

人  
工  
The  
**ShanghAI**  
智  
能  
上海  
AI  
Lectures  
授

Freitag, 30. September 2011



# 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 THINKLab  
University of Salford, UK

欢迎您参与  
“来自上海的人工智能系列讲座”

# Lecture 1

---

**Intelligence — An Eternal Mystery  
What it is and how it can be studied**

**September 2011**



University of Zurich



**ai lab**



3

Freitag, 30. September 2011

# Goals

---

- **What is intelligence? Natural and artificial?**
- **conceptual and technical know-how in the field**
- **informed opinion on media reports**
- **things can always be seen differently**
- **new ways of thinking about ourselves and the world around us**



University of Zurich



ai lab



# Goals

- What is intelligence? Natural and artificial?
- conceptual and technical know-how in the field
- informed opinion on media reports

with a student presentation  
from Salford University



University of Zurich



ai lab



# Goals

---

- What is intelligence? Natural and artificial?
- conceptual and technical know-how in the field
- **informed opinion on media reports**
- things can always be seen differently
- new ways of thinking about ourselves and the world around us



University of Zurich



ai lab



6

# Robots, artificial intelligence in the media

HAL, the “Hybrid  
Assistive Limb ®”  
Cyberdyne Inc.



Sex and marriage with  
robots? “It could  
happen” (David Levy)



Engkey, the Korean English  
language Teacher

Beer-serving robot



Freitag, 30. September 2011

[http://www.koreatimes.co.kr/www/news/biz/2010/12/123\\_77813.html](http://www.koreatimes.co.kr/www/news/biz/2010/12/123_77813.html)

# Engkey: the English language teacher

## **Korea to offer commercially viable English-speaking robots in 2013** 한글

By Kim Tae-gyu

A total of 29 English-language education robots will be placed in 21 elementary schools in Daegu next week for a four-month feasibility study to check the commercial viability of robotic teachers, to go on sale in 2013.

The state-run Korea Institute of Science and Technology (KIST) said Friday that the robotic assistants, dubbed "Engkey" combining "English" and "disc jockey," will help teachers during English classes.

"We will carry out the second-phase pilot program with Engkey until next March after wrapping up the first project over the past year in Muan, South Gyeongsang Province," KIST



An English-language education robot named Engkey

# Goals

---

- What is intelligence? Natural and artificial?
- conceptual and technical know-how in the field
- informed opinion on media reports
- **things can always be seen differently**
- **new ways of thinking about ourselves and the world around us**



University of Zurich



ai lab



9

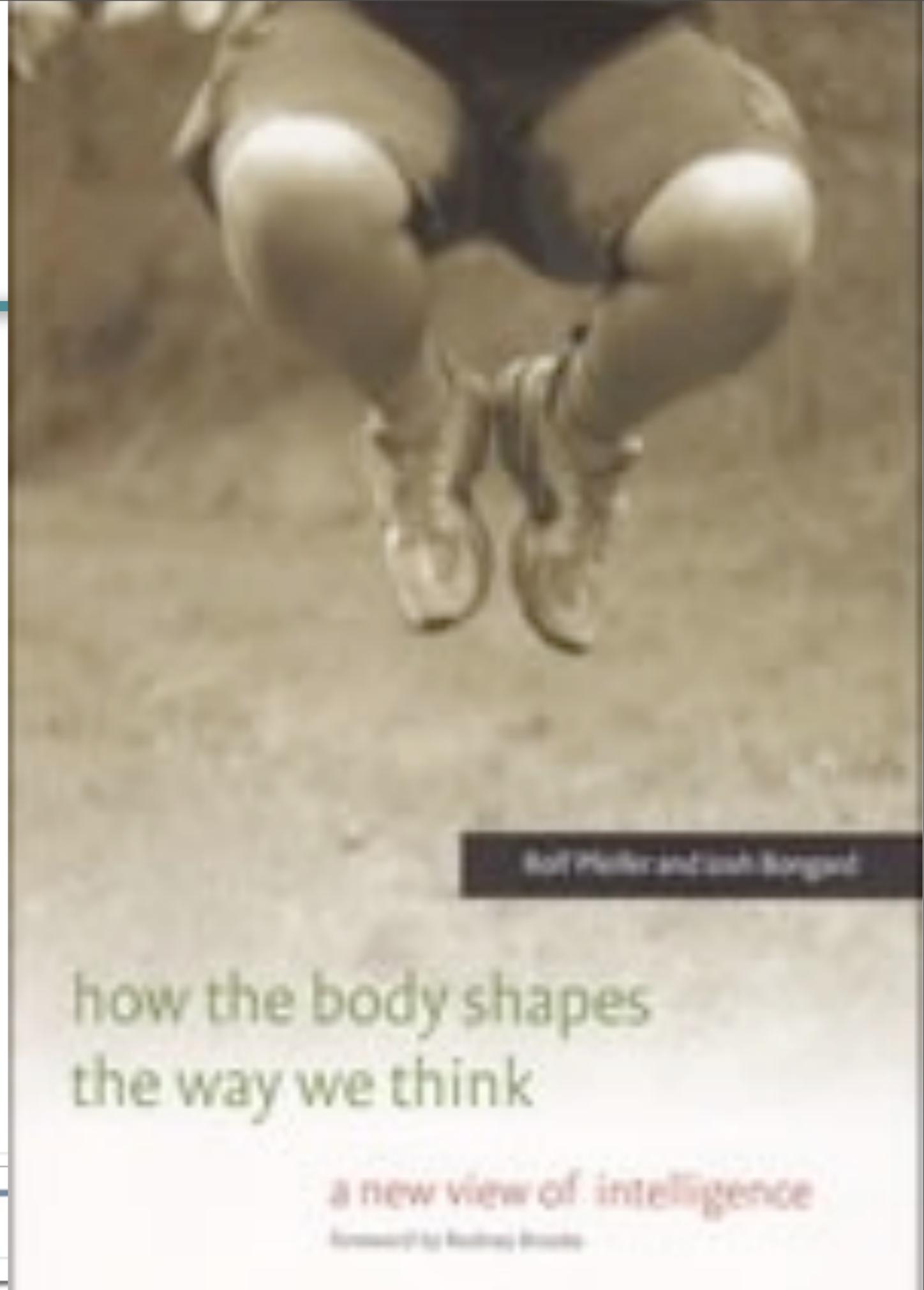
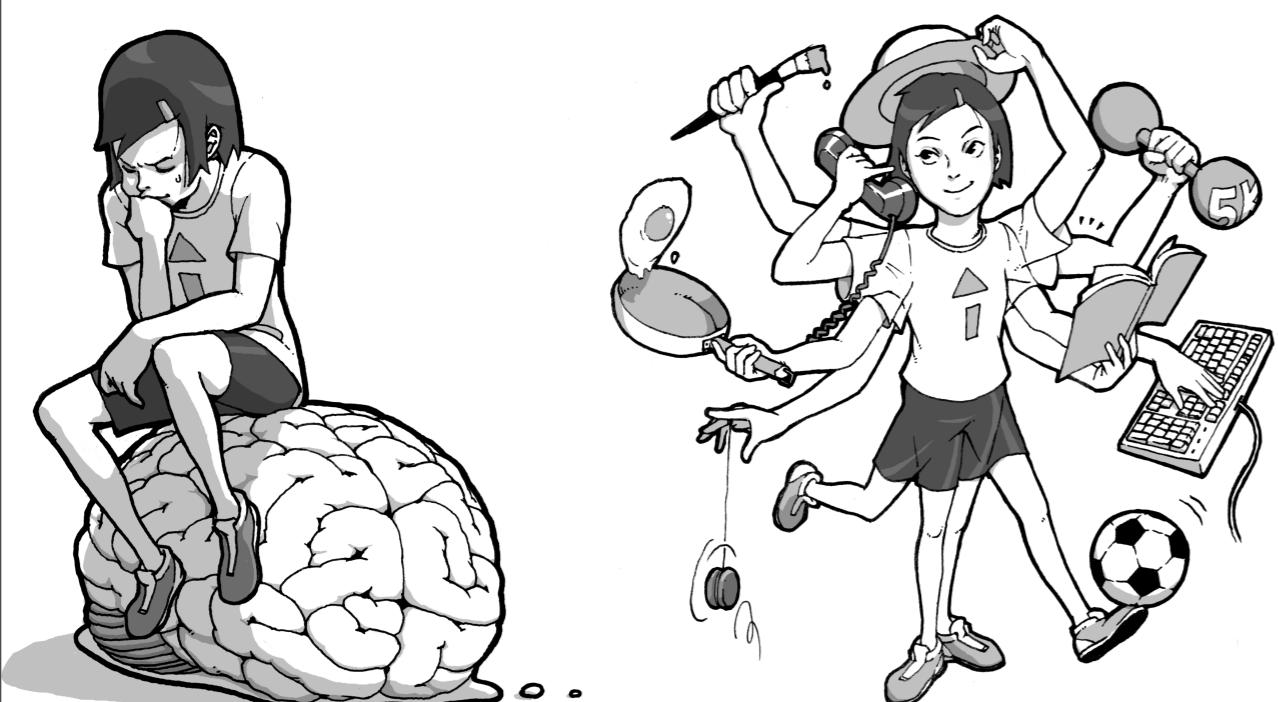
# Book for class

Rolf Pfeifer and Josh Bongard

How the body shapes the way we think — a new view of intelligence

MIT Press, 2007

Illustrations by Shun Iwasawa

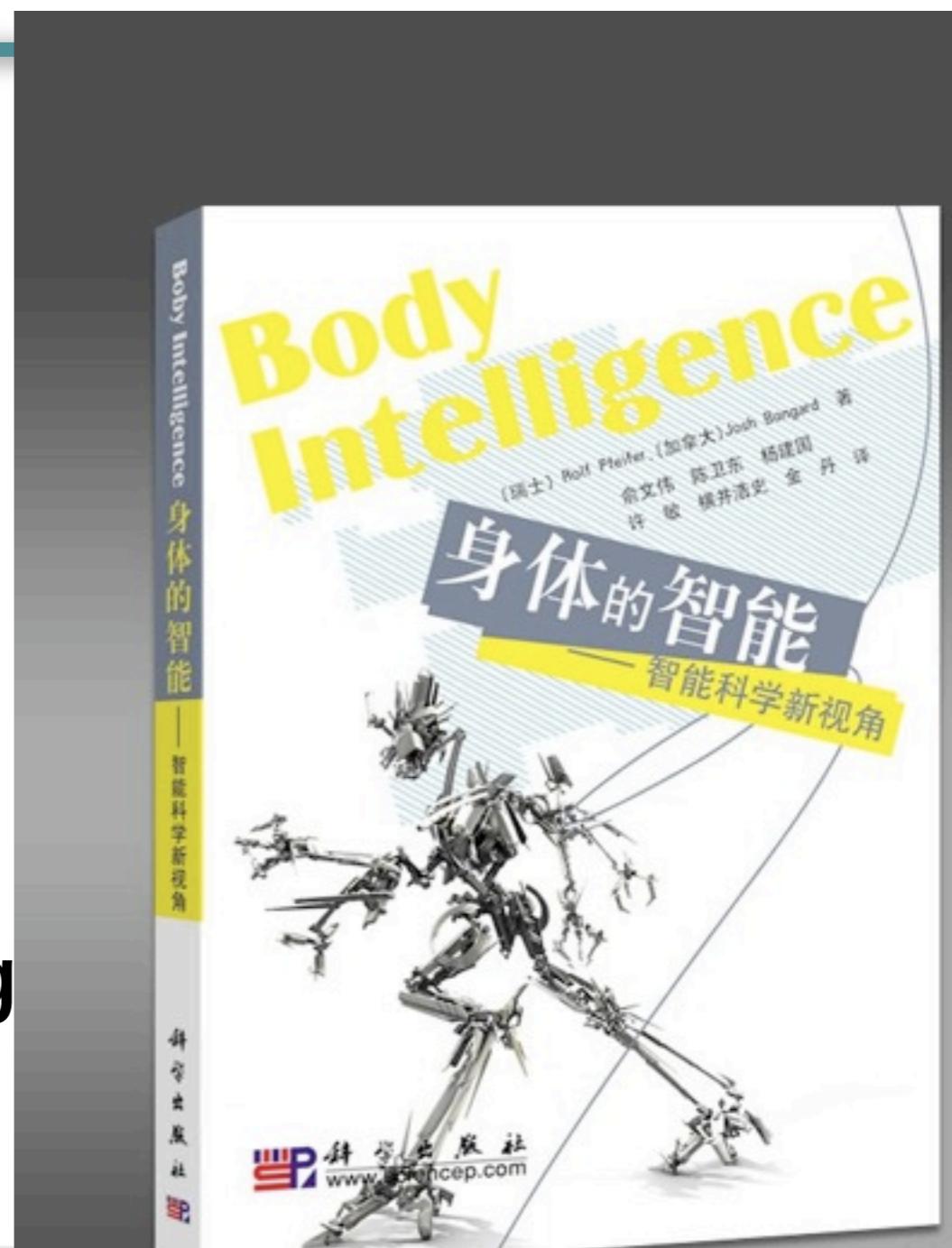


Freitag, 30. September 2011

# Chinese translation

Translated by  
**Weidong Chen**  
Shanghai Jiao Tong University  
and  
**Wenwei Yu**  
Chiba University, Japan

Foreword by  
**Lin Chen**  
Chinese Academy of Science, Beijing



耕者设计



University of Zurich



# Japanese Edition

How  
the way  
we think :  
a new view of  
intelligence

ISBN978-4-320-05697-8

C3045 ¥2900E



978432005697

アタリ



192304502900

定価（本体2,900円+税）

# 知能の原理

R. Pfeifer, J. Bongard 著

細田 耕・石黒 章夫 訳

身体性に基づく構成論的アプローチ



共立出版



Centre of Competence  
in Research



University of Zurich

FOCUS

12

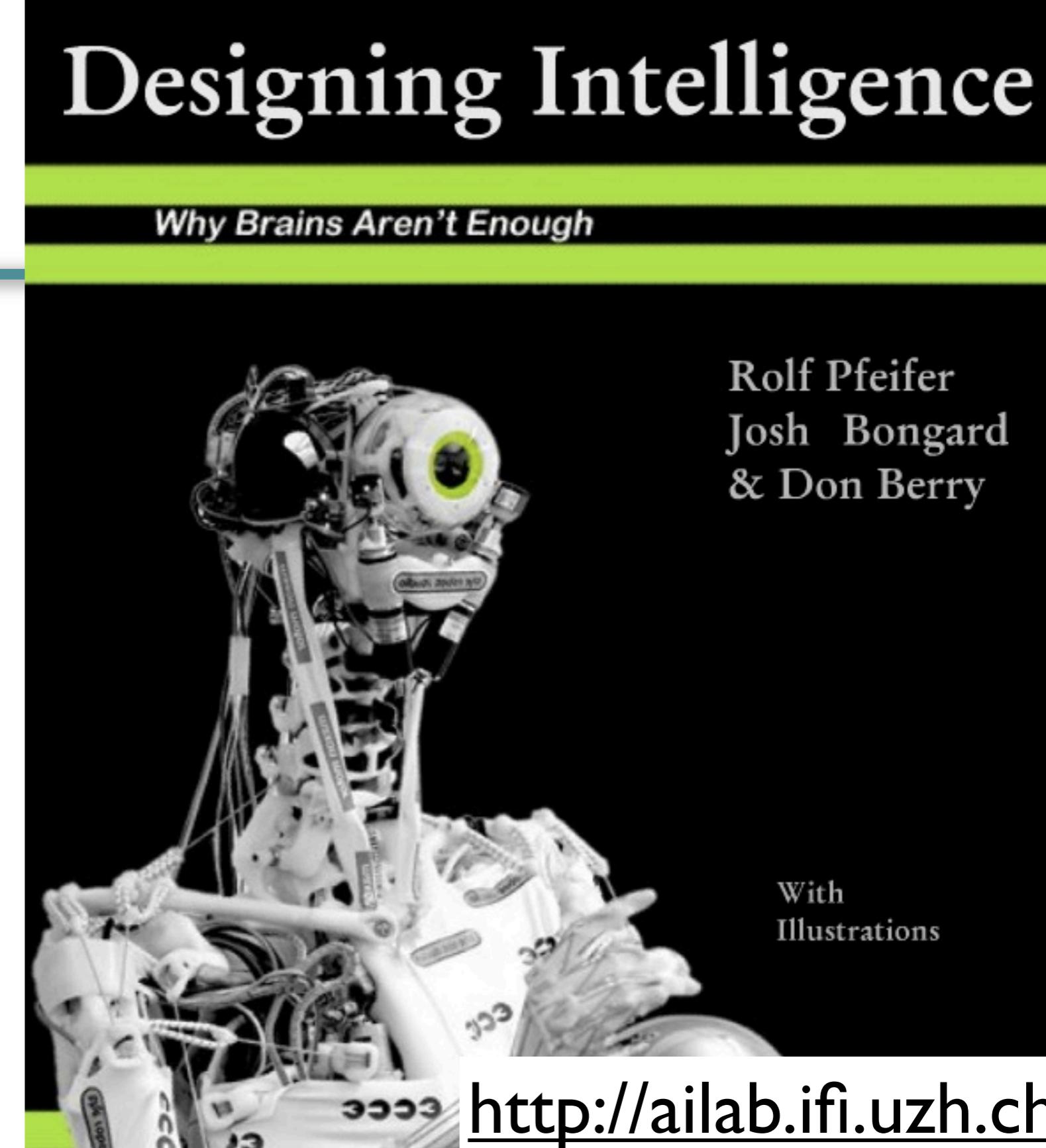
# Short e-book version

Designing  
Intelligence

Why Brains  
Aren't Enough

Rolf Pfeifer  
Josh Bongard  
Don Berry

(100 pages)



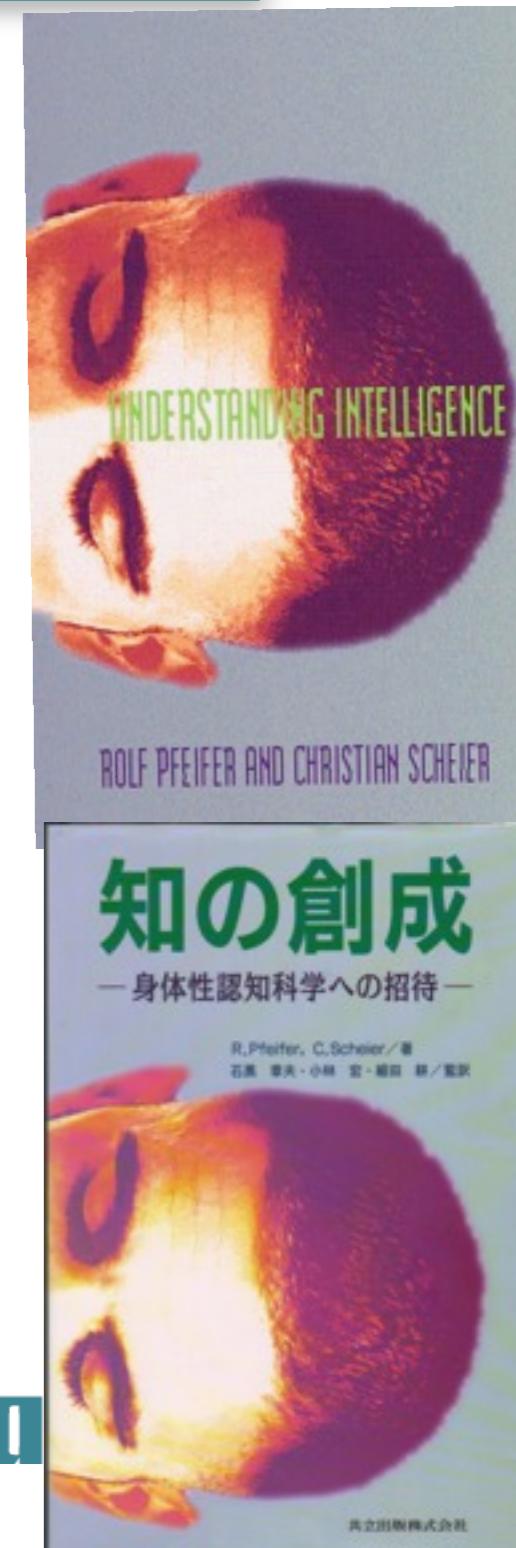
Can be downloaded from here:

<http://www.grin.com/e-book/165548/designing-intelligence#inside>

ai lab

# Can be complemented by

Rolf Pfeifer and Christian Scheier  
Understanding Intelligence  
MIT Press, 1999 (paperback edition)



知の創成、共立出版、2001



University of Zurich



ai lab

# Today's topics

---

- characterizing intelligence, thinking, and cognition
- “Turing Test” and “Chinese Room Experiment”
- intelligence testing — IQ
- artificial intelligence and its goals
- how to study intelligence: the “synthetic methodology”



University of Zurich



ai lab



15

# Today's topics

---

- **characterizing intelligence, thinking, and cognition**
- “Turing Test” and “Chinese Room Experiment”
- intelligence testing — IQ
- artificial intelligence and its goals
- how to study intelligence: the “synthetic” methodology



University of Zurich



ai lab



16

# Intelligence?

---



University of Zurich

17

ai lab



Freitag, 30. September 2011

What do we intuitively think intelligence is about? We all feel that we know very well what it means - pinning it down exactly is very hard.

- learning
- solving abstract problems
- generalization
- language
- playing chess
- doing math
- creativity
- memory
- generalization
- playing a musical instrument
- sports
- surviving in the wild
- etc.

# Intelligence?

---



University of Zurich

18

ai lab



Freitag, 30. September 2011

# From the Penguin Dictionary of Psychology

---

**“Few concepts in psychology have received more devoted attention and few have resisted clarification so thoroughly.” (Reber, 1995, p. 379)**



University of Zurich



ai lab



19

# Some definitions

“The ability to carry on abstract thinking” (L. M. Terman)

“Having learned or ability to learn to adjust oneself to the environment” (S. S. Colvin)

“The ability to adapt oneself adequately to relatively new situations in life” (R. Pintner)

“A biological mechanism by which the effects of a complexity of stimuli are brought together and given a somewhat unified effect in behavior” (J. Peterson)

“The capacity to acquire capacity” (W. Woodrow)

“The capacity to learn or to profit by experience”  
(W. F. Dearborn)



University of Zurich



ai lab



20

Freitag, 30. September 2011

From a 1927 edition of the Journal of Educational Psychology; leading psychologists at the time were asked for their definitions. Some of these “definitions” are rather odd: what are “relatively new situations in life” (in a definition!); or “... and given a somewhat unified effect in behavior”.

# Definitions of intelligence

---

<http://www.vetta.org/definitions-of-intelligence/>

with 70 definitions

**"... there seem to be almost as many definitions of intelligence as there were experts asked to define it." R.J. Sternberg**

(Robert J. Sternberg, distinguished psychologist; famous book "Beyond IQ: A triarchic theory of human intelligence", 1985)



University of Zurich



ai lab



21

Freitag, 30. September 2011

Robert Sternberg is a distinguished psychologist at Tufts University in Boston. He has contributed much work to the study of intelligence from a psychological point of view. He is also one of the critics of the IQ, arguing that the IQ is too limited.

# Definitions of intelligence

---

<http://www.vetta.org/definitions-of-intelligence/>

## Legg and Hutter (webpage): three commonalities

A property that an individual agent has as it interacts with its environment or environments.

Is related to the agent's ability to succeed or profit with respect to some goal or objective.

Depends on how able the agent is to adapt to different objectives and environments.

Their definition:

**"Intelligence measures an agent's ability to achieve goals in a wide range of environments."**

2

Freitag, 30. September 2011

Robert Sternberg is a distinguished psychologist at Tufts University in Boston. He has contributed much work to the study of intelligence from a psychological point of view. He is also one of the critics of the IQ, arguing that the IQ is too limited.

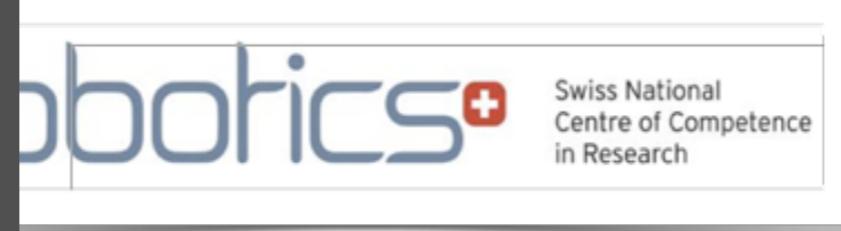
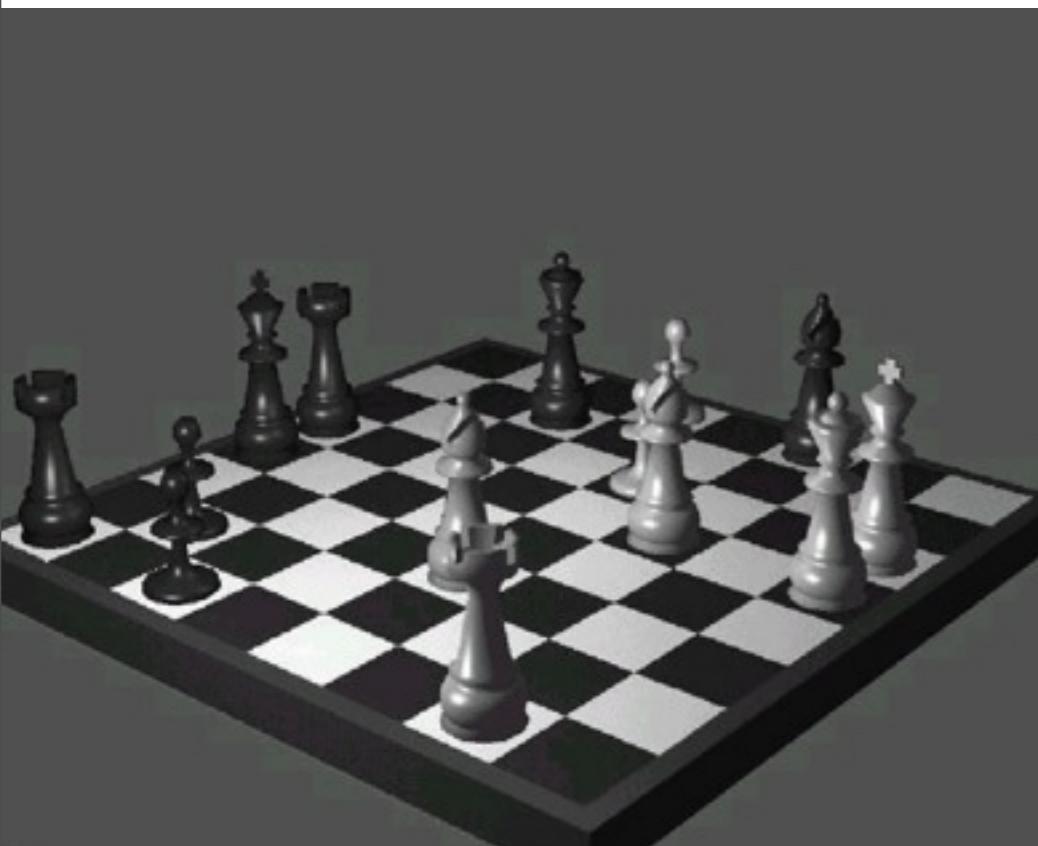
This definition doesn't get us much further because (a) it's very general and (b) it refers to the highly problematic notion of "goals". Do ants have goals?

# Subjectivity, expectations

---

Playing chess

Rolf playing chess



ai lab



23

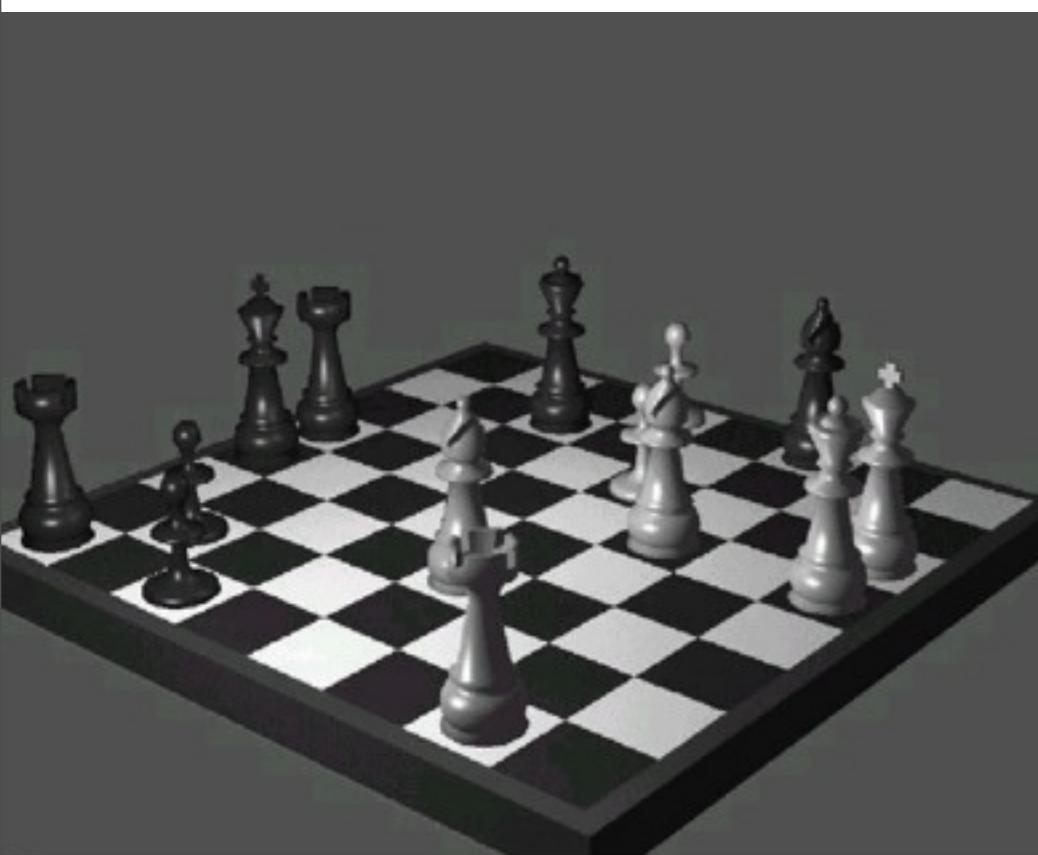
Freitag, 30. September 2011

Personally, I am a mediocre player. If you watch me play, you will not be very convinced of my level of intelligence.

# Subjectivity, expectations

---

Playing chess



Rolf playing chess



Freitag, 30. September 2011

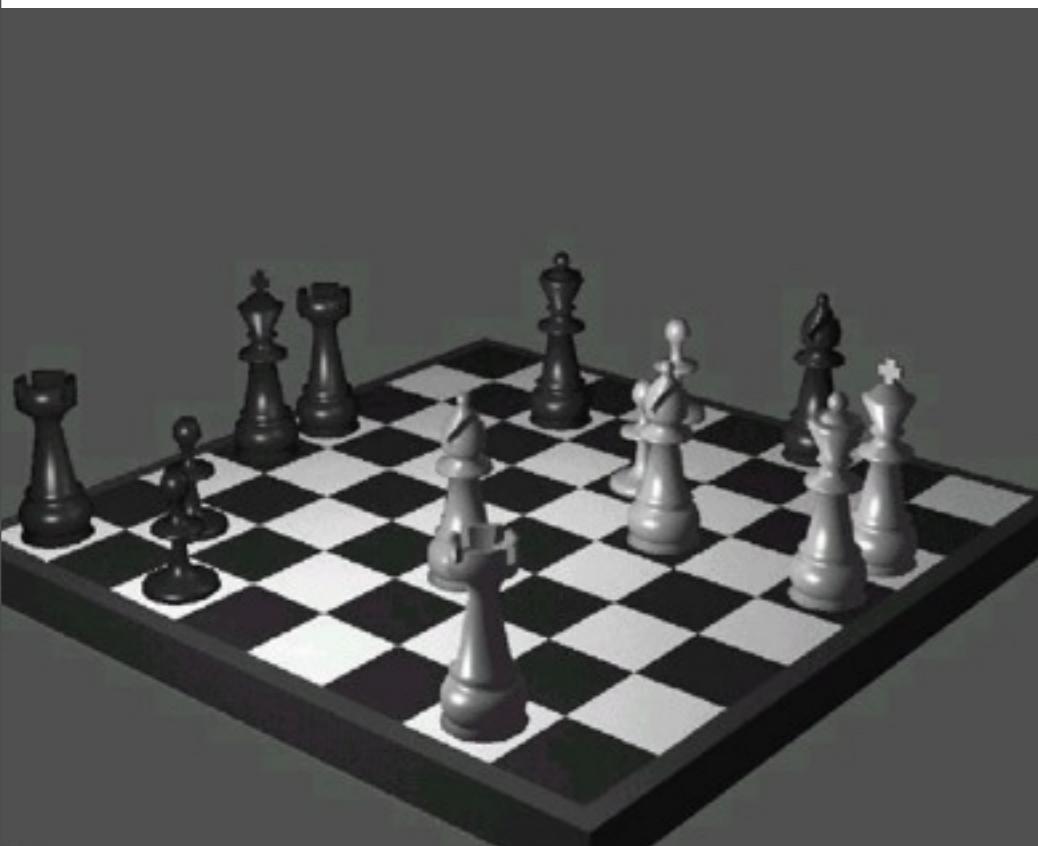
Personally, I am a mediocre player. If you watch me play, you will not be very convinced of my level of intelligence.

# Subjectivity, expectations

---

## Playing chess

baby girl playing chess



Freitag, 30. September 2011

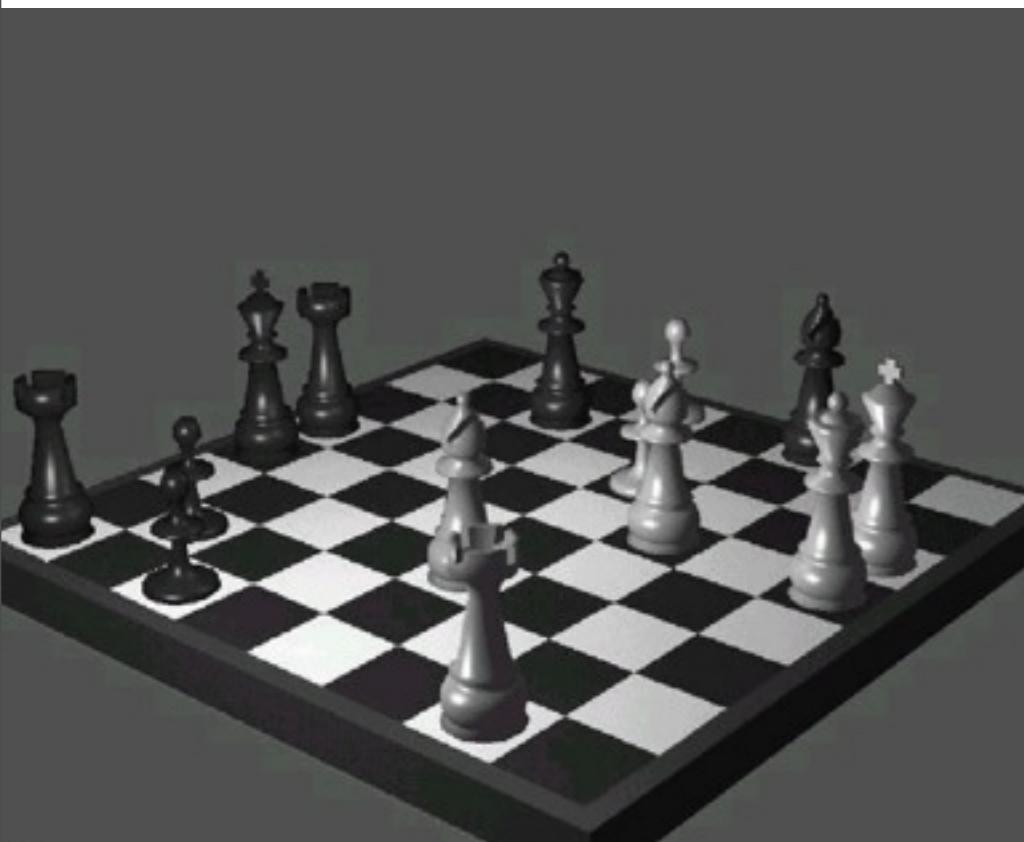
Personally, I am a mediocre player. If you watch me play, you will not be very convinced of my level of intelligence. However, replace myself by a baby girl. If she makes precisely the same moves as I do, you will be very impressed with her level of intelligence.

# Subjectivity, expectations

---

## Playing chess

### dog playing chess



Freitag, 30. September 2011

Personally, I am a mediocre player. If you watch me play, you will not be very convinced of my level of intelligence. Replace myself by a dog. If he made the same moves as I you would think he is a genius.

# Definitions, arguments

---

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



University of Zurich



ai lab



26

Freitag, 30. September 2011

Are ants intelligent? Pro: they can learn, they cooperate, they have high navigational skills, communication abilities, they live in sophisticated societies; Con: neural plasticity limited, language?, tool use, building artifacts, abstract problem solving?

# Definitions, arguments

---

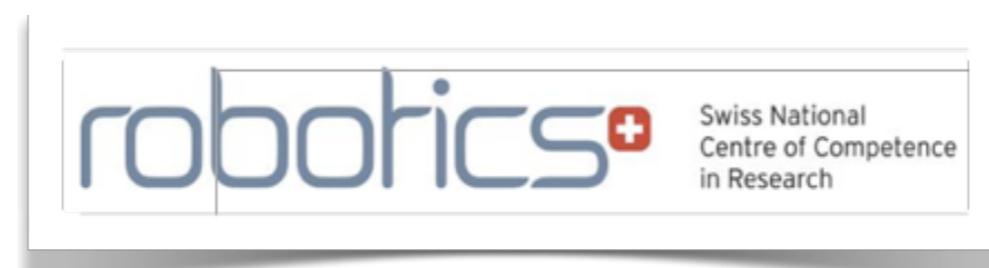
- hard to agree on
- necessary and sufficient conditions?
- are robots, ants, humans intelligent?

more productive question:

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



University of Zurich



ai lab



27

# Interaction and observation

Video "Robovie"

Video "iCub attention"



University of Zurich



ai lab



28

Freitag, 30. September 2011

The most widespread method to judge whether an agent is intelligent is to observe its behavior.

1st video clip: Robovie: interaction of robot with kids in Japanese school

2nd video clip: iCub attention: the fact that iCub seems to be "looking at" objects and humans in the environment makes us attribution intelligence and emotions to the robot

# Interaction and observation

---

videos:

intelligent?

—> highly subjective

—> Turing suggests empirical test



University of Zurich



ai lab



29

Freitag, 30. September 2011

Robovie: interaction of robot with kids in Japanese school

real dog vs. Aibo: short interaction of robot dog Aibo with real dog

iCub attention: the fact that iCub seems to be "looking at" objects and humans in the environment makes us attribution intelligence and emotions to the robot

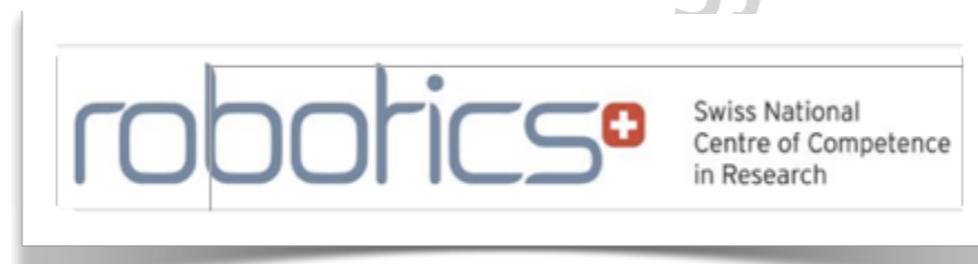
# Today's topics

---

- characterizing intelligence, thinking, and cognition
- “Turing Test” and “Chinese Room Experiment”
- intelligence testing — IQ
- artificial intelligence and its goals
- how to study intelligence: the “synthetic” methodology



University of Zurich



ai lab

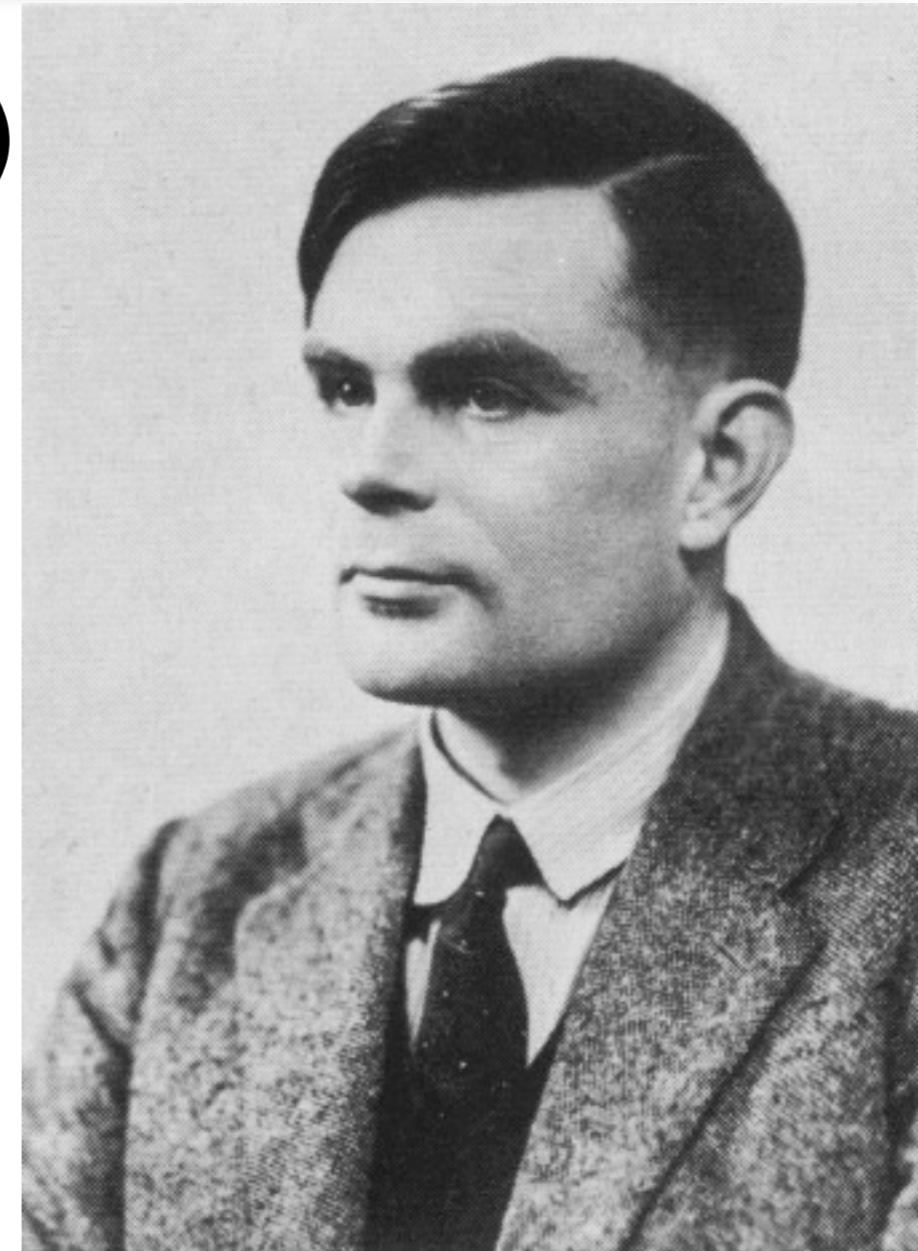


30

# An empirical test?

Alan Turing (1912 - 1954)

- computer
- “computation”
- intelligence



University of Zurich

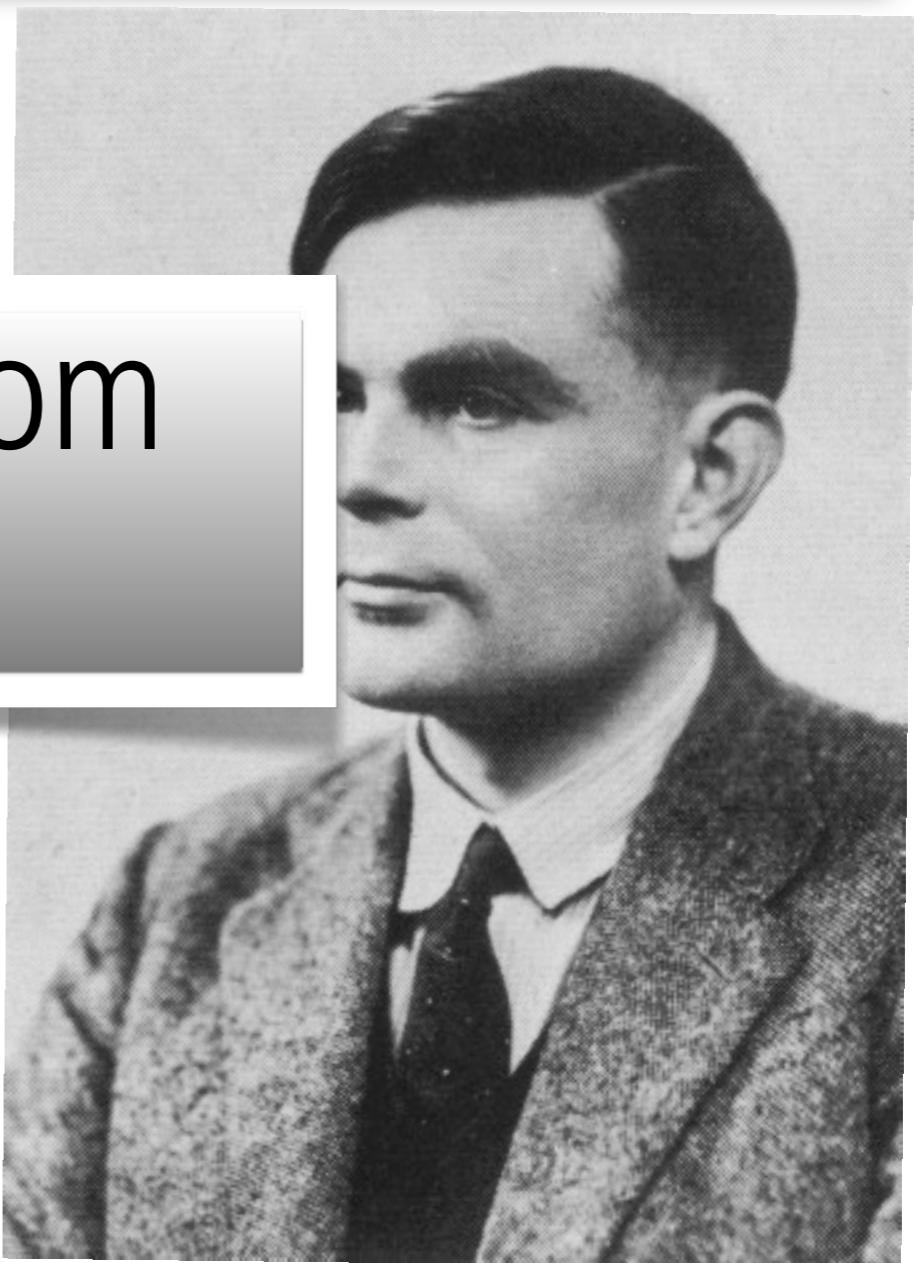


ai lab



# An empirical test?

Alan Turing (1912 - 1954)



Student presentation from  
Salford University

Intelligence



University of Zurich



ai lab



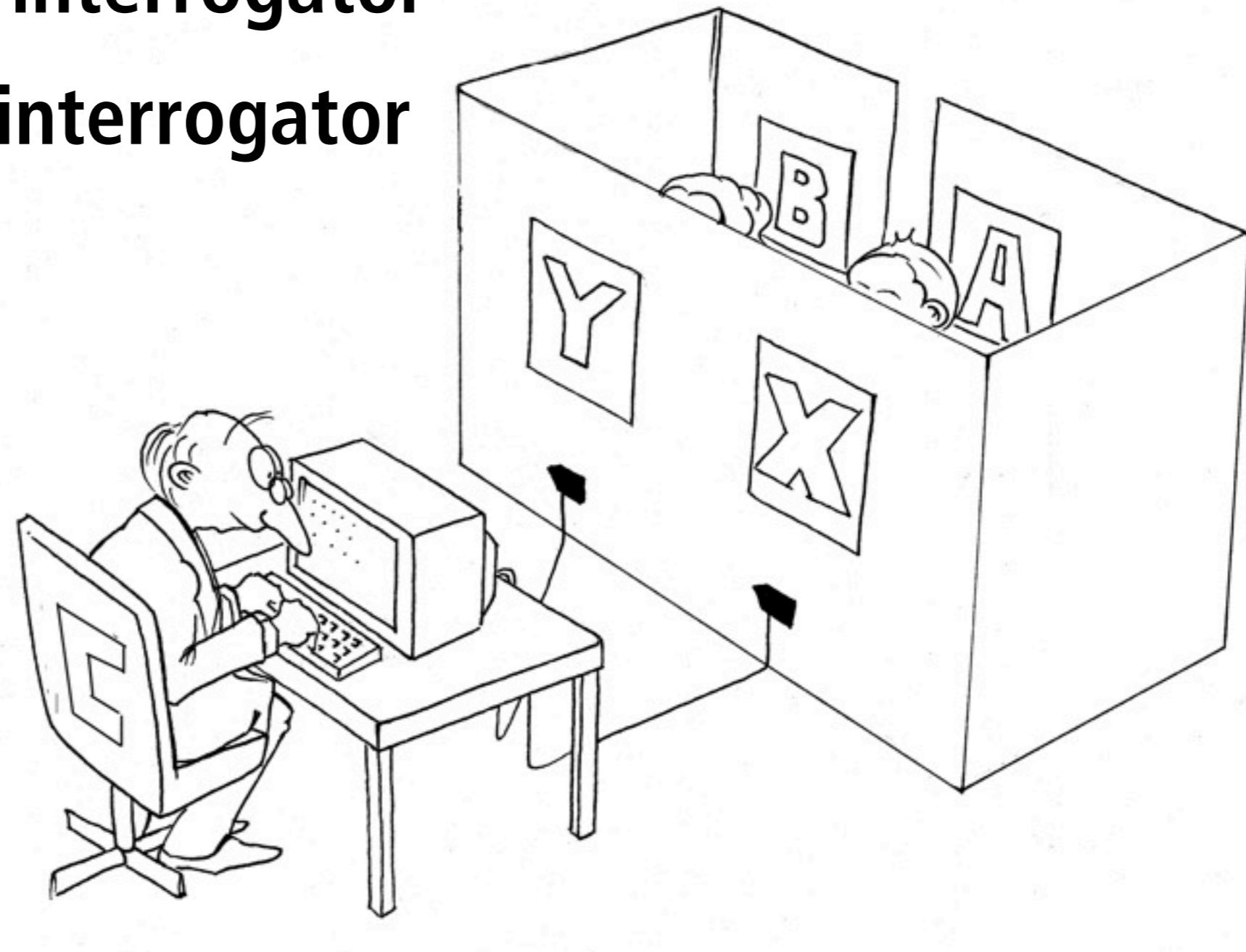
32

# The Turing Test

A: man, confuse interrogator

B: woman, help interrogator

C: interrogator



University of Zurich

课 33

Freitag, 30. September 2011

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 man 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?

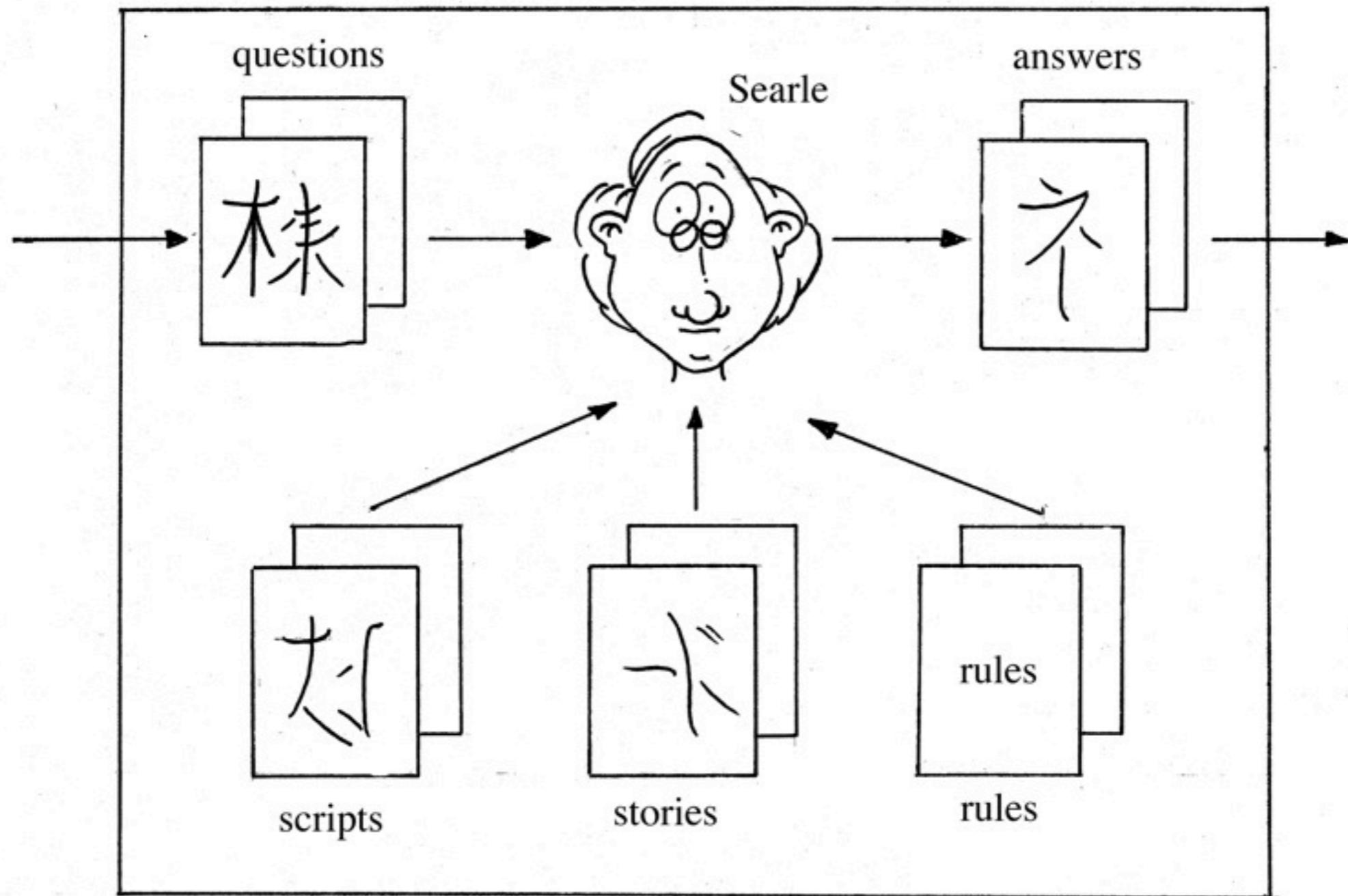
Now suppose the X is actually A, then A must answer. It is A's object in the game to try and cause C to make the wrong identification.

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?". (U1 pp. 16/17).

Often, simplified 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.

# Searle's "Chinese Room" thought experiment

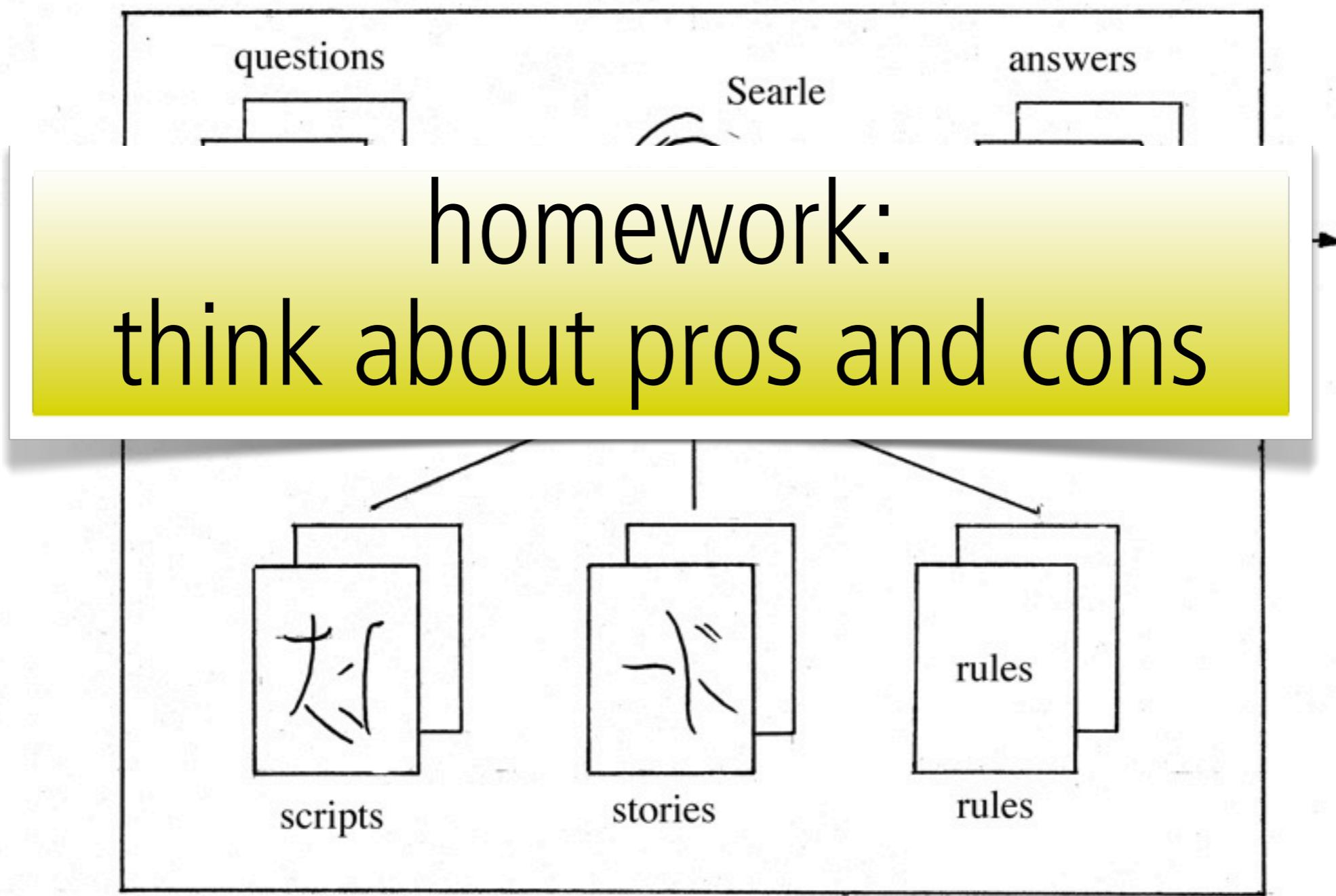


Freitag, 30. September 2011

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.

# Searle's "Chinese Room" thought experiment



Freitag, 30. September 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.

# Variations on the Turing Test

- Historical: ELIZA (Doctor), Josef Weizenbaum, 1966
- Movie "Blade Runner", 1982, based on novel by Philipp K. Dick ("replicants" look like humans, programmed to die after 4 years —> video clip)
- The Loebner Prize Competition (every year)
- Chatterbots (text-based conversational agents)
- Simplified versions: Computer or Human?



University of Zurich



ai lab



36

Freitag, 30. September 2011

Weizenbaum, J. (1966). ELIZA--A Computer Program For the Study of Natural Language Communication Between Man and Machine. Communications of the ACM. Volume 9, Number 1 (January 1966): 36-35.

(Excerpt of conversation with ELIZA (the DOCTOR program) of a visitor to MIT from Russia)

DOCTOR: Good afternoon. Please type in your name.

[The visitor did so, and the doctor continued with some polite preliminaries.]

DOCTOR: What brought you here to see me today?

VISITOR: Oh, nothing much. I'm feeling a bit tired, that's all.

DOCTOR: Why do you think you're feeling a bit tired?

VISITOR: Well, I've been traveling a lot, and away from home.

DOCTOR: Tell me about your family.

...

[visitor sends people out of the room]

Blade Runner abstract: Deckard, a blade runner, has to track down and terminate 4 replicants who hijacked a ship in space and have returned to earth seeking their maker.

The Loebner Prize in Artificial Intelligence is the first formal implementation of a Turing test with a substantial prize. The ultimate winner of this contest will receive US \$100,000 and each year, approximately US \$3,000 is given to the creator of the computer program that converses in the most human-like manner.

<http://www.loebner.net/Prizef/loebner-prize.html>

# Turing tests

Video: "Blade runner"

Video "real dog vs. Aibo"



University of Zurich



ai lab



37

Freitag, 30. September 2011

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 Wikipedia): **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

# Measuring intelligence

---



University of Zurich



ai lab



38

Freitag, 30. September 2011

Probably the most famous means of measuring intelligence is the IQ test. In fact, many IQ-like tests have been developed to measure particular abilities.

# Today's topics

---

- characterizing intelligence, thinking, and cognition
- “Turing Test” and “Chinese Room Experiment”
- **intelligence testing — IQ**
- artificial intelligence and its goals
- how to study intelligence: the “synthetic” methodology



University of Zurich

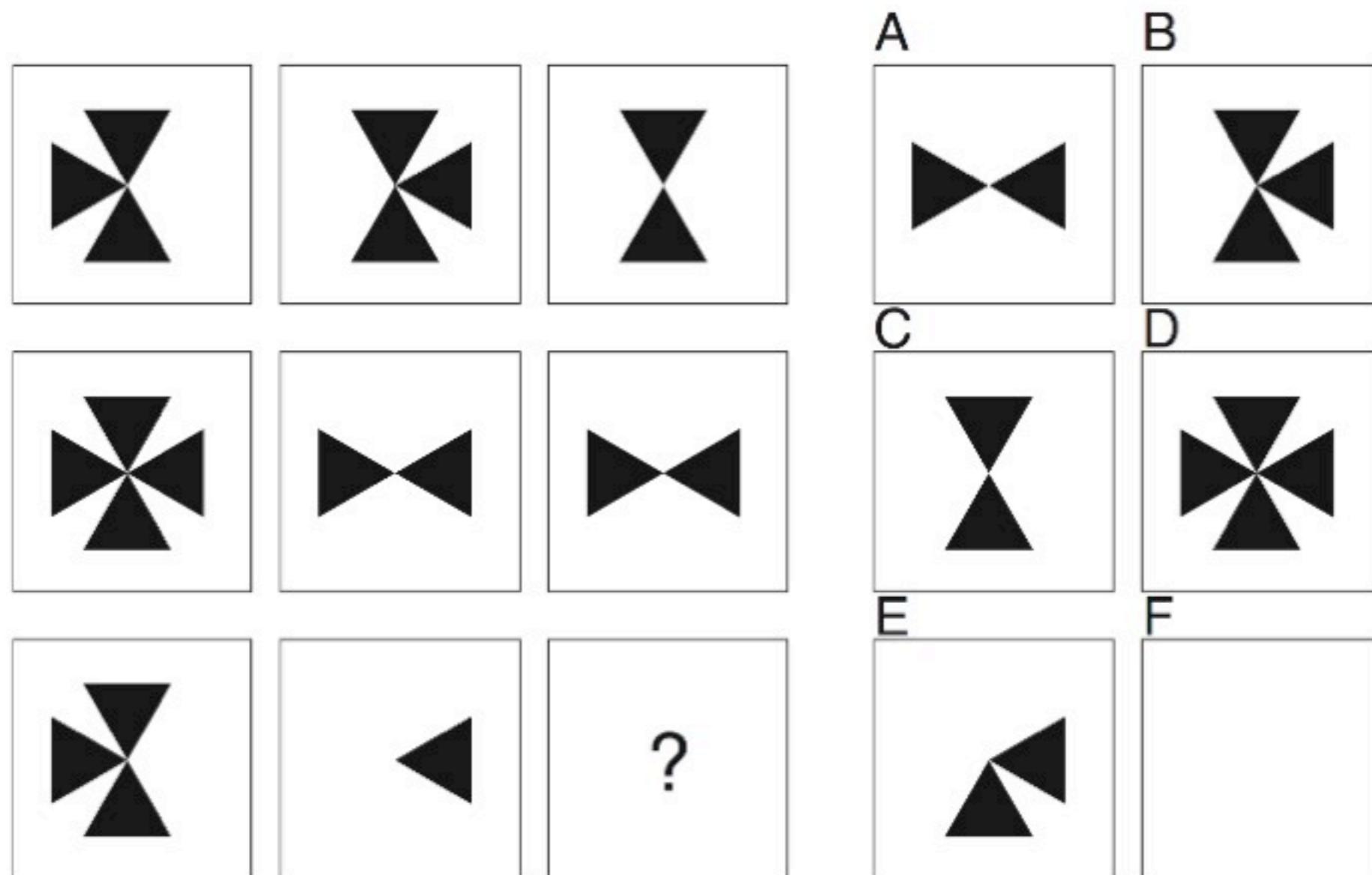


ai lab



39

# Measuring intelligence



University of Zurich



ai lab



40

Freitag, 30. September 2011

Typical item from an IQ test.

# IQ testing — issues

---



University of Zurich



ai lab



41

Freitag, 30. September 2011

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 “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?



University of Zurich



ai lab



42

Freitag, 30. September 2011

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)



University of Zurich



ai lab



43

# Today's topics

---

- characterizing intelligence, thinking, and cognition
- “Turing Test” and “Chinese Room Experiment”
- intelligence testing — IQ
- **artificial intelligence and its goals**
- how to study intelligence: the “synthetic” methodology



University of Zurich



ai lab



# Artificial Intelligence — goals

1. Understanding biological systems

*animals*



2. Making abstractions, developing theory

*beer-serving robot*



*humans*



*Engkey*

3. Applications



University of Zurich

*vacuum cleaner*



# Today's topics

---

- characterizing intelligence, thinking, and cognition
- “Turing Test” and “Chinese Room Experiment”
- intelligence testing — IQ
- artificial intelligence and its goals
- **how to study intelligence: the “synthetic” methodology**



University of Zurich

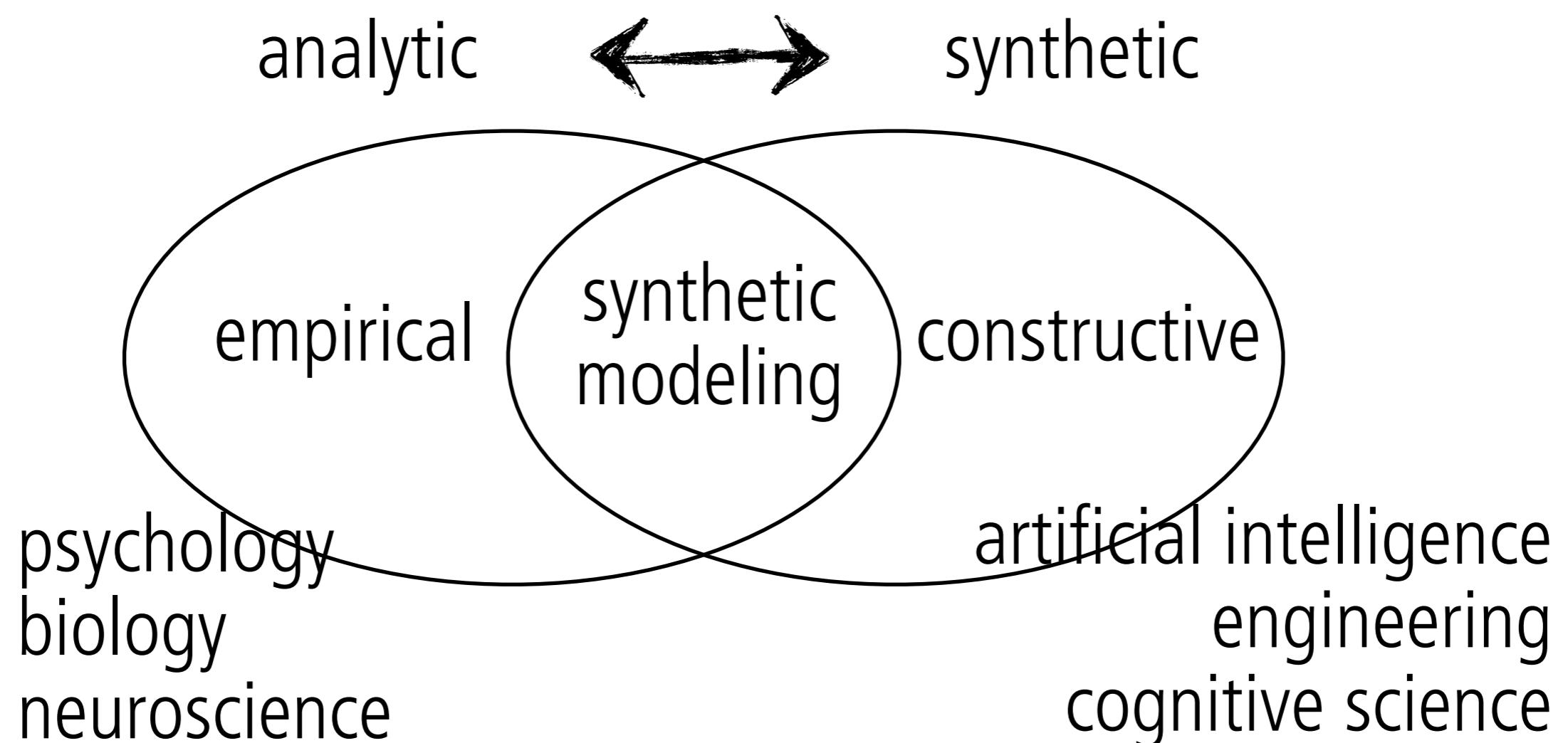


ai lab



46

# How to study intelligence?



University of Zurich



ai lab



47

# The synthetic methodology

Slogan:

**“Understanding by building”**

**modeling behavior of interest  
abstraction of principles**

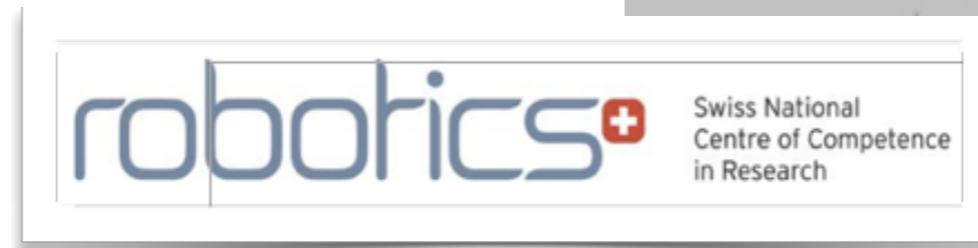


**robots as tools for scientific  
investigation**

**abstractions, NOT copy of nature**



University of Zurich



**ai lab**



48

# The synthetic methodology

Slogan:

“Understanding by building”

modeling behavior of interest  
abstraction of principles



robots as tools for scientific  
investigation

Many examples during ShanghAI  
lectures



University of Zurich



ai lab



49

# Issues to think about: IQ and professional success

---

The “Mensa International” <http://www.mensa.org/> is an organization whose roughly 100.000 members worldwide score in the top 2 % on intelligence tests. On standard IQ tests, this is around 140 or above. While IQ has sometimes been taken as a predictor for professional success, it is interesting that some of the “Mensa” members are professionally successful whereas others aren’t. Why could that be?



University of Zurich



ai lab



50

Freitag, 30. September 2011

A highly interesting and entertaining book looking into this, and which is also fun to read is: Malcolm Gladwell, “The Outliers: The story of success”. Little, Brown and Co., 2008.

# Assignments for next week

---

- No lecture on 6 October 2011: an exercise sheet for self-checking will be uploaded
- Next Global Video Conference: 13 October 2011 from the University of Vermont, Burlington, US
- Read chapters 1 and 2 of "How the body ..."
- Additional reading materials (on web site)



University of Zurich



ai lab



51

# End of lecture 1

---

Thank you for your attention!

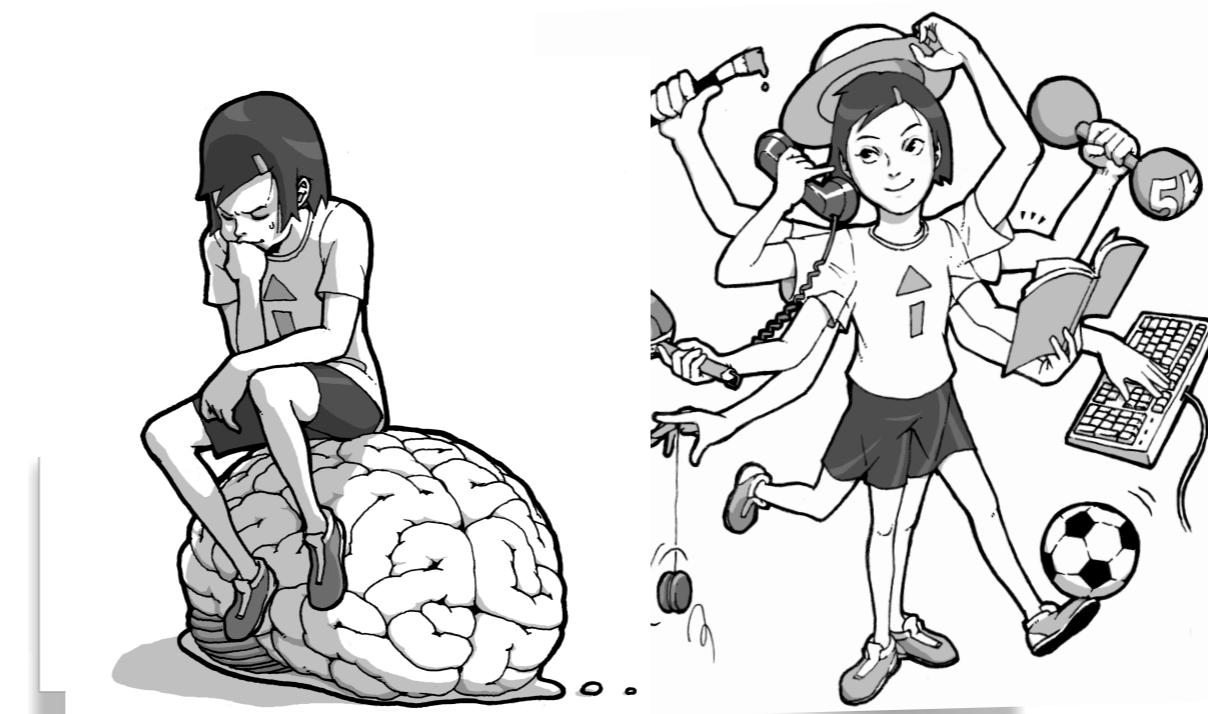


stay tuned for lecture 2

**“The need for an embodied perspective on intelligence”**



University of Zurich



lab



52