人工智能

The ShanghAI Lectures

上海授课

The ShanghAI Lectures by the University of Zurich
An experiment in global teaching

Rolf Pfeifer and Nathan Labhart
National Competence Center Research in Robotics (NCCR Robotics)
Artificial Intelligence Laboratory
University of Zurich

Today from the University of Vermont, US
(Josh Bongard's laboratory)

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“来自上海的人工智能系列讲座”

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UNIVERSITY COMMUNICATIONS

President Obama Honors UVM Robotics Scientist

09-27-2011 | By Joshua E. Brown

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For his work to understand how to build better robots, Joshua Bongard, a researcher at the University of Vermont, has received the highest award given by the U.S. government to young scientists.

On Sept. 26, President Barack Obama announced Bongard as one of 94 winners of the Presidential Early Career Award for Scientists and Engineers; he will be honored at a White House ceremony in October.

Bongard is only the second researcher in UVM history to receive the PECASE award, which provides $500,000 in research funds over several years.

Inspired by evolution

Bongard's far-reaching work looks to nature for ideas. "The goal is to borrow ideas from neuroscience and evolution to help us build better and more intelligent robots," he says.

So far, scientists have had little success in building resilient machines that can continually perform behaviors that are fairly simple but require ongoing adaptation to changing conditions — like paving a road or cleaning up a toxic dump.

Lecture 2

Cognition as computation: Successes and failures

The need for an embodied perspective on intelligence

13 October 2011

University of Zurich

Lecture 2: Guest speaker

from ABB Manchester

Alan Spreckley, ABB, Manchester, UK
"Robots in industry"

Today, 10.20 CET (9.20 GMT)

Today's topics

- short recap
- The classical approach: Cognition as computation
- Successes and failures of the classical approach
- Some problems of the classical approach
- The need for an embodied approach
- The "frame-of-reference" problem

Today's topics

- short recap
- The classical approach: Cognition as computation

with a student presentation from Russian State University for the humanities in Moscow

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Definitions, arguments

- **hard to agree on**
- **necessary and sufficient conditions?**
- **are robots, ants, humans intelligent?**

more productive question:

"Given a behavior of interest, how does it come about?"

Definitions, arguments

3 pros and
3 cons
—> Zurich

- hard to agree on
- necessary and sufficient conditions?
- are robots, ants, humans intelligent?

more productive question:

"Given a behavior of interest, how does it come about?"

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Measuring intelligence

- e.g. IQ
- ...

IQ testing — issues (1)

- IQ in genes (nature) or acquired (nurture)? — the "nature-nurture debate"
- IQ trainable — increased through practice?
- cultural differences?
- professional success? why are some with high IQ successful, others not?
- emotional intelligence?
- relation to brain processes?

There is a huge literature on IQ testing, and also about many other kinds of testing. There is still a lively debate going on on whether IQ testing is useful or not.

IQ testing — issues (1)

- IQ in genes (nature) or acquired (nurture)? — the

presentation from Russian State University for the humanities in Moscow
"Emotional Intelligence"

- h IQ
- emotional intelligence?
- relation to brain processes?

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There is a huge literature on IQ testing, and also about many other kinds of testing. There is still a lively debate going on on whether IQ testing is useful or not.

IQ testing — issues (2)

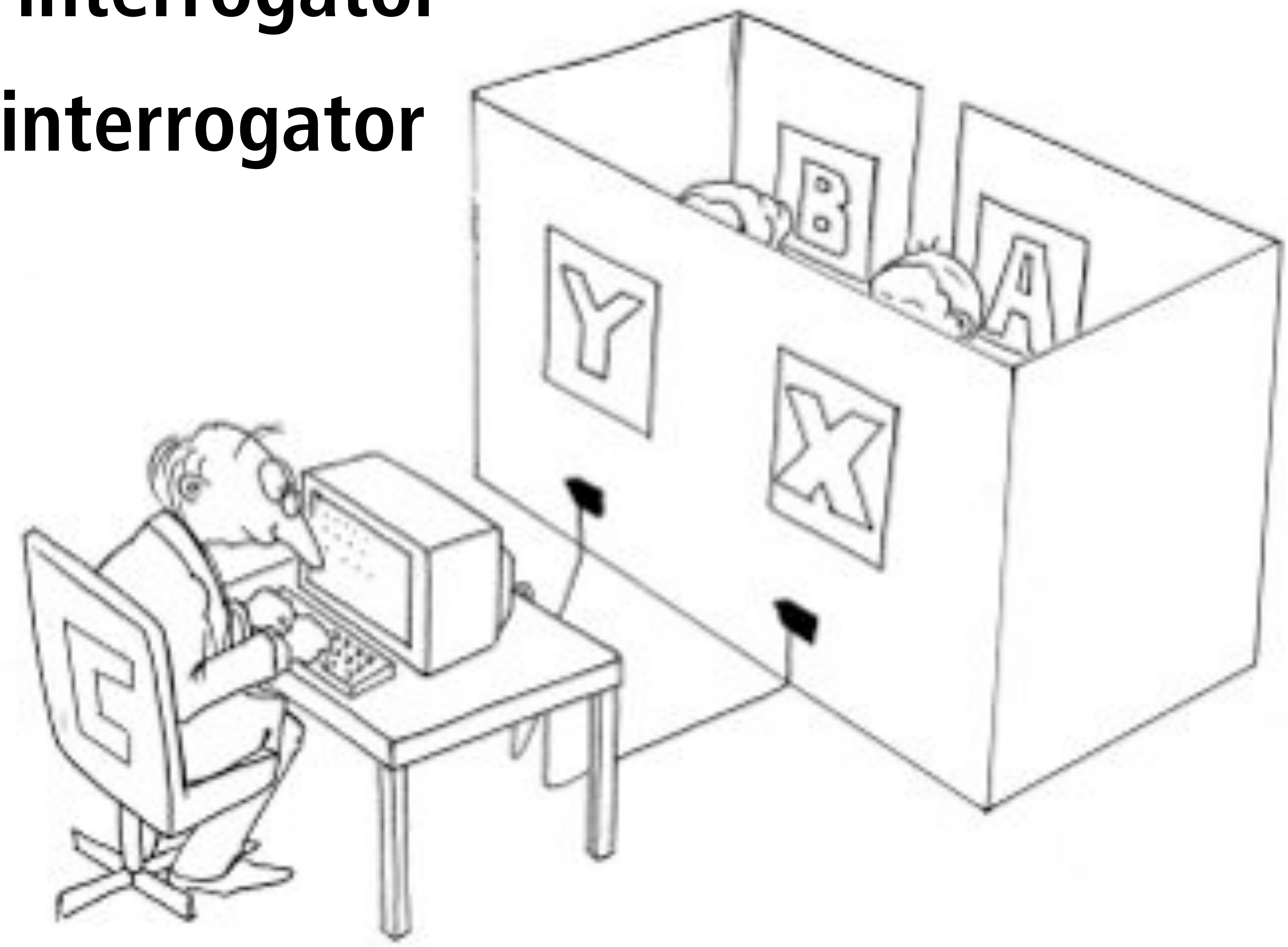
- many different abilities, not just one number? (tests for different abilities; see Howard Gardner, Robert Sternberg, Steven J. Gould, and many others)
- the “Flynn Effect” (IQ increasing over the years)

The Turing Test

A: man, confuse interrogator

B: woman, help interrogator

C: interrogator



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The imitation game is played by three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the two. The object of the game for the interrogator is to determine which of the other two is the mand and which is the woman. He knows them by labels X and Y, and at the end of the game he says either “X is A and Y is B” or “X is B and Y is A”. The interrogator is allowed to put questions to A and B thus: Will X please tell me the length of his or her hair?
Now suppose the X is actually A, then A must answer. It is A’s object in the game to try and cause C to make the wrong identification.
The object of the game for the third player (B) is to help the interrogator.
We now ask the question, “What will happen when a machine takes the part of A in this game? Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman?” These questions replace the original “Can machines think?”. (UI pp. 16/17).
Often, simplifies versions of the imitation game are used, where there is only a computer and a human and the interrogator has to find out who is the human and who is the computer.

The Turing Test

A: man, confuse interrogator

B: woman, help interrogator

C: interrogator

last week: Student presentation from Salford University

The imitation game is played by three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the two. The object of the game for the interrogator is to determine which of the other two is the mand and which is the woman. He knows them by labels X and Y, and at the end of the game he says either “X is A and Y is B” or “X is B and Y is A”. The interrogator is allowed to put questions to A and B thus: Will X please tell me the length of his or her hair?

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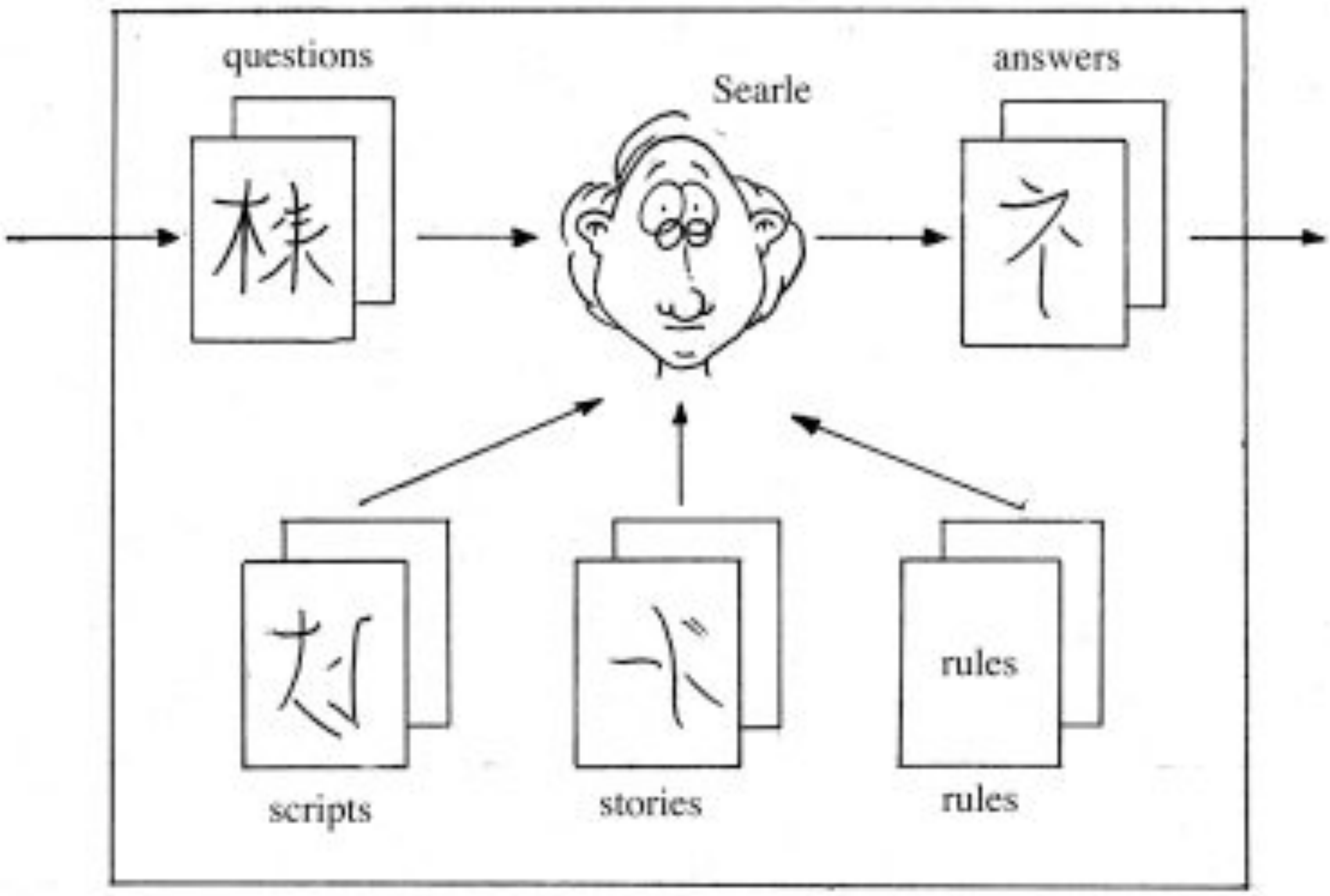
Searle's "Chinese Room" thought experiment



Mittwoch, 12. Oktober 2011

In this original paper, the person locked in the Chinese Room was Searle himself. The argument holds for anyone else, as long as he doesn't speak Chinese. Initially Searle is given two large batches of writing, one with Chinese characters and one written in English. The batch with the Chinese characters represents a data base of commonsense knowledge required to answer questions handed to him through the opening on the left of the room. The second batch consists of rules containing the instructions on how to ``process'' the questions, that is, they tell Searle how to produce an answer from the questions written with Chinese characters. This is done by comparing the characters of the question to the characters in the commonsense knowledge base and by choosing certain characters that will make up the answer. When this process is finished, the answer is handed through the opening on the right of the room. Note that the comparison of Chinese characters and the choice of characters that make up the answer is done entirely on the basis of their shapes, that is, on a purely formal or syntactic basis. Let us now suppose that Searle keeps playing this game for a while and gets really proficient at following the instructions for manipulating the Chinese symbols. From an external point of view, that is from the point of view of somebody outside the Chinese Room, Searle's answers to the questions are indistinguishable from those of native Chinese speakers. Nobody looking at Searle's answers can tell that he doesn't speak a word of Chinese. He has produced answers by manipulating uninterpreted formal symbols.

Searle, quite in contrast to Turing, is not willing to accept a definition (or a test) of intelligence that relies entirely on behavior. It is not sufficient for him that a system produce the same output as a human. He does not view the Turing test as a good means to judge the intelligence of a system. For true understanding, true intelligence---in his view---something else is required. Many papers that have been written about the Chinese Room, and we cannot do justice to the entire discussion. Instead of going into that debate, let us, just for the fun of it, ask the following question: According to Searle, the Chinese Room does not understand Chinese. Now, how do we know Searle understands English? All we can do is say something, observe Searle's behavior and what he says in a particular situation, and if that makes sense, we attribute understanding to him. Just like the Chinese Room! But more probably, we know that Searle is human, we are human and we understand English, so we simply assume that he also understands.

Turing test for animals

Video "real dog vs. Aibo"

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1st video clip: from the cult movie "Blade runner", showing a TTT, a Total Turing Test, where not only the input-output behavior is relevant, but also the external appearance.
(from Wipedia): Blade Runner is a 1982 American science fiction film directed by Ridley Scott and starring Harrison Ford, Rutger Hauer, and Sean Young. The screenplay, written by Hampton Fancher and David Peoples, is loosely based on the novel Do Androids Dream of Electric Sheep? by Philip K. Dick.
The film depicts a dystopian Los Angeles in November 2019 in which genetically engineered organic robots called replicants—visually indistinguishable from adult humans—are manufactured by the powerful Tyrell Corporation as well as other mega manufacturers around the world. Their use on Earth is banned, and replicants are exclusively used for dangerous, menial or leisure work on Earth's off-world colonies. Replicants who defy the ban and return to Earth are hunted down and "retired" by police special operatives known as "Blade Runners". The plot focuses on a brutal and cunning group of recently escaped replicants hiding in Los Angeles and the burnt out expert blade runner, Rick Deckard (Harrison Ford), who reluctantly agrees to take on one more assignment to hunt them down.

2nd video clip: real dog vs. Aibo: short (10sec) interaction of robot dog Aibo with real dog

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"Birth" of AI

George A. Miller, Psychologist
"The Magical Number Seven Plus or Minus Two"

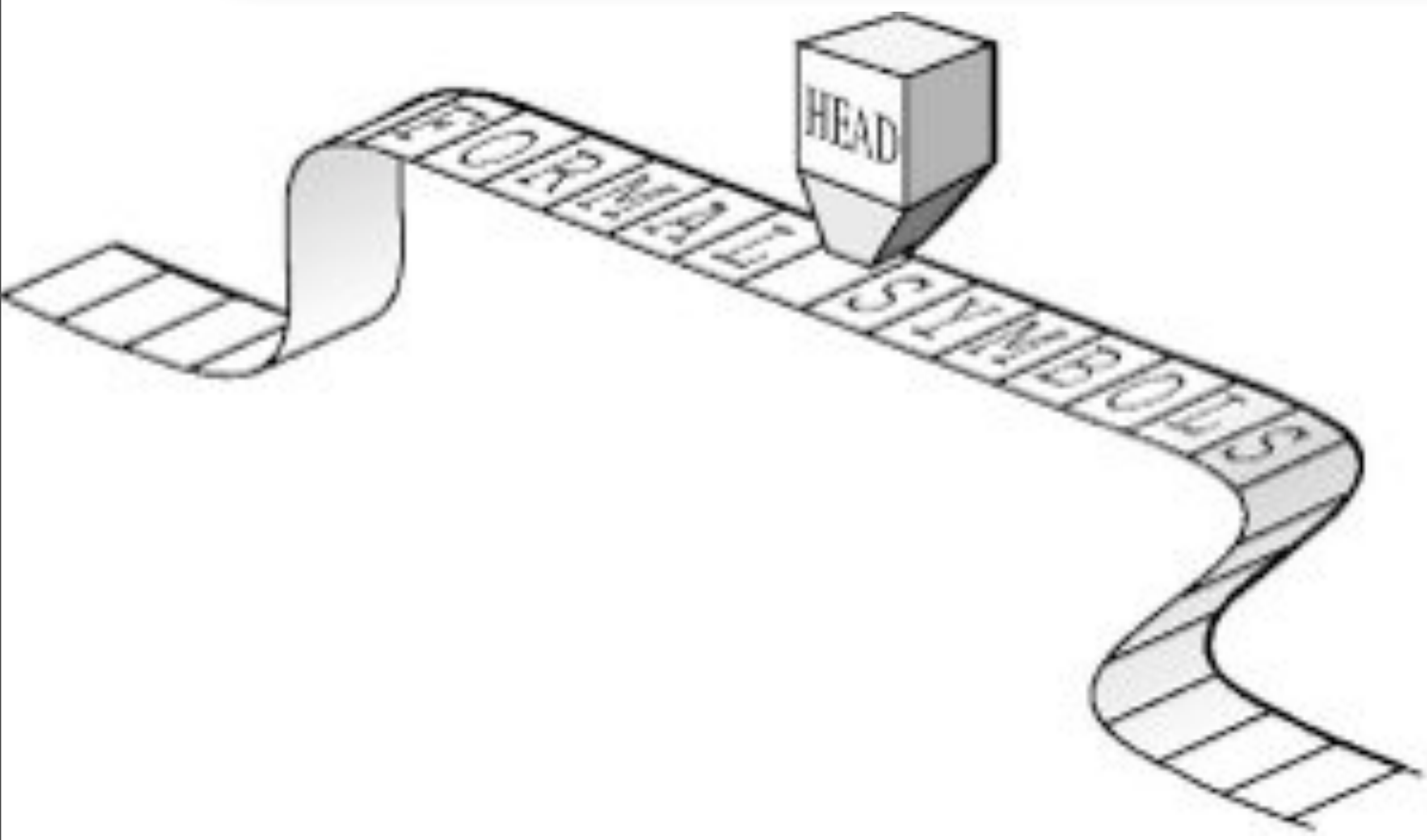
John McCarthy, Computer Scientist
Initiator of Artificial Intelligence

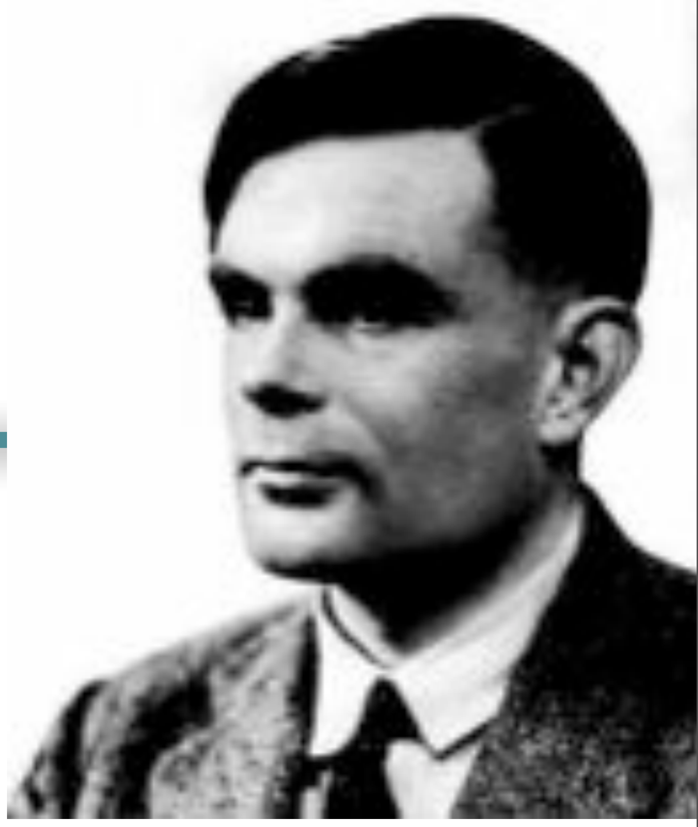
Herbert Simon
and Allen Newell
The "Logic Theorist"

Noam Chomsky, Linguist
"Syntactic Structures"

Conference in 1956: three seminal papers
Newell and Simon: For the first time in history, a thinking machine.
Noam Chomsky: Syntactic structures, a computational approach to language (transformational grammars)
George Miller: Capacity of STM - hard to measure in bits and bytes —> "chunks" (e.g. phone number in Germany: international access code, country code, area code, number.

Turing Machine (1)





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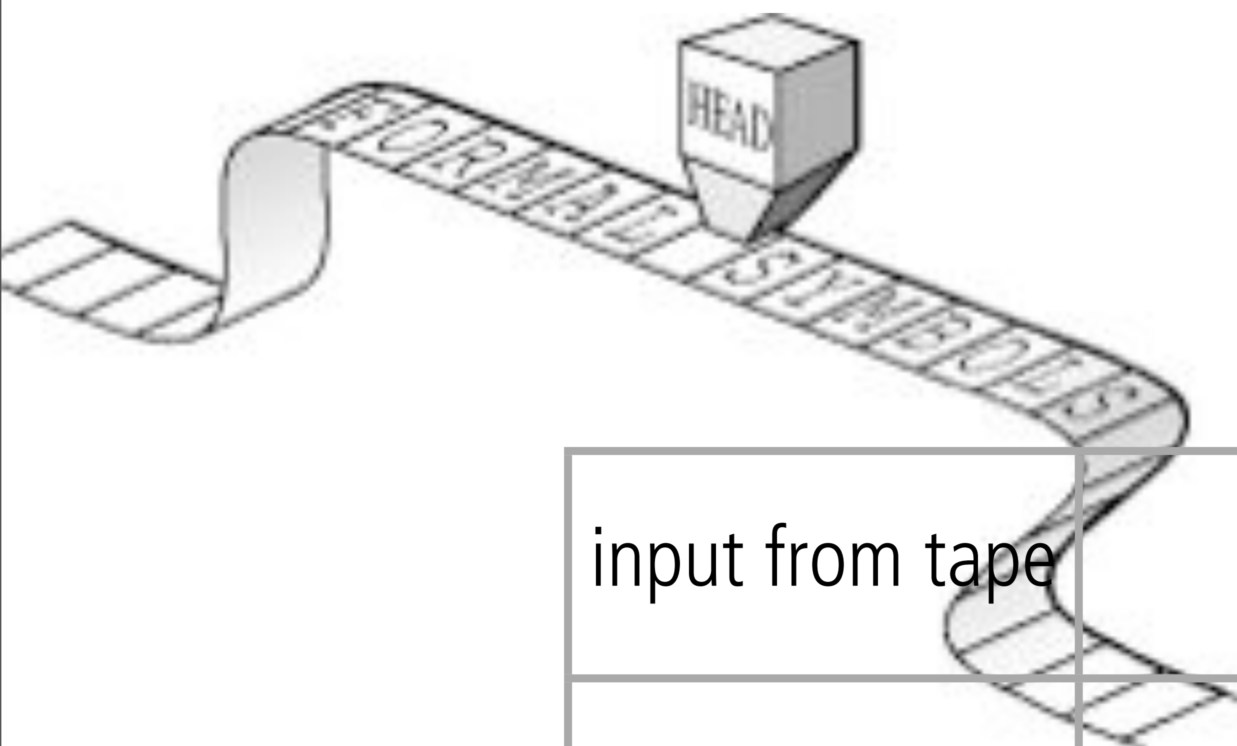
What is computation: Turing



Turing Machine (2)

input from tape	1	2	state of read/ write head
_	_R2	HALT	
A	AL1	BR2	
B	BL1	AR2	
C	CL1	CR2	

write on tape   move tape L/R   next state of r/w head

Turing Machine (3)

initial situation: state r/w head = 1
initial content of tape:

. . A A B A A C C C C A B A C C C C B B A B . . .

r/w head initial pos. ↑

input from tape	1	2	state of read/ write head
_	_R2	HALT	
A	AL1	BR2	
B	BL1	AR2	
C	CL1	CR2	

write on tape   move tape L/R   next state of r/w head

initial situation: state r/w head = 1
initial content of tape:

.	.	A	A	B	A	A	C	C	C	C	A	B	A	C	C	C	C	B	B	A	B	.	.	.			

r/w head initial pos. ↑

Turing Machine (3)

what does this TM do?
—> HIT Lab

input from tape	1	2	state of read/ write head
_	_R2	HALT	
A	AL1	BR2	
B	BL1	AR2	
C	CL1	CR2	

write on tape   move tape L/R   next state of r/w head

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If state=1 and input=A: write A, move tape to left, remain in state 1
If state=1 and input=B: write B, move tape to left, remain in state 1
tape moves to the left until a blank is encountered, then a blank is written on the tape, the tape is moved to the right and the r/w head enters state 2
As are exchanged by Bs an vice versa; Cs remain unchanged. HALT when encountering a blank

initial situation: state r/w head = 1
initial content of tape:

_	_	A	A	B	A	A	C	C	C	C	A	B	A	C	C	C	C	B	B	A	B	_	_	_				

r/w head initial pos. ↑

Turing Machine (4)

input from tape	1	2	state of read/ write head
_	_R2	HALT	
A	AL1	BR2	
B	BL1	AR2	
C	CL1	CR2	

write on tape

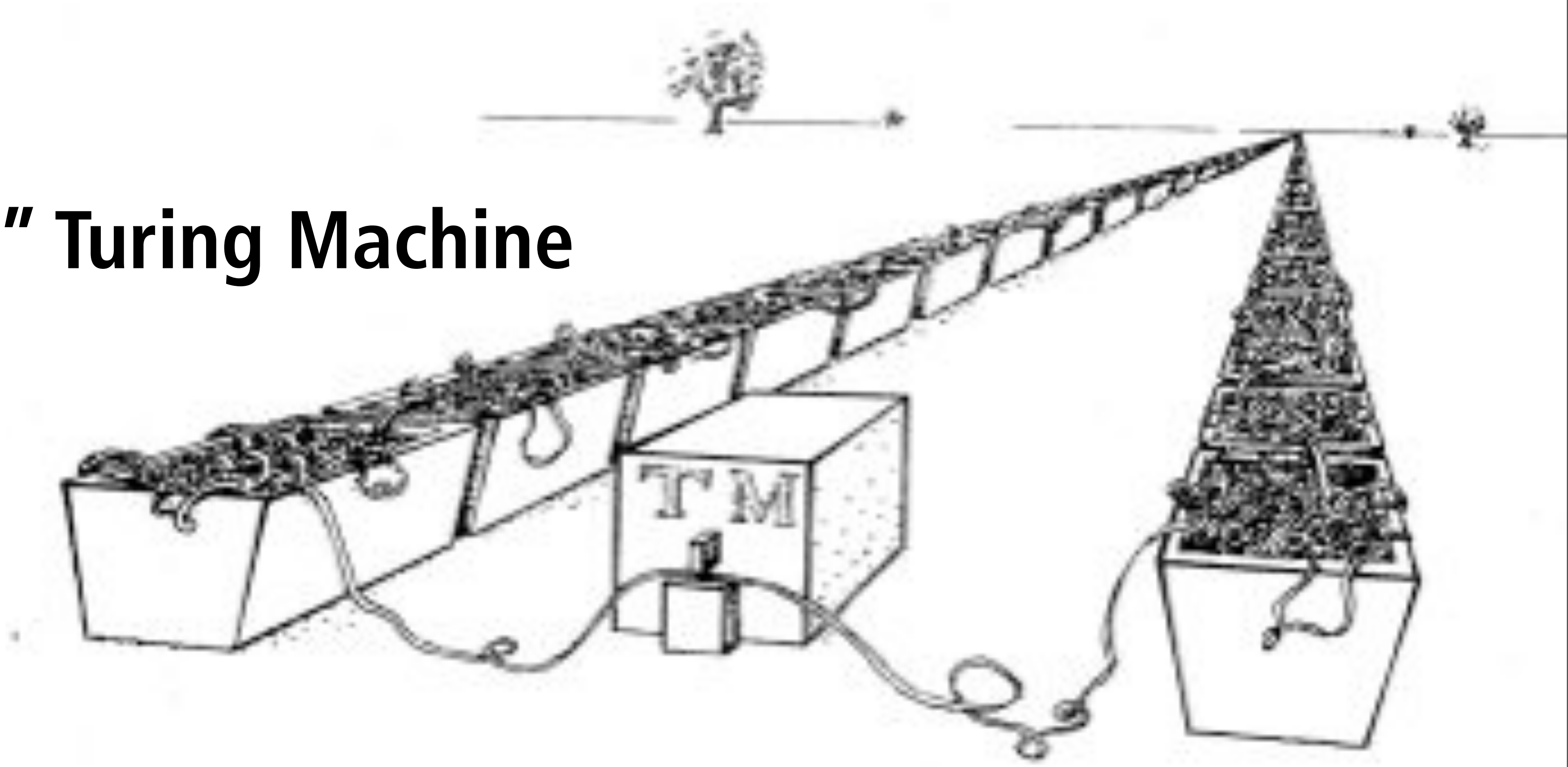
move tape L/R

next state of r/w head

The Universal Turing Machine

Turing Machine (5)

an "embodied" Turing Machine



Cartoon by
Roger Penrose

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This cartoon shows that physically handling a tape of potentially infinite length might in fact be the bigger problem than performing computation.

Functionalism and the “Physical Symbol Systems Hypothesis”

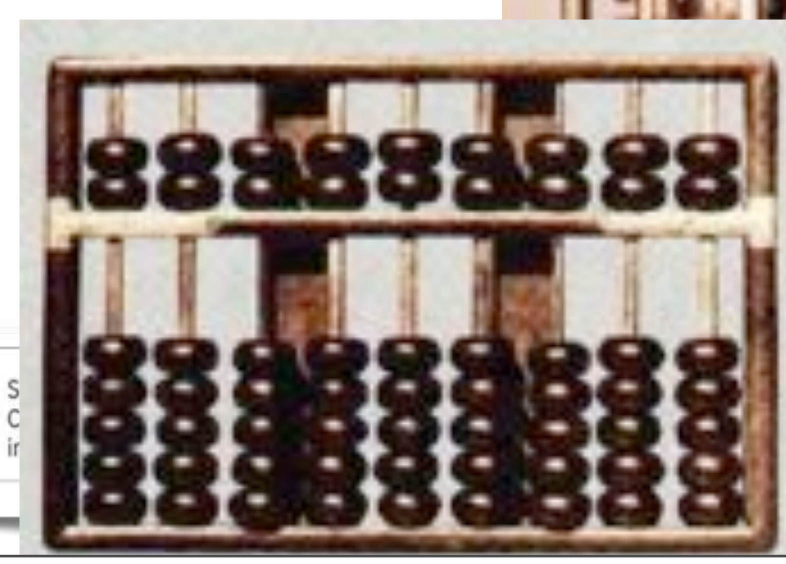
biological

electronic

Swiss cheese
Hilary Putnam
(American
Philosopher)

robotics

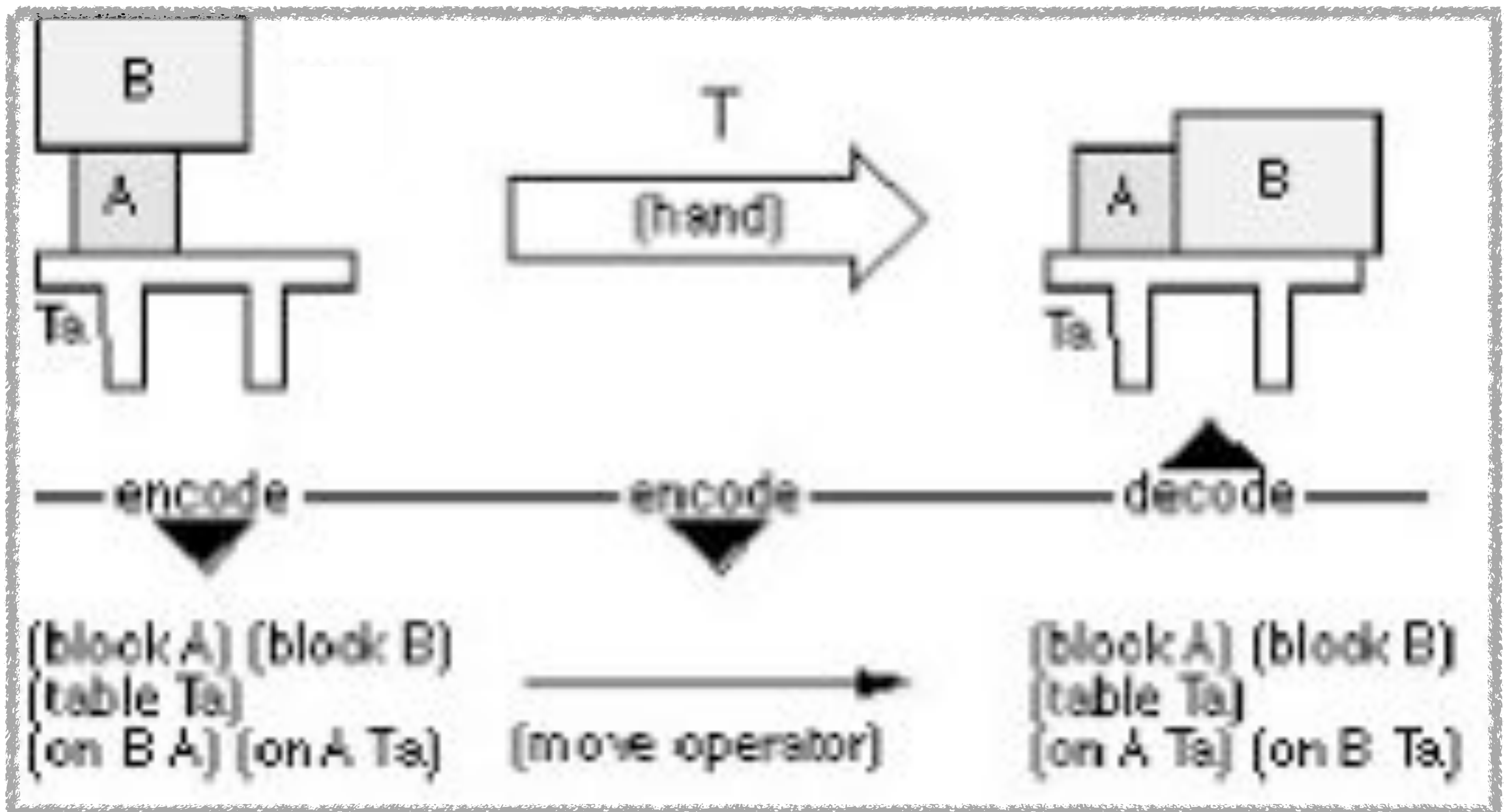
mechanical



The term functionalism is used differently in different contexts. Here we use Putnam’s notion, i.e. the idea that a (mental) process can be implemented in different physical media, mechanical, neural spikes in a biological systems, flip-flops in a computers, or “Swiss cheese”.

Functionalism and the “Physical Symbol Systems Hypothesis”

Model/Representation:



The so-called physical symbol systems hypothesis (PSSH) by Allen Newell and Herbert Simon states that for “general intelligent action” it is a necessary and sufficient condition that the system be a “physical symbol system”, i.e., a system that can build and manipulate symbol structures and has a physical implementation (e.g., a brain or a computer).

GOFAI

G

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A

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(John Haugeland, Philosopher)

From John Haugeland, “Artificial intelligence — the very idea.” MIT Press, 1993.
Write on Smartboard: Good Old Fashioned Artificial Intelligence

Classical AI: Research areas

- **problem solving**
- **knowledge representation and reasoning**
- **acting logically**
- **uncertain knowledge and reasoning**
- **learning and memory**
- **communicating, perceiving and acting**

(adapted from Russell/Norvig: Artificial intelligence, a modern approach)

Today's topics

- short recap
- The classical approach: Cognition as computation
- **Successes and failures of the classical approach**
- Some problems of the classical approach
- The need for an embodied approach
- The "frame-of-reference" problem

Classical AI: Successes

- search engines
- formal games (chess!)
- text processing systems
- data mining systems
- restricted natural language systems
- appliances
- manufacturing

Indistinguishable from computer applications in general

Chess: New York, 1997

1 win 3 draws 2 wins

Classical AI: Failures

- recognizing a face in the crowd
- vision/perception in the real world
- common sense
- movement, manipulation of objects
- walking, running, swimming, flying
- speech (everyday natural language)

in general:
more natural forms of intelligence

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Why is perception hard?

Why is perception hard?

—> HIT Lab, Tasmania

I will write the points that are mentioned on the smart board, something like:
- distal/proximal sensory stimulation
- stimulation (proximal) depends on: distance, orientation, lighting conditions
- distances continuously change - because we are moving in the environment

--> not simply “computation” - there is much more to it
we will deal with perception in various places as we go along.

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Fundamental problems of the classical approach

Monika Seps, chess master
former master student
AI Lab, Zurich

in general:
anything to do with real world interaction

fundamental differences: real — virtual

virtual, formal world

real world

Fundamental problems of the classical approach

in general:
anything to do with real world interaction

fundamental differences: real — virtual

virtual, formal world

real world

Differences real vs. virtual worlds

real vs. virtual world —> Xi'an

I will write the following points on the smart board:
- information acquisition takes time
- only limited information available (high level of uncertainty)
- physical devices subject to noise and malfunction
- no clearly defined, discrete states
- must do several things simultaneously
- real world has own dynamics - things change rapidly
- non-linear, limited predictability

Herbert Simon's "bounded rationality"

Successes and failures of the classical approach

successes

applications (e.g. Google)

chess

manufacturing

(applications: "controlled" artificial worlds)

failures

foundations of behavior

natural forms of intelligence

interaction with real world

(scientific: "real worlds")

Industrial environments vs. real world

industrial environments

environment well-known

little uncertainty

predictability

("controlled"artificial worlds)

real world environment

limited knowledge and predictability

rapidly changing

high-level of uncertainty

("real" worlds)

Industrial robots vs. natural systems

principles:
- **strong, precise, fast motors**
- **centralized control**
- **computing power**
- **optimization**

Industrial robots

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Industrial robots vs. natural systems

principles:
- **low precision**
- **compliant**
- **reactive**
- **coping with uncertainty**

humans

→ no direct transfer of methods

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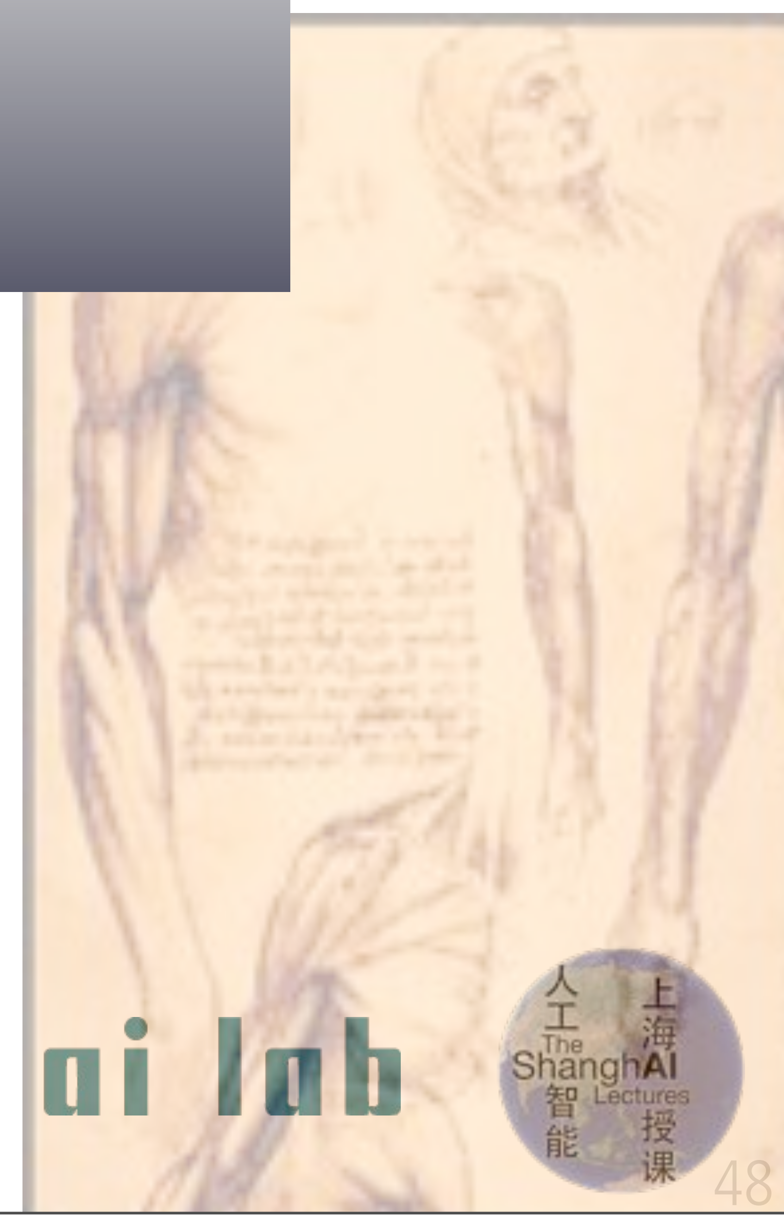
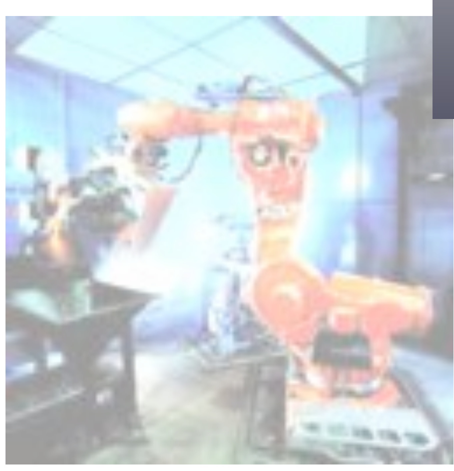
Industrial robots vs. natural systems

principles:

humans



**examples:
see next lecture**



uncertainty

→ no direct transfer of methods

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Fundamental problems of classical approach

- "symbol grounding problem"
- "frame problem"
- "homunculus problem"

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The "symbol grounding" problem

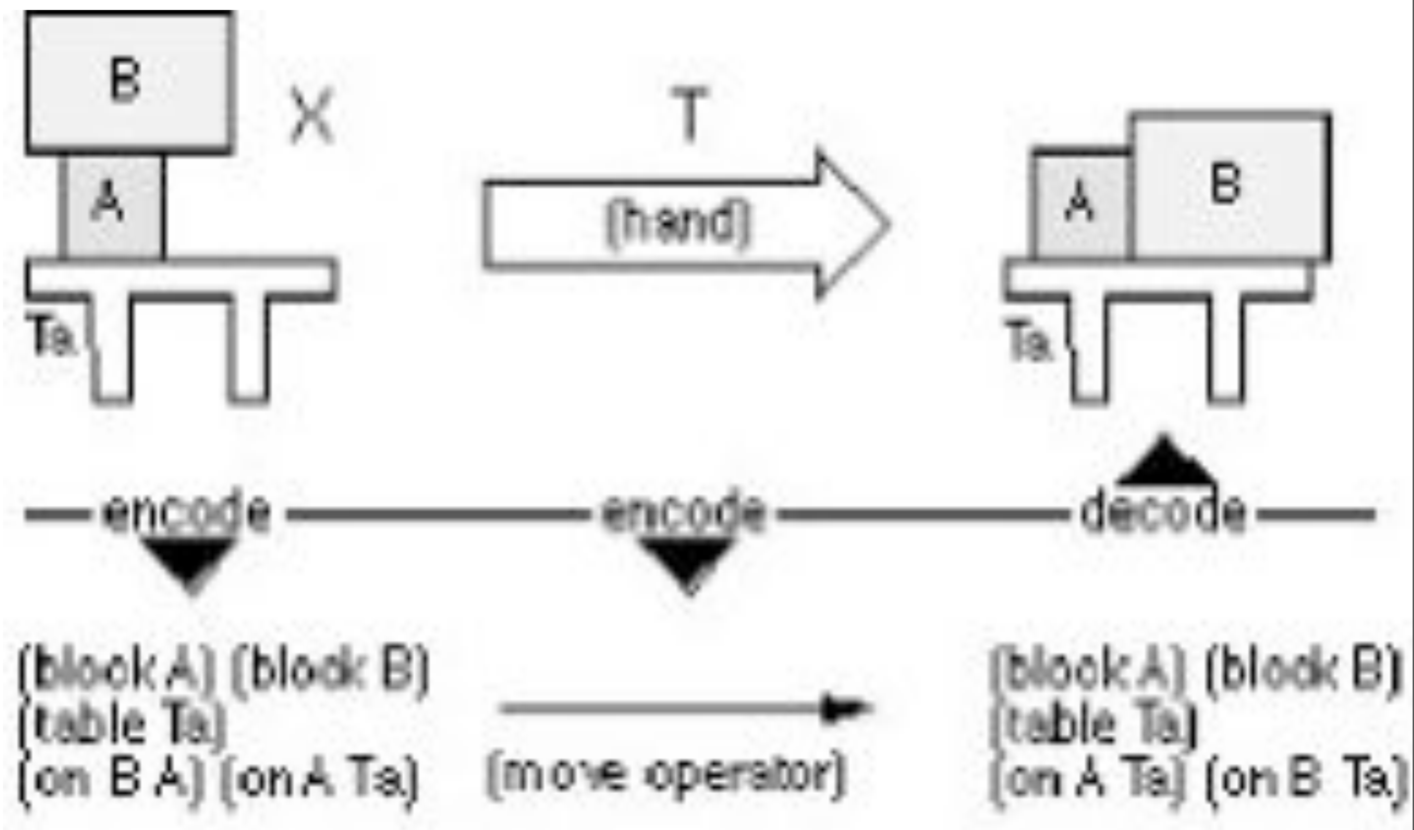
real world: doesn't come with labels ...

"Now! ... That should clear up a few things around here!"

Gary Larson

The "frame problem"
Maintaining model of real world

- the more detailed the harder
- information acquisition
- most changes: irrelevant to current situation



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The “frame problem” (1)

Daniel Dennett, American philosopher (philosophy of mind)

R1: robot

R1D1: robot deducer

R2D1: robot relevant deducer

Illustration: Isabelle Follath

Once upon a time there was a robot, named R1 by its creators. Its only task was to fend for itself. One day its designers arranged for it to learn that its spare battery, its precious energy supply, was locked in a room with a time bomb set to go off soon.

R1 located the room, and the key to the door, and formulated a plan to rescue its battery. There was a wagon in the room, and the battery was on the wagon, and R1 hypothesized that a certain action which it called PULLOUT(WAGON, ROOM) would result in the battery removed from the room. Straightaway it acted, and did succeed in getting the battery out of the room before the bomb went off. Unfortunately, however, the bomb was also on the wagon. R1 knew that the bomb was on the wagon in the room, but didn't realize that pulling the wagon would bring the bomb out along with the battery. Poor R1 had missed that obvious implication of its planned act.

The "frame problem" (2)

Daniel Dennett, American philosopher (philosophy of mind)

R1: robot

R1D1: robot deducer

R2D1: robot relevant deducer

Illustration: Isabelle Follath

Back to the drawing board. ``The solution is obvious,'' said the designers. ``Our next robot must be made to recognize not just the intended implications of its acts, but also the implications about their side-effects, by deducing these implications from the descriptions it uses in formulating its plans.'' They called their next model, the robot-deducer, R1D1. They placed R1D1, in much the same predicament that R1 had succumbed to, and as it too hit upon the idea of PULLOUT(WAGON, ROOM) it began, as designed, to consider the implications of such a course of action. It had just finished deducing that pulling the wagon out of the room would not change the colour of the room's walls, and was embarking on a proof of the further implication that pulling the wagon out would cause its wheels to turn more revolutions than there were wheels on the wagon---when the bomb exploded.

The "frame problem" (3)

Daniel Dennett, American philosopher (philosophy of mind)

R1: robot

R1D1: robot deducer

R2D1: robot relevant deducer

Illustration: Isabelle Follath

Back to the drawing board. ``We must teach it the difference between relevant implications and irrelevant implications," said the designers, ``and teach it to ignore the irrelevant ones." So they developed a method of tagging implications as either relevant or irrelevant to the project at hand, and installed the method in their next model, the robot-relevant-deducer, R2D1 for short. When they subjected R2D1 to the test that had so unequivocally selected its ancestors for extinction, they were surprised to see it sitting, Hamlet-like, outside the room containing the ticking bomb, the native hue of its resolution sicklied o'er with the pale case of thought, as Shakespeare (and more recently Fodor) has aptly put it. ``Do something!" they yelled at it. ``I am," it retorted. ``I'm busily ignoring some thousands of implications I have determined to be irrelevant. Just as soon as I find an irrelevant implication, I put it on the list of those I must ignore, and ..." the bomb went off.

(from Dennett, D. (1987). Cognitive wheels: the frame problem in AI. In C. Hookway (Ed.), Minds, Machines, and Evolution: Philosophical Studies. Bantain: Bean Books.)

Summary of Dennett's points

- obvious to humans, not obvious to robots (robot only has symbolic model/representation of world)
- vast number of potential side effects, mostly irrelevant
- distinction between relevant and irrelevant inferences → must test all

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Two views of intelligence

classical:
cognition as computation

embodiment:
cognition emergent from sensory-motor and interaction processes

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Cognition as computation: many problems, e.g.
- perception
- manipulation
- movement
- locomotion (walking, running)

has lead to the problems mentioned (symbol grounding, frame problem, etc.).
In general: neglect of interaction with real world

The need for an embodied perspective

- "failures" of classical AI
- fundamental problems of classical approach
- Wolpert's quote:

The need for an embodied perspective

"Why do plants not have brains?"

The need for an embodied perspective

"Why do plants not have brains? The answer is actually quite simple — they don't have to move." Lewis Wolpert, UCL

evolutionary perspective on development of intelligence/cognition

The need for an embodied perspective

- "failures" of classical AI
- fundamental problems of classical approach
- Wolpert's quote: Why do plants not …?
- Interaction with environment: always mediated by body

Today’s topics

- short recap
- The classical approach: Cognition as computation
- Successes and failures of the classical approach
- Some problems of the classical approach
- The need for an embodied approach
- **The “frame-of-reference” problem**

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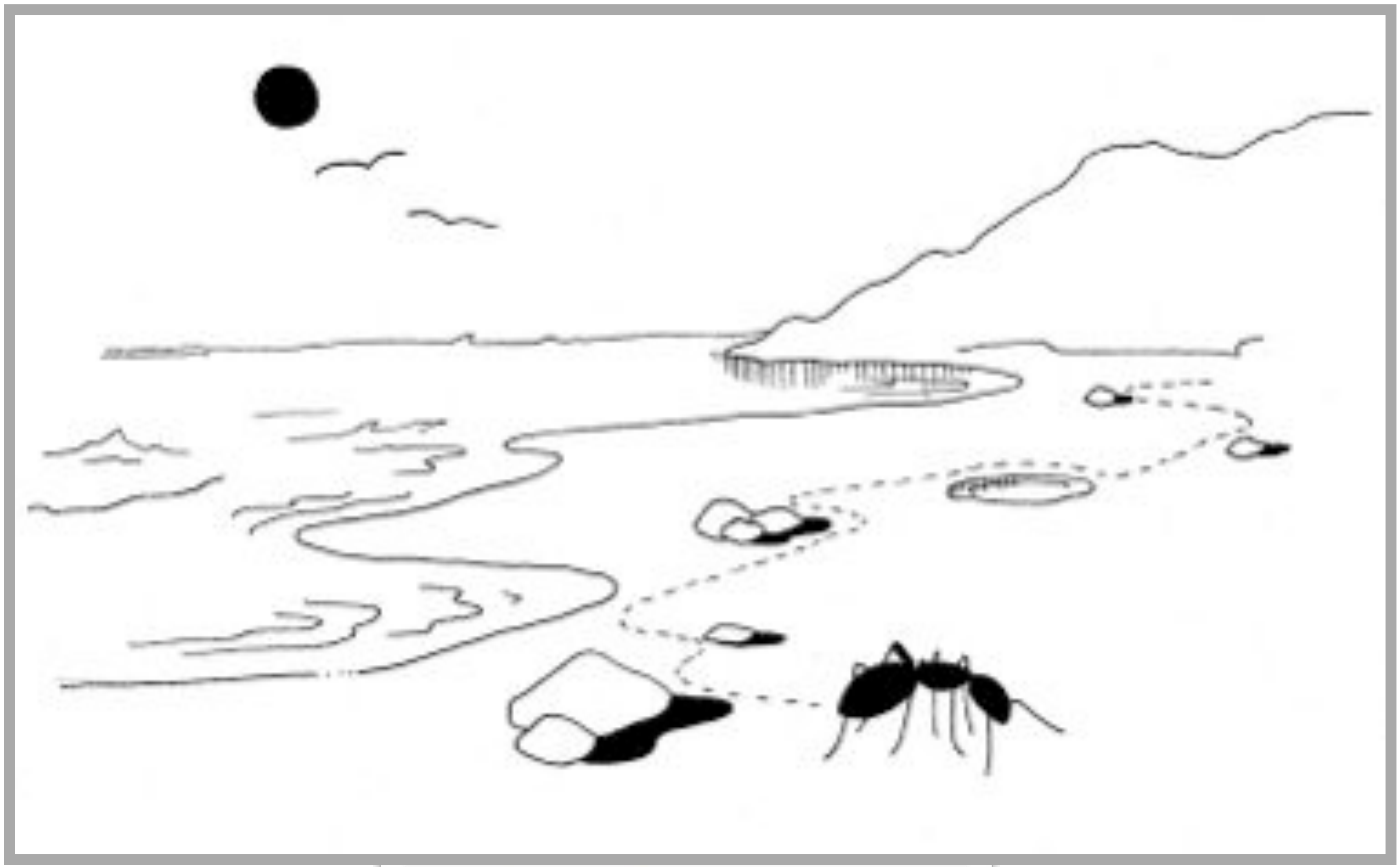
The "frame-of-reference" problem — introduction

Video "Heider and Simmel"

More than sixty years ago (1944) the psychologists Fritz Heider and Marianne Simmel conducted an experimental study, which can be seen as the starting point of attribution theory research. Moving symbols were shown during a short animated cartoon which subjects unanimously described as living objects (mostly people).
"Anthropomorphization, the incurable disease", David McFarland, Oxford University

"Frame-of-reference" Simon's ant on the beach



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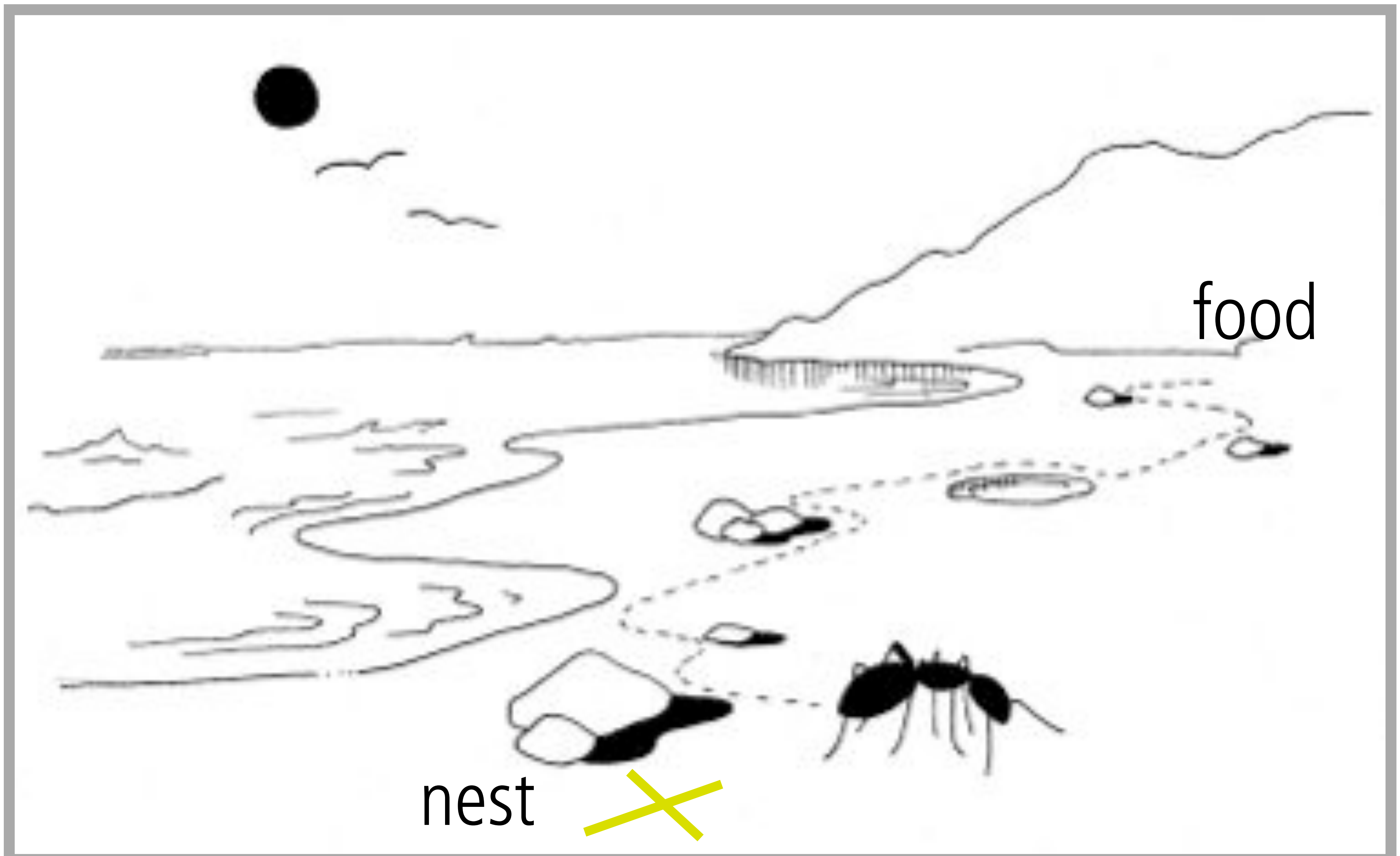
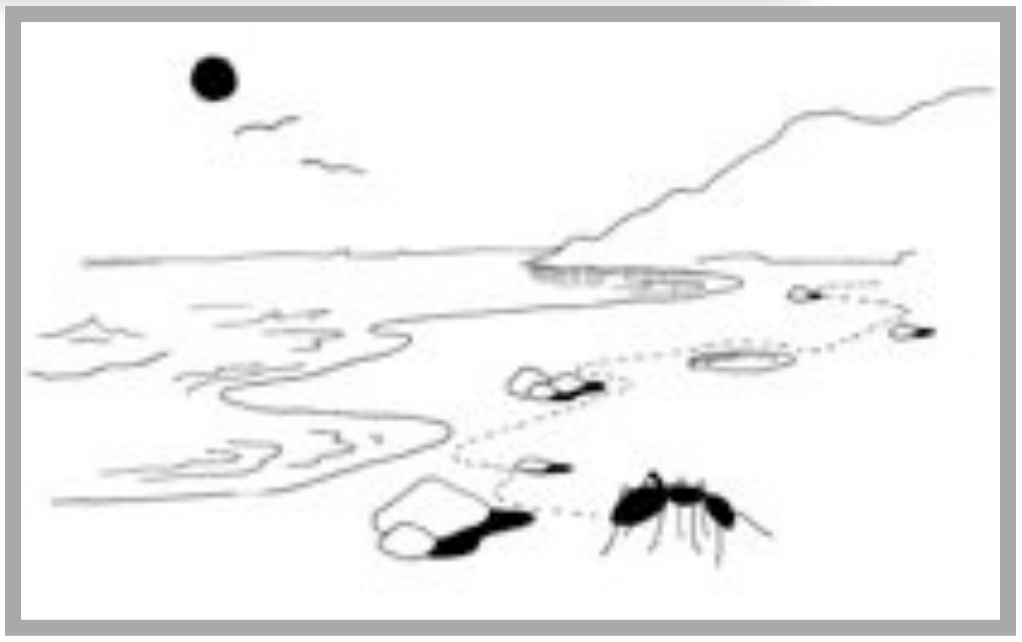
From Herbert A. Simon: The sciences of the artificial. MIT Press.

“Frame-of-reference” Simon’s ant on the beach



“Frame-of-reference”
Simon’s ant on the beach

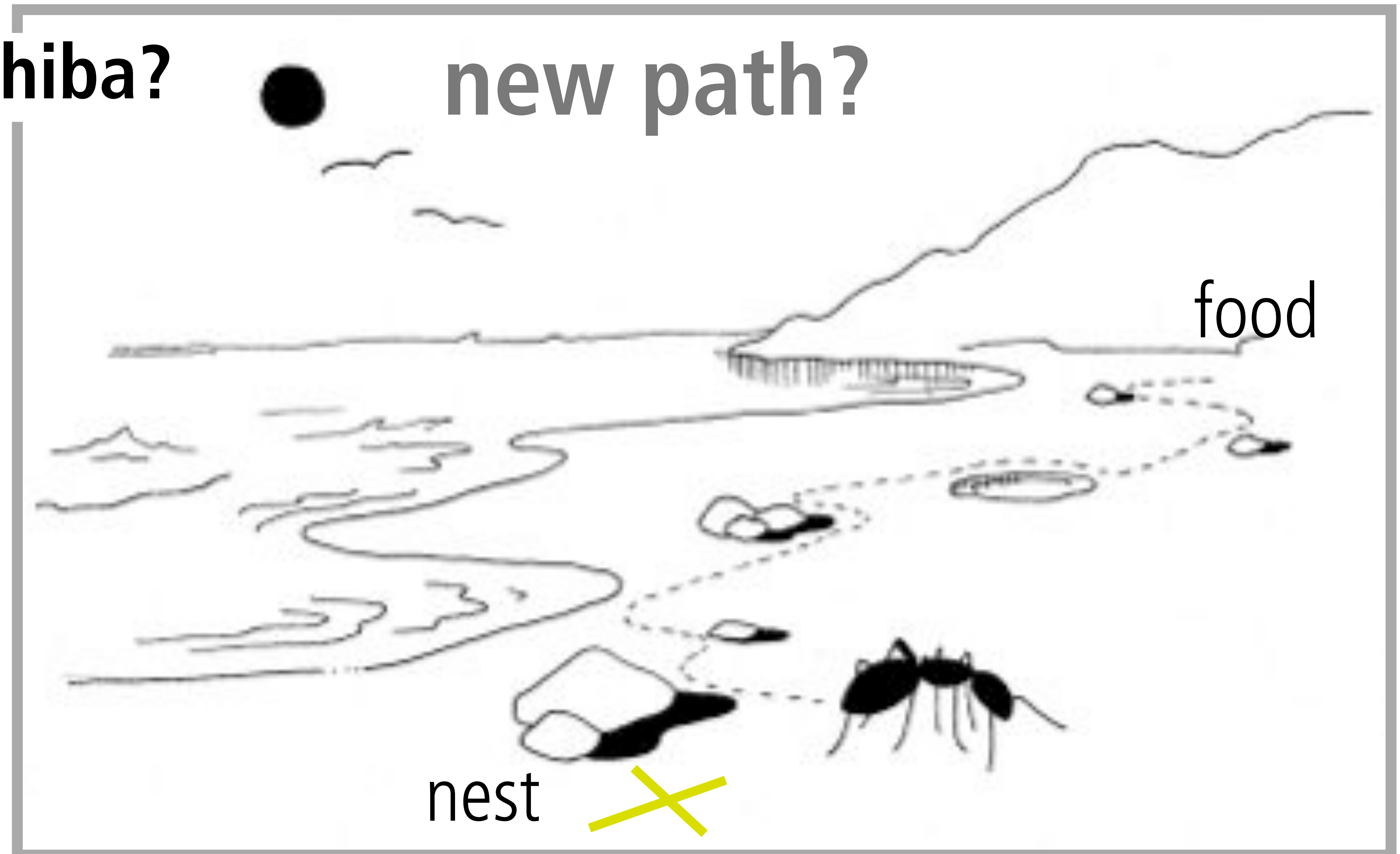


- **simple behavioral rules**
- **complexity in interaction, not — necessarily — in brain**

- thought experiment:
  increase body by factor of 1000
  everything else the same

“Frame-of-reference”
Simon’s ant on the beach

—> **Chiba?**



"Frame-of-reference" F-O-R

- perspectives issue
- behavior vs. mechanism issue
- complexity issue

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F-O-R competition ?

Swiss Chocolate

Champagne

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Mittwoch, 12. Oktober 2011

Should I forget to mention the FOR problem in any of the lectures, the first to discover will get either a box of chocolate or a bottle of champagne. If there is one idea that everyone should remember, it’s the FOR problem.

Assignments for next week

- Read chapter 3 of "How the body …"
- Familiarize yourself with the main brain imaging techniques (there are many good basic introductions on the internet)

End of lecture 2

Thank you for your attention!

stay tuned for lecture 3

“Towards a theory of intelligence”

Additional slide materials for self-study

The "homunculus problem"

"Homunculus" literally means "little man"; as used here, it designates a "little man in the head."

The homunculus problem, or the homunculus fallacy, as it is also called, refers to circular accounts of psychological processes. These processes are circular because they ascribe to some internal mechanism (the homunculus) the very psychological properties being investigated in the first place. For example, a theory of vision might postulate that there is within the brain a mechanism - the "homunculus" that scans, views, or inspects images on the retina. Such a theory would be vacuous, however, since scanning, viewing, and inspecting are all instances of the very visual processes the theory was supposed to illuminate in the first place (Gregory 1987, p. 313). In other words, the theory has assumed the very things it set out to explain.

Issue of infinite regress

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Gregory, R.L (1987). The Oxford companion to the mind. Oxford, UK: Oxford University Press.

Problems to think about: Meaning?

Imagine that you are using an electronic train schedule to figure out a train from Shanghai to Beijing. What does the program know about trains and train schedules? What is the input to the program and what is its output? How come, you will finally end up in the right train? Where does the meaning come from?

End of additional slide materials for self-study