Computational Cognitive Neuroscience (CCN)

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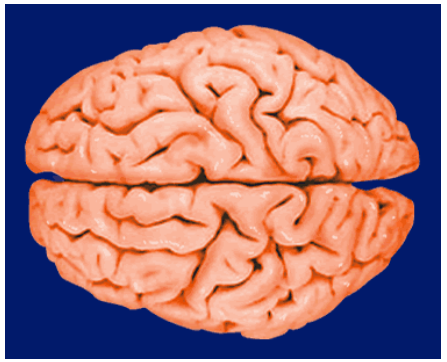
How are we ever going to understand this ?



Practical things

- **Lecturer**: Peggy Series
pseries@inf.ed.ac.uk
course materials: http://homepages.inf.ed.ac.uk/pseries
- **Tutor**: Hannes Saal
- 2 **Lectures** / week:
Monday 9 am, Thursday 9 am -- DHT 7.18.
- **Labs**: one week/2 (5 labs in total).
Monday 1-3 pm (TBC)
Matlab implementation of simple models.
- **Office hour**. Thursday 10 - 11 am (after class) in my office FH-C2.

Practical things

- **Assessments:**
- 2 reports / Matlab implementation of simple models. (50%)
- 1 paper on an article (or 2) of your choice. If unsure, ask me. (50%)

- **no textbook**, useful references:
- Dayan & Abbott, Theoretical Neuroscience, MIT press (online)
- O Reilly, Computational explorations in cognitive neuroscience, MIT press (online)
review papers that i will provide.

what is computational cognitive neuroscience ?

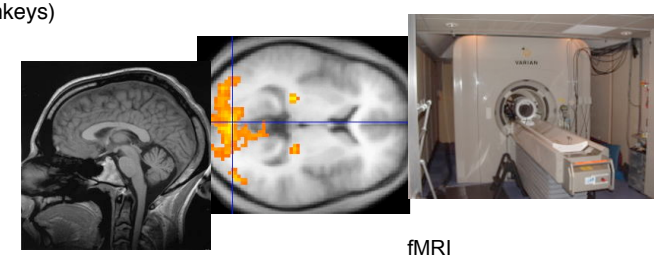
The tools of computational neuroscience + The questions of cognitive neuroscience

The questions of cognitive neuroscience

- How does the brain create our mental world?

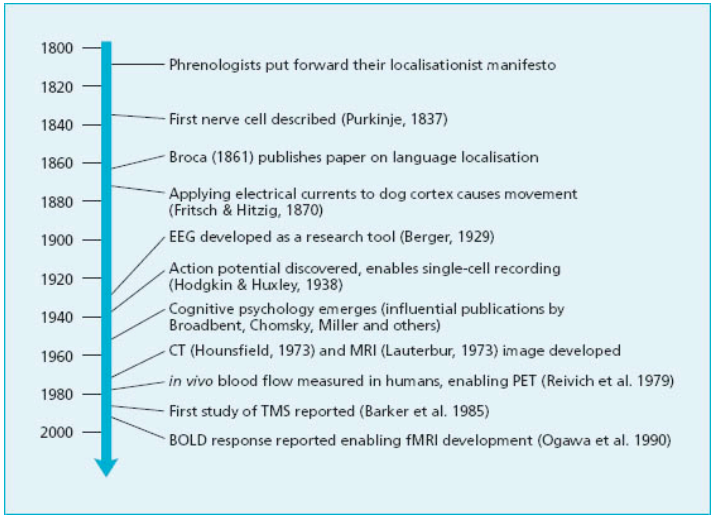
How does the physical substance (body) give rise to our sensations, feelings, thoughts and emotions? (our mind) (physical reductionism)

- = psychology meeting neuroscience
- perception, action, language, attention and memory
- Recent explosion of the field, due to development of methods, in particular neuro-imaging (but also TMS, electrophysiology in awake monkeys)



structural MRI fMRI

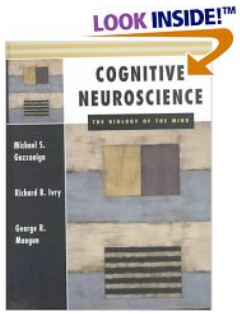
Cognitive neuroscience time-line



from J. Ward, student's guide to cognitive neuroscience, 2007.

The questions of cognitive neuroscience

perception, action, language, attention and memory



Gazzaniga

1- A Brief History of Cognitive Neuroscience
2- The Substrates of Cognition
3- The Methods of Cognitive Neuroscience
4- Perception and Encoding (vision, audition)
5- Higher Perceptual Functions (object & shape recognition)
6- Attention and Selective Perception
7- Memory Systems (short term memory, long term, amnesia..)
8 - Language in the brain
9- Cerebral Lateralization and Specialization
10- Motor Control
11- Executive Functions and Frontal Lobes
12- Development and Plasticity
13- Evolutionary Perspectives
14 - The Problem of Consciousness

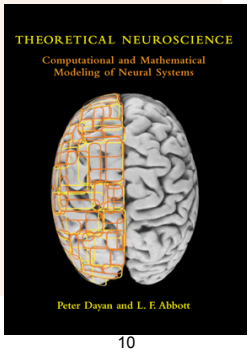
What is Computational Neuroscience ?

❖ A tool of neuroscience, use mathematical and computer models to understand how the brain works / the principles of computation and representation and their neural implementation

❖ Aims:
- what? description: unify data in a single framework.
- how? understand mechanisms.
- why? understand principles underlying functions (optimality for eg).
- make predictions - guide experiments. better data analysis.

❖ Many different levels of modeling (synapses, neuron, networks), levels of abstraction (computational, algorithmic, implementation) and set of tools.
❖A relatively recent field that is growing fast while its grounds / techniques are getting more solid
❖ Textbook : Dayan and Abbott (2001)

Contents



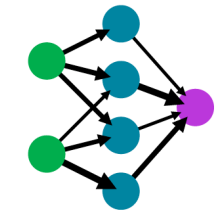
Computational Cognitive Neuroscience

❖ A very recent field, still in infancy

❖ Previously: Connectionism
80s, Mc Clelland, Rumelhart et al, 1986. PDP
(O Reilly's book)

Connectionism

A simple neural network



❖ a reaction against the computer metaphor of the brain (serial computation, symbolic, if-then rules)
❖ explain how the brain works using neural networks. Mental phenomena = emergent processes of interconnected networks of simpler units.
❖ Distributed, graded representation.
❖ Showed that such networks can learn any arbitrary mapping by changing strength of connections; developped sophisticated learning rules (e.g. backpropagation).

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❖ New approaches. Closer to Biology. (this course)
- New data: e.g. development of electrophysiology in awake behaving monkey.
- new models: simulations of physiological data, Bayesian models

❖ a new conference -- reflects progress of the field.
http://www.ccnconference.org/

❖ Very exciting times !

Rough Schedule of the Course

- Perception: linking physiology and behavior (psychophysics)
- encoding
- decoding
- Attention
- Learning: methods: supervised, unsupervised, reinforcement, and models of perceptual learning
- models of Memory
- models of Decision Making
- a connectionist model of Language
- Bayesian Cognition
- Emotions
- Mental disorder (schizophrenia)
- Consciousness