Definition

SAND2008-7755P

Cognitive Science – The study of Mind.

Mind – What you are thinking *with* right now. Most people believe that other minds also exist.

– This study encompasses all aspects of Mind, including its causes (such as brain, embodiment, …) and phenomena (such as human behavior, emotions, …).

Science – Goal is a description that has attributes such as:

Objective – Anyone can repeat the results.

Formal – Precise language, preferably one that can be reduced to computation.

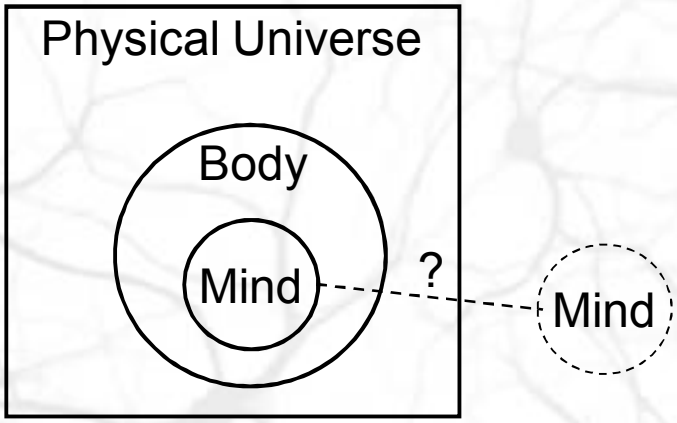
Complete – Explains all relevant observations.

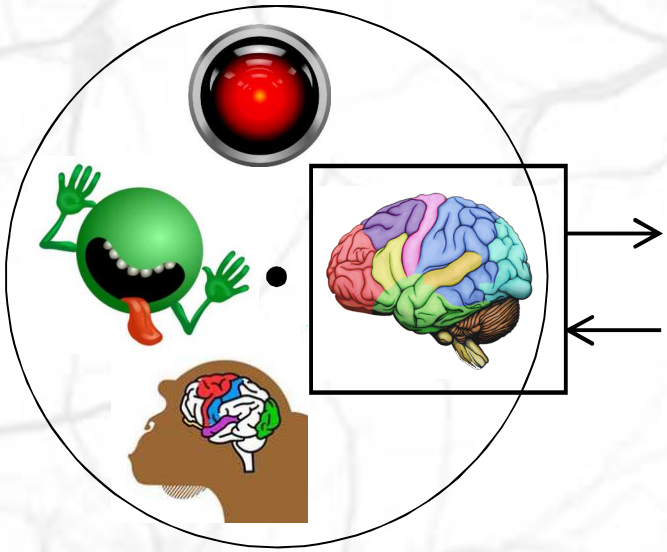
Cognitive Technology – Application of the results of Cognitive Science to specific problems.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Philosophical Basis

Principal commitment – Mind is accessible to scientific inquiry.



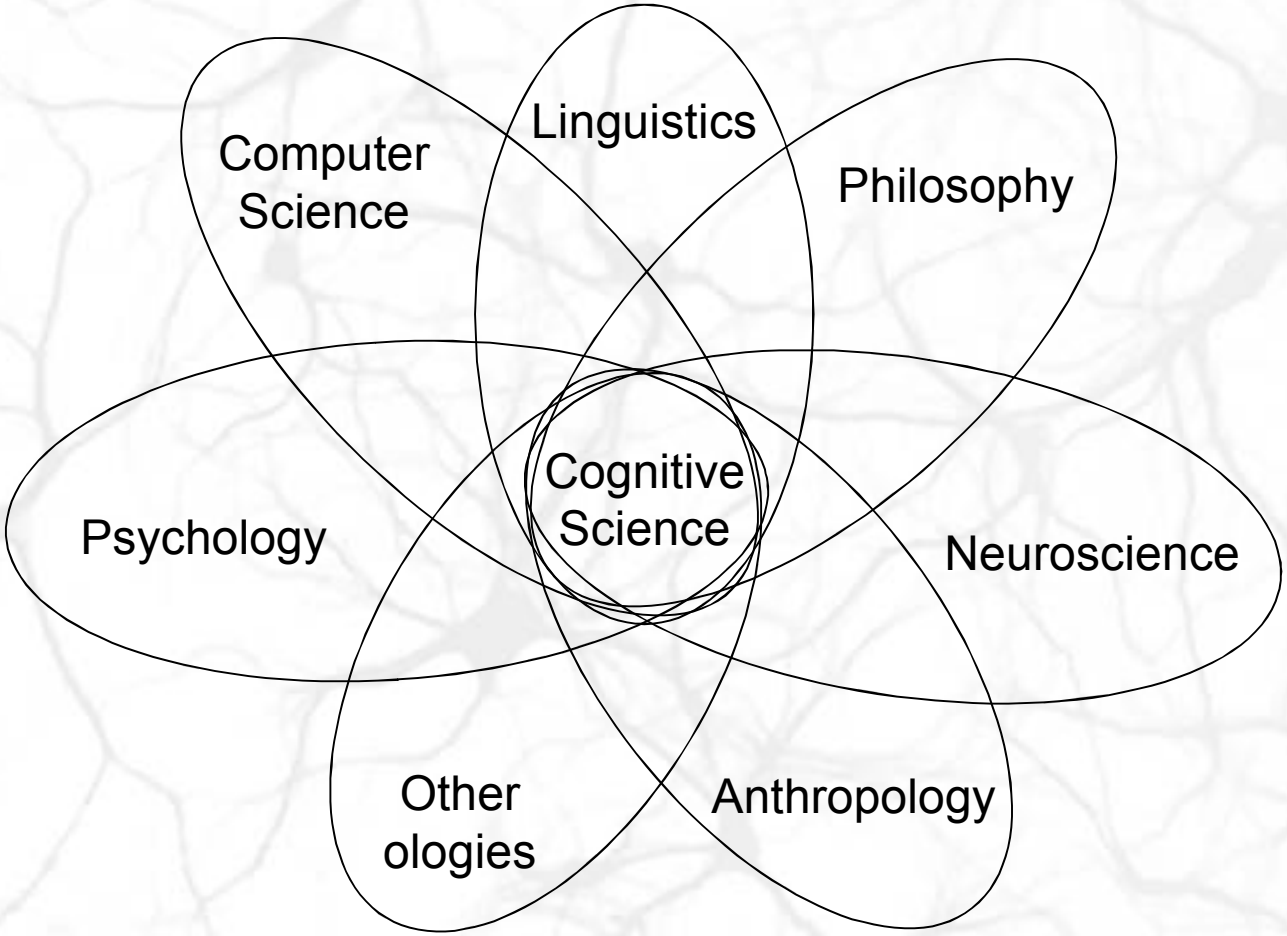


Corollary commitments (not universally held):

- Physicalism – Mind is entirely a physical phenomenon.
- Functionalism – A mental state is fully defined by its causal relationship to the "outside world". Therefore, mental states can be implemented in more than one way: brains of various species, computers, alien life forms, etc.
- Mind follows basic principles which can be expressed in human language.

Interdisciplinary

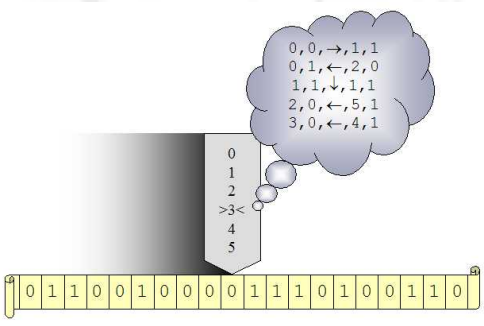
Cognitive Science draws on and contributes to many disciplines.

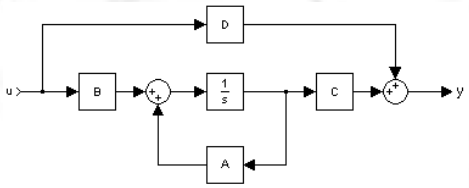


Most of these disciplines have a "cognitive" specialization that constitutes a sub-discipline of cogsci: Cognitive Psychology, Cognitive Neuroscience, etc. The relevant Computer Science sub-discipline is called Artificial Intelligence.

Classes of Cognitive Models

$$\forall x(Man(x) \rightarrow Mortal(x))$$
$$Man(Socrates)$$
$$\therefore Mortal(Socrates)$$





Symbolic – Finite representations manipulated according to rules.

- formal logic systems
- production systems – syntactic transformations with an "if-then" form
- Turing machines – read and write symbols on a tape while following simple rules in a lookup table. Originally designed as a minimalist model of a human carrying out a mathematical procedure.

Dynamic – A set of variables (state) that evolves over time according to a set of equations.

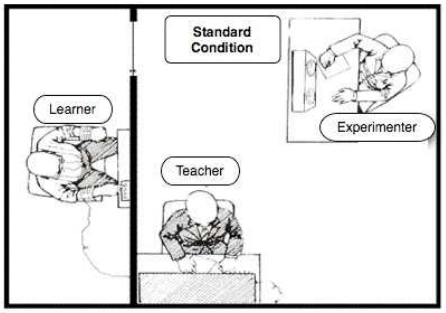
- "neural" networks – Interconnected nodes that implement mathematical functions.

Models exist that have characteristics of both classes.

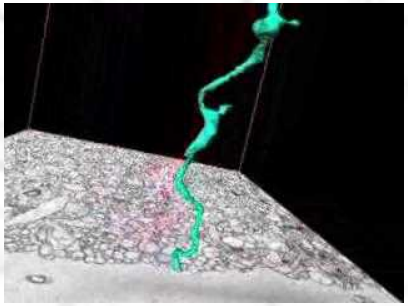
Cognitive Science

Methods

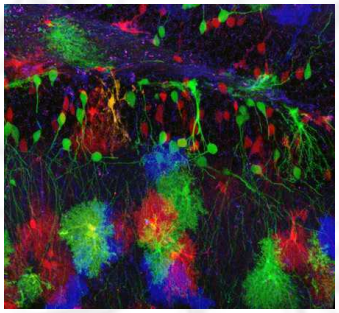
[Gazzaniga]



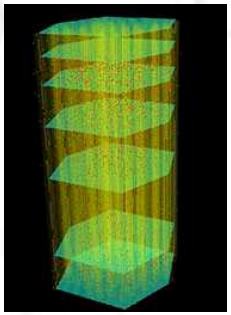
[Milgram 74]



[Jain et al. 07]



[Livet et al. 07]



[Blue Brain Project]

Behavioral experiments

- tests on Psych 101 students
- lesion studies – Effectively associates parts of the brain with given capabilities.

Neurophysiology

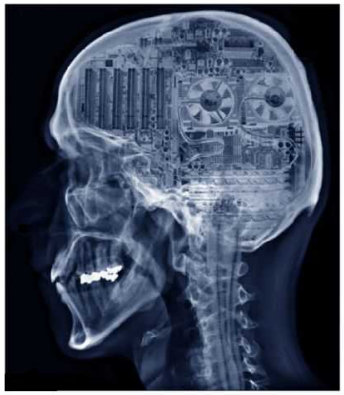
- functional imaging
- electrical recordings
- emerging techniques (eg: “brainbow“, SBFSEM).

Computational modeling

Philosophical reflection

Cognitive Science

Controversies

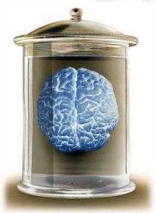


Is Mind fundamentally *computational*?

Most cognitive scientists accept that Mind is *computable*, which is a somewhat different notion.

Is embodiment necessary?

VS



Symbolic vs Dynamic models

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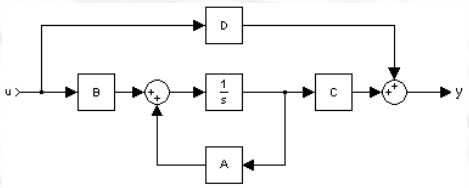
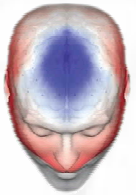
VS



Open Problems

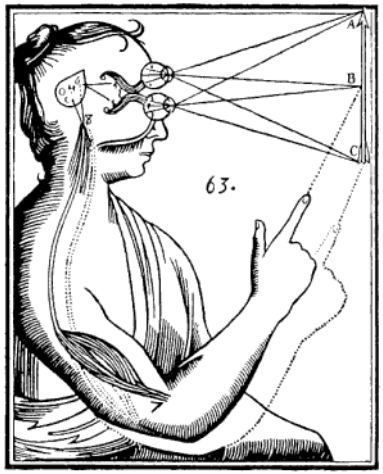


• Nature vs. Nurture – Information capacity of the brain is much larger than information capacity of genetic code. What cognitive abilities do our genes encode, versus abilities we learn? How do these interact?

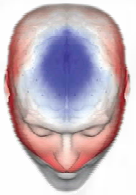
• Consciousness – What is it?

• Emotions – What role do they play in cognition? How to they work?

• Perception – How to attach meaning to sensory inputs. Part of the larger problem of embodiment.



References



For a more in-depth introduction, read one or more of these general overviews:

- http://en.wikipedia.org/wiki/Cognitive_science
- http://plato.stanford.edu/entries/cognitive-science
- http://www.cse.buffalo.edu/~rapaport/Papers/cogsci.pdf
- http://www.aaai.org/AITopics/html/cogsci.html