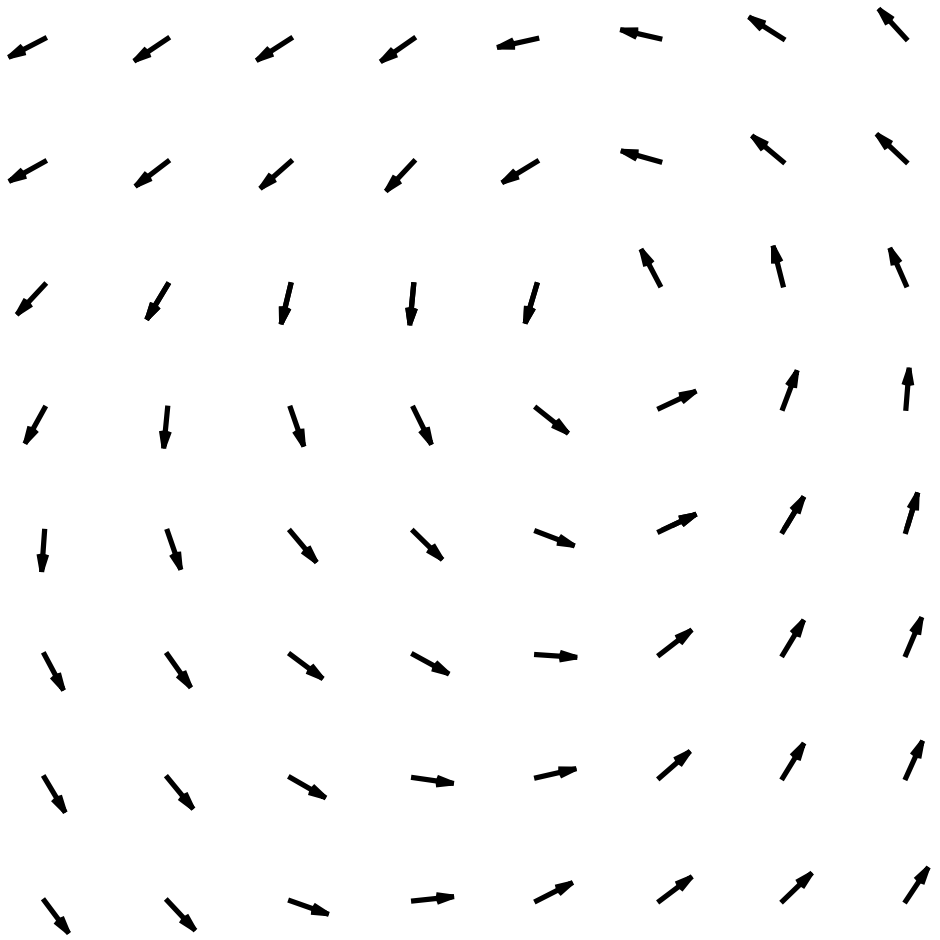
Bi and Poo (1998)

Phase Dynamics of Sleep Spindles

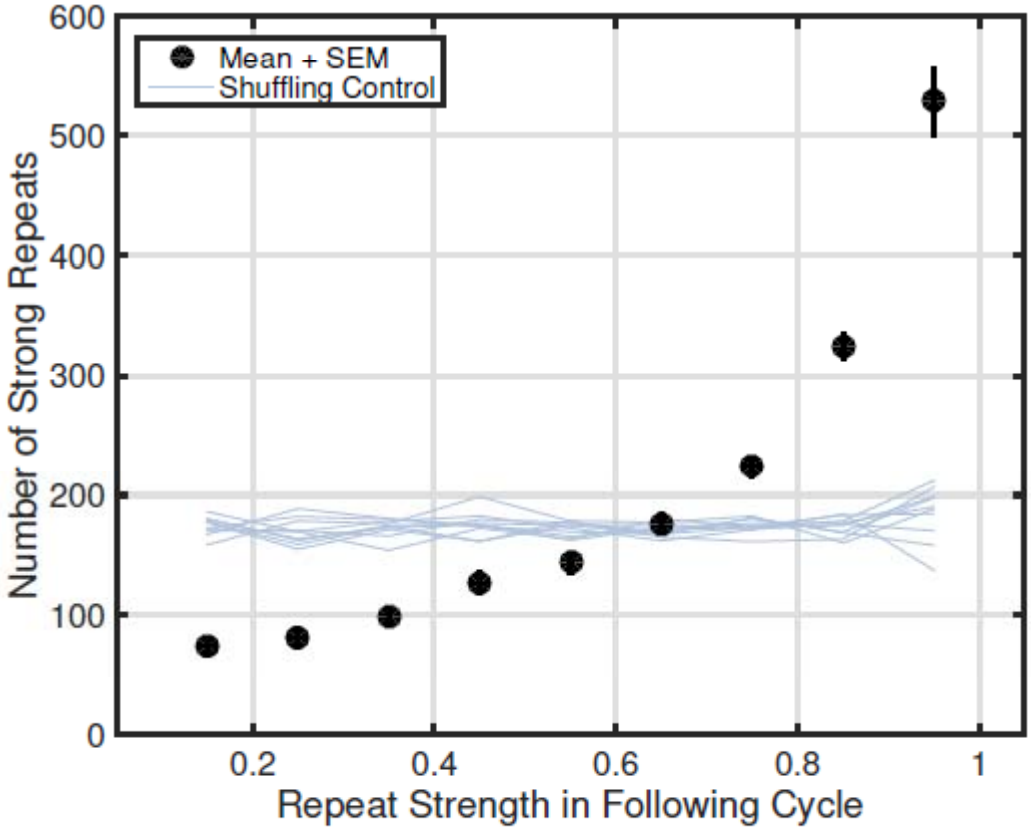


Muller, Halgren, Cash and Sejnowski 2016

Averaged vector field, MG67

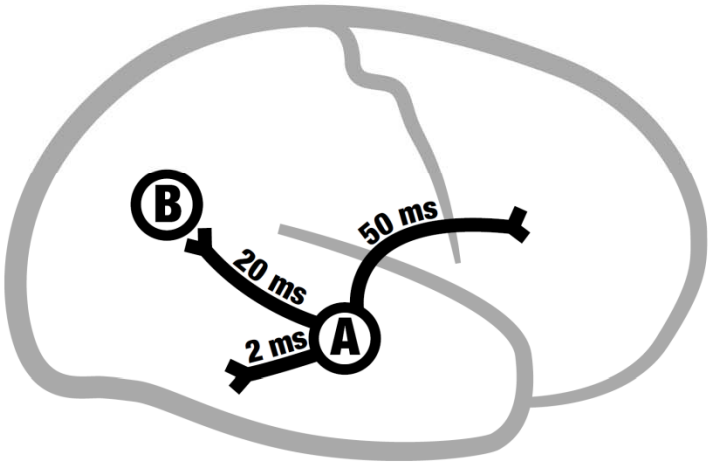


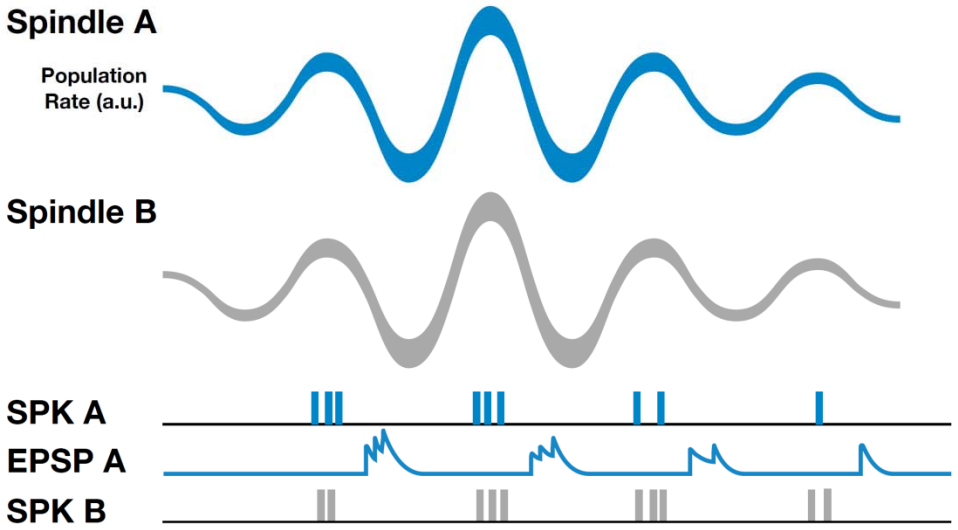
Repeated Spatial Patterns During Spindles

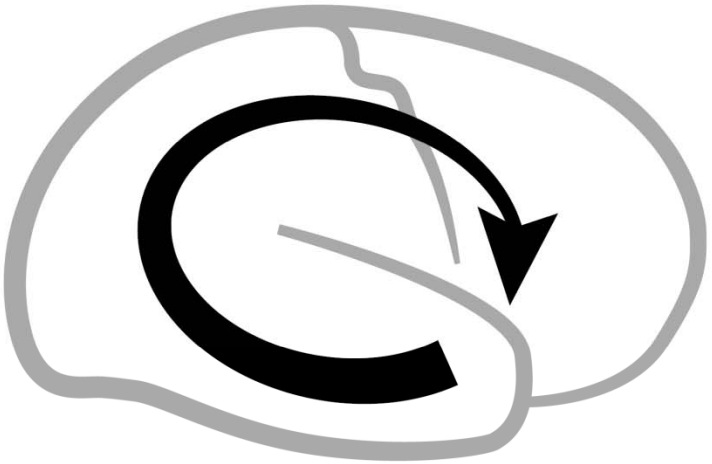


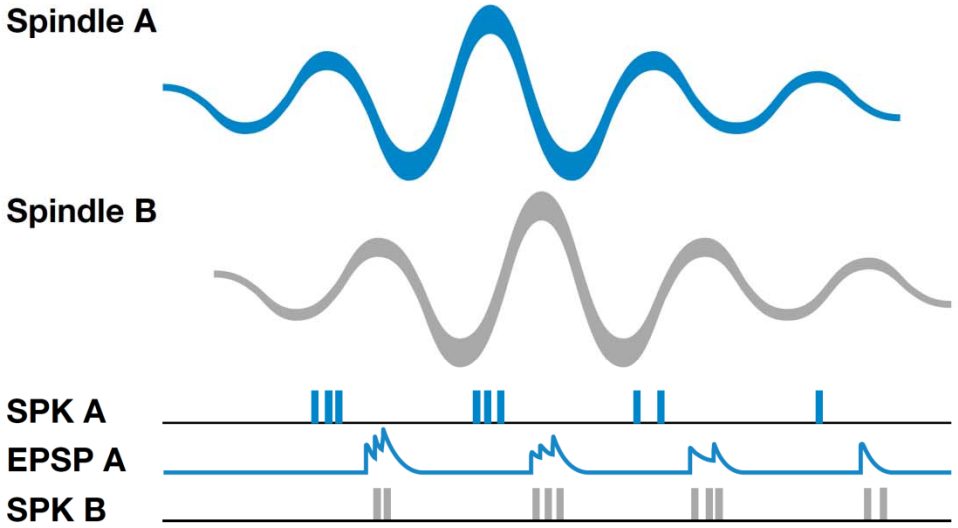
Muller, Halgren, Cash and Sejnowski 2015

STDP and Sleep Spindles

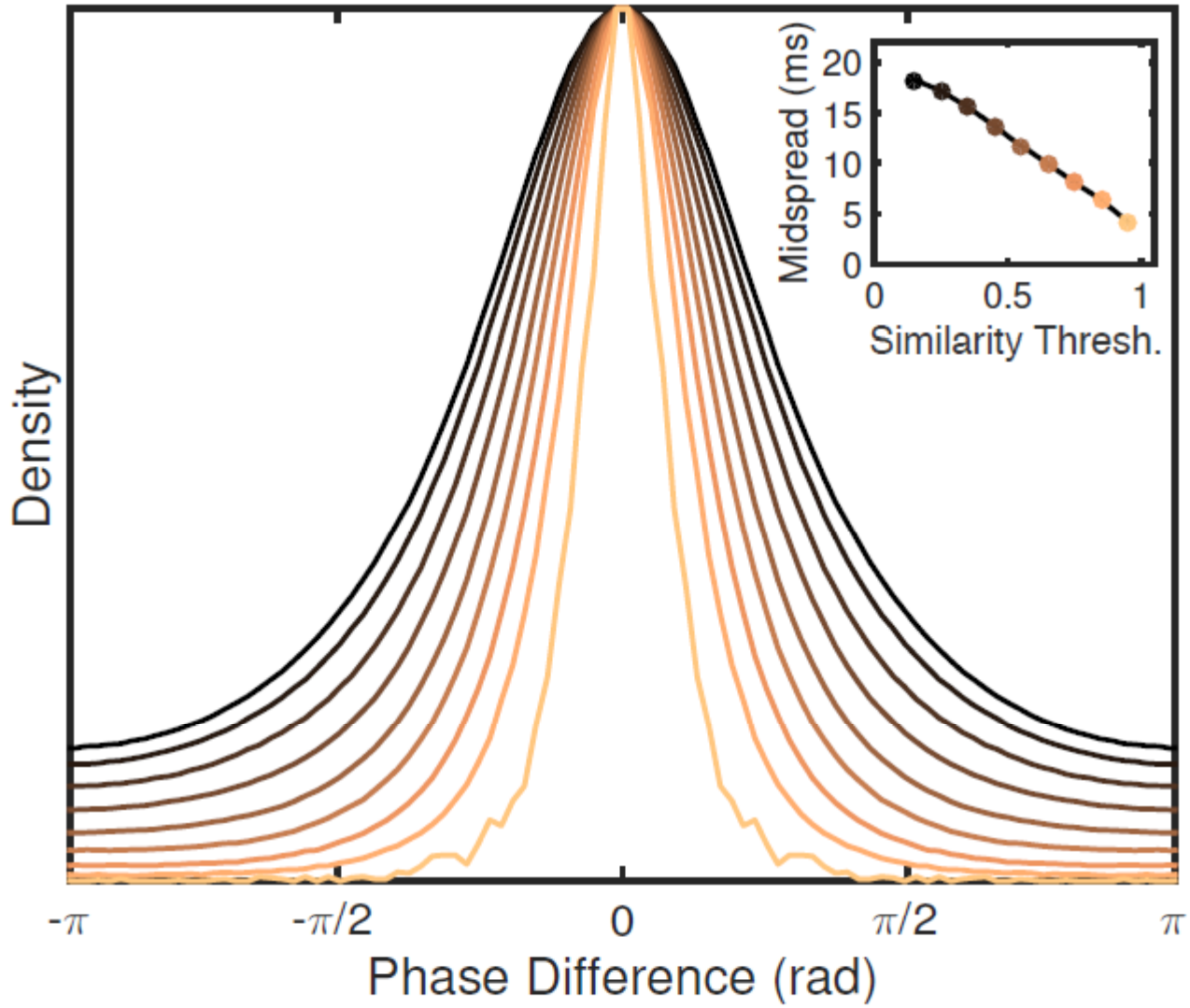








STDP and Sleep Spindles



Extended Kuramoto Model of Coupled Oscillators

$$\frac{d\theta_i(t)}{dt} = \omega_i + \frac{K}{\#S_i}\sum_{j\in S_i} sin\big(\theta_j(t-\tau_{ij}) - \theta_i(t)\big), \qquad i = 1\ldots N$$

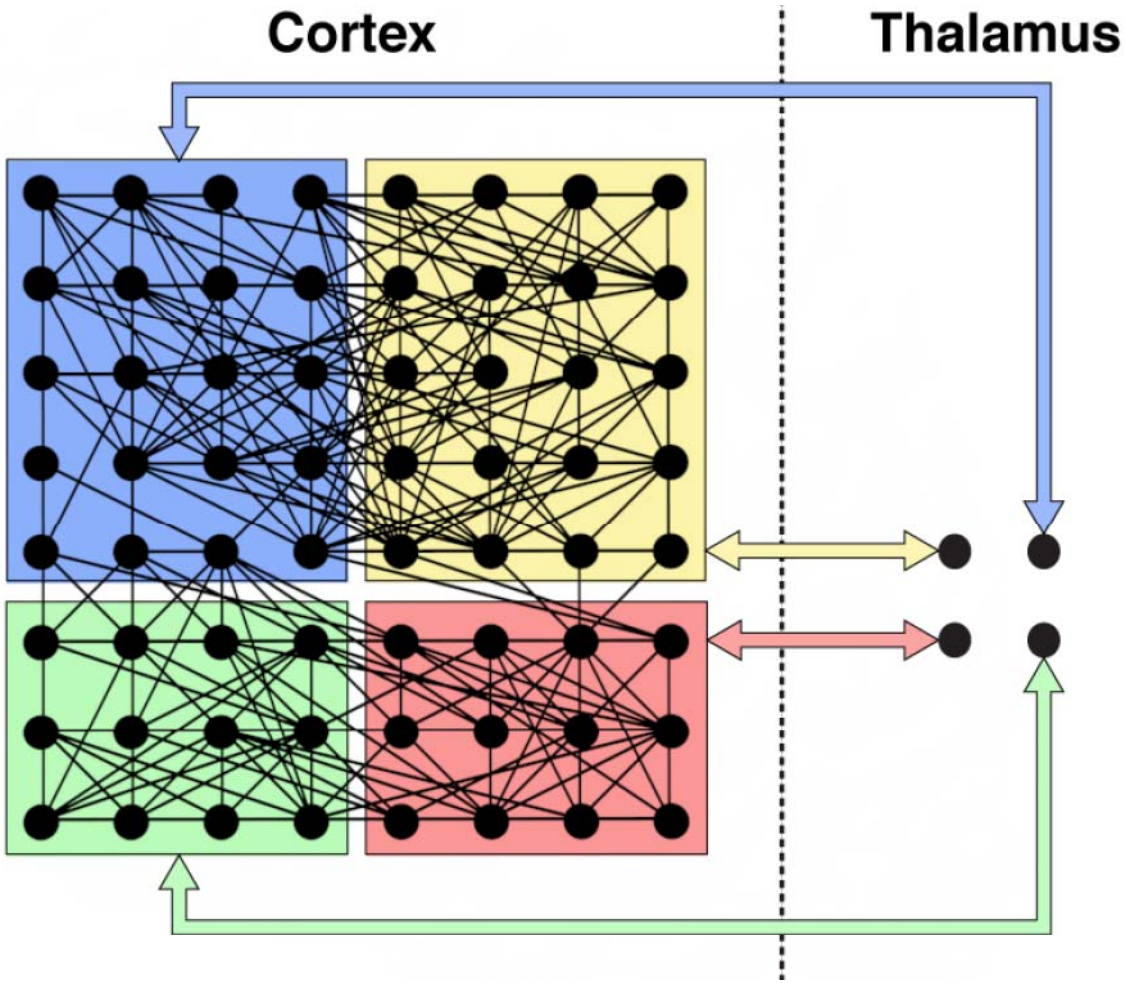
N ... number of oscillators
θ_i ... instantaneous phase of oscillator i
ω_i ... intrinsic angular frequency of oscillator i
K ... coupling strength
S_i ... set of nodes connected to i
τ_{ij} ... delay between node j and i

$$\tau_{ij} = \frac{d_{ij}}{3.5\,\mathrm{m/s}}$$

$$\tau_{\text{THAL-CTX}} = 4\,\mathrm{ms}$$

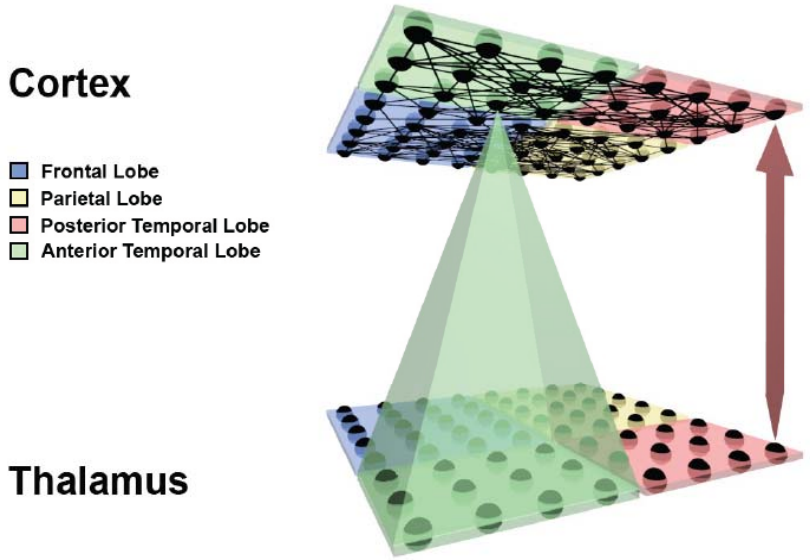
$$\tau_{\text{CTX-THAL}} = 10\,\mathrm{ms}$$

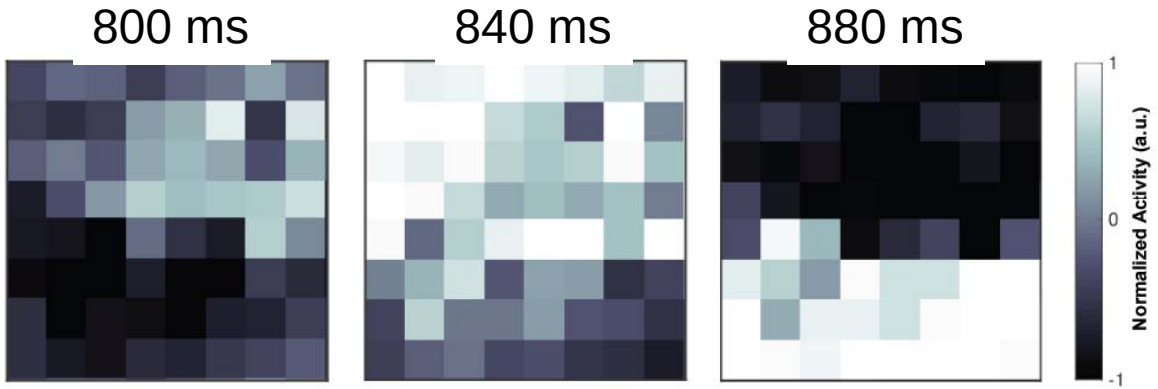
Coupled Oscillator Model of Sleep Spindles



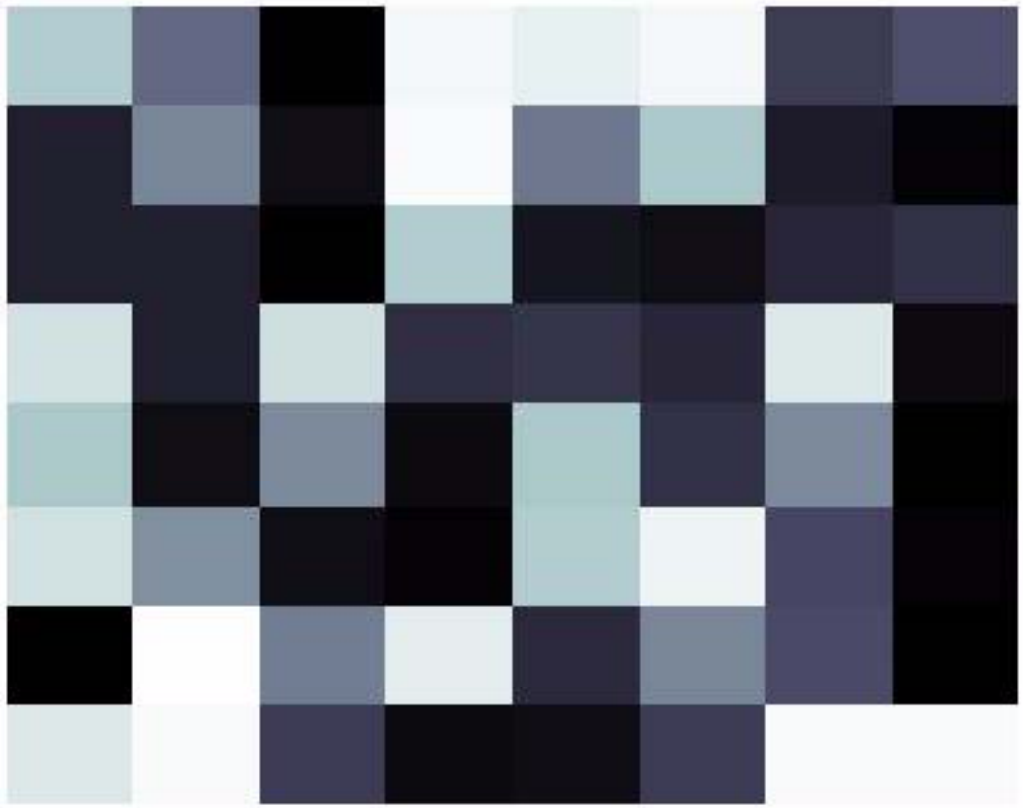
Koller, Muller and Sejnowski 2015

Kuramoto Model of Traveling Waves

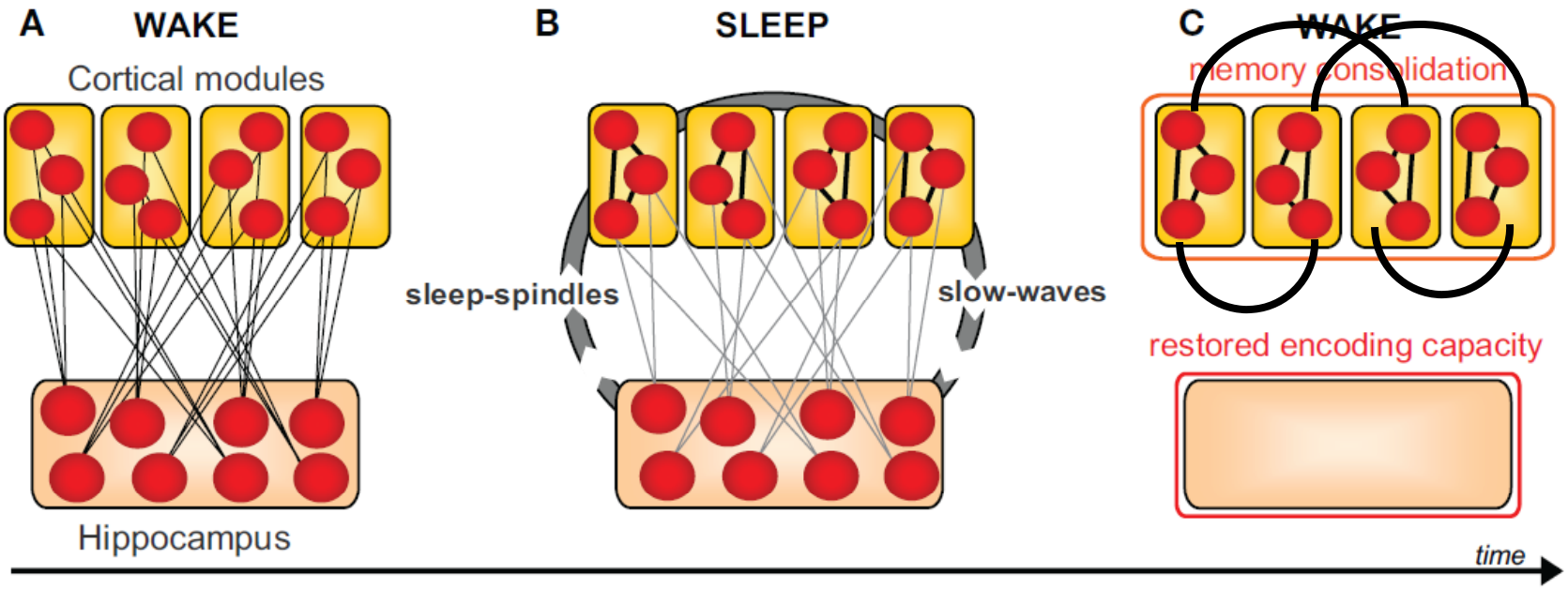




Muller, Koller and Sejnowski

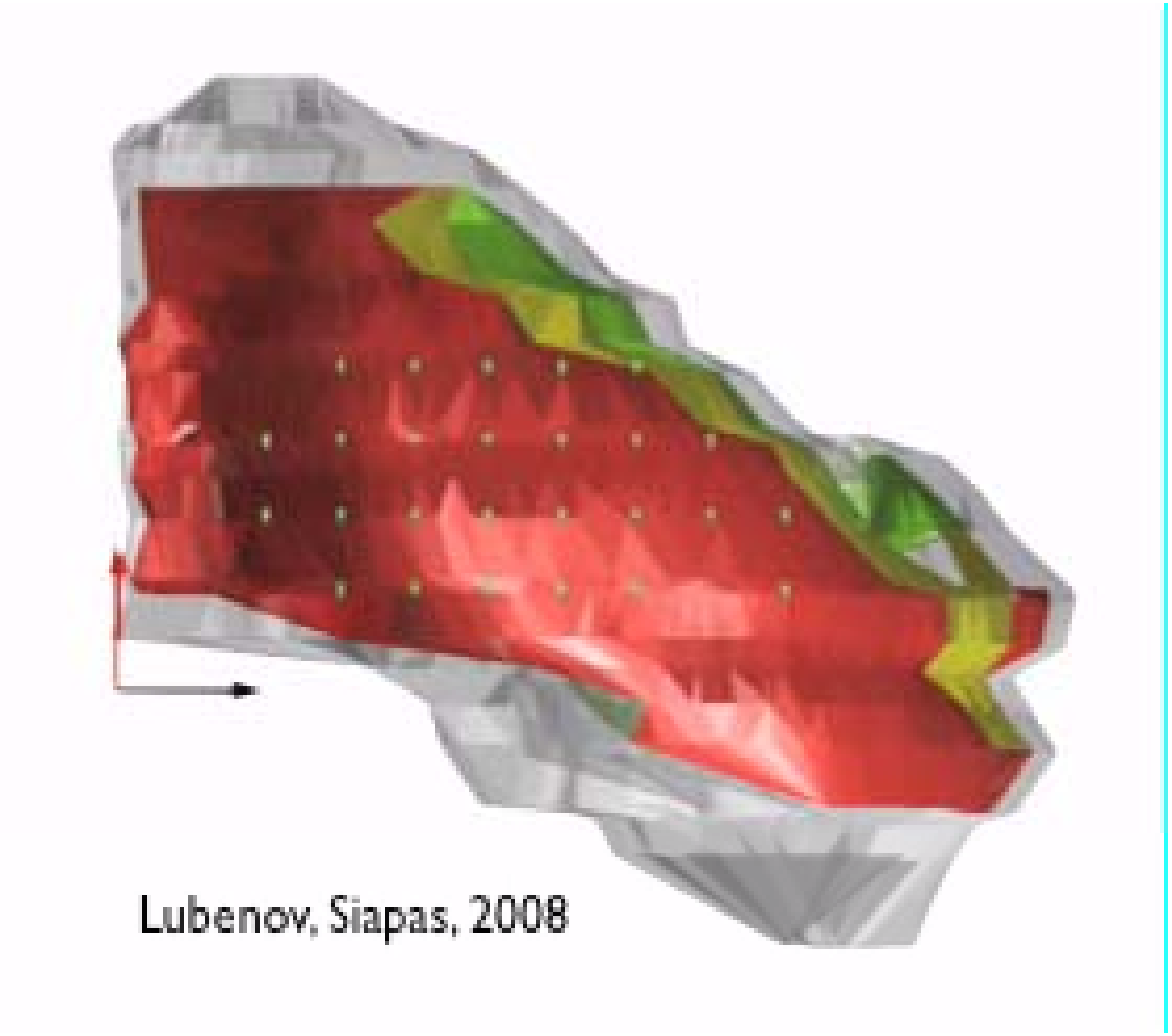


Memory Consolidation



Gyorgi Buzsaki

Traveling Waves in the Hippocampus



Lubenov and Siapas(2008)

Work in Progress

Cortical traveling waves in awake monkeys
John Reynolds

Human memory consolidation
Eric Halgren, Syd Cash

Large-scale Hodgkin-Huxley corticothalamic models
Maxim Bazhenov

Lyle Muller
Aaron Sampson
Claudia Laineschek

Eric Halgren
Syd Cash
Gio Piantoni

Max Bonjean
Maxim Bazhenov
Giri Krishnan
Alain Destexhe

David McCormick
Mircea Steriade
Alex Borbely