EECS 391
Introduction to Artificial Intelligence

Introduction

L1: Thu, Aug 31, 2017

Lecture Overview

- Questions of the day:
  - What is intelligence? How can we define it?
  - What is (still) beyond AI?
  - How do we make something “intelligent”?
- Foundations of AI and some history
- Different approaches to AI
- “Natural" intelligence

What is "intelligence?" Can it be formalized?

- **Gottfried Wilhelm Leibniz** (1646-1716)

  Believed that human reasoning - symbolic thought — could be reduced to calculation.

  "*When there are disputes among persons let us calculate to see who is right.*"

- **Pierre-Simon Laplace** (1749-1827)

  Developed "Bayesian" probability theory — the calculus of optimal reasoning.

  "*Probability theory is just common sense reduced to calculus.*"

- **George Boole** (1815-1864)

  Wrote "A Mathematical Analysis of Logic" and "The Laws of Thought"
  Introduced Boolean algebra, a systematic basis for Aristotelian logic
  Basis for digital electronics and modern computers

Foundations of Artificial Intelligence

- Philosophy
  - Can formal rules be used to draw valid conclusions?
  - How does intelligence arise from the brain (or physical system)?
  - Where does knowledge come from?
- Computer Science / Mathematics
  - What are the formal rules (or algorithms) to draw logical conclusions?
  - How do we reason with uncertainty?
  - What is computable?
- Economics
  - Decision theory, utility
  - Game theory
- Psychology, Linguistics, Neuroscience
- Computer Engineering

Some approaches to AI

Performance: Human or "ideal"

Behavior vs Reasoning

Thinking humanly: *cognitive modeling* • introspection • cognitive science: testable theories of human mind • computational perception • human is not necessarily ideal	Thinking rationally: *laws of thought* • logical & deductive reasoning • provably correct / optimal • not always possible • not always feasible
Acting humanly: *Turing test* • needs many deep capabilities • natural language processing • knowledge representation • automatic reasoning • machine learning • vision & robotics	Acting rationally: *rational agents* • design of intelligent agents • act to achieve best outcome

Approaches to AI: Systems that act like humans

- Turing test: (Turing, 1950) operational definition of AI
  - Can a machine fool a human into thinking that it is a human?
  - Is the machine *really* intelligent?
- A computer needs many basic abilities to be able to pass: natural language processing, knowledge representation, automated reasoning, machine learning, etc.
- ELIZA (1966): a parody of a psychotherapist, but one of the first attempts at interactive natural language processing and fooled some people very well. (See "doctor" in emacs)
- Loebner Prize annual Turning test competition (and still rather tongue in cheek)
- "Eugene Goostman" convinced 33% of judges that "he" was a 13 year-old boy from Ukraine.

Turing's idea of passing the Turing test

- *Interrogator*: In the first line of your sonnet which reads 'Shall I compare thee to a summer's day', would not 'a spring day' do as well or better?
- **Computer**: It wouldn't scan.
- *Interrogator*: How about 'a winter's day'? That would scan all right.
- **Computer**: Yes, but nobody wants to be compared to a winter's day.
- *Interrogator*: Would you say Mr. Pickwick reminded you of Christmas?
- **Computer**: In a way.
- *Interrogator*: Yet Christmas is a winter's day, and I do not think Mr. Pickwick would mind the comparison
- **Computer**: I don't think you're serious. By a winter's day one means a typical winter's day, rather than a special one like Christmas

From the DailyBeast article by Elizabeth Lopatto, *The AI That Wasn't*

Eugene Goostman

- *Interrogator*: In the first line of a sonnet which reads ‘Shall I compare thee to a summer’s day,’ wouldn’t ‘a spring day’ be better?
- **Goostman**: What makes you ask me this? Sound like you can't choose a right answer yourself! Rely on your intuition! :-) Maybe, let's talk about something else? What would you like to discuss?
- *Interrogator*: I’d like to talk about poetry.
- **Goostman**: Classics? I hope you aren't going to read "King Lear" or something like that to me right now :-)))
- *Interrogator*: No, we can talk contemporary poetry. Do you like Patricia Lockwood's work?
- **Goostman**: I am only 13, so I'm attending school so far.
- *Interrogator*: Oh, that’s when I first read Auden. Do you have a favorite poem?
- **Goostman**: No, I haven't a best-liked poem! How could you imagine such a trash! Did I forget it or you really haven't told me about the place you are from?
- …

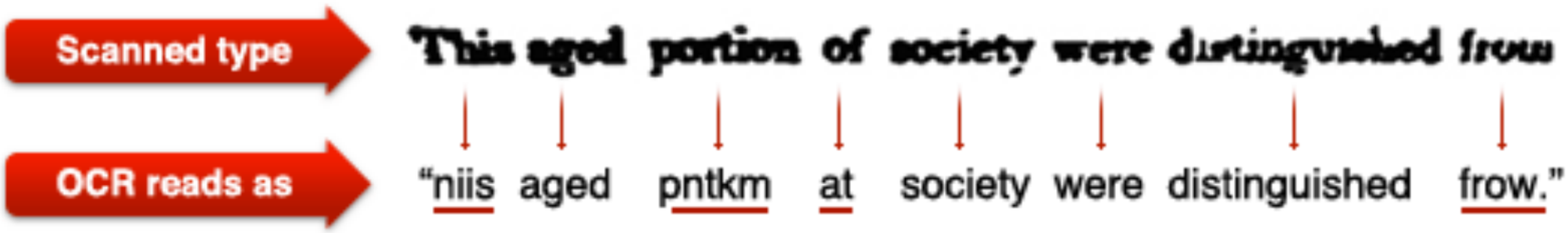
Limitations of this approach

AI research focuses on underlying principles. Russel & Norvig:

Aeronautical engineering texts do not define the goal of their field as making "machines that fly so exactly like pigeons that they can fool even other pigeons."

Reverse Turing tests

- Computers are so intelligent that we need to prove to them that we're human!



CAPTCHA (Completely Automated Public Turing Test To Tell Computers and Humans Apart) was coined in 2000 by Luis von Ahn, Manuel Blum, Nicholas Hopper and John Langford of Carnegie Mellon University.

Cognitive modeling approach to AI

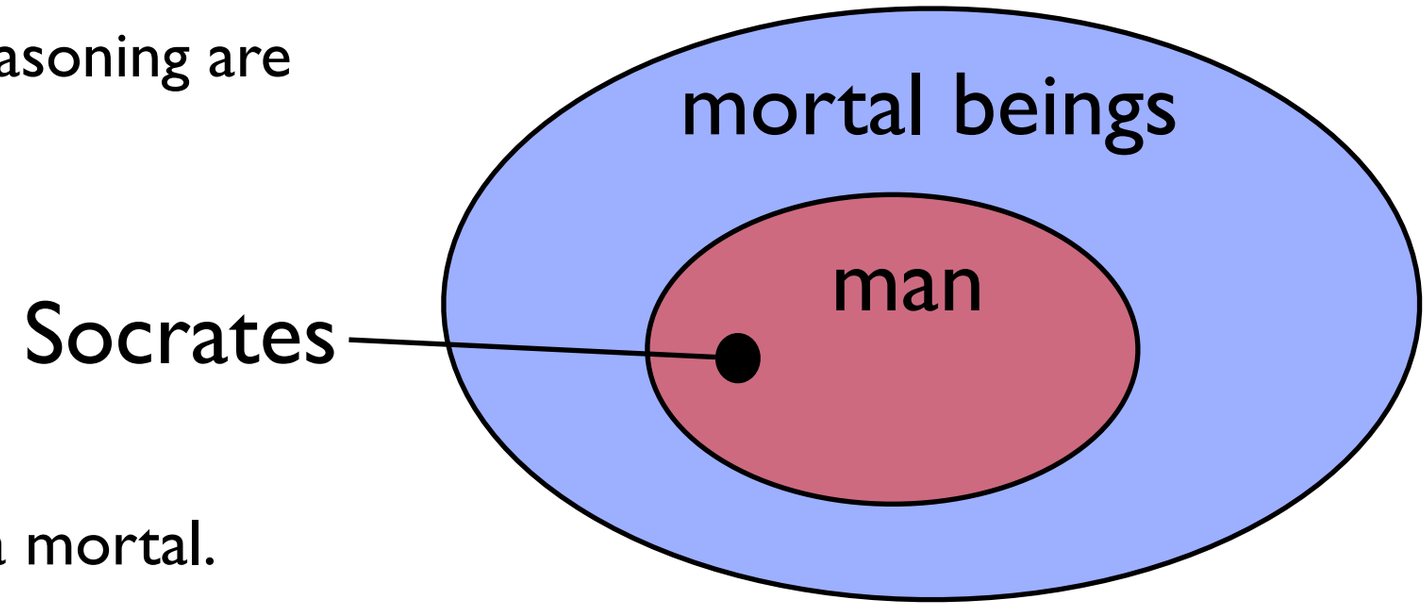
- Develop models and theories of human cognitive processes (cognitive science)
- Implement them with computers
- "expert systems" take this approach
  - consult a group of experts
  - compile a broad range knowledge and rules
  - incorporate them into a rule-based expert system
- downsides
  - not flexible, hard to adapt to new circumstances or situations
  - hard to incorporate new knowledge
  - some knowledge is very difficult to model (e.g. anything intuitive or perceptual)
- many game playing programs incorporate some human-based strategies
- what determines good human performance may have nothing to do with optimal algorithms and vice versa

Allen Newell & Herbert Simon

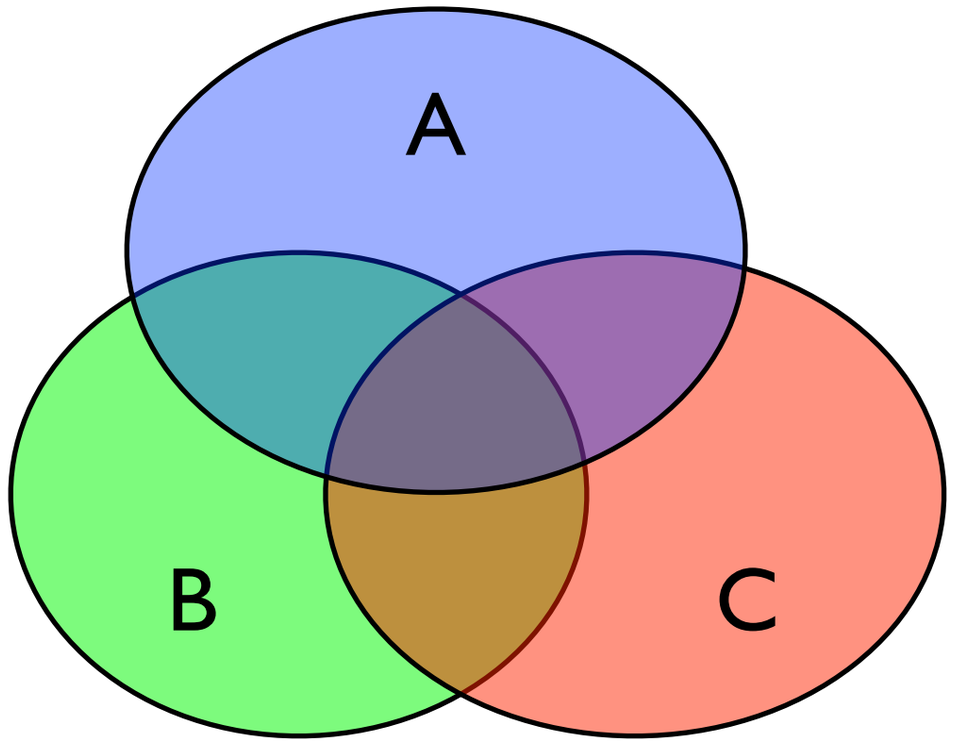
Rational thinking approach: logical inference and reasoning

- Some processes of reasoning are fundamental
- Logical syllogisms:

  All men are mortal.
  Socrates is a man.
  Therefore Socrates is a mortal.



- Can generalize: Logic and Set theory
- Downsides:
  - hard to quantify informal knowledge
  - not all knowledge is certain
  - hard to give structure to large collections of facts
  - lots of knowledge is difficult to describe this way

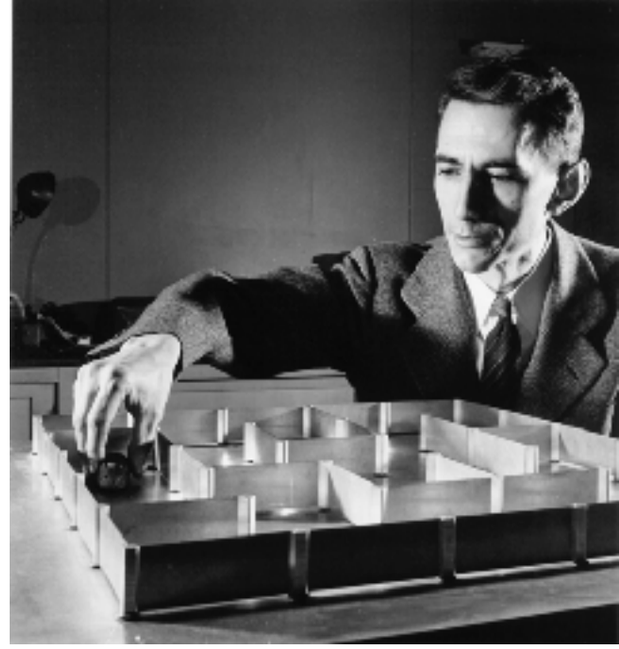


Rational agent approach: Thinking with action

- There is more to intelligence than inference
- Intelligent systems must ***act***
- They ***achieve goals***: find the shortest path, win the game, etc.
- Acting does not have to involve inference, e.g. reflexes
- Agents:
  - act autonomously
  - perceive and represent their environment
  - adapt to change
  - create and pursue goals

- Advantages "Rational agents" approach to AI:
  - more general
  - more amenable to scientific development
- perfect rationality is not always desirable
  - time/resource constraints
  - limited certainty

Some history

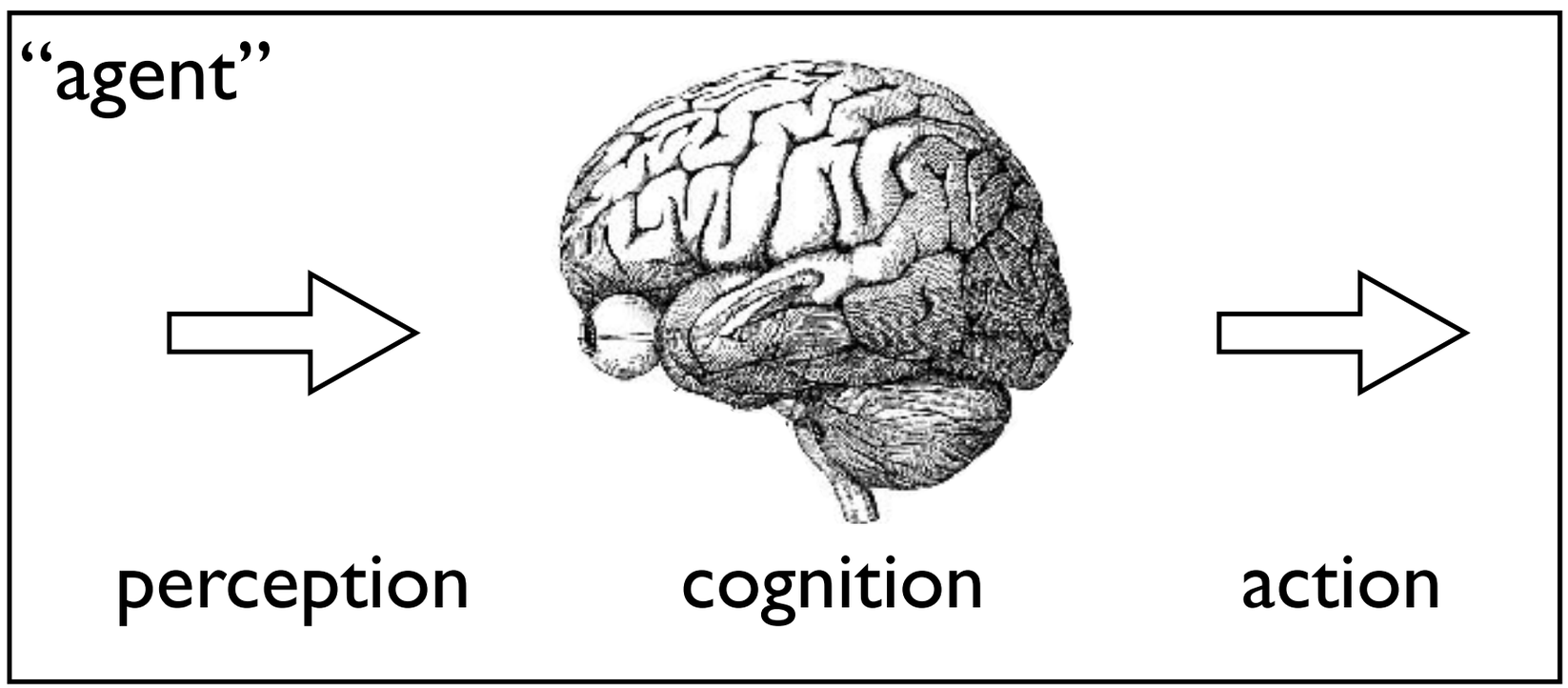


- early AI: 1943-1955
  - first neural networks (McCulloch and Pitts)
  - early computers, Shannon's maze robots
- Birth of AI: 1956: Newell and Simon's Logic Theorist, GPS
- Early AI: (1952 - 1969)
  - McCarthy's LISP language
  - Neural networks that learn
  - first vision systems
- Knowledge based ('expert') systems (1969 - 1979)
- Continuing realization AI is (really) hard (1966 - present)
- Early modern neural networks and machine learning (1986 - present)
- Probabilistic foundations of AI and related areas (1987 - present)
- Deep Learning (more modern neural nets, 2006 - present)
- Numerous modern AI success stories

What are intelligent systems?

Three key steps of a knowledge-based agent (Craik, 1943):

1. the stimulus (or world or problem space) must be translated into an internal representation
2. the representation is manipulated by cognitive processes to derive new internal representations
3. these in turn are translated into action



First, there was natural intelligence

Origins of "natural" intelligence

- Highly symbolic patterns of culture and technology date back at least 70,000 yr BP in Africa:
  - complex bone technology
  - multiple-component missile heads
  - perforated sea-shell ornaments
  - complex abstract "artistic" designs

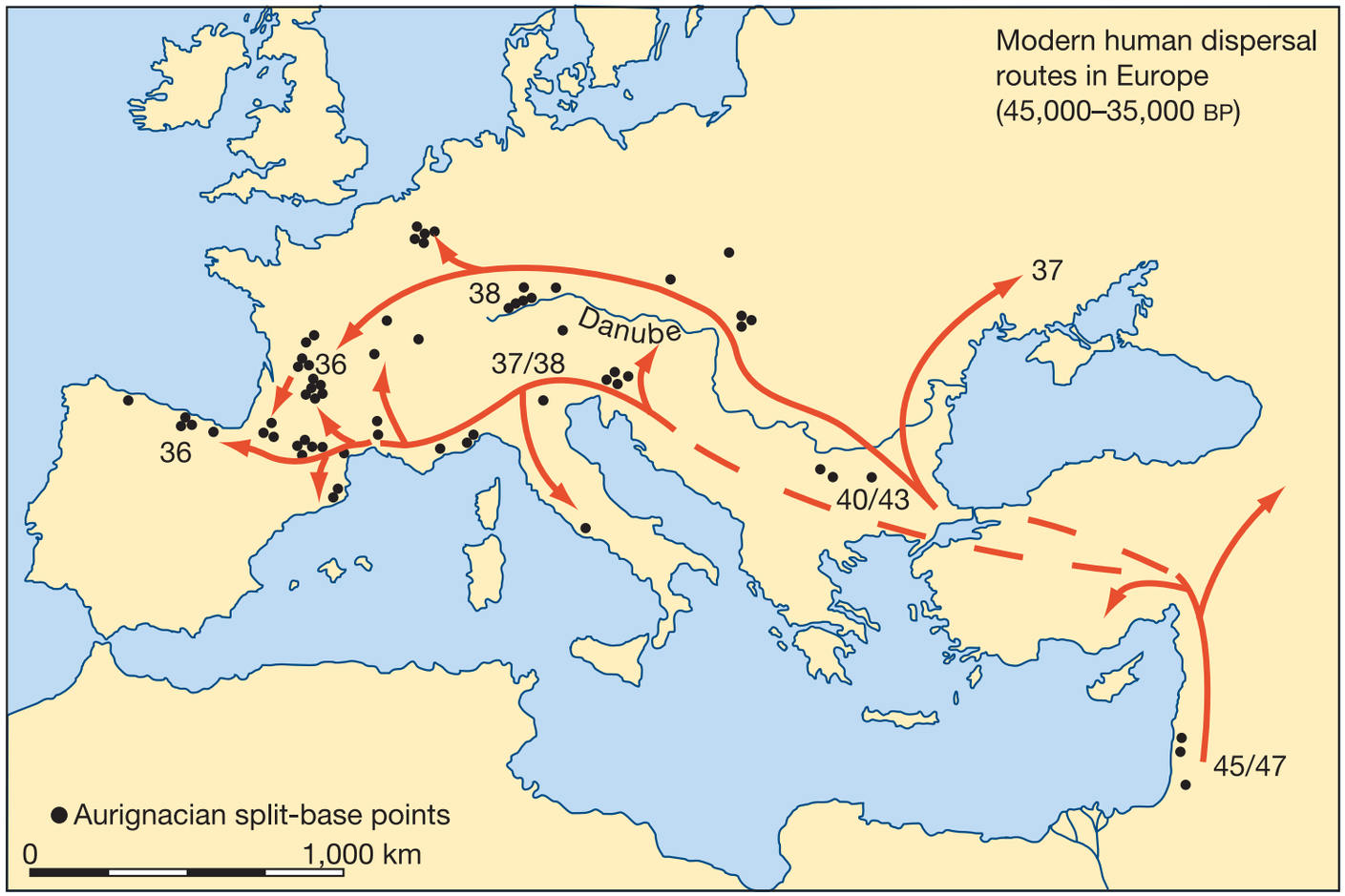
Earlier humans: Neanderthals

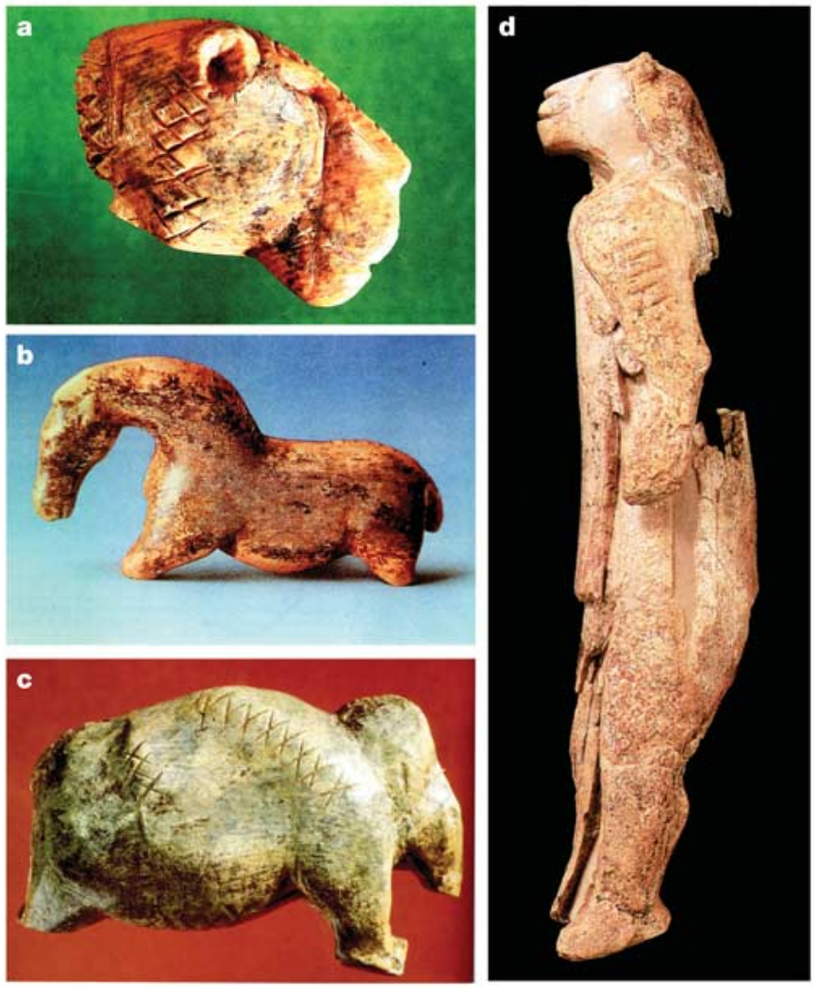
- Neanderthals survived at least 200,000 years in Europe and Western Asia
  - But abruptly disappeared between 30,000 and 40,000 years ago.
  - Why?
  - They had larger brains on average than modern humans.
  - They used tools, but showed no evidence of explicitly symbolic behavior.

http://www.pbs.org/wgbh/nova/neanderthals/skul_vrs.html

Neanderthal extinction coincided with modern human dispersal

- culture and technology was remarkable across a wide range of early modern human sites
- these were very different from Neanderthals
- One hypothesis: these groups out completed the Neanderthal population for scarce food resources by having superior technology and organization.





Early carved animal and human figures

(from Mellars, 2004)

Different aspects of human intelligence

- Perception, learning, and memory
- Causal reasoning
- Prediction
- Adaptability
- Imagination
- Problem solving
- Symbolic thought and language

- *Are these uniquely human?*

Are humans uniquely intelligent?

- Consider the raven (Heinrich, 1995)
- Five ravens were shown meat (hard salami), suspended on string, 70 cm below horizontal poles
- Can the ravens figure out how to get the food?
- How do they do it?

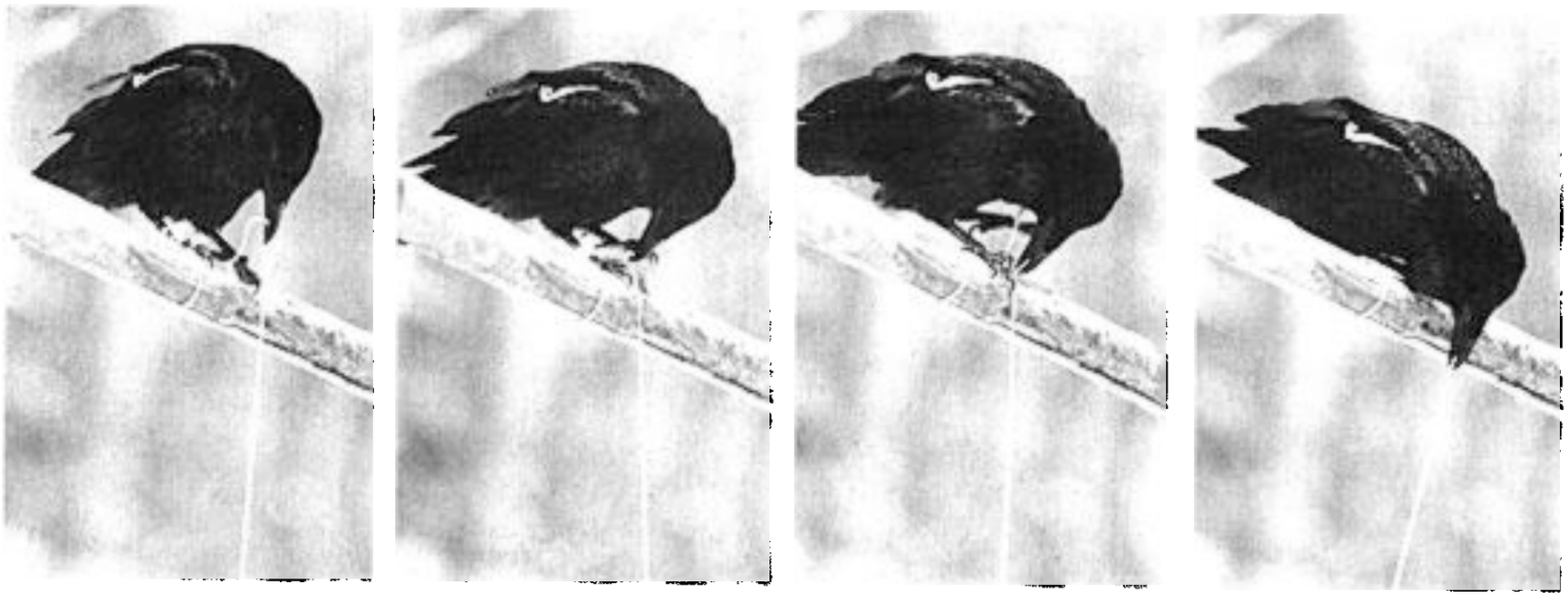
(fig from Emery and Clayton, 2004)

Trial 1: 6 hours

- All birds eventually walked on the perch and examined the meat dangling below
- Bird 3:
  - pecked at the string holding the meat and yanked it from above
  - after 5 unsuccessful attempts, the bird examined from the ground instead
  - made 5 unsuccessful attempts to grab meat by jumping and flying at it
  - tried no other strategy over next 6 days
- Bird 27:
  - also tried jumping and flying at the suspended meat, but failed
  - didn't try any other method

Bird 4 on trial 1

- like bird 3, pecked and tugged from above, but did not jump or fly at it
- he then appeared to abandon all attempts to get the meat
- then, 6 hours later, he perched above the meat again, but this time:
  - after one of the yanks, he put one foot on the string
  - then pulled up more string, and put his foot on that
  - then repeated this without mistake at least 5 times until he got the meat
- On subsequent trials, this bird immediately pulled up the meat in the same manner without hesitation.



Bird 5

- tried yanking on the string from above the first day, then stopped
- After bird 4 pulled up the meat however, bird 5 closely followed this bird, and never attempted to get the meat on the other strings.
- Instead, his only feeding strategy was to take the meat bird 4 had pulled up.
- But he redeemed himself, because on the 6th day, bird 5 figured out how to get the meat using the same method as bird 4.