

COGNITIVE COMPUTATIONAL NEUROSCIENCE

Kriegeskorte & Douglas (2018) Nature Neuroscience

October 6, 2018 | Journal Club | Julia Sprenger | INM-6

Historical Background

Cognitive psychology

- study of mental processes such as 'attention, language use, memory, perception, problem solving, creativity, and thinking'¹

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Cognitive Science (1980)

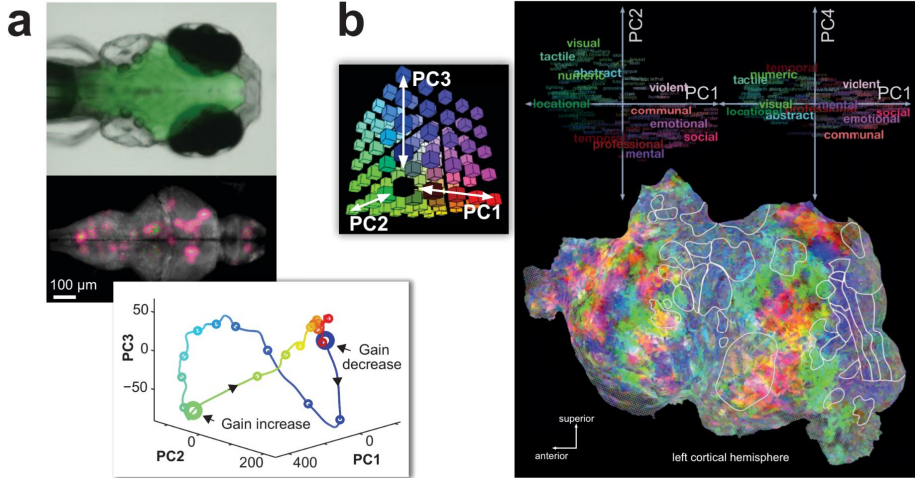
introduction of task-performing computational models (symbolic cognitive architectures, neural networks based on behavioural data)

Historical Background

Cognitive Neuroscience

- relate cognitive theories to the (human) brain using functional brain imaging
- mapping of cognitive functions to brain regions using
 - EEG (1875)
 - MEG (1968)
 - PET (1950s)
 - fMRI (1990)

Modern Imaging Techniques



- a brain map does not reveal the computational mechanism
- but constrains for theory
- data-driven analysis provides only limited insights

Advances in Cognitive Science

- face-selective regions in human
- spacial clustering of face neurons in non-human primates

Different Approaches

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- how humans learn & think

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Computational Neuroscience

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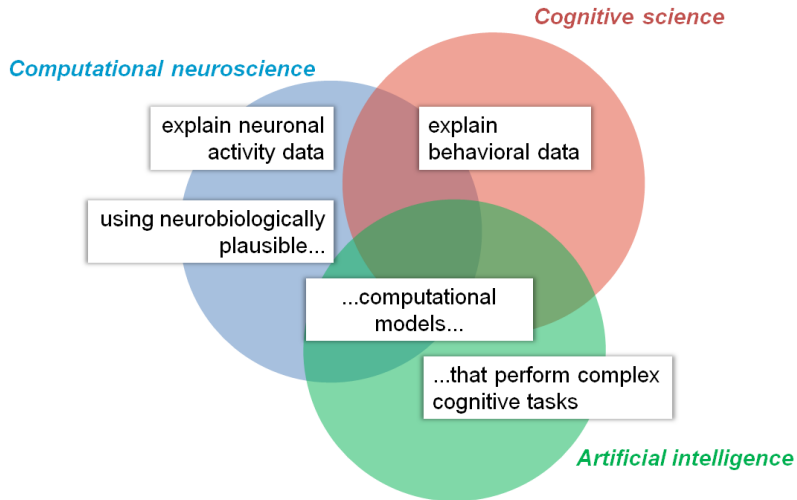
Computational Neuroscience

- how brains adapt and compute

Artificial Intelligence

- how to generate intelligent behaviour

Disciplines



Recent advances

Cognitive Science

- top-down approach
- Bayesian cognitive models (optimal combination of prior knowledge with sensory evidence)
- unified perspective on probabilistic empirical inference

Computational Neuroscience

- bottom-up approach
- mathematical models of elementary computational components and their implementation with biological neurons

Artificial Intelligence

- demonstrates how component functions can be combined to create intelligent behaviour
- machine learning, deep neural networks

Overarching Challenge build solid bridges between theory and experiment

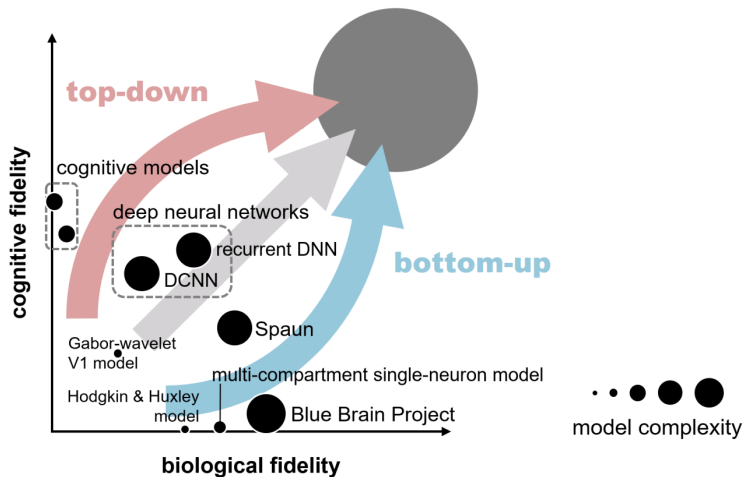
From Experiment Toward Theory

- Models of connectivity and dynamics
- Decoding models
- Representational models

The many meaning of model

- Data-analysis models (statistical description of measured variables)
- box-and-arrow models (information processing)
- oracle model (relies on information without describing the extraction from input)
- brain-computational model (mimics brain information processing, eg sensory encoding)
- ...

The Space of Process Models



Interaction Among Sharable Components

