The scientific study of thought

~ The credo of this course ~

- In cognitive psychology, we study mental processes with the same method by which any scientist studies anything:
  - We observe the phenomena
  - We invent "mechanistic" models that we hope can explain what we observe
- Mental phenomena may seem more magical or mysterious than other phenomena, but they're not
  - They are the product of real physical mechanisms just like anything else!

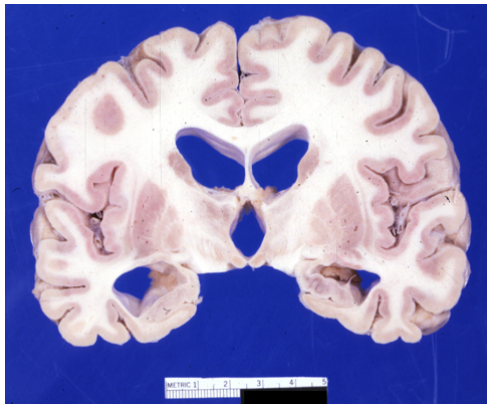
- Dualism: the idea that mind and body are fundamentally different substances or processes

Descartes, ca 1650

- vs. Monism or Materialism: The universe is made of only one kind of physical material ("atoms")

  - "Everything reduces to physics"

- In Descartes' time, the ventricles (empty spaces) were thought to hold a nonmaterial substance responsible for higher thought processes.



- de la Mettrie (1748): "L'homme Machine"

  - People are machines with mechanical systems plumbing, ventilation, temperature control, etc.

- Darwin (ca. 1850) :

  all biological structures are "devices" that are adapted to serve the survival of the organism

- *-> The mind as a machine*

- *The mind is a machine.*

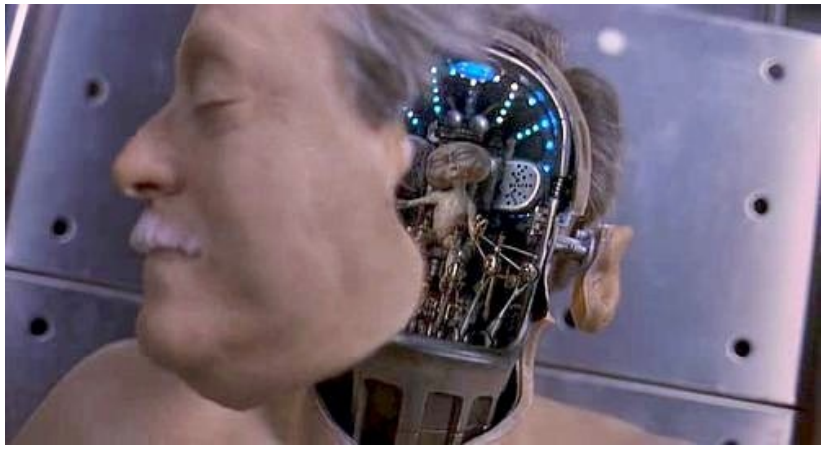
  - What does this mean? What is a "machine?"

- A machine is a process consisting entirely of physical, material elements that affect each other causally—that is, via physical processes.

- In cognition, a mechanistic theory is one in which every element is understood in terms of the combination of simpler, stupider, elements.

  - In other words, we reduce things we DON'T understand to combinations of things we DO understand.

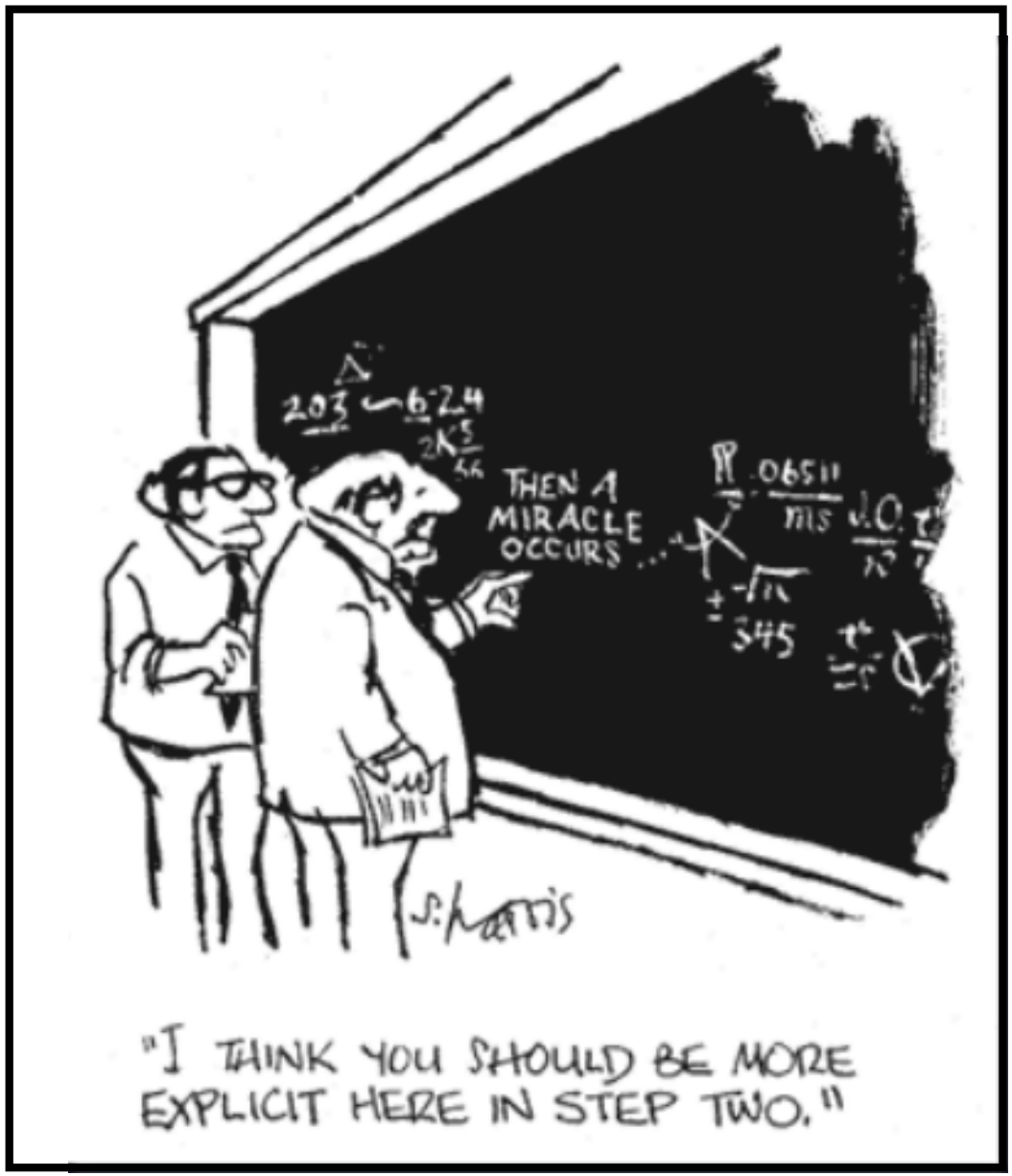
- A homonculus is an imaginary "man inside the head".



- A theory of cognition that relies on a homonculus—an intelligent component—is cheating!

  - It doesn't explain how the homunculus works

- In cognitive psychology, we seek to *Banish the Homonculus!*



In other words:

"No miracles allowed!"

Levels of explanation

- What is "weather"?
- Weather is a complex combination of air, water, temperature, motion, etc.
- Complex weather events (storms, fronts, etc.) are really combinations of these basic elements interacting causally.
- Complex mental events (thoughts, beliefs, ideas, memories, perceptions, etc.) are really complex combinations of basic elements interacting causally.
- Like weather, mental functions can be described at both levels of analysis (storms or air molecules).

Levels of explanation

Storms..... Air molecules

Macroscopic.....Microscopic

Holistic*.....Reductionist

[Cognitive Psychology.....Neuroscience]

**Holistic* here means "concerning the big picture", not "alternative"

Explanation is *reduction to simpler phenomena*.
—>In cognition, simpler means "stupider"

Banish the homonculus!

- Thought has patterns

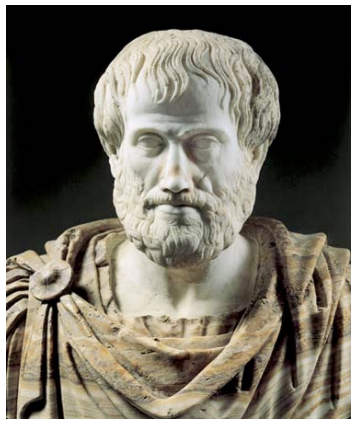
  ...standard procedures that work because of their form, not their content

  This suggests that thought can be standardized or converted into a mechanical process (->AI)

  This also suggests that mental processes can be understood in mechanistic terms (->cognitive psychology)

- Understanding how the mind works mechanistically and building a mechanical mind are two sides of the same coin

Aristotle



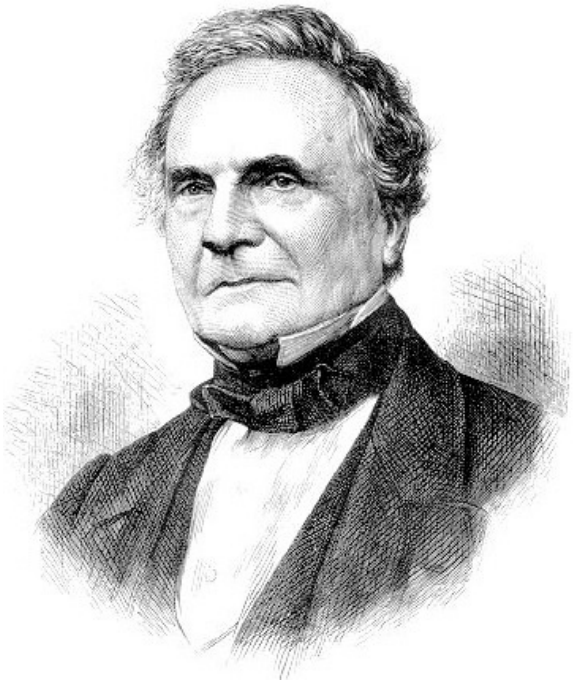
Syllogism: A chain of deductive reasoning

Premise: All men are mortal
Premise: Socrates is a man
Conclusion: Socrates is mortal

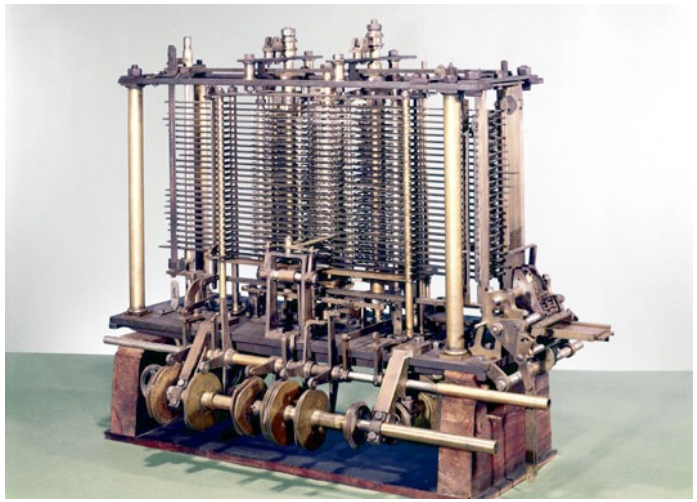
Premise: All ducks are green
Premise: Josephine is a duck
Conclusion: Josephine is green

The truth of the conclusion is logically certain based on the form of the argument, regardless of the content

The machinery of thought

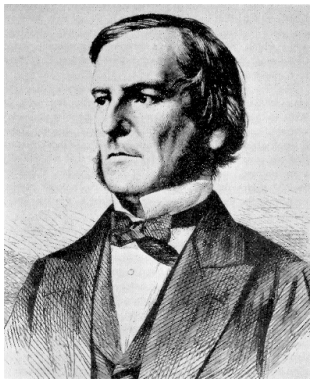


Charles Babbage: (~1830) - Analytical Engine



Ada Lovelace (~1840)

- Thought patterns could be reduced to algorithms
- "Symbols" in the machine can correspond to ideas, musical patterns, etc. — not just numbers



George Boole: An Investigation of the Laws of Thought (1854)

Mathematical rules for reasoning with propositions

- In algebra, we can make statements about numbers that are true regardless of the specific values of the numbers:

$$x + x = 2x$$

- Boole proposed to do the same thing with propositions instead of numbers.

  Propositions are ideas—statements that are true or false.

- This leads to a way of "calculating" with ideas instead of with numbers, called Propositional Calculus or Boolean algebra

Examples:

A = “the sky is blue”

B = “all men are mortal”

We put propositions together with logical connectives:

A∧B: conjunction: “A is true AND B is true”

A∨B: disjunction: “A is true OR B is true (or both)”

~A : negation: “not A” = “A is not true”

A → B : implication/conditional/entailment:

“If A is true then B is true”.

(Equivalent to ~(A∧~B), which is equivalent to ~A∨B ....

not really a separate connective)

Truth tables

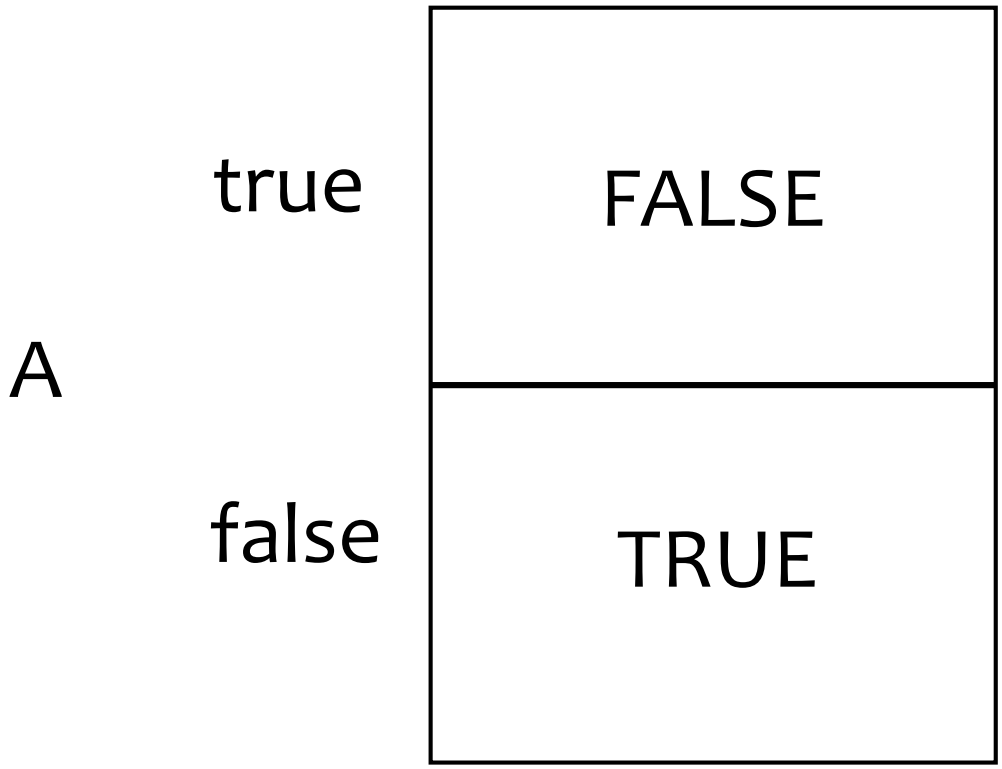
And (conjunction) $A \wedge B$

A \ B	true	false
true	TRUE	FALSE
false	FALSE	FALSE

Inclusive or (disjunction) $A \vee B$

A \ B	true	false
true	TRUE	TRUE
false	TRUE	FALSE

Negation ~A



Propositions with connectives make a "language" for expressing complex ideas, for example:

$$\sim(((A \wedge B) \wedge C) \vee (A \wedge \sim D)) \wedge E$$

Or, you can prove conclusions from premises, like

Premise: $A \wedge B$

Conclusion: B

Premise: $A \rightarrow B$, i.e. $\sim A \vee B$

Premise: $\sim B$

Conclusion: $\sim A$

The process is so automatic, maybe a machine could do it!

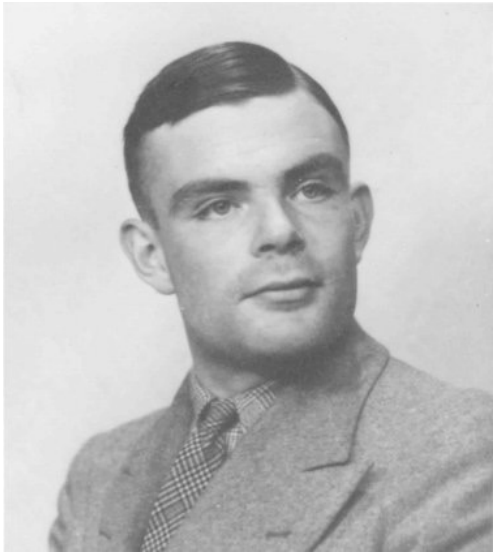
- Alan Turing proposed a hypothetical computing device, now called a Turing machine
- A Turing Machine has all the elements of a modern computer:

  - A method for data input and output

  - A general-purpose procedure for applying a sequence of logical operations to data

  - A distinction between software (the program or algorithm) and hardware (the machine)—making TMs programmable

Alan Turing



- Modern computers are all essentially versions of Turing's general-purpose computing device