What's so special about language

LIN 313 Language and Computers
UT Austin
September 3, 2025
Instructor: Gabriella Chronis

Administrivia

- Homework due September 12
- Office hours
- Readings through 9/12 on the schedule
- Option to attend FAI talk Friday instead of class (extra credit)
  - check in with Sooji at the talk!
  - GDC 6th floor, left out of the elevators across the little sky bridge and all the way to the back of the hall
  - It's not in the biggest room so we can't all invade

Overview

- The concept map!: https://gchronis.github.io/lin313/concept_map.html
- Instapoll
- What makes language unique?
    - symbolic reasoning
    - features of natural language
  - GOFAI
- (likely save for friday)
    - Winograd Schemas
    - garden path effects

What are the goals of AI?

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- practical
- scientific

What is intelligence?

What is intelligence?

- abstract reasoning
- complex problem solving
- emotional intelligence
- creativity
- understanding
- planning
- "symbolic reasoning"

- learning from the past
- coming up with new ideas (scientific breakthrough)
- generalizing based on what you have seen

Why language?

What is the connection between intelligence and language?

- Language is what makes people unique (distinct from other creatures)
  - other things that might make us unique: culture, endless variations on a theme like cooking or art
  - expression for its own sake: art, music, literature
- Language is how we build a social world
  - being social creatures is another thing that makes us unique!
  - there are other social animals (like ants and primates) but Aristotle claimed that humans are distinct because we are *political animals*. This means we are not just thrown together, but we are constantly questioning and puzzling through *how* to be together. And to do this we use our faculties of reason!
- Language has unique features that enable our uniquely human activities

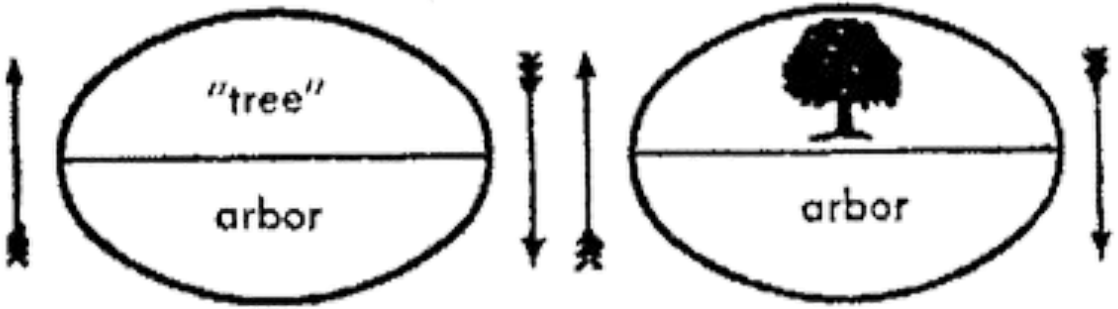
Why language? Features unique to human language

- arbitrariness: words don't sound like what they mean
- systematicity: there are regular rules for combining words
- recursion: you can always add more structure
- productivity: it's possible to make new words out of word parts

animal communication systems might have one or some of these features, but no research has demonstrated evidence of a system that uses them all.

Features of Language: Arbitrariness

From de Saussure's Course in General Linguistics (1916), on the nature of the linguistic sign



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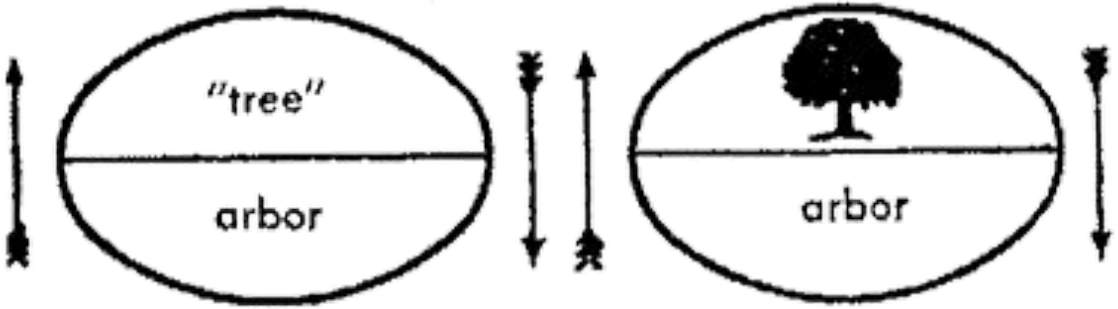

- "The linguistic sign unites, not a thing and a name, but a concept and a sound-image. The latter is not the material sound, a purely physical thing, but the psychological imprint of the sound, the impression that it makes on our senses. The sound-image is sensory, and if I happen to call it “material,” it is only in that sense, and by way of opposing it to the other term of the association, the concept, which is generally more abstract." (p. 66)

Features of Language: Systematicity

There are **syntactic rules** for combining components of language independent of their meaning

- pen → black pen (but not *pen black)
- garage → open garage (but not *garage open)
- short → short walk (but not *walk short)

What is the rule?

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What is the rule?

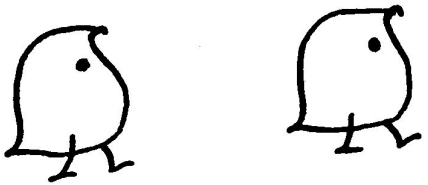
- Noun → Adjective Noun

Features of Language: Recursion

(1) The little old lady who swallowed a fly.
   (a) She swallowed a spider to catch the fly.
   (b) She swallowed a bird to catch the spider that caught the fly.
   (c) She swallowed a cat to catch the bird that ate the spider that the trapped the fly.

Features of Language: Productivity

THIS IS A WUG.



NOW THERE IS ANOTHER ONE.

THERE ARE TWO OF THEM.

THERE ARE TWO _____.

Features of Language: Productivity

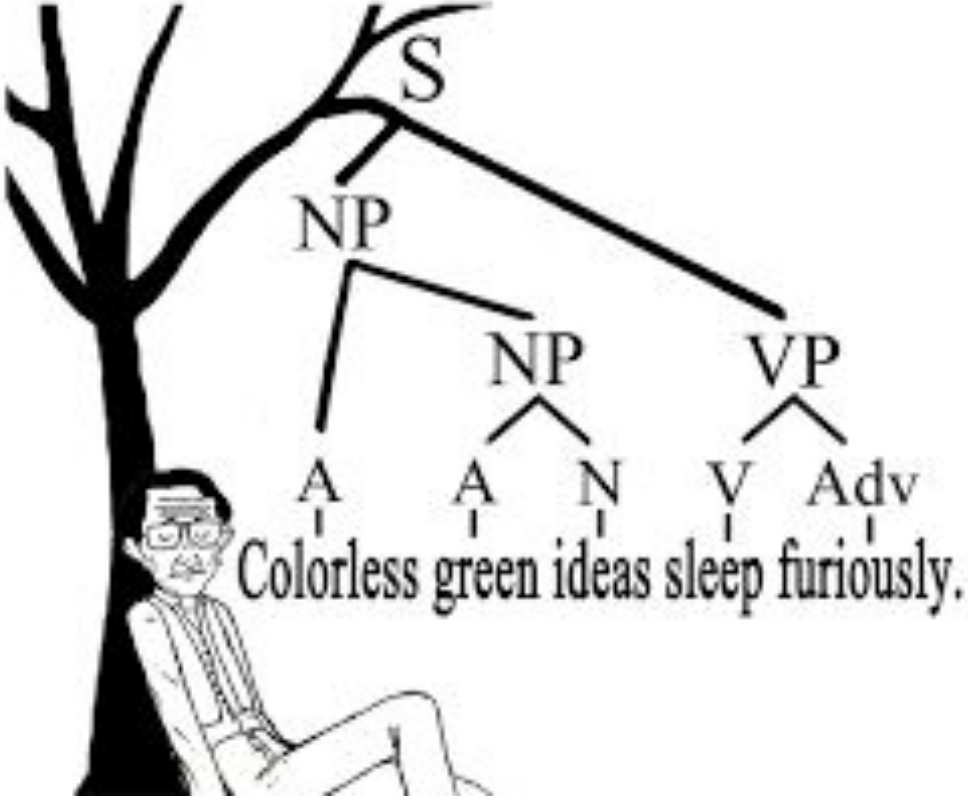
Jean Berko (1958): The Wug Test

The Experiment: Berko showed children (mostly 4-7 years old) pictures of novel creatures and objects with made-up names. The most famous example:

- Shows a bird-like creature: "This is a **wug**"
- Shows two of them: "Now there are two of them. There are two ____"
- Children consistently answered "**wugs**" [wʌgz]

Conclusions: rather than memorizing word-by-word, children internalize productive rules

Separation of levels



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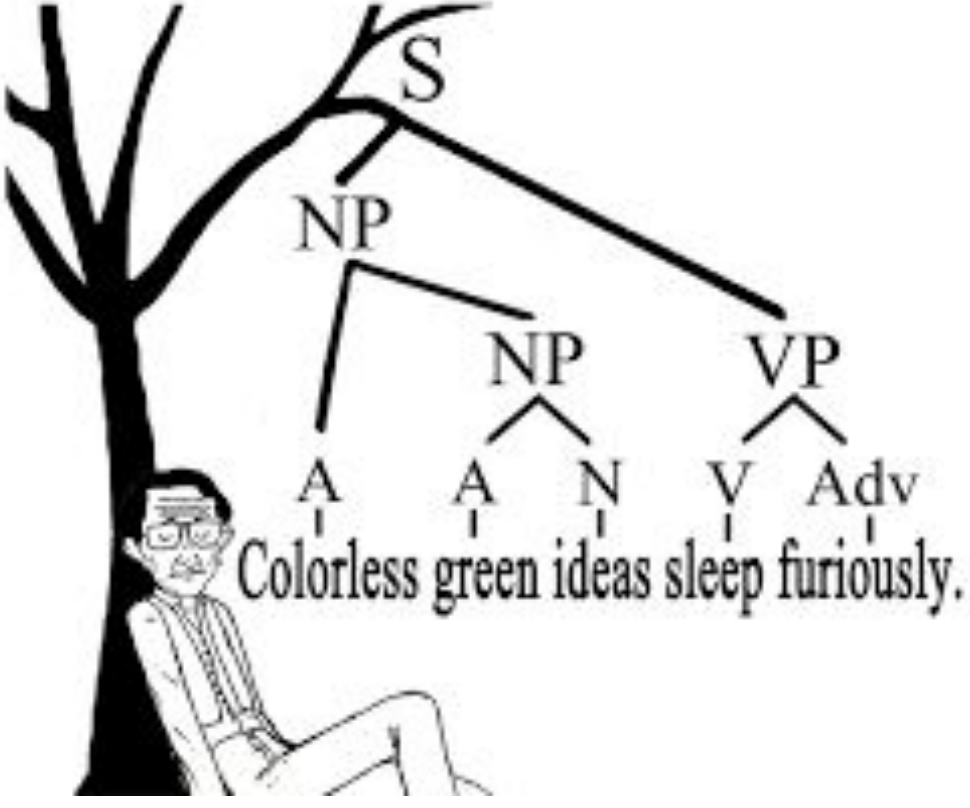

Chomsky (1956): "Three Models for the Description of Language"

- grammatically **correct**, semantically **anomalous**
- evidence for separation between syntax and semantics

GOFAI: Symbolic Reasoning

insight: **formal logical systems** have many of these important properties of language

innovation: use computers to model thought using formal languages

- the world consists of symbols (entities, events, properties)
- and predefined relationships between those symbols (subset/superset relationships, causality, etc.)

inspiration: **mathematical logic** used to describe mathematical systems

Why language?

What is the connection between intelligence and language?

The 2000 year influence of Aristotle:

- Aristotle believed that **reason** is what separates humans from other creatures
- He described reason in terms of language
- multiple millennia later, this connection continues to fascinate

Symbolic Reasoning

All men are mortal.

Socrates is a man.

Therefore _____

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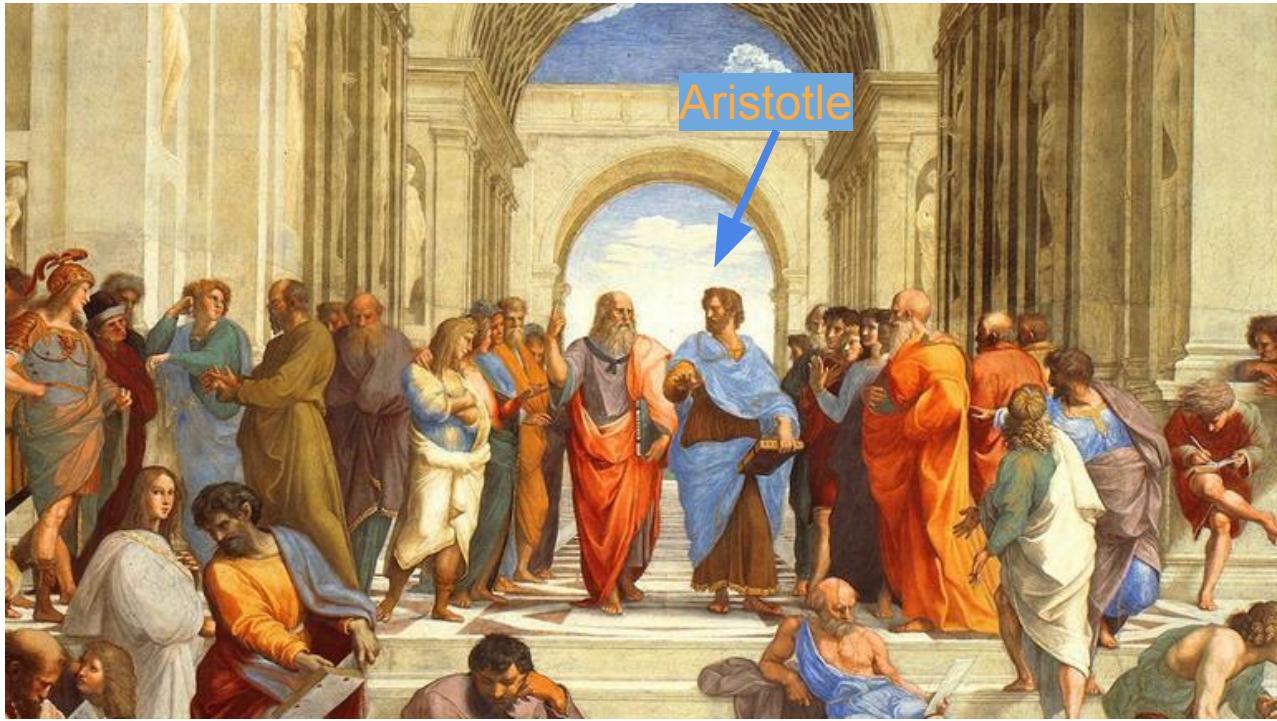

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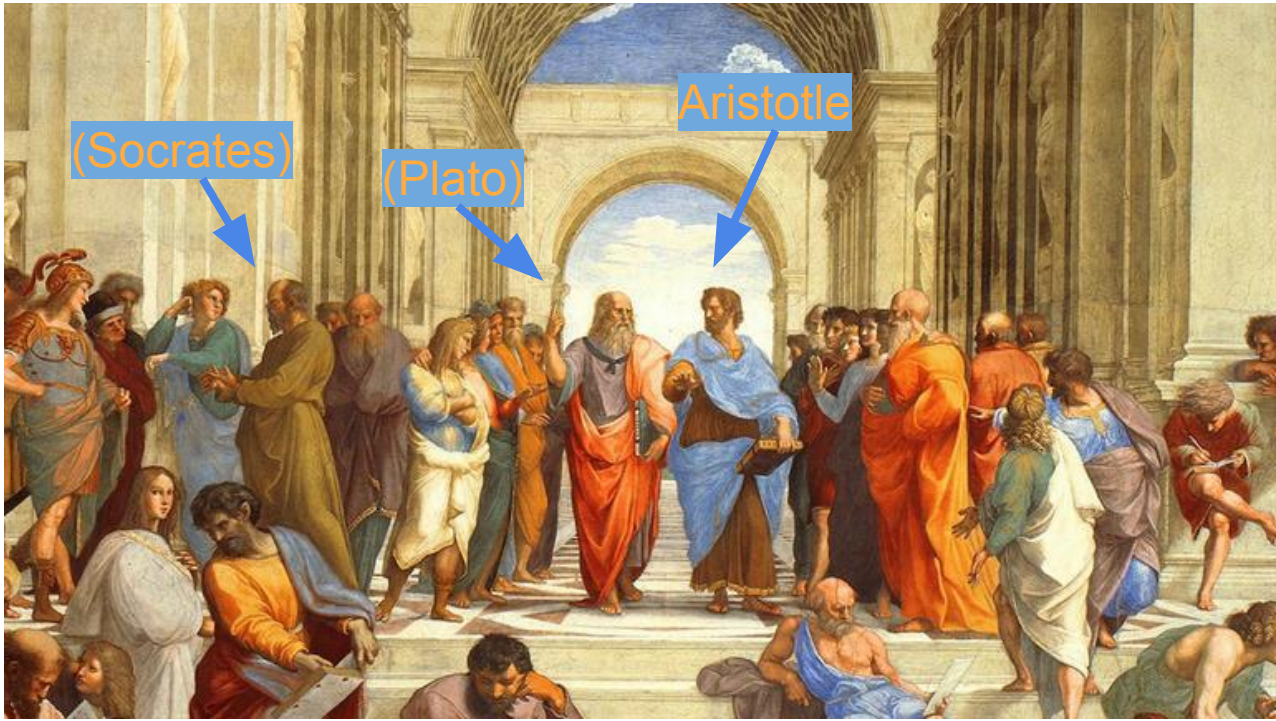

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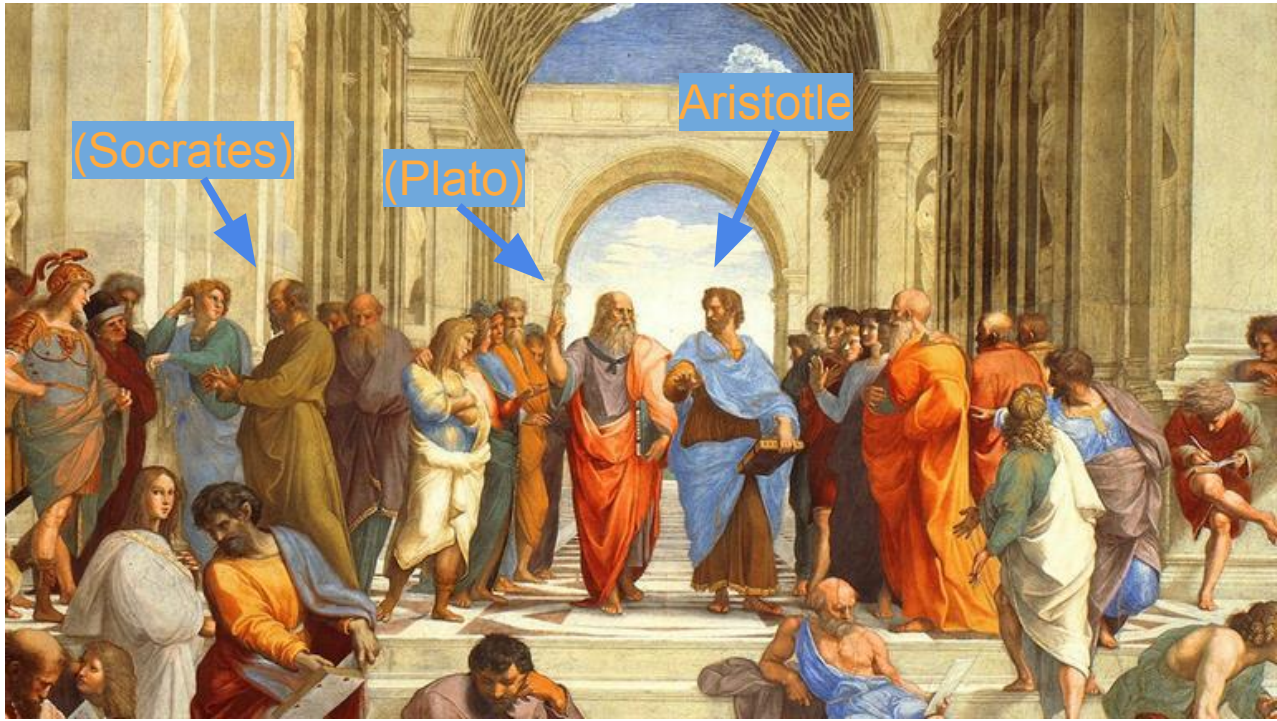

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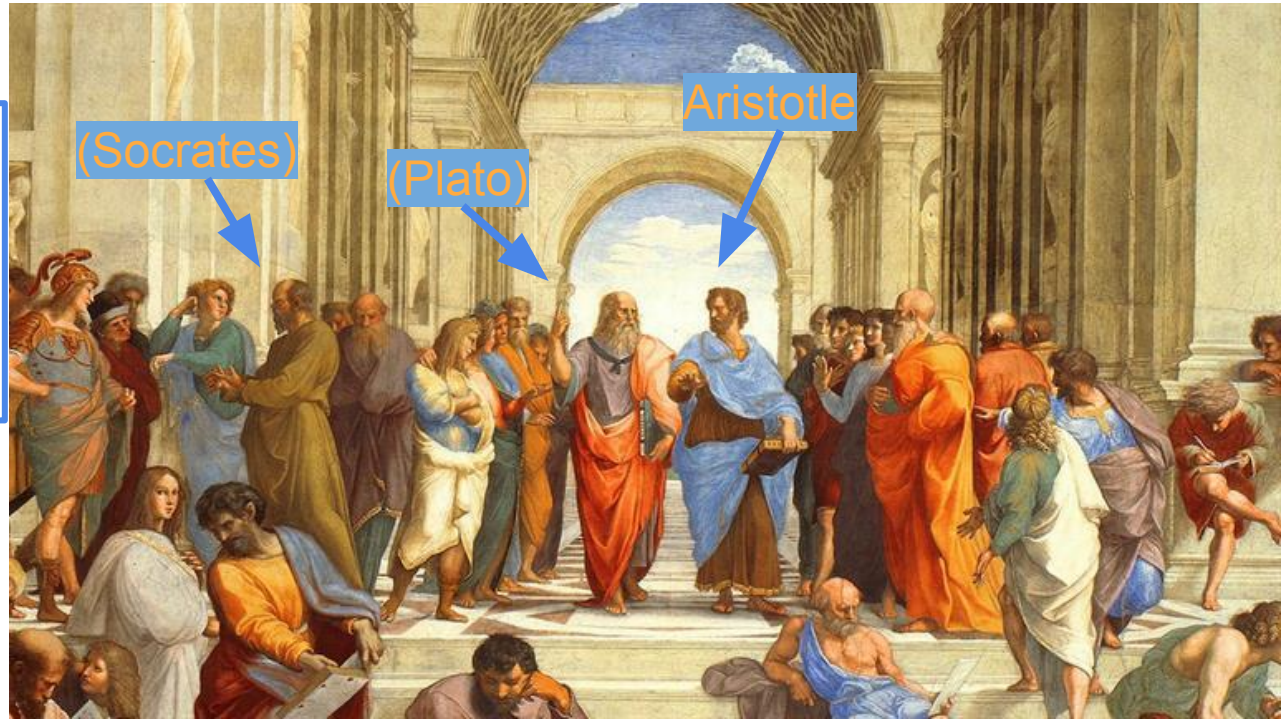

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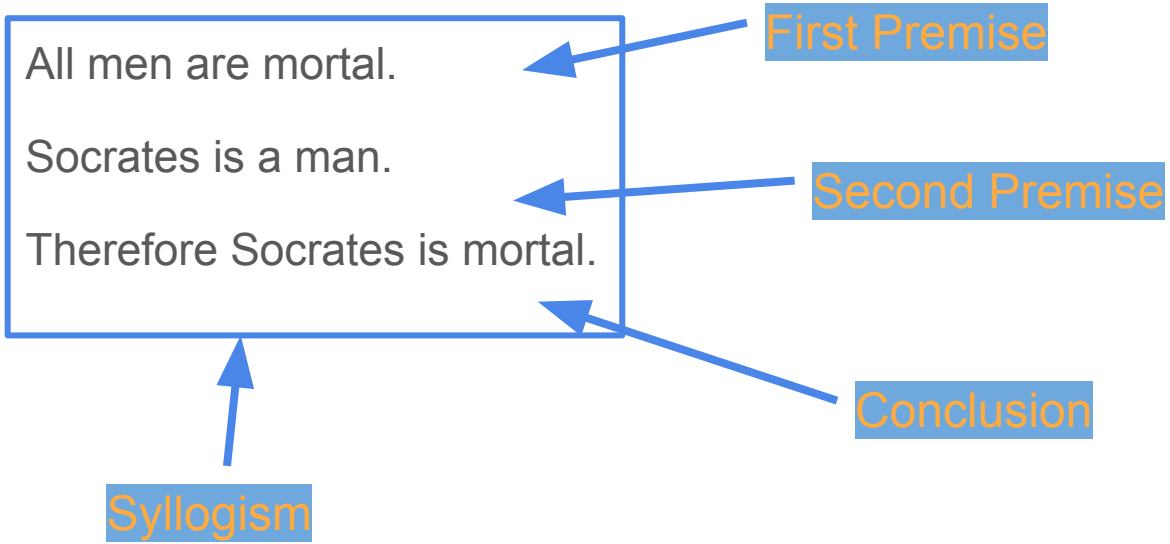

"speech (*logos*) in which, certain things having been supposed, something different from those supposed results of necessity because of their being so." (Aristotle, *Prior Analytics* I.2, 24b18–20)

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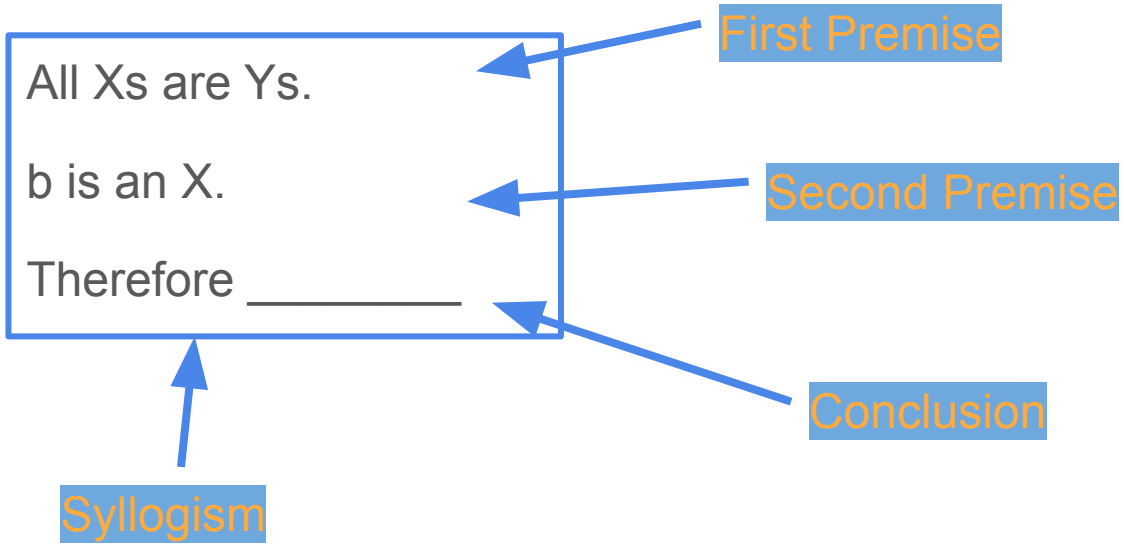

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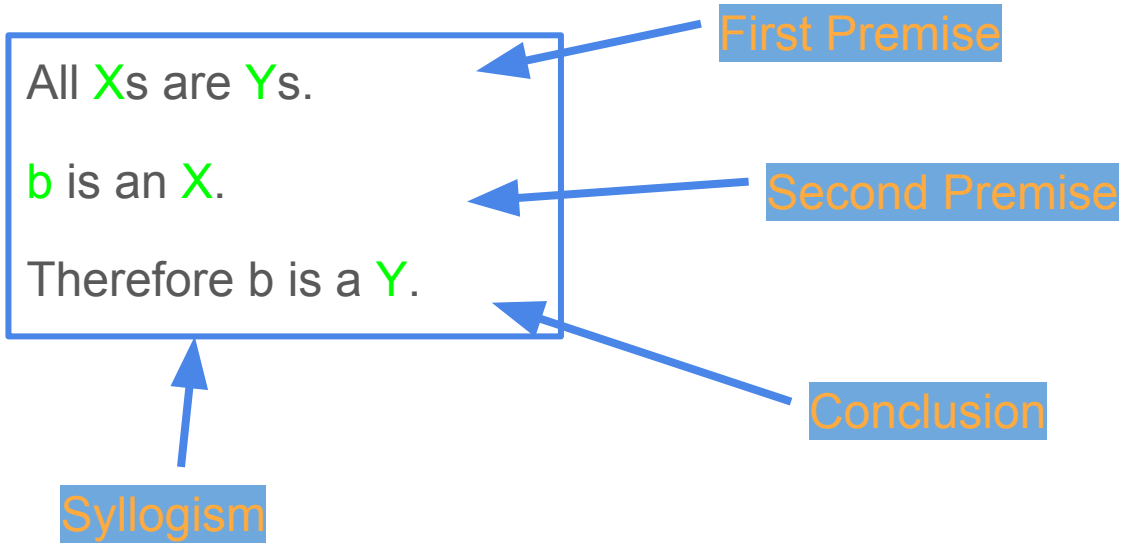
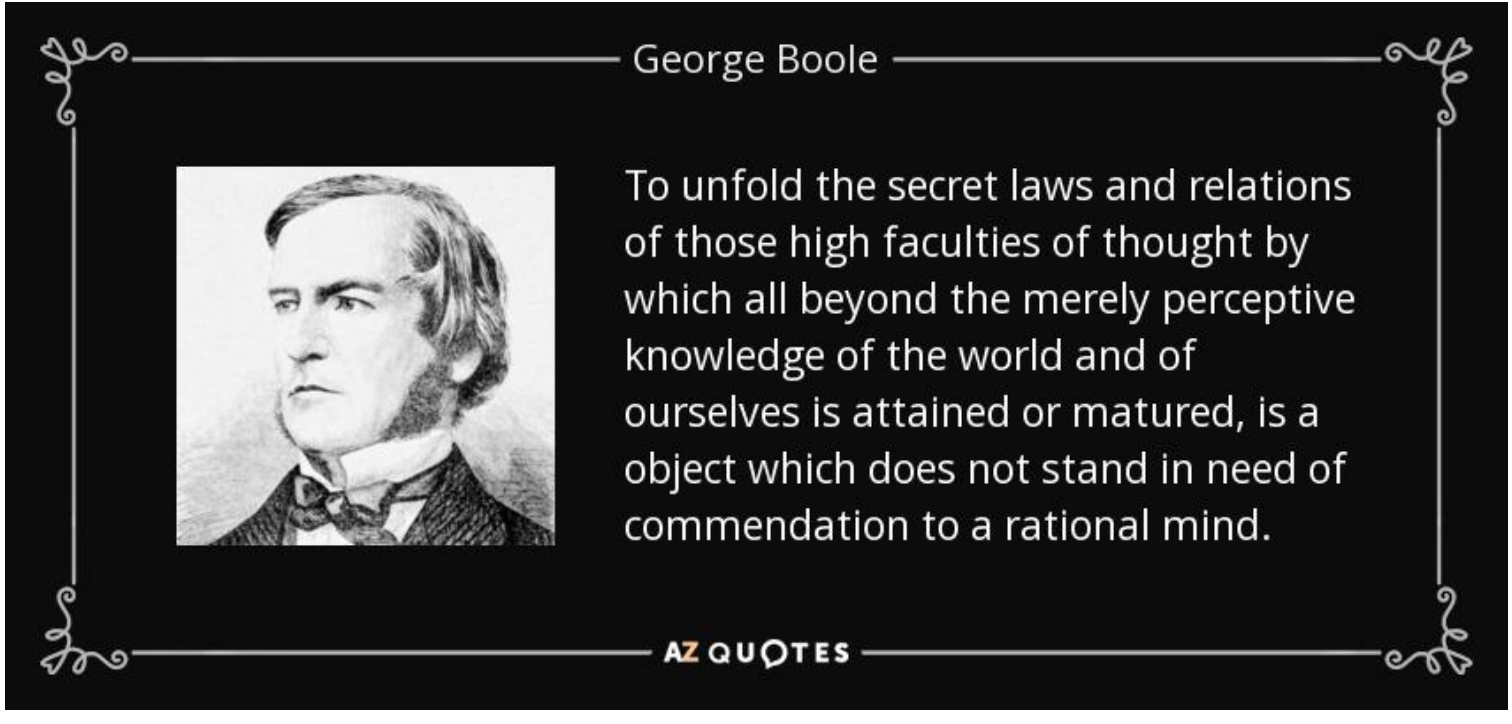


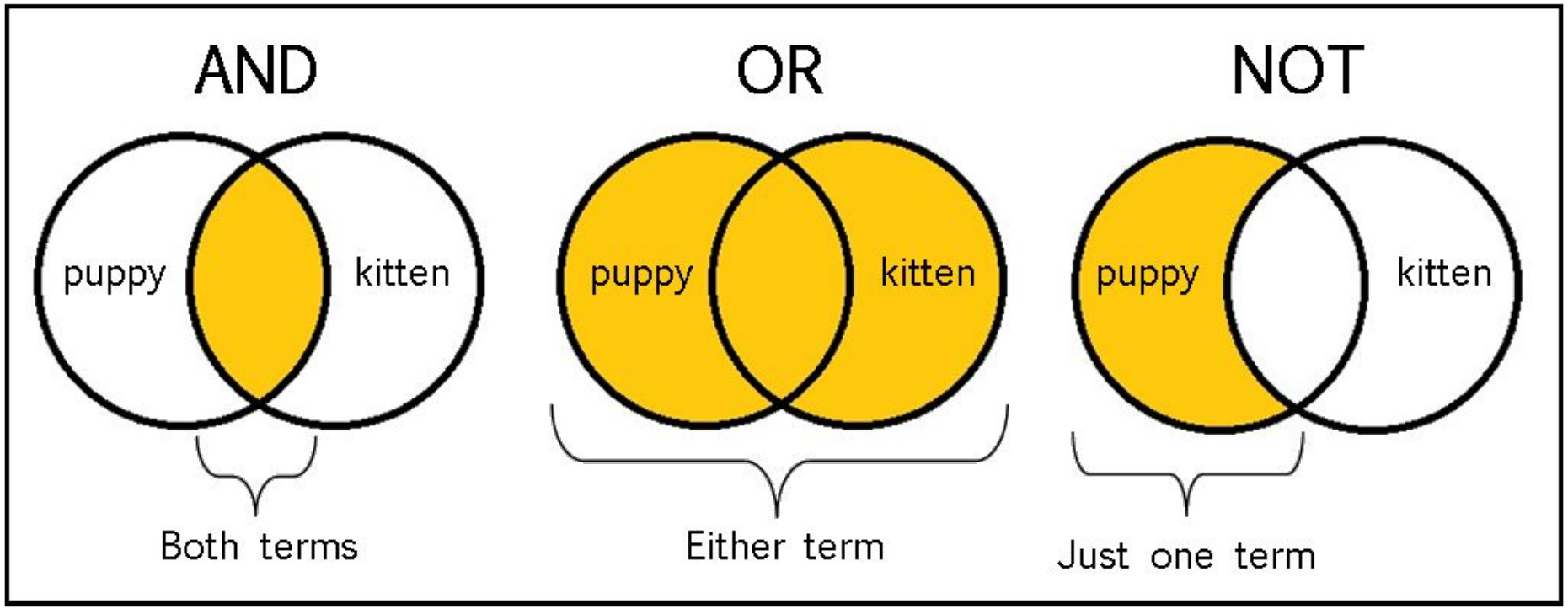
- tool for generating **new truths based on what we already know**
- syllogisms abstract away from *content* to reason based on *form*
- it doesn't matter what *content* you sub in for X and Y and a and b
- if both premises are true and in the right *form*, we know that the conclusion will be true

Mathematical Logic?

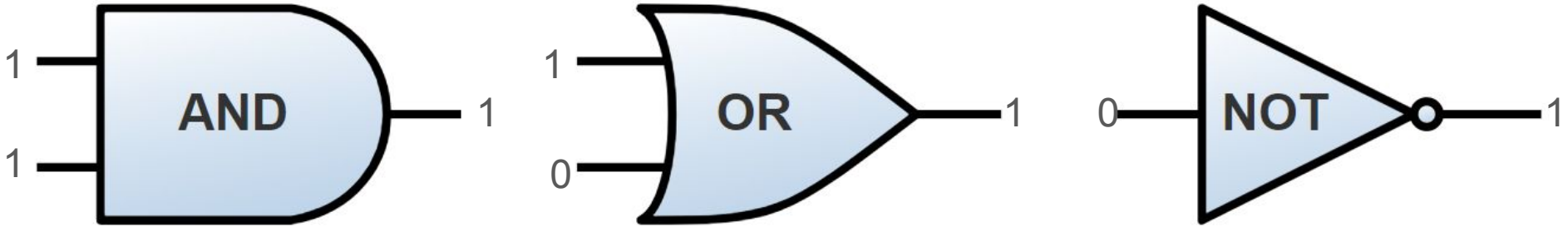
George Boole *The Laws of Thought (1854)*



Boolean Logic



Logic Gates: the building blocks of computers



The General Problem Solver

Simon and Newell (1957, RAND Corporation)

Hypotheses:

- intelligence can be abstracted away from particular problem domains
- thinking is a search through a space of possibilities
  - the solution is the shortest path to the goal
- thinking is essentially logical reasoning about arbitrary symbols

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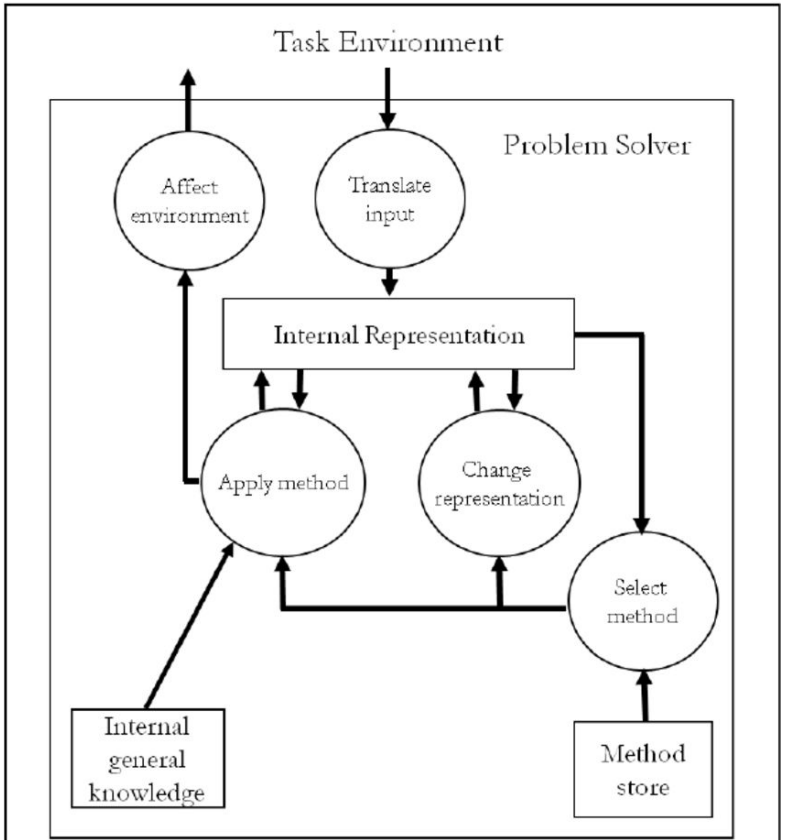
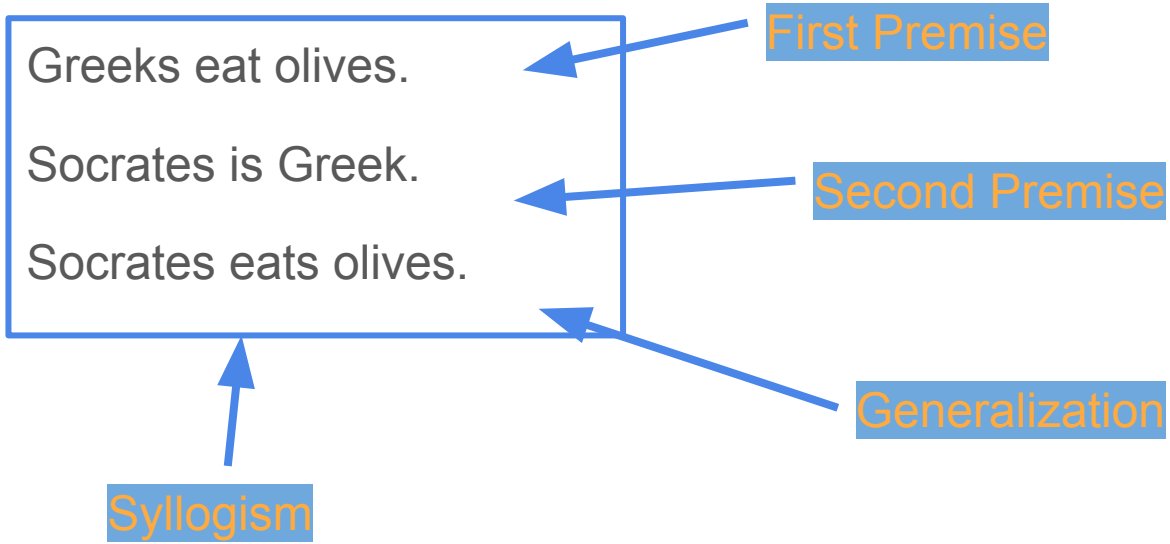


Induction: Aristotle's **other** kind of reasoning

“reasoning from particulars to universals” (epagôgê).

The conclusion is *likely* true based on the premises.



There are two kinds of programs in this world...

- Option 1: Rule Based. Humans write instructions to make decisions
  - “If the word follows an article and precedes a noun, label it as an adjective”
  - “If *apple* is capitalized outside of the first word in a sentence, label it as a company”
  - “If you see the word *excellent* in a review, label it as positive”

- Option 2: Machine Learning. Program figures out how to write instructions
  - Unsupervised Learning: figuring out patterns in data
  - Supervised Learning: learning by example

A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence

John McCarthy, Marvin Minsky, Claude Shannon (1956)

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.

The following are some aspects of the artificial intelligence problem:

1 **Automatic Computers**

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

2. **How Can a Computer be Programmed to Use a Language**

It may be speculated that a large part of human thought consists of manipulating words according to rules of reasoning and rules of conjecture. From this point of view, forming a generalization

FIrst AI Winter (1974-1980)

AI research funding dried up and public enthusiasm for artificial intelligence dramatically declined due to overpromised results and underwhelming performance.

- The Perceptron Controversy: Minsky and Papert's 1969 book Perceptrons showed fundamental limitations of single-layer neural networks, dampening enthusiasm for connectionist approaches
- Machine Translation Failures: The ALPAC report (1966) concluded that MT was more expensive and less accurate than human translation, leading to massive funding cuts
- Combinatorial Explosion: Early AI systems couldn't scale - they worked on toy problems but failed catastrophically on real-world complexity
- Expert System Limitations: Rule-based systems proved brittle and couldn't handle uncertainty or common-sense reasoning