

INTRODUCTION TO COGNITIVE SCIENCE

SESSION 1

ISC 2010 – Dana Retova

What is cognitive science?

- Stainton (in *Contemporary Debates in Cognitive Science*, 2006):
 - “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.”



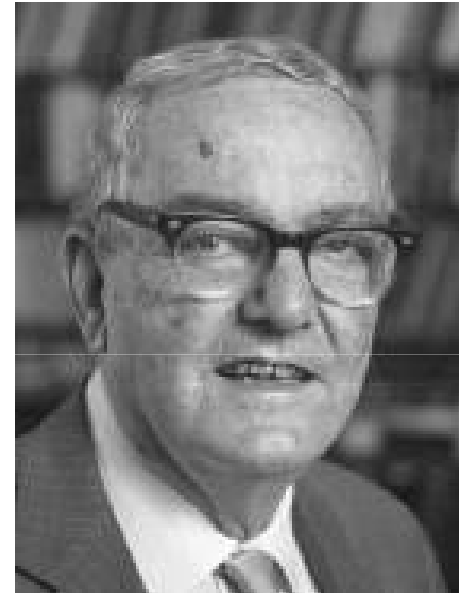
What is cognitive science?

- **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)



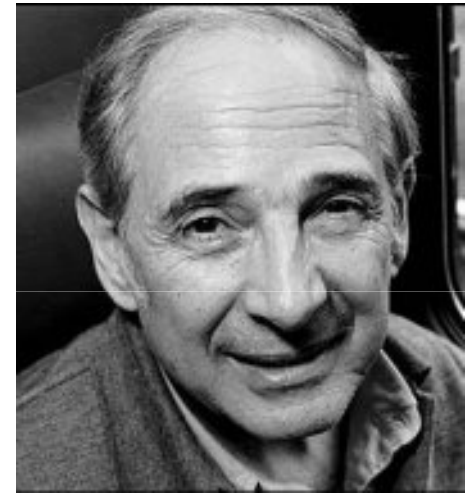
What is cognitive science?

- 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.”



What is cognitive science?

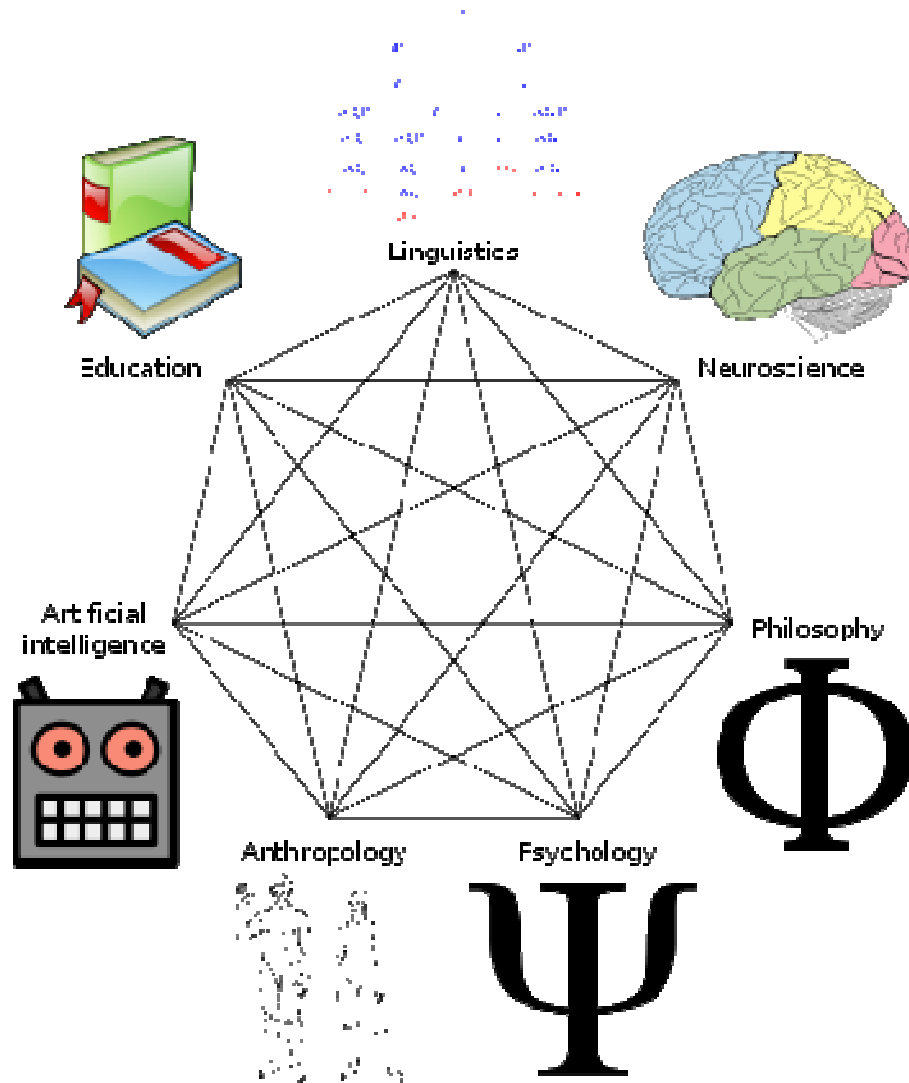


- The central hypothesis of cognitive science:
 - ▣ “Thinking can best be understood in terms of representational structures in the mind and computational procedures that operate on those structures” (Thagard, 1996)
 - ▣ However, there is disagreement about the nature of the representations and computations that constitute thinking

What do these definitions have in common?

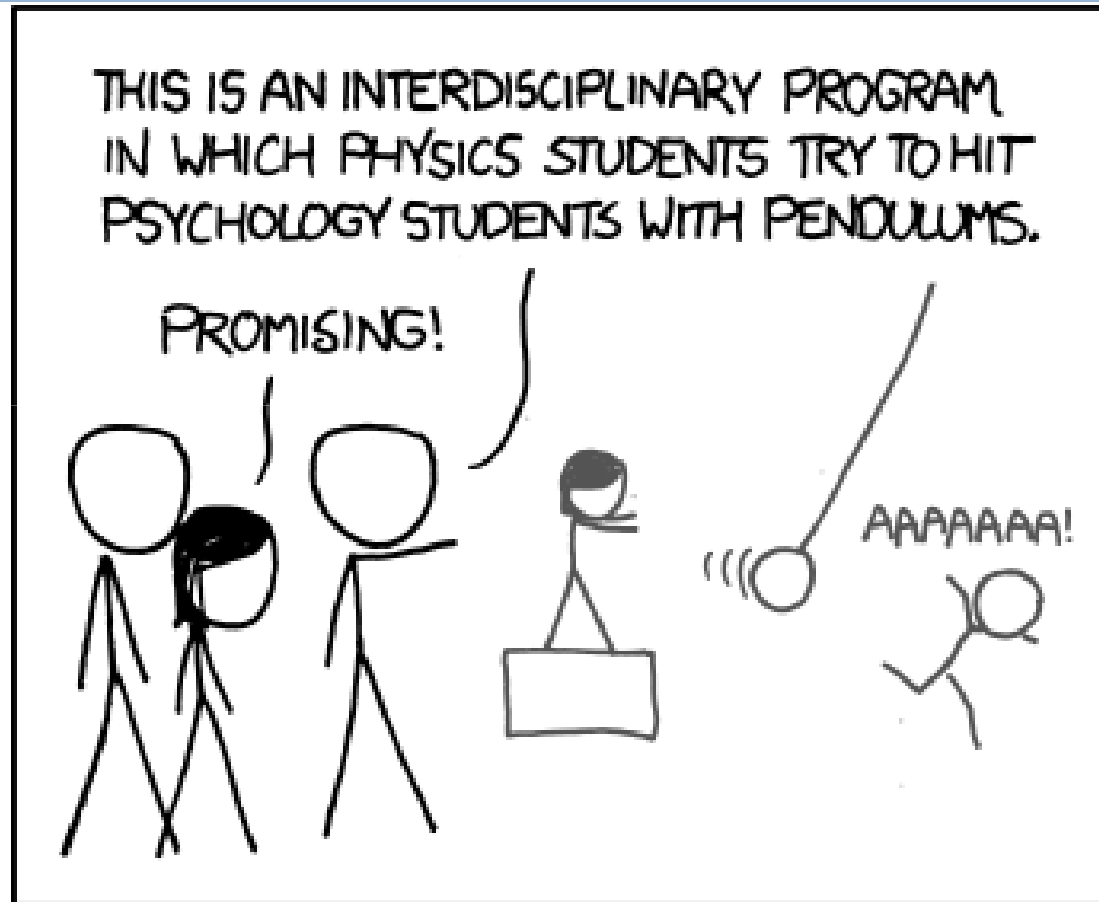
1. The subject of study in cognitive science is usually **mind, intelligence, thinking or cognition.**
 2. The nature of cognitive scientific investigation is **interdisciplinary.**
 3. The subject of cognitive science is characterized in **computational-representational terms.**
- Broad definition 1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

Interdisciplinarity



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

Do we need interdisciplinarity?



MY PROFESSORS HAD AN ONGOING COMPETITION
TO GET THE WEIRDEST THING TAKEN SERIOUSLY
UNDER THE LABEL "INTERDISCIPLINARY PROGRAM."

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,...

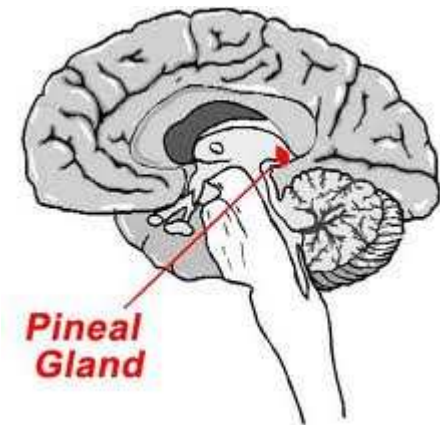
Philosophy of mind – historical background

□ Descartes

□ “cogito ergo sum”

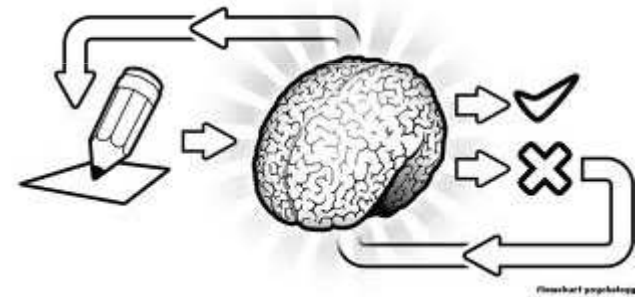
- Methodological scepticism – rejects any ideas that can be doubted
- Cartesian Dualism – body works like a machine, mind is separate

□ Marvin Minsky “Minds are simply what brains do”



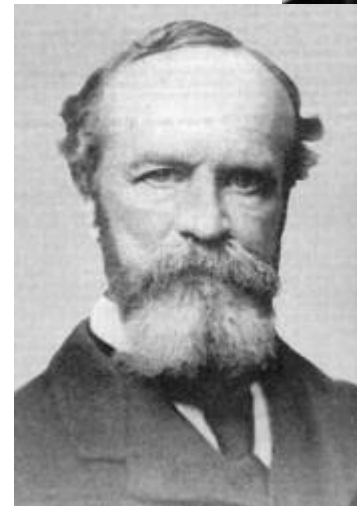
Psychology

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



Psychology – historical background

- Since 1590
- 1879 Wilhelm Wundt – first psychological experiments
- 1890 William James – “Principles of Psychology”



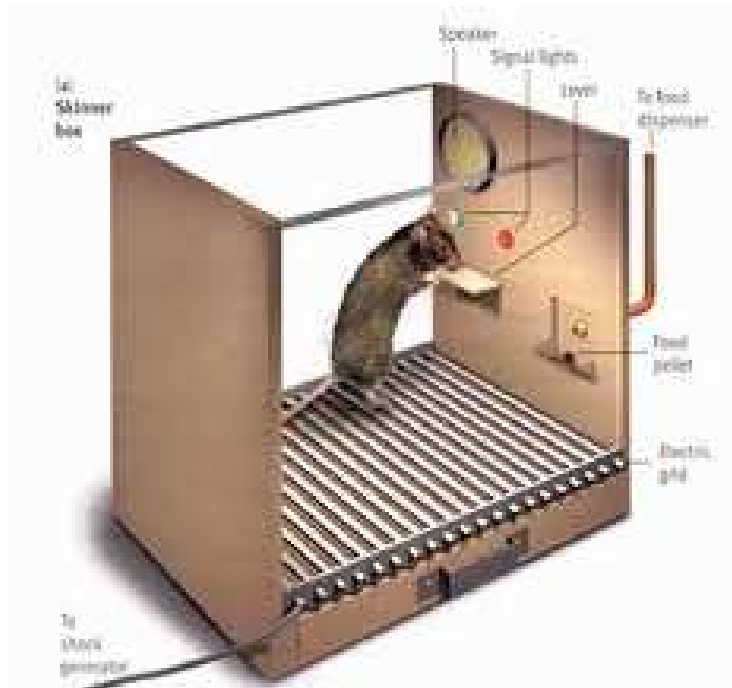
Behaviourism

- Mind as a black box
- Mental states are unobservable
 - ▣ We don't need them
- Controlled conditions
 - ▣ Measuring reactions
- Ivan Pavlov
- <http://www.youtube.com/watch?v=Eo7jcl8fAul>



Behaviourism

- BF Skinner
- Operant conditioning



Neuroscience

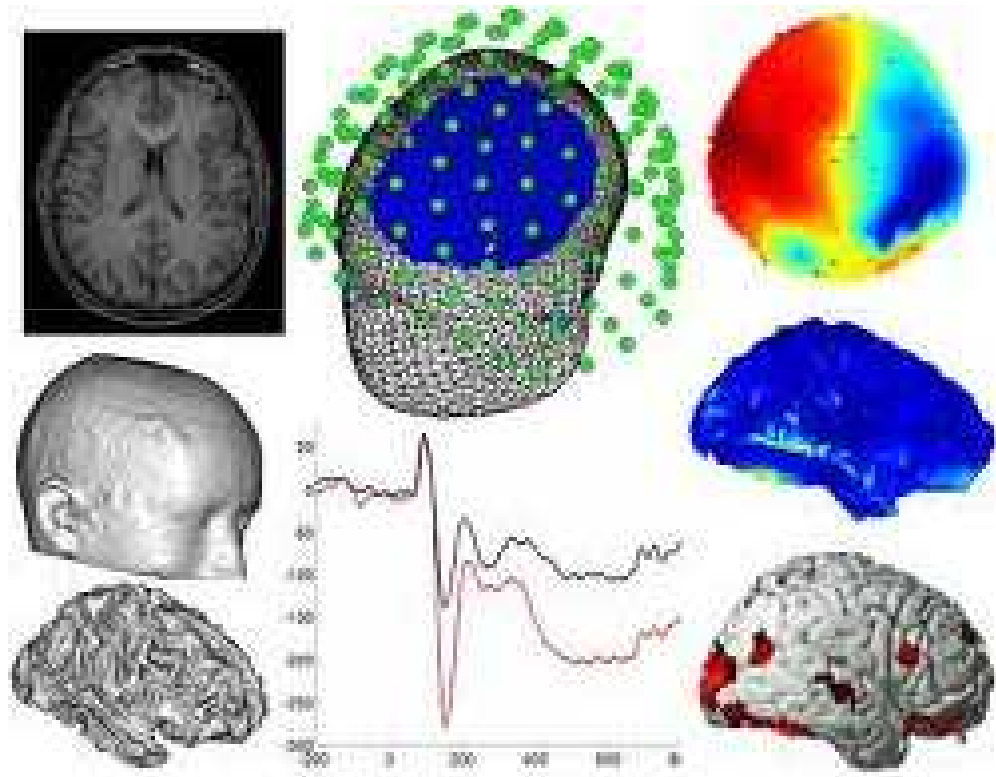
□ Implementation in the brain

□ Brain imaging

- PET
- EEG
- FMRI
- MEG

□ Neurobiology

- single-cell recording
- animal models
- lesion studies



Linguistics

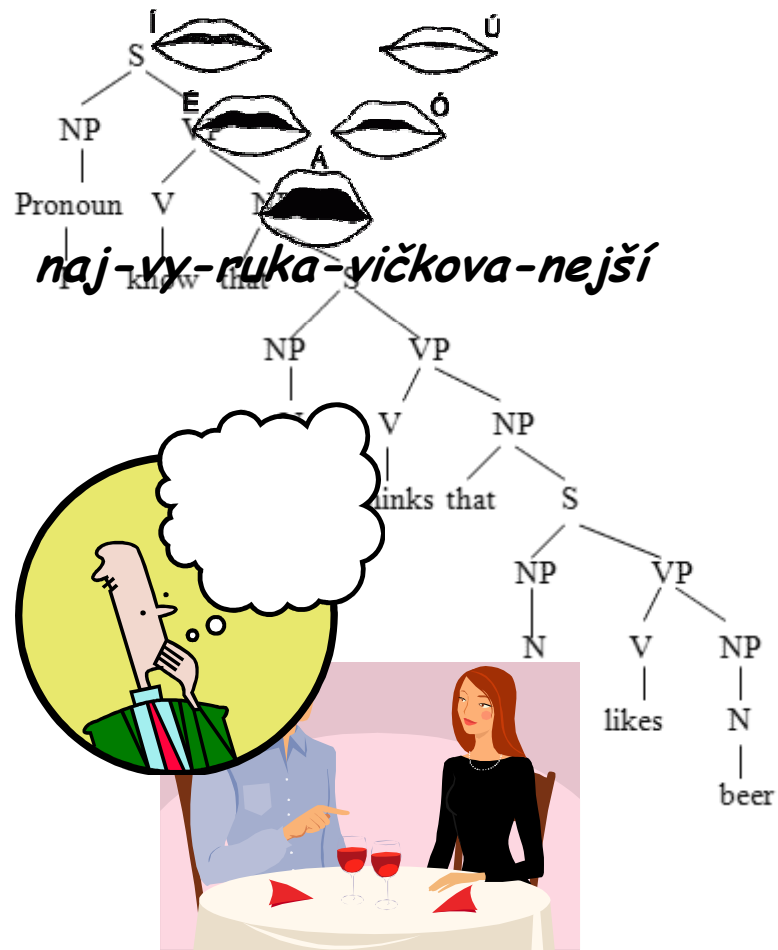
□ Phonology

□ Morphology

□ Syntax

□ Semantics

□ Pragmatics



Anthropology

- 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

- 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.



Conference at Dartmouth College (1956)

- 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)

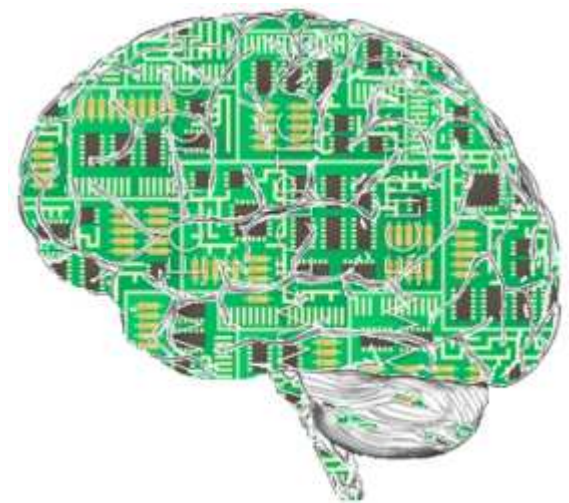
Conference at Dartmouth College (1956)



- 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”

Computer metaphor

- ❑ Software vs. hardware
- ❑ Church-Turing thesis
- ❑ Architecture similarities: processor, memory, I/O devices
- ❑ Mental representations \sim computer data structures
- ❑ Computational procedures \sim 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?

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 AI



- Symbolic - GOFAI
 - SOAR
 - Logic based – Prolog
 - Knowledge based – expert systems
- Subsymbolic
 - Connectionism
- Dynamical systems
- Evolutionary algorithms
- Embodied approach
 - Robotics

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