ITI Cognitive Engineering

Module 1: repairing/augmenting the brain

PSL* 2014-2015

Overview

General question: how does the brain learn?

- repairing the brain
  - sensory and motor interfaces (I,II)
  - neurocognitive interventions (I,II)
- augmenting the brain
  - neuroeducation (I,II)
- modeling brain plasticity (I,II,III)
  - biophysics, spikes, supervised, unsupervised, & reinforcement learning
- ethics

Sensory and motor interfaces (I)

(Alain de Cheveigné)

- Brain-computer interfaces, **Thorsten Zander**, TU-Berlin
  - the need
  - technology (overview)
  - potential and limitations
  - usability, plasticity, and learning
  - challenges and perspectives

Sensory and motor interfaces (II)

(Alain de Cheveigné)

- Cochlear and brainstem implants, **David McAlpine and Jessica Monaghan**, UCL Ear Institute
  - the cochlear implant: a success story
  - basics of normal and impaired auditory anatomy, physiology and function
  - implant technology, industrial and clinical aspects
  - hearing with an implant
  - success and failure
  - challenges and perspectives: brainstem and midbrain implants, electro-acoustic stimulation, binaural stimulation, optical stimulation, optogenetics, regeneration, pharmaceutics, learning and plasticity

Neurocognitive interventions (I)

(Anne Catherine Bachoud Levi/Charlotte Jacquemot, 26 septembre, 9am-1pm)

- repairing cognitive functions
  - functional models of cognition
  - localizing a deficit
  - cognitive training
- grafts and genetic therapies
  -
- biblio
  -

Neurocognitive interventions (II)

(Jean Lorenceau/ACBL, 3 octobre, 9am-1pm)

- Part I: Eye mouvements and applications
  - control of eye movements
  - pupil dilation
  - applications

- Part II: Practical neuroethics
  - benefit/risk balance
  - informed consents in cognitive impairment
  - placebo and control groups
- biblio
  -

Neuroeducation (I)

(Elena Pasquinelli/Daniel Andler)

Pedagogy and social learning

- Topics
  - How we (and other animals) learn from others
  - Teaching others
- Contents
  - Social learning mechanisms
  - Natural pedagogy
  - Selective trust
  - Cultural transmission and the making of human nature
  - The evolved apprentice
- Biblio (* = un peu difficile)

(*) Csibra, G., & Gergely, G. (2005). Social learning and social cognition: The case for pedagogy. in Johnson M.H. & Munakata Y. (eds.) *Processes of Change in Brain and Cognitive Development.* Oxford University Press, 2005.

Harris, Paul L. (2012). *Trusting What You're Told,* Cambridge, MA : Harvard University Press

Tomasello, M. (2013). Why we cooperate: introduction (pp. 1–10).

Neuroeducation (II)

(Elena Pasquinelli/Daniel Andler)

Is technology making us stupid?

- Topics
  - The concept of evidence-based in educational technologies
  - Myths: brain gym, digital natives, multitasking, the stultifying effects of ICT, etc.
  - Collective intelligence, distributed cognition
  - Really useful technology
- Contents
  - From teaching machines to technology-inspired education
  - Serious games and motivation
  - The extended mind
- Biblio

  - Bavelier, D. et al. (2010). Children, wired: for better and for worse, *Neuron* **67**: 692-701.
  - Carr, N. (2008). Is Google making us stupid?, *The Atlantic.*
  - Hutchins, E. (1995), How a Cockpit Remembers Its Speeds, *Cognitive Science* **19**: 265-288.

Modeling brain plasticity (I)

(Srdjan Ostojic)

- General introduction (Ostojic)
  - basic models of neurons and synapses
  - different types of plasticity and learning
  - brain-inspired algorithms
- Biophysical models of plasticity (Graupner)
  - experimental evidence for synaptic plasticity
  - biophysical processes underlying induction and maintenance of plasticity
  - modeling biophysical processes
  - studying pharmaceutical interventions using biophysical plasticity models

Modeling brain plasticity (II)

(Srdjan Ostojic)

- Spike-based models of plasticity (Gerstner)
  - spike-time dependent plasticity

- Machine learning and applications (Dreyfus)
  - Getting inspiration from the brain: basic concepts of machine learning
  - Applications (computer-aided medical diagnostic and therapy, intelligent prosthesis, computer-aided drug design, BCI…)

Modeling brain plasticity (III)

(Srdjan Ostojic)

- Supervised learning (Nadal)
  - Perceptrons: Rosenblatt's perceptron, the perceptron algorithm, learning capacity, hebbian learning, the Willshaw model, learning from examples
  - Beyond the simple perceptron: support vector machines, deep learning, applications to classification
- Reinforcement learning (Khamassi)
  - Classical conditionning
  - predictions error and dopaminergic activity
  - applications to robotics
- Bibliography

Dayan, P (2005). Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems

Ethics

(Elena Pasquinelli/Daniel Andler)

Neuroethics and education

- Topics
  - The two general problems of neuroethics
  - The special problem of cognitive enhancers
  - The specious attraction of neuroimaging images
- Contents
  - Does our brain relieve us of responsability?
  - Is it OK to change our brains permanently or temporarily to perform better intellectually?
  - What's the difference with education as an cultural cognitive enhancer?
  - What do images from fMRI actually tell us?
- Biblio
  - Farah, M., Neuroethics: the practical and the philosophical,*Trends in Cognitive Sciences* **9** (1) January 2005: 34-40
  - Greely, H. *et. al.* Towards responsible use of cognitive- enhancing drugs by the healthy, *Nature* **456** 11 December 2008: 702-705
  - Weisberg, D.S. *et al.,* The seductive allure of neuroscience explanations, *J. of Cognitive Neuroscience* **20** (3), 2008: 470-477