

Neurocognition

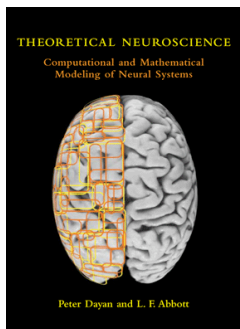


CHEMNITZ UNIVERSITY
OF TECHNOLOGY

Prof. Dr. Fred Hamker
Department of Computer Science
Artificial Intelligence

Introduction 1

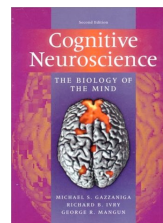
Literature



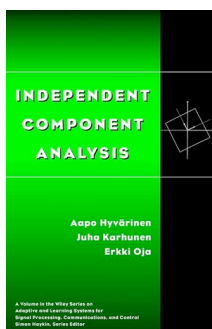
Dayan, P. & Abbott, L.,
Theoretical Neuroscience,
MIT Press, 2001.



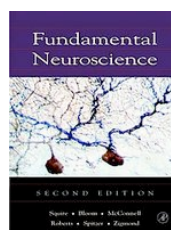
Purves, D. et al.
Neuroscience, 3rd ed.,
Sinauer Associates, 2004.



Gazzaniga, M.S., et al.,
Cognitive Neuroscience.
New York: Norton, 2002.

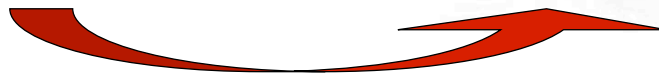
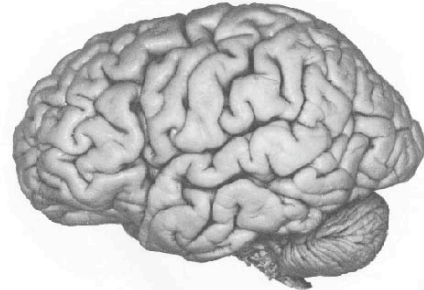
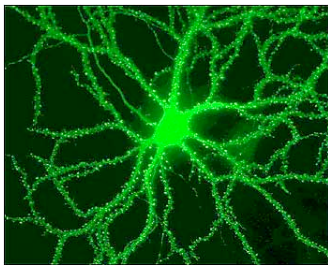


Hyvärinen, A., Karhunen, J., &
Oja, E.,
Independent Component
Analysis
John Wiley & Sons, 2001.



Squire, L.R., et al.,
Fundamental Neuroscience.
Elsevier, 2003.

Aims: Identify the neuronal basis of brain performance



Biophysics

Systems Neuroscience

Behavior

Why should we build a computational model ?

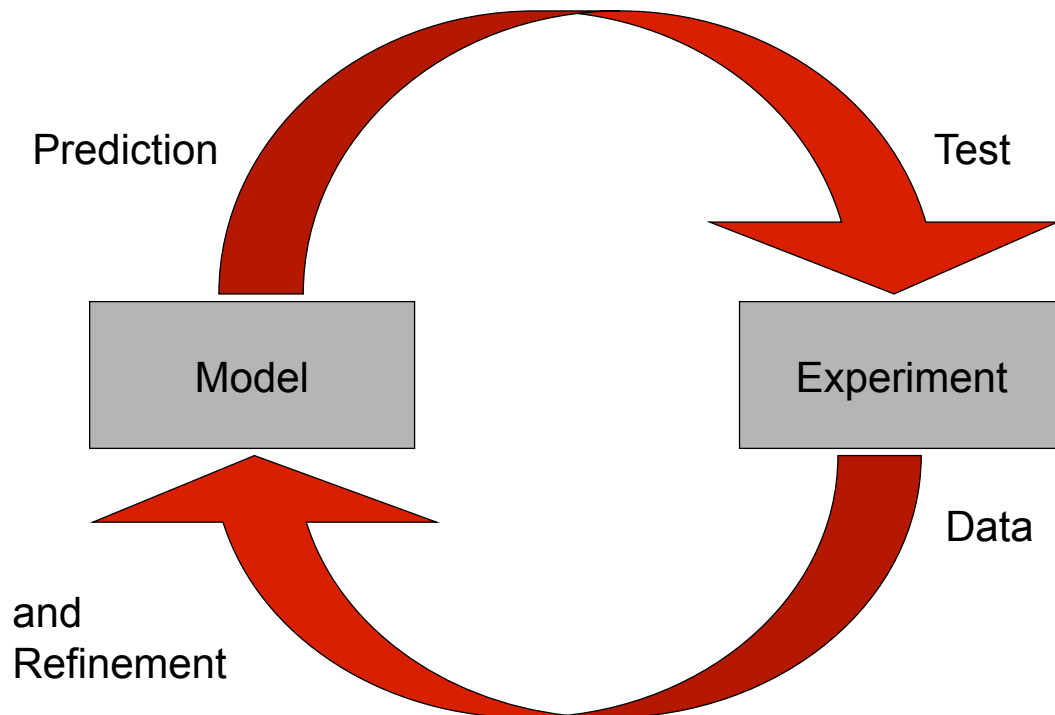
- Models help us to understand phenomena
- Models deal with complexity
- Models are explicit (assumptions and processes)
- Models allow control
- Models provide a unified framework

- Models are too simple
- Models are too complex
- Models can do anything
- Models are reductionistic

Suggested reading:

Chapter 1 in O'Reilly & Munakata, Computational Explorations in Cognitive Neuroscience, MIT Press, 2000.

Aims: Combining computational methodologies with experimental findings



Methods: What do we need for building a model?

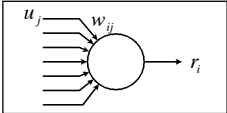
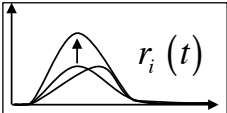
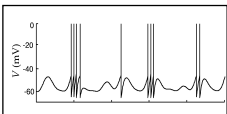
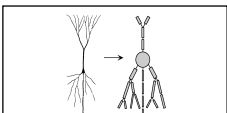
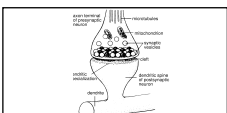
Neurobiology

Anatomy of the nervous system
Physiology of the neuron
Biophysics of the synapse theory
Psychophysical and Physiological Exp.

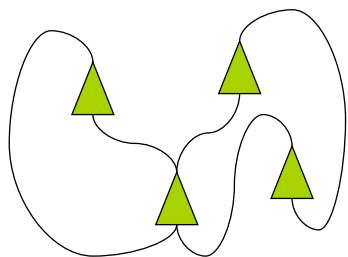
Mathematics

Information theory
Linear systems theory
Dynamical systems

Methods: Levels of implementation detail

Behavioral	$\frac{p(A B)p(B)}{p(A)}$	Mathematical (Bayesian) models
Psychophysical		static rate code feedforward process
Large-scale electrophys. (EEG, fMRI)		dynamic rate code population code
Small-scale electrophys. (LFP, Spike Rate)		integrate & fire
Specific currents, neuromodulator		biophysical compartment
		chemical pharmacology

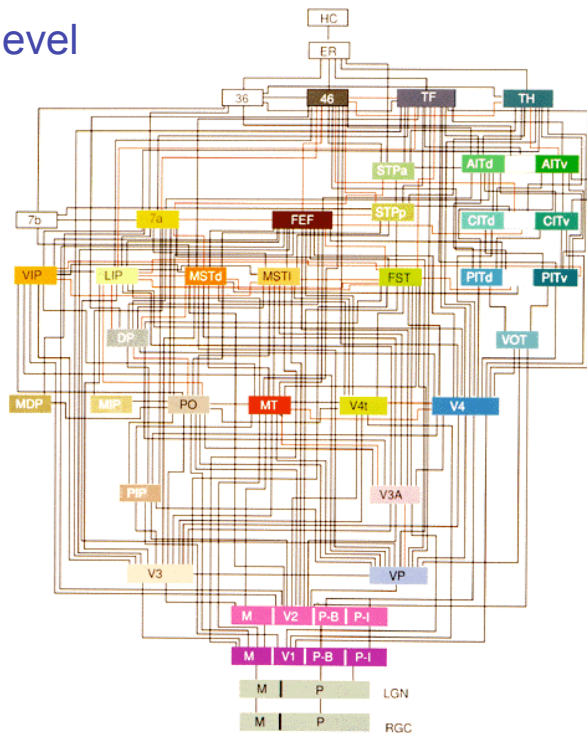
Challenges: The systems level



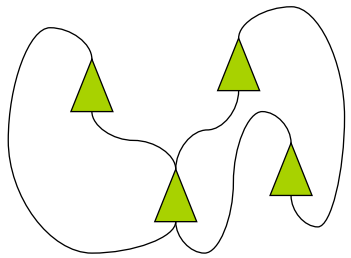
I have not enough data



We have fairly good methods, but poor models



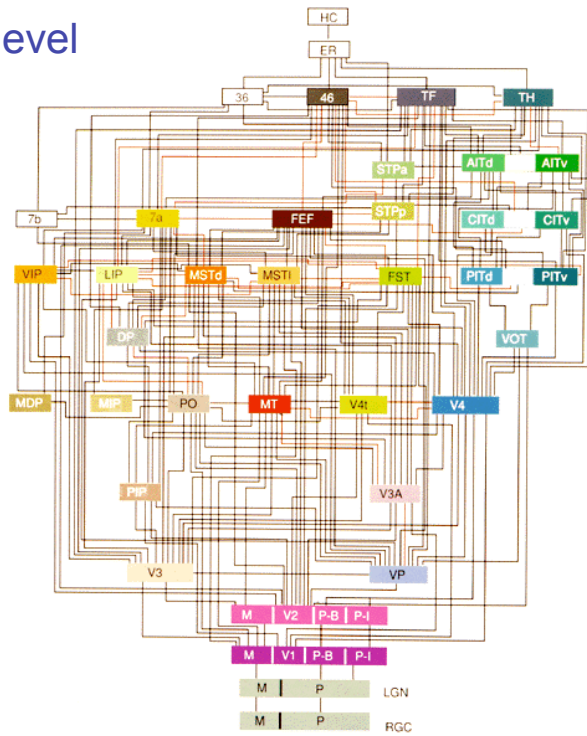
Challenges: The systems level



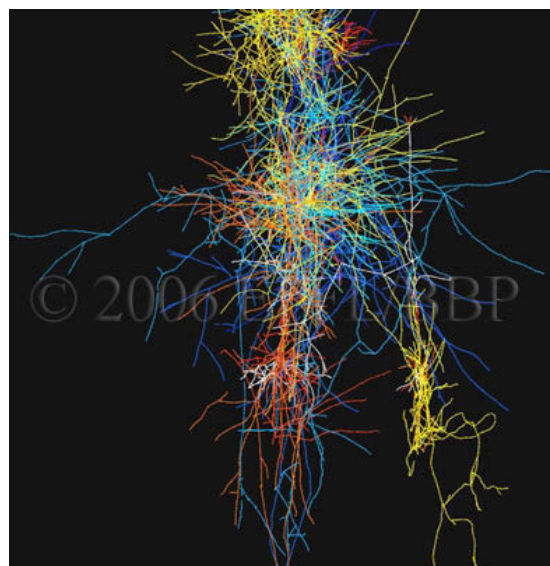
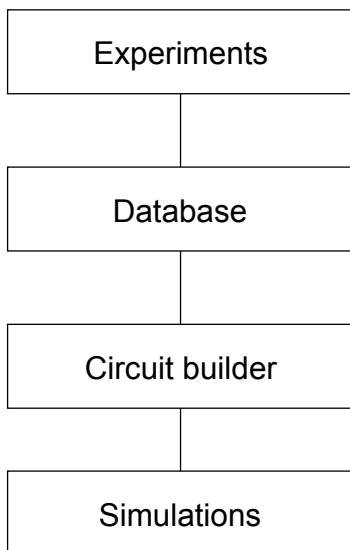
Hey, this model makes cool predictions



Computational Neuroscience is highly interdisciplinary and creative



Challenges: Reverse engineering large-scale biological systems



Henry Markram, Brain and Mind Institute, Lausanne

Challenges: From behavior to underlying neural principles

Illuminating the relationship between behavior, brain areas, neuronal code and function

- Psychophysics
- Anatomy
- Single cell studies
- EEG/MEG
- fMRI
- Patient studies
- Neuromodulators (Dopamine, Acetylcholine, ...)

Computational Modeling

Contents:

Model neurons

- Electrical circuits
- Membrane equation
- Integrate & Fire
- Hodgkin & Huxley
- Poisson
- Synapses
- Rate coded neurons

Learning

Model networks

Information theory