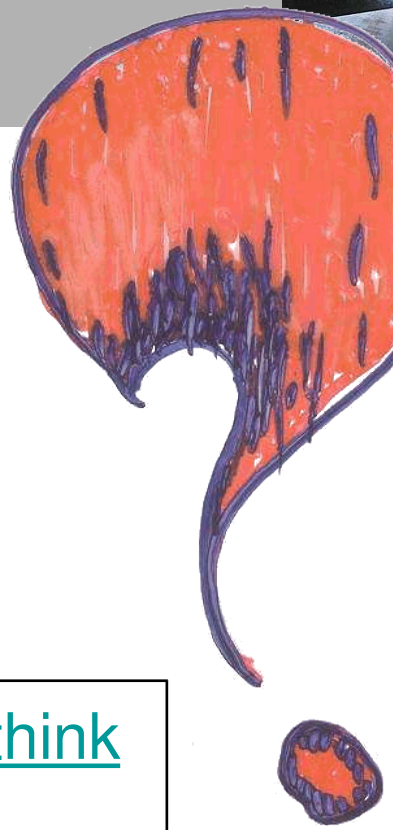
What is AI

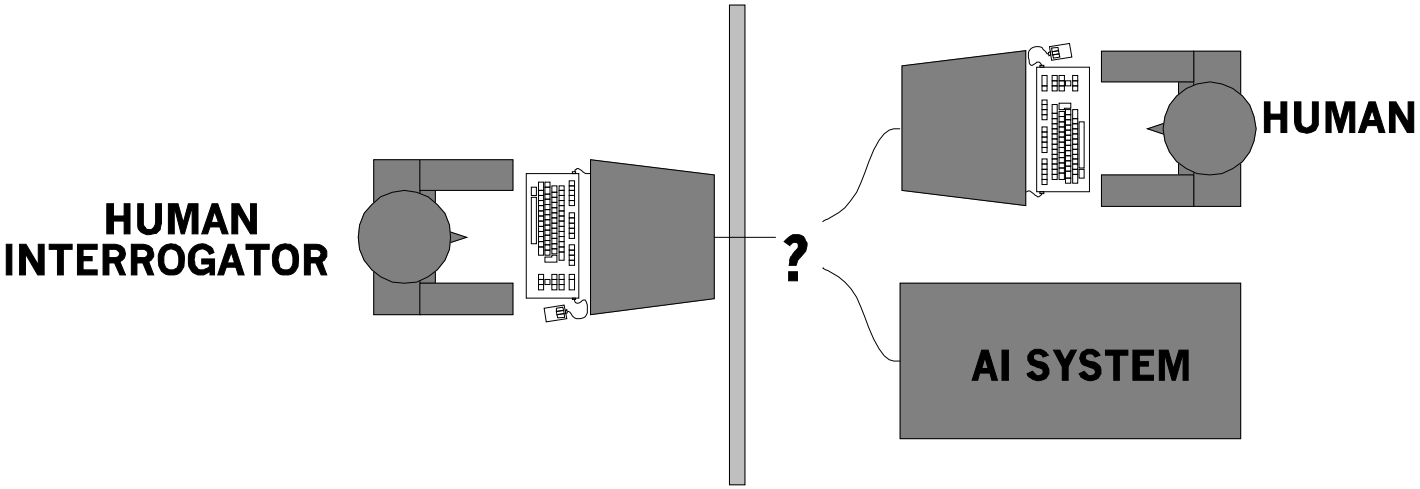


Systems that think like humans	Systems that think rationally
Systems that *act* like humans	Systems that *act* rationally

Acting humanly: The Turing test (I)

Turing (1950) “Computing machinery and intelligence"

- “Can machines think?“ → “Can machines behave intelligently?“
- Operational test for intelligent behaviour: the Imitation Game



Problem: Turing test is not reproducible, constructive, or amenable to mathematical analysis

1960s "Cognitive Revolution":

Information-processing psychology replaced prevailing orthodoxy of behaviorism

Requires scientific theories of internal activities of the brain

- What level of abstraction? "Knowledge" or "(neural) circuit" ?
- How to validate?

Both fields (Cognitive Science and Cognitive Neuroscience)

are now distinct from AI, but both share with AI some characteristics and general goals

Hence, all three fields share one principal direction!

Saarbrücken: M.Sc in Cognitive Systems

Thinking rationally: Laws of Thought

Normative (or prescriptive) rather than descriptive

Several Greek schools developed various forms of logic: notation and rules of derivation for thoughts

Direct line from logic, mathematics and the philosophy of mind to modern Artificial Intelligence, Cognitive Science and Neuropsychology

Problems:

1. Not all intelligent behavior is mediated by logical deliberation
2. Symbolic versus Subsymbolic Representation
3. Situatedness

Acting rationally

Rational behavior: doing the right thing

The right thing: that which is expected to maximize goal achievement, given the available information

Doesn't necessarily involve thinking---e.g., blinking reflex---but thinking should be in the service of rational action

Aristotle (Nicomachean Ethics):

Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good

Rational Agents

An agent is an entity that perceives and acts

This course on AI is about designing rational agents

Abstractly, an agent is a function from percept histories to actions:

$$f: \quad P^* \quad \rightarrow \quad A$$

For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caveat: *computational limitations make perfect rationality unachievable*

→ design best program for given machine resources

AI: related Disciplines

Philosophy	logic, methods of reasoning, mind as a physical system foundations of learning, language, rationality
Mathematics	formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
Psychology	phenomena of perception and motor control experimental techniques (psychophysics, etc.)

AI: related Disciplines

Economics	formal theory of rational decisions
Linguistics	knowledge representation and grammar
Neuroscience	plastic physical substrate for mental activity
Control Theory	homeostatic systems, stability simple optimal agent designs

COMPUTER SCIENCE !

Potted History of AI

1943	McCulloch and Pitts: Boolean circuit model of the brain
2	Turing‘s “Computing Machinery and Intelligence”
1956	Dartmouth Meeting: “Artificial Intelligence”
1960s	Early AI programs, including Samuel‘s checkers program, Newell & Simon‘s Logic Theorist, Gelernter‘s Geometry Engine, ….
	⟶ „Look, Ma, no hands !“
6	Robinson‘s Resolution Principle for machine oriented logical reasoning
1970s	Logic and AI

Potted History of AI

1965-75 AI discovers computational complexity
Neural network research almost disappears

1975 Paradigm Shift: Knowledge-based systems

1980-88 Expert systems industry booms

1988-95 Expert systems industry busts: "AI Winter"

5 - Neural Networks new popularity: Subsymbolic Representation

- Paradigm Attack: „Let the world be it´s own representation"
(Rodney Brooks)

- P

9 R nputing

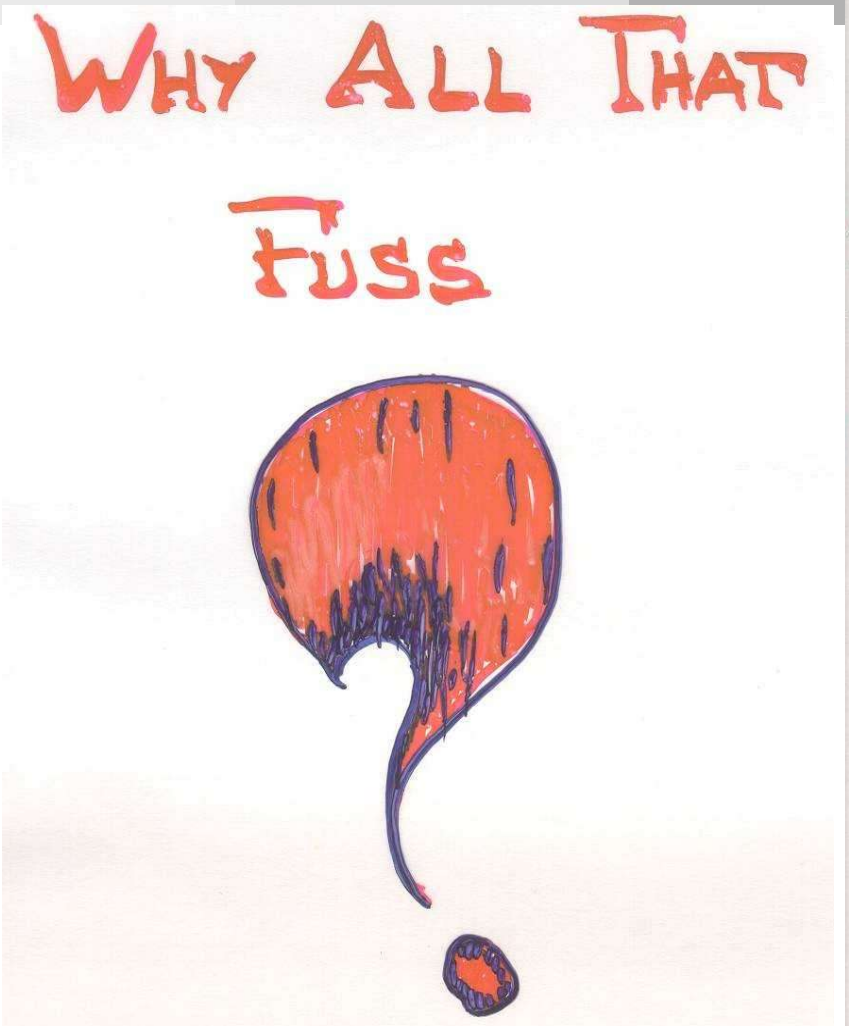
1995 - A

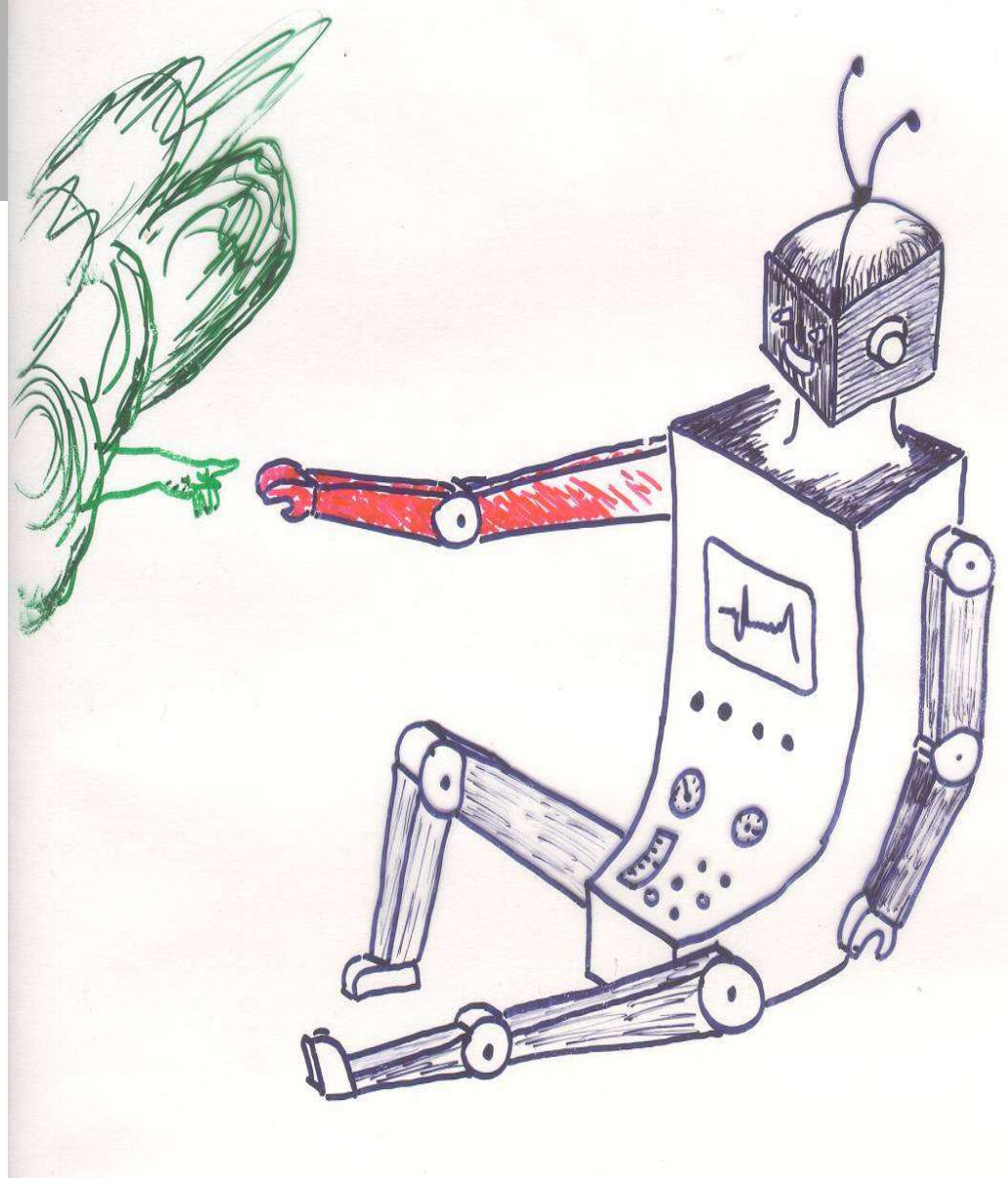
2000 - **Fir**

COGNITIVE SYSTEMS

- Natural Language Processing, Computer Vision, Robotics, - XPS, Agents and Software Engineering, Deduction Tools for - Verification, Multimodal Semantic Web and Knowledge Representation,
- AI in ubiquetous and ambient computing
- AI in Virtual Worlds, Games, Films and Entertainment

ARTIFICIAL INTELLIGENCE:





Understanding in the light of our experience:

"VERSTEHEN IM LICHTE UNSERER ERFAHRUNG"

17th Century:

positiv: ▷ HARVEY : Blood Circulation

analog: pumping station

negativ: ▷ DESCARTES : Nerve Fibres

?? analog: pump ?

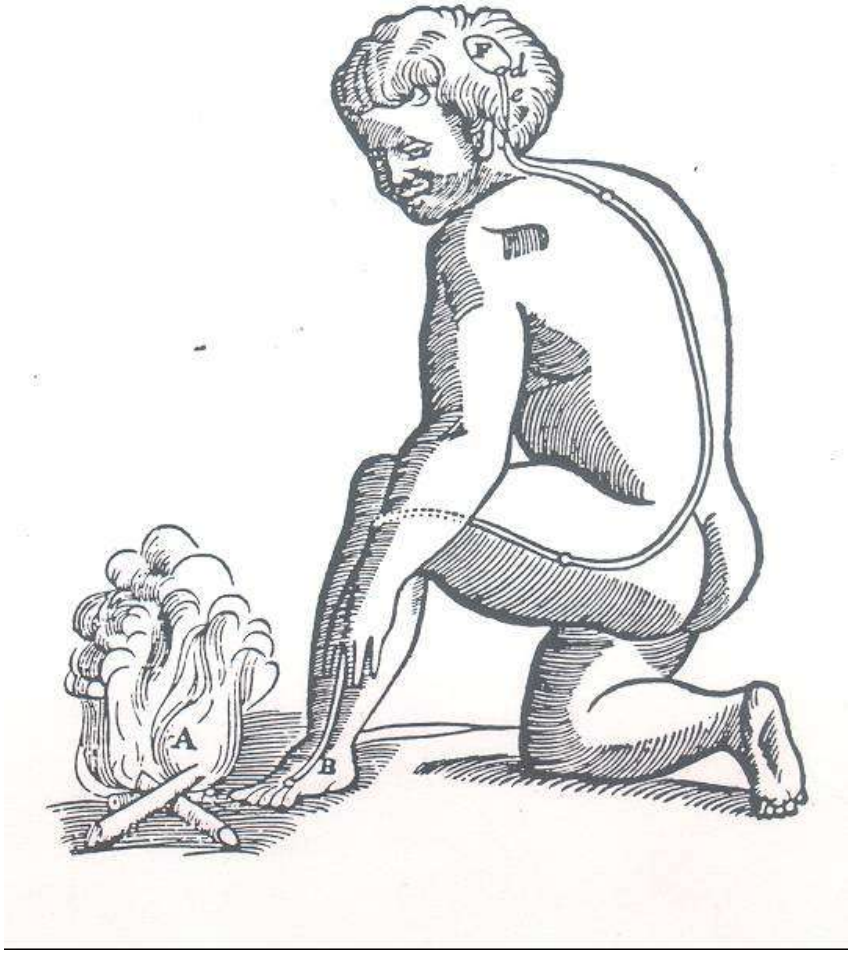
("UNDERSTANDING IN THE LIGHT OF OUR EXPERIENCE")

Understanding in the light of our experience:

- **Harvey:**
  Blood Circulation

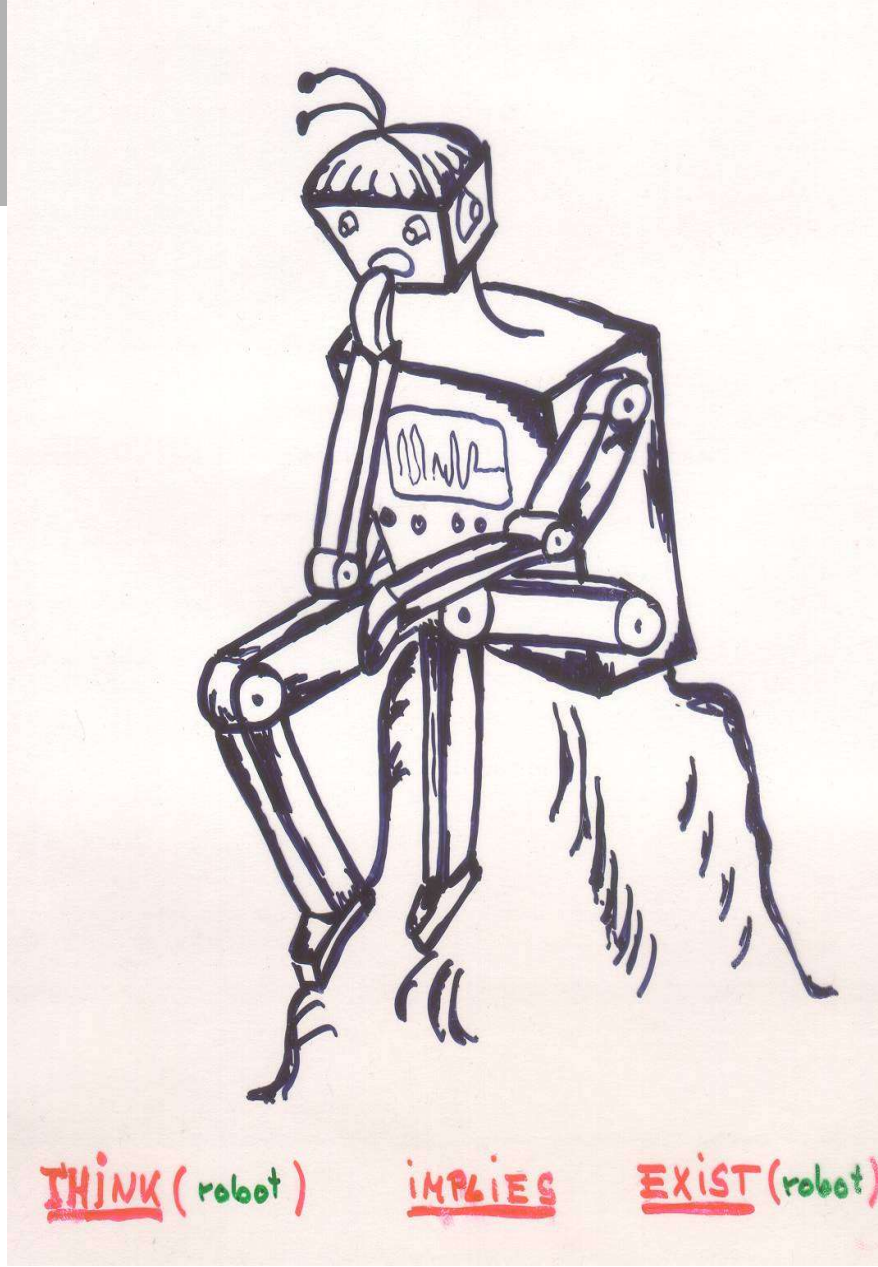
- **Descartes:**
  Traite de l`Homme

(17th century)



The new concept of “machine” provided by artificial intelligence is so much more powerful than familiar concepts of mechanism that the old metaphysical puzzle of how mind and body can possibly be related is largely resolved . . . Artificial intelligence, in short, cannot only acknowledge but can even elucidate the essentially subjective mental realities so stressed by humanist psychologists (as opposed to behaviorists or neurophysiologists).

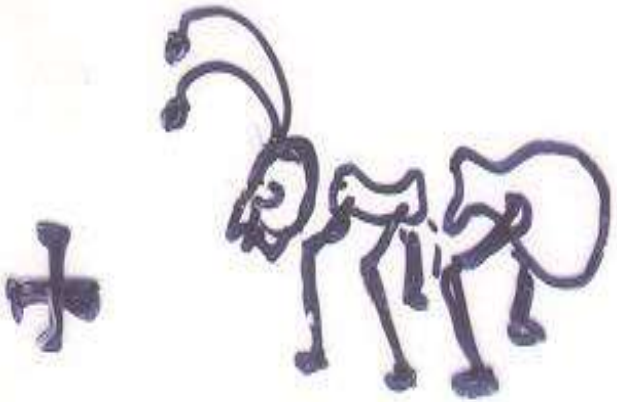
M.Boden, Artificial Intelligence and Natural Man,1977



AI Methods: Essentials

METHODE 1:

+



Method 2: Symbolic Representation

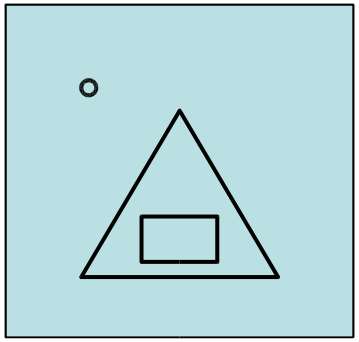


Figure A

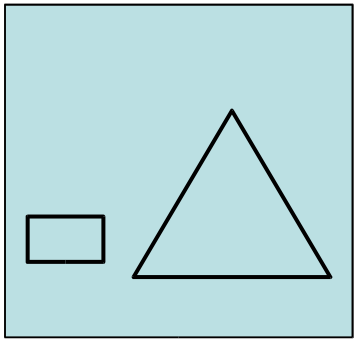


Figure B

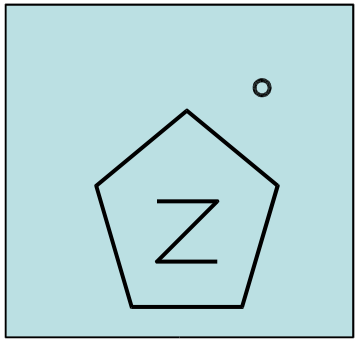


Figure C

Figure 1

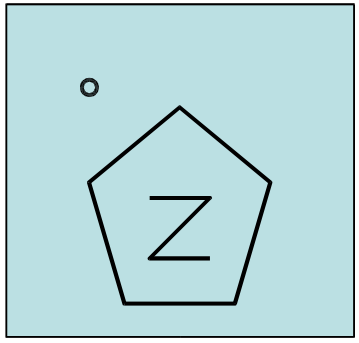


Figure 2

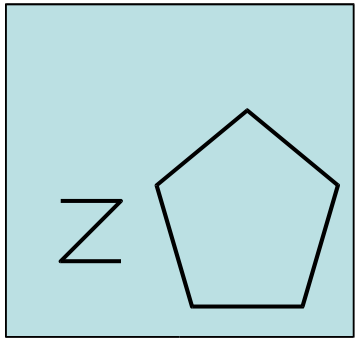


Figure 3

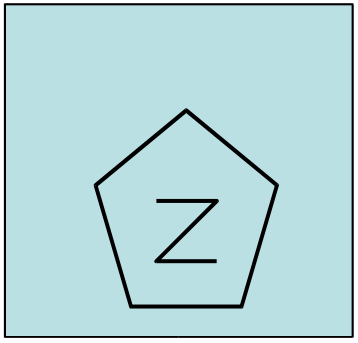


Figure 4

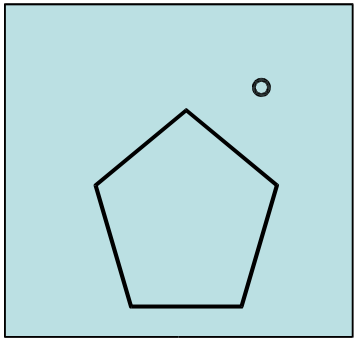
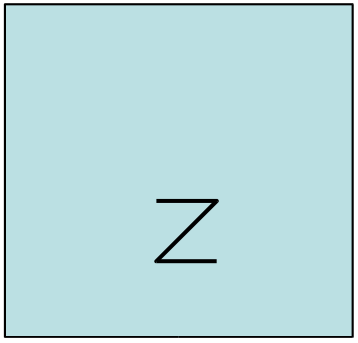


Figure 5



Method 2: Symbolic Representation

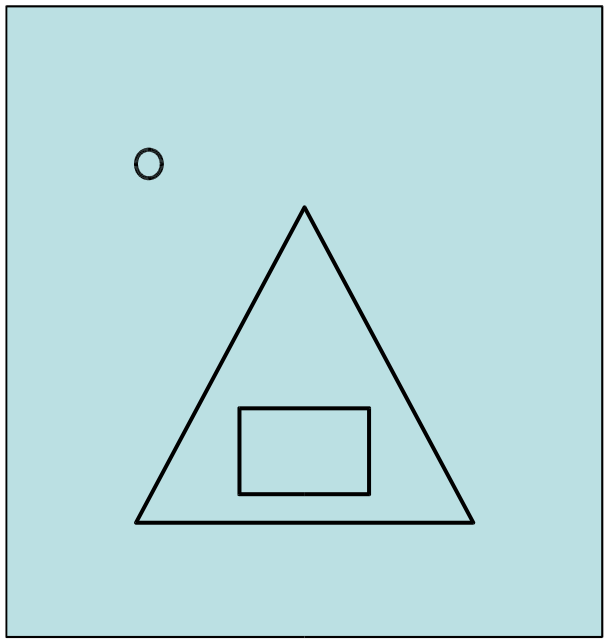


Figure A

```
(FIGURE A
        (CONSISTS-OF P1 P2 P3)
        ( (P1 Dot)
          (P2 Rectangle)
          (P3 Triangle))
        (RELATIONS
          (Inside     P2 P3)
          (Above P1 P2)
          (Above P1 P3))
        )
```

Methode 3:

"Levels Of Abstraction"

Abstraktion

Software:
- → Ontologien, Wissens-Rep.
- → Anwendungsprogramme
- → Basic, Pascal, Algol, Prolog, Lisp, Java

Assembler / Mc-Code

Hardware:

Elektronik: Transistoren, AND/OR-Gates, Elektronen-Fluss

Opto-Elektronik

Quanten (Computing)

Method 3: Levels of Abstraction

Brain

Computer

„Biological“ Pr

Language

ects

e.g.

Prolog

mbler

AND

Gates etc.

Neural Cells, Syn

tors etc.

Elect

nic flow

The First Cognitive Revolution:

The Brain and the Nerve Net as an Information Processing Machine

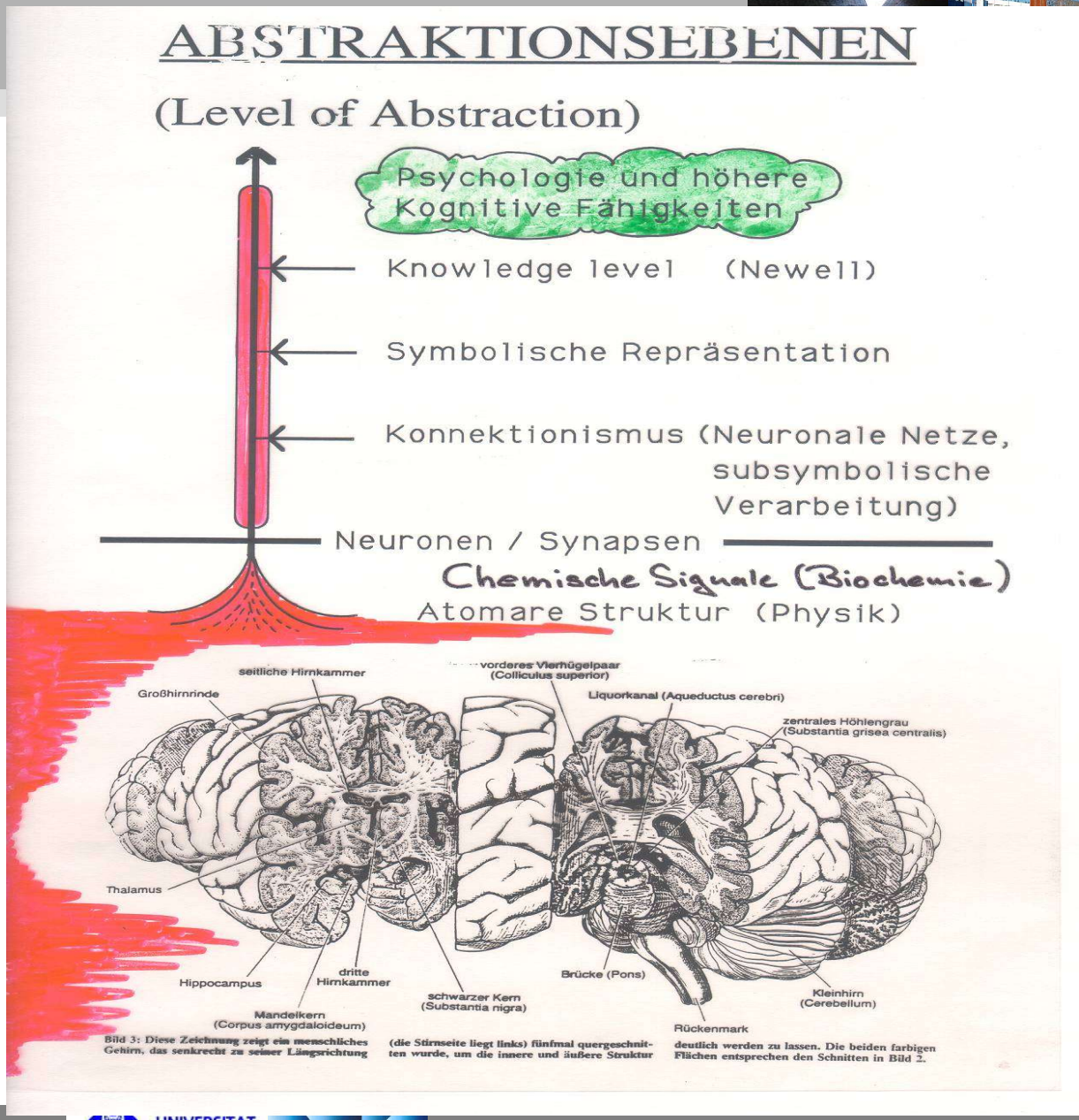
NeuroPeptide based Information Processing

“GOD IS A NEURO PEPTIDE”

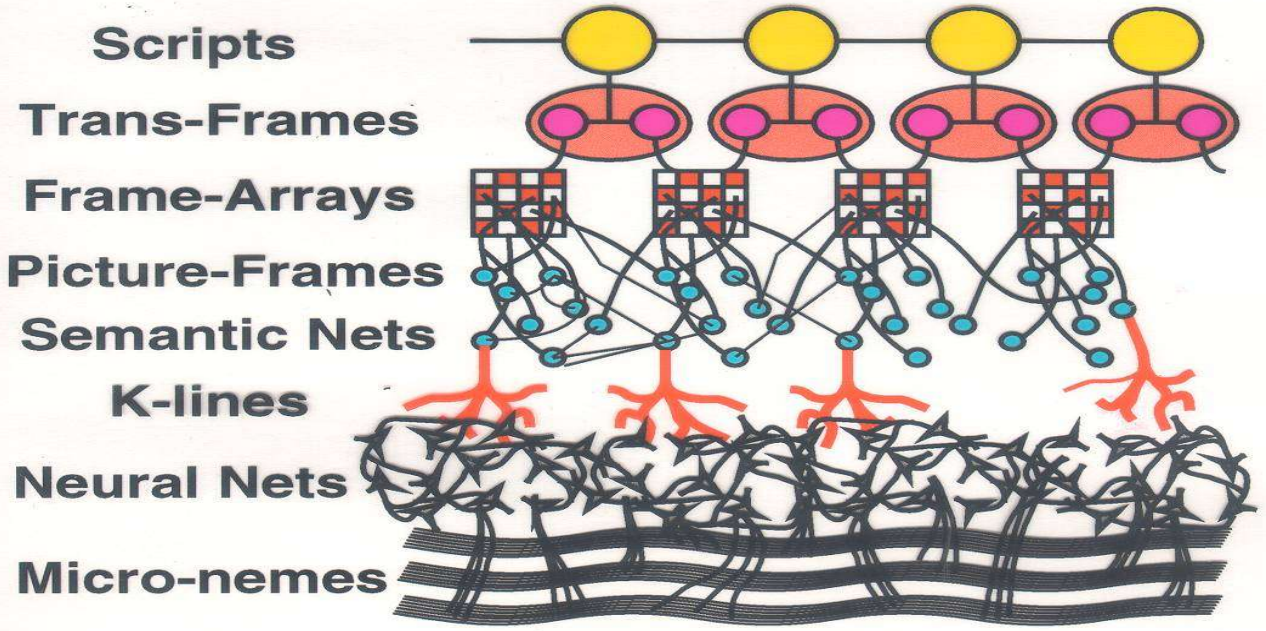
Candace B Pert
Molecules of Emotion
Why you feel the way you feel
Scribner, New York,1997

Candace B Pert
Moleküle der Gefühle
rororo Science
Rowohlt, Hamburg, 1999

A unifying theory ?



Representation Levels

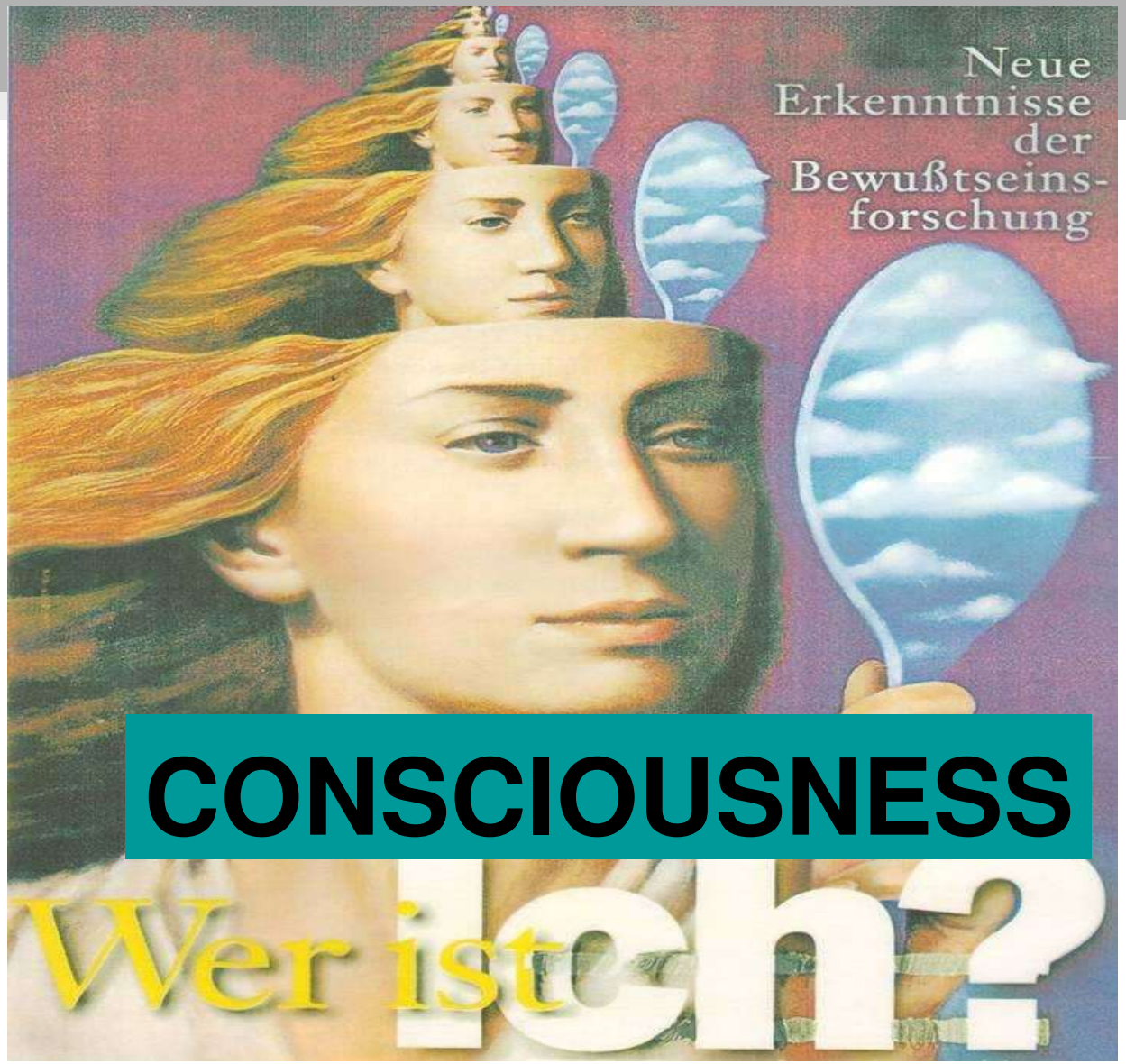


Marvin Minsky 1993

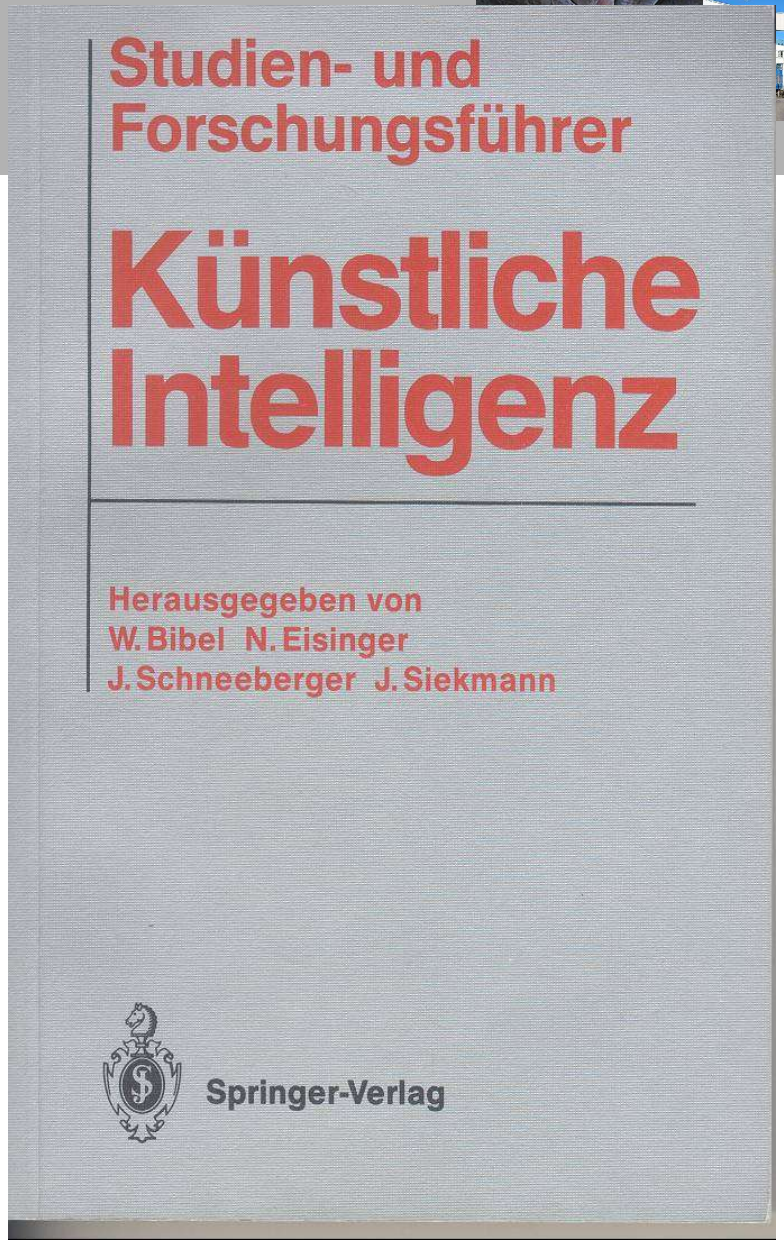
THE BRAIN
HAPPENS
TO BE A
MEAT
MACHINE

MARVIN MINSKY

Contemporary AI and Neuro-Science: Consciousness



CONSCIOUSNESS

QUALIA

AI in Germany: