Introduction to cognitive science
Session 1: Introduction

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Cognitive science is the interdisciplinary study of mind and how information, e.g., concerning perception, language, reasoning, and emotion, is represented and transformed in the brain. It consists of multiple research disciplines, including psychology, artificial intelligence, philosophy, neuroscience, learning sciences, linguistics, anthropology, sociology, and education. (Thagard, 2008)
What is cognitive science?

  - “It is the **multidisciplinary** attempt to understand the **mind**, most especially the human mind. [...] there are **behavioral** and **brain sciences** [...] **formal disciplines** [...] and **parts of philosophy**.”
What is cognitive science?

Simon (Foundations of Cognitive Science, 1989):

“Cognitive science is the study of intelligence and intelligent systems, with particular reference to intelligent behavior as computation.”
What is cognitive science?

- Searle (Minds, Brains and Science, 1984) on cognitivism:
  - “[...] the task of cognitive science is to characterize the brain, not at the level of nerve cells, nor at the level of conscious mental states, but rather at the level of its functioning as an information processing system.”
Interdisciplinarity

- Philosophy
- Psychology
- Artificial Intelligence
- Neuroscience
- Anthropology
- Linguistics
Interdisciplinarity or multidisciplinarity?

This is an interdisciplinary program in which physics students try to hit psychology students with pendulums.

Promising!

My professors had an ongoing competition to get the weirdest thing taken seriously under the label "interdisciplinary program."
Cognitive science or sciences?

- **Common object of study?**
  - Cognition (= information processing?)
  - Mind (more than knowledge, includes emotions, etc.)
  - Product of brain and neural activity
  - Situated-embodied action, “life”

- **Common methods?**
  - Not shared by *all* disciplines
“Cognitive scientists tend to take as objects of study of CS what they normally investigate in their own background disciplines: subjective experiences if they are philosophers, brain activations if they are neuroscientists, information processing if they are cognitive psychologists, and so on. And they use their own methods.” (Greco, 2012)
What do these definitions have in common?

1. The subject of study in cognitive science is usually mind, intelligence, thinking or cognition.
2. The nature of cognitive scientific investigation is interdisciplinary.
3. The subject of cognitive science is characterized in computational-representational terms.

- Broad definition 1+2
- Narrow definition 1+2+3
**Historical background**

- **René Descartes** (1596-1650)
  - "cogito ergo sum"
    - Methodological scepticism – rejects any ideas that can be doubted
    - Cartesian Dualism – body works like a machine, mind is separate
    - Introspection as a method
  - $\Rightarrow$ Cognition is conscious
Historical background

- Hermann von Helmholtz (1821-94)
- Sigmund Freud (1881-1939)

⇒ Cognition is not only conscious
Historical background

- 1879 Wilhelm Wundt – first psychological experiments
- 1890 William James – “Principles of Psychology”:
  - four methods in psychology: analysis, introspection, experiment, and comparison
Behaviourism

- Mind as a black box
- Mental states are unobservable
  - We don’t need them
- Controled conditions
  - Measuring reactions

- Ivan Pavlov

- [http://www.youtube.com/watch?v=Eo7jcl8fAuI](http://www.youtube.com/watch?v=Eo7jcl8fAuI)
Behaviourism

- BF Skinner
- Operant conditioning
- $\Rightarrow$ Mind (internal states) excluded from scientific consideration
Historical background

- WWI – neuropsychology – lesions (Lurija).
- Cognitive psychology during WWII – noisy speech recognition, attention, vigilance, etc.
- Boom After WWII:
  - Computer science: visual perception
  - Linguistics: language acquisition in children
  - Ethology: social behaviour in animals
  - Neurophysiology, Anthropology…
Historical background

- Cybernetics: - Norbert Wiener, feedback
- Information theory: Shannon
- Neuropsychology: Donald Hebb
- Computer science: Von Neumann, Turing

⇒ Information-processing psychology
Computer metaphor

- Software vs. hardware
- Church-Turing thesis
- Architecture similarities: processor, memory, I/O devices
- Mental representations ~ computer data structures
- Computational procedures ~ computational algorithms
Two methodological consequences of the computer model

- Computer models can be built to test theories of mental processes.
- There are different levels of analysis for a complex information processing system.
Three Levels of Description
(David Marr)

- A complete understanding of a computational system has to involve three (kinds of) levels:
  - **Computational theory**
    - What is computed and why.
    - What the system is capable of doing.
  - **Representation and algorithm** (software)
    - What program is used.
    - What are the symbols and how are they processed.
  - **Hardware**
    - Where in the brain?
    - What kind of neurons and how are they connected?
Historical background

- Formal linguistics: Noam Chomsky
- Devices with internal states/memory computationally stronger than mere associations
  ⇒ Rejects behaviourism
Artificial Intelligence

- 1956 J. McCarthy
- the study and design of intelligent agents
Dreams of AI

- Wolfgang von Kempelen
- Judah Loew
- Mary Shelley’s Frankenstein
- Čapek’s R.U.R.
John McCarthy

“We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.” (McCarthy et al. 1955)
Conference at Dartmouth College (1956)

- Marvin Minsky
  - “within a generation… the problem of creating ‘artificial intelligence’ will substantially be solved”

- Allen Newell

- Herbert Simon
  - “machines will be capable, within 20 years, of doing any work a man can do”
Origin of the term Cognitive Science

- George Miller after the MIT conference on Shannon’s information theory (1956).
- Journal Cognitive Science since 1975
Interdisciplinarity

- Philosophy
- Psychology
- Artificial Intelligence
- Neuroscience
- Anthropology
- Linguistics
Philosophy

- Theoretical / methodological questions
  - What is mind?
  - How can we study it?
    - First person perspective vs. third person perspective
  - How can we know anything in principle?
    - Philosophy of science

- Thought experiments
  - Brain in a vat
  - Mary the color scientist,…
Psychology

- How can we structure the mind?
- What are the cognitive processes/mechanisms behind it?
- Empirical research
- Behavioral experiments
  - reaction times
  - psychophysical responses
  - eye tracking
Neuroscience

- Implementation in the brain
  - Brain imaging
    - PET
    - EEG
    - FMRI
    - MEG
  - Neurobiology
    - single-cell recording
    - animal models
    - lesion studies
Linguistics

- Phonology
- Morphology: naj-vy-ruka-vičkova-nejší
- Syntax
- Semantics
- Pragmatics
Núñez & Sweetser (2006):

- Analyzed gestures when speaking about events
- Aymara speakers look towards the past and have future behind their backs
  - Nayra = past (eye, sight, ancestor)
  - Q’’ipa = future (back, behind)
  - Q’’ipüru = tomorrow = q’’ipa + uru (day behind one’s back)
Artificial Intelligence

- **Weak AI**
  - Solves partial problems
  - Does not intend to match capabilities of humans
  - E.g. Deep blue

- **Strong AI**
  - John Searle:
    - “according to strong AI, the computer is not merely a tool in the study of the mind; rather, the appropriately programmed computer really is a mind”
Paradigms in Cognitive Science

Scientific paradigm is a set of assumptions, theories, research methods and established standards for what constitutes a valid research.

Paradigms in Cognitive science:

- Cognitivism
- Connectionism
- Embodiment
- Dynamical systems
- Enactivism
Methods in Cognitive Science

- empirical (observation, experiment)
- computational modeling
- neuroimaging
- philosophical analysis
Next week’s topic: Functionalism

- Multiple realizability argument
- Church-Turing
- Turing test of intelligence
- Criticism:
  - Chinese room argument
Questions?
Discussion

- What is cognition? Where to draw the line?
  - Hunger, emotions, memory, attention, reflexes, drives...

- What is the connection between mind and brain?

- What do you think of the computer metaphor of mind?

- Why the predictions from Dartmouth College Conference were not fulfilled?

- Strong AI vs. weak AI