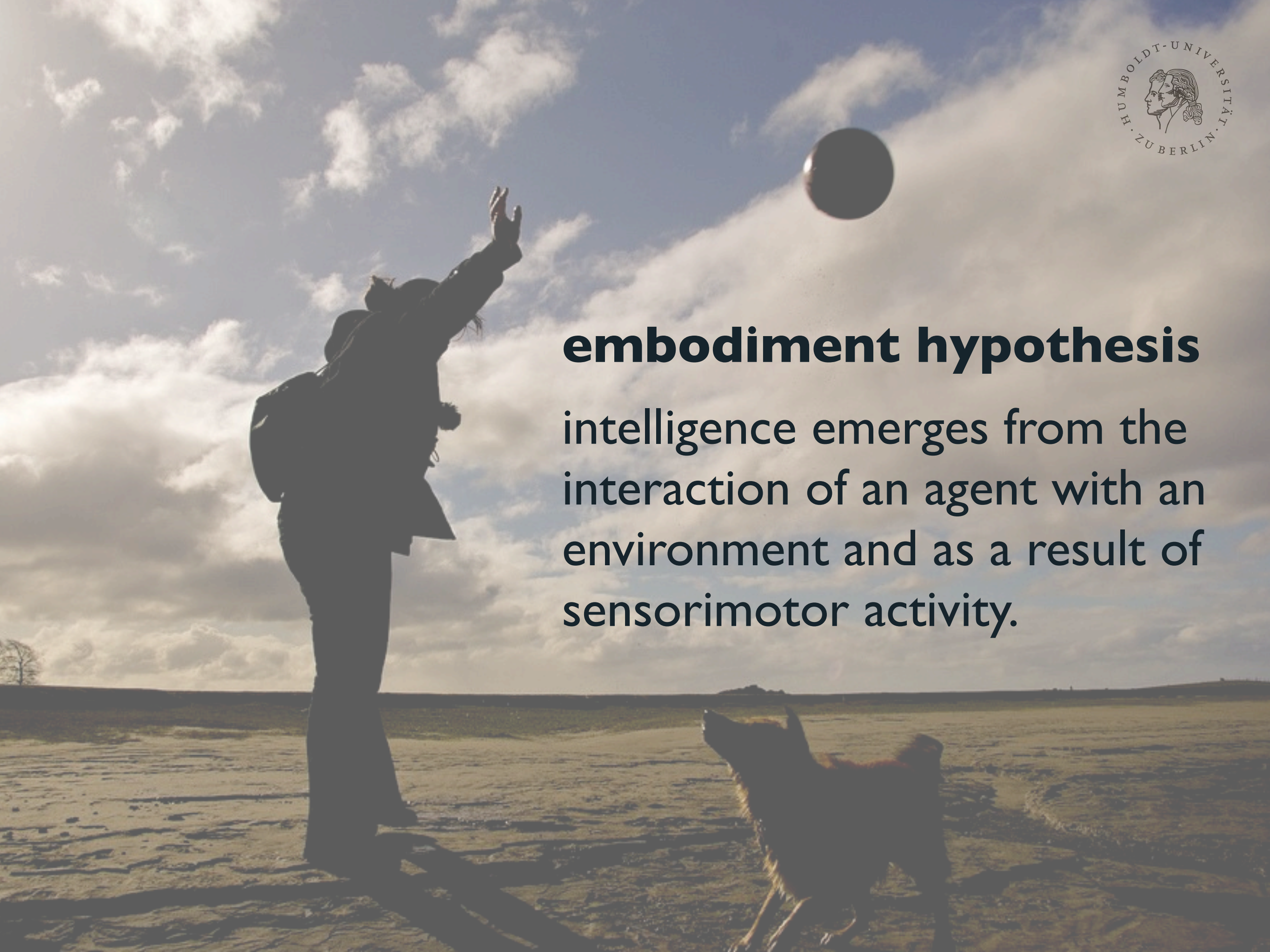
人工智能 上海AI授课
The ShanghAI Lectures

Embodied Artificial Intelligence. Guest lecture on Interactive Robotics

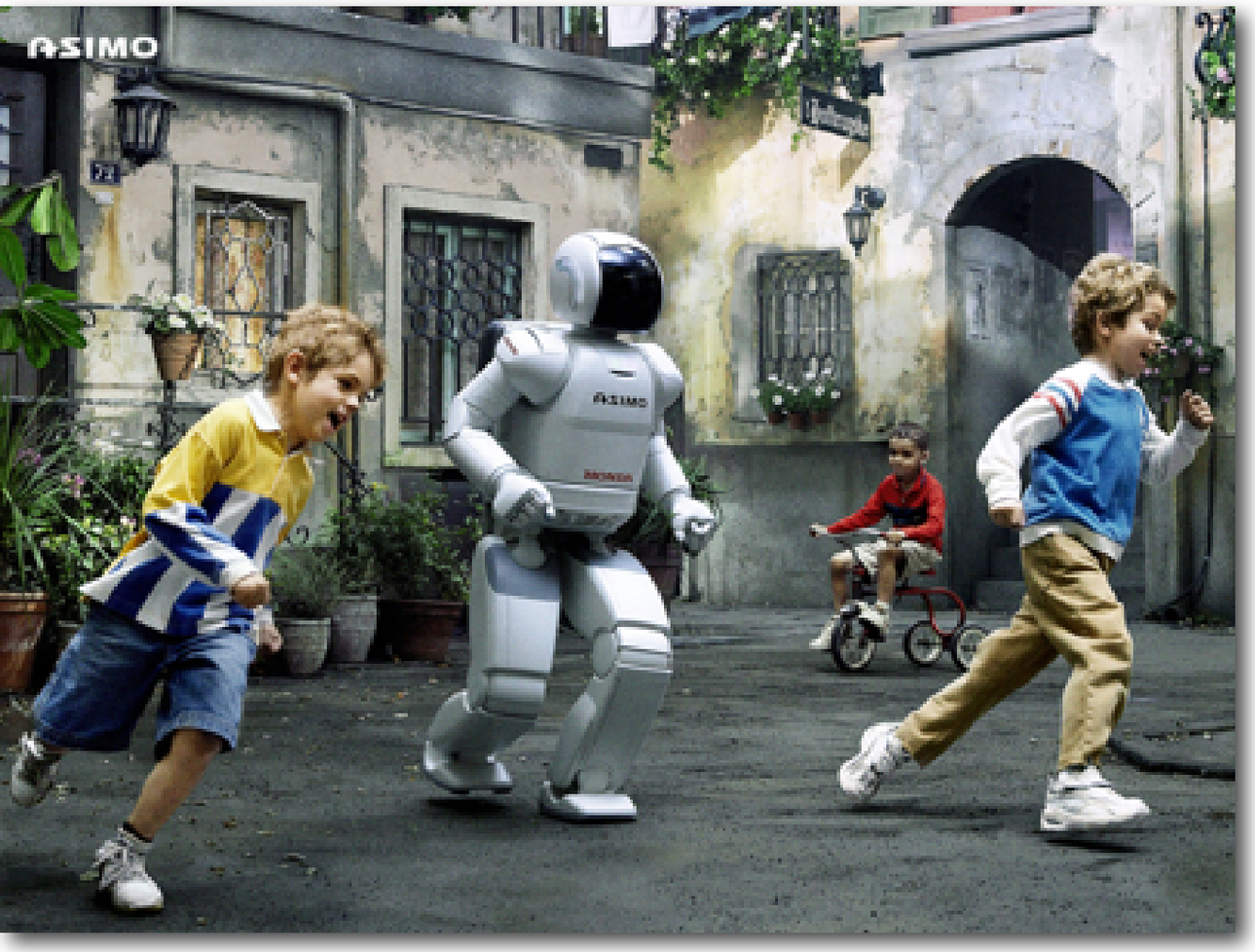
Verena V. Hafner, Humboldt-Universität zu Berlin



embodiment hypothesis

intelligence emerges from the interaction of an agent with an environment and as a result of sensorimotor activity.

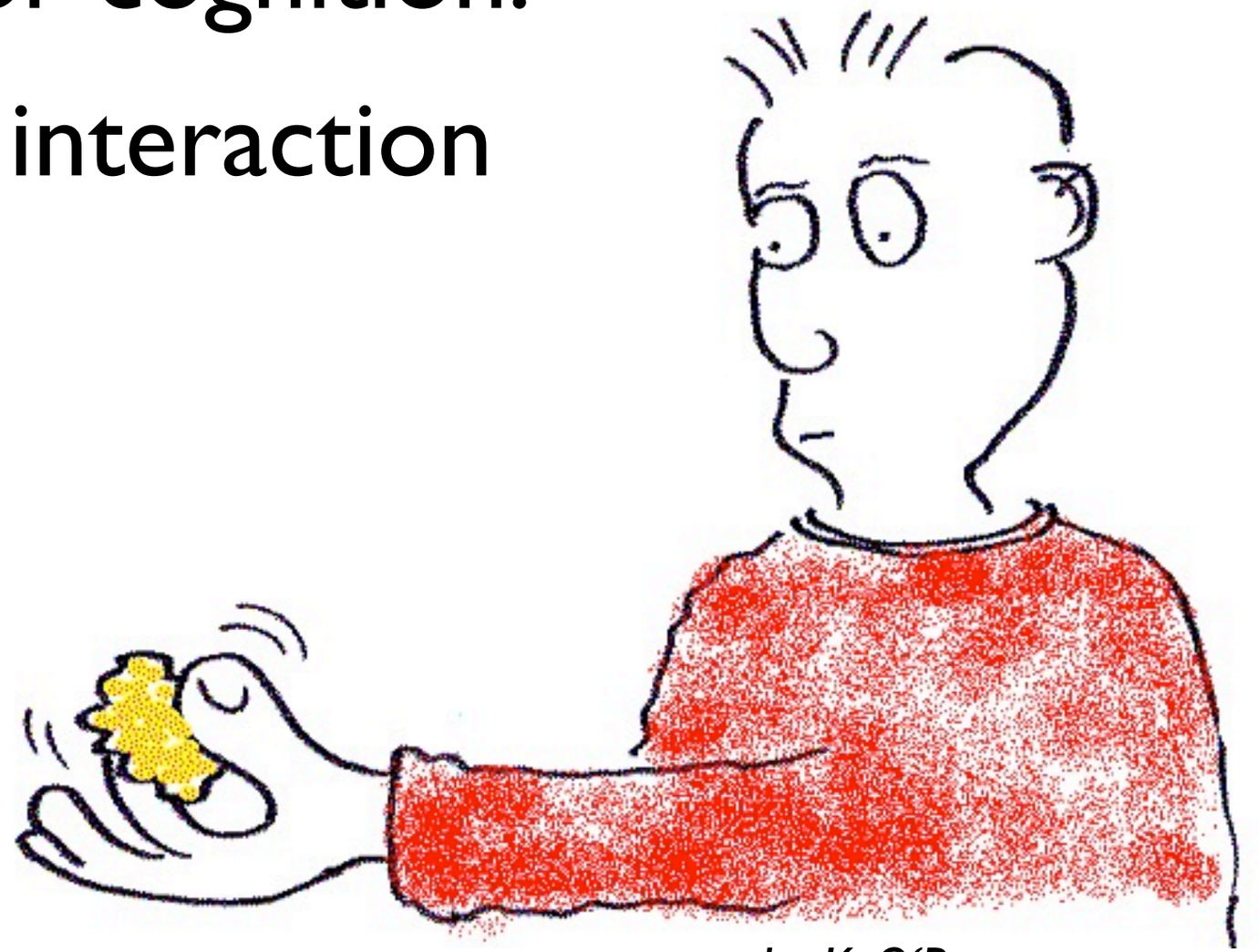
Interaction



ASIMO by Honda

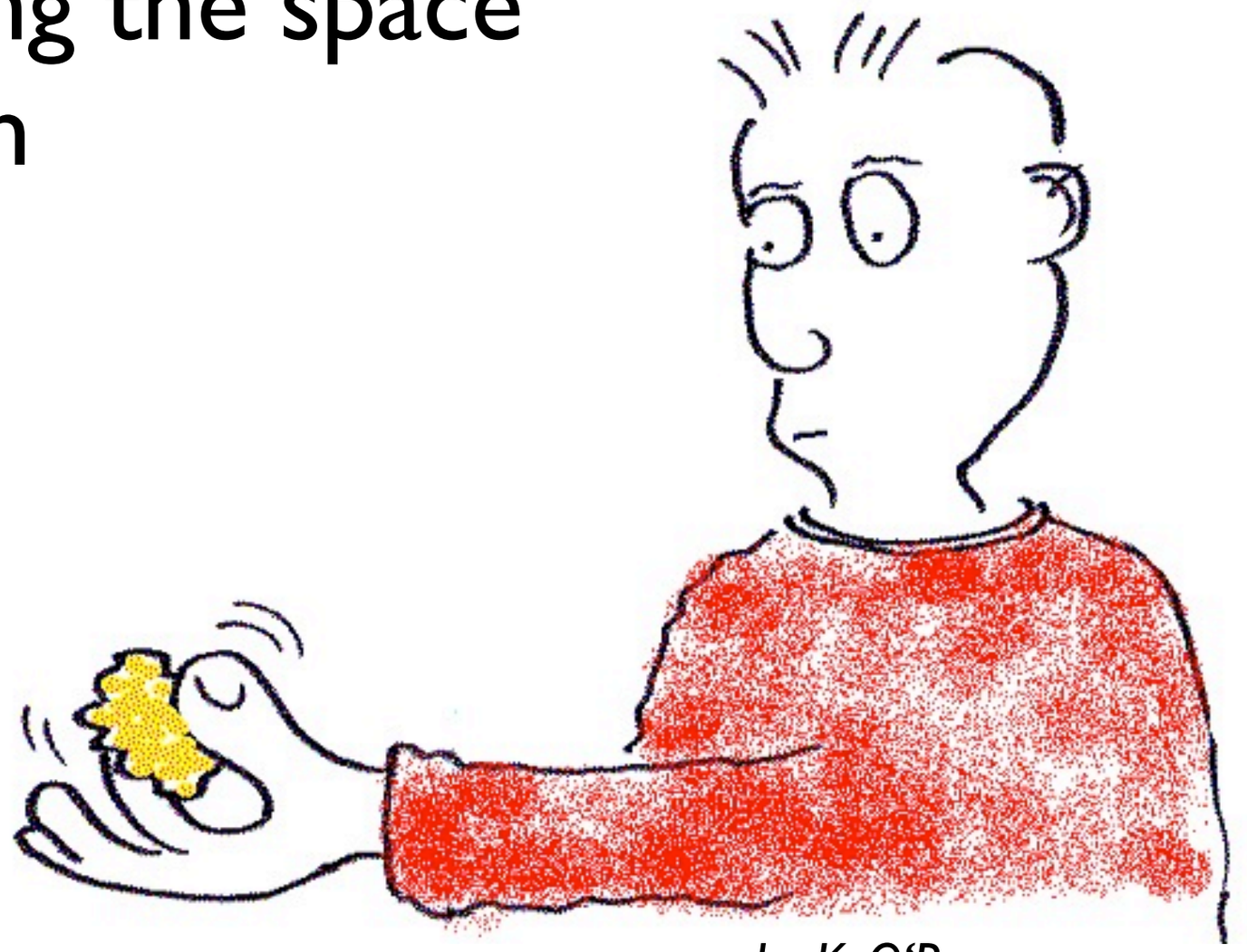
- focus on interaction
  - with the environment
  - with others
- important: dynamics & closed loop
- from sensorimotor to social interaction

prerequisite for cognition: sensorimotor interaction



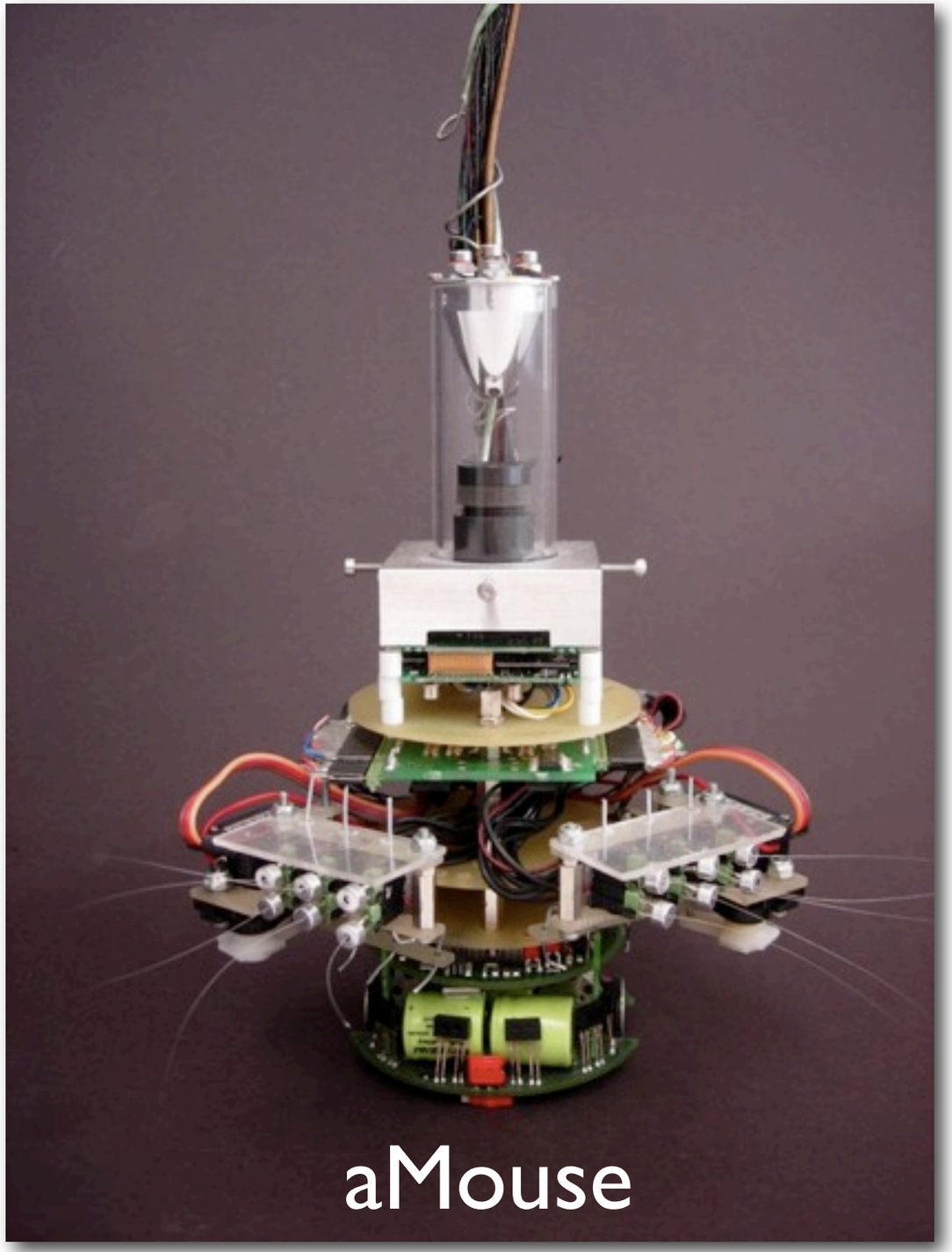
by K. O'Regan

actively shaping the space of information

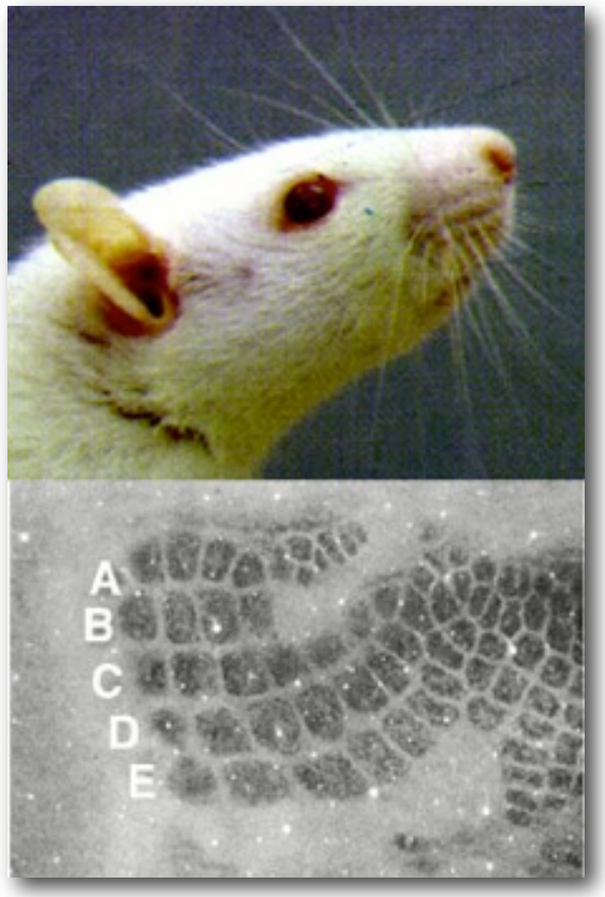


by K. O'Regan

multimodality



artificial mouse, University of Zurich



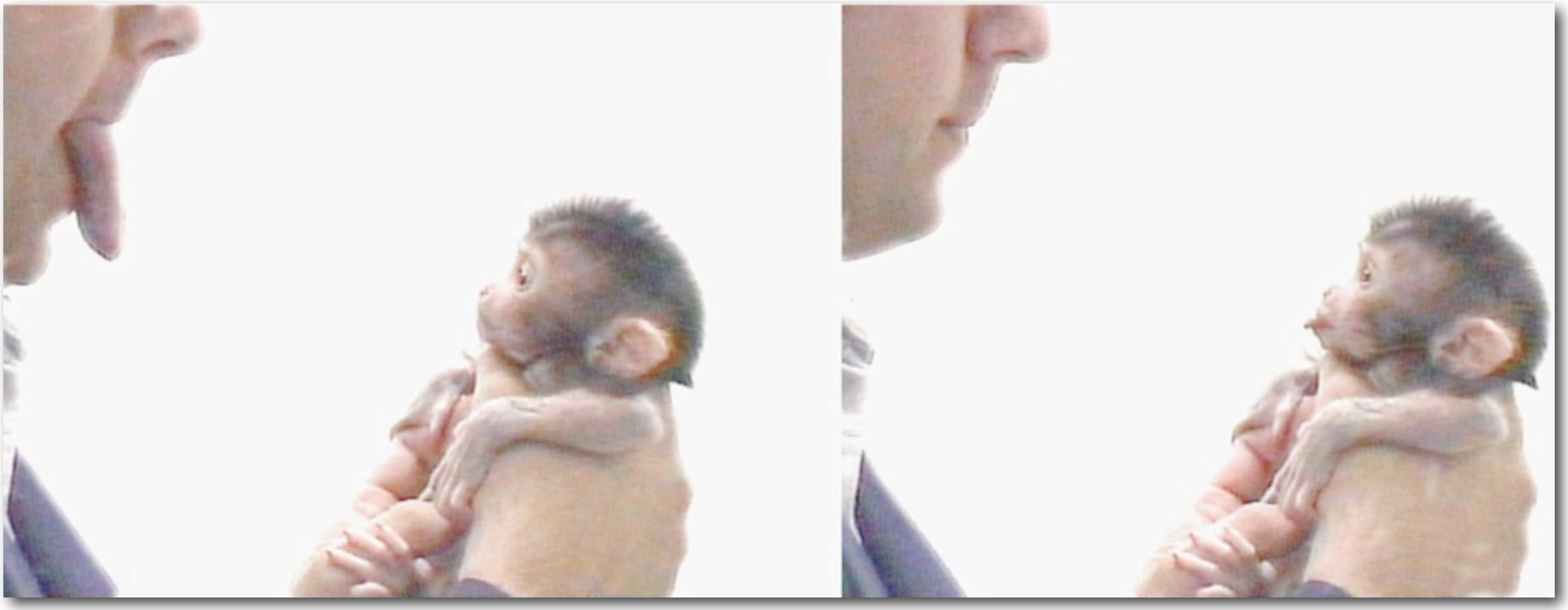
interaction in robotics

Keepon (Hideki Kozima)

Rhythmic Interaction

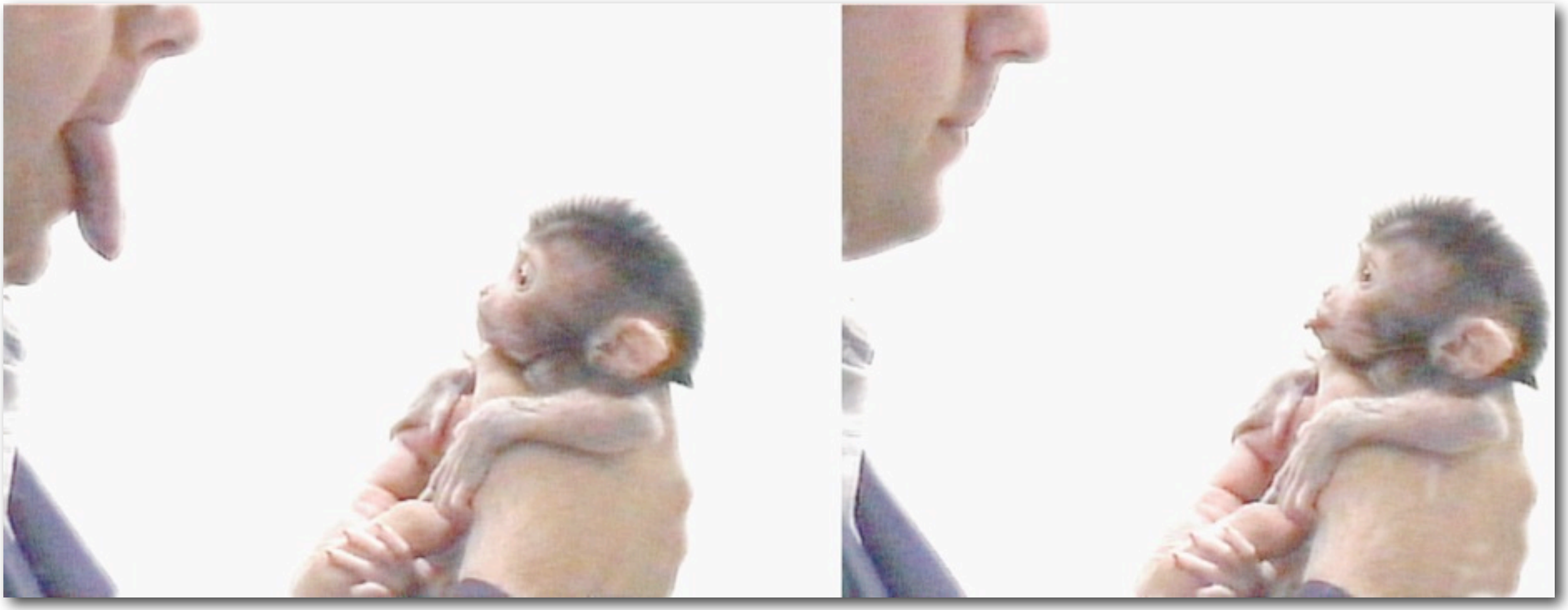
Video 1

Imitation



Prerequisites?
mapping observed behaviour onto own body

Imitation



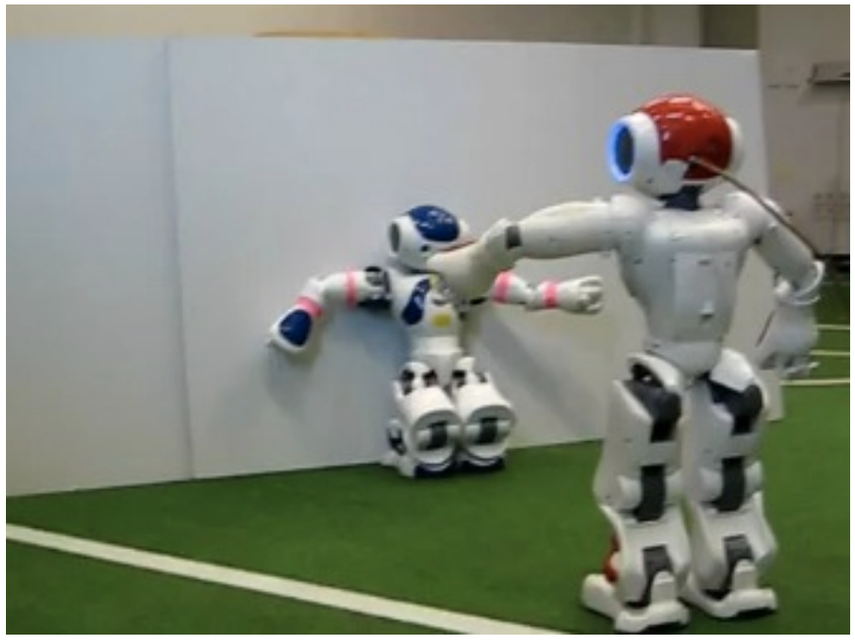
mirror system (Rizzolatti, Galese)

imitation experiments

Video 2

Aibo-Aibo imitation, experiment by Thomas Krause

imitation experiments



Video 3

Nao-Nao imitation, experiment by Thomas Krause

body schema - body image

- conceptual distinction [Gallagher]

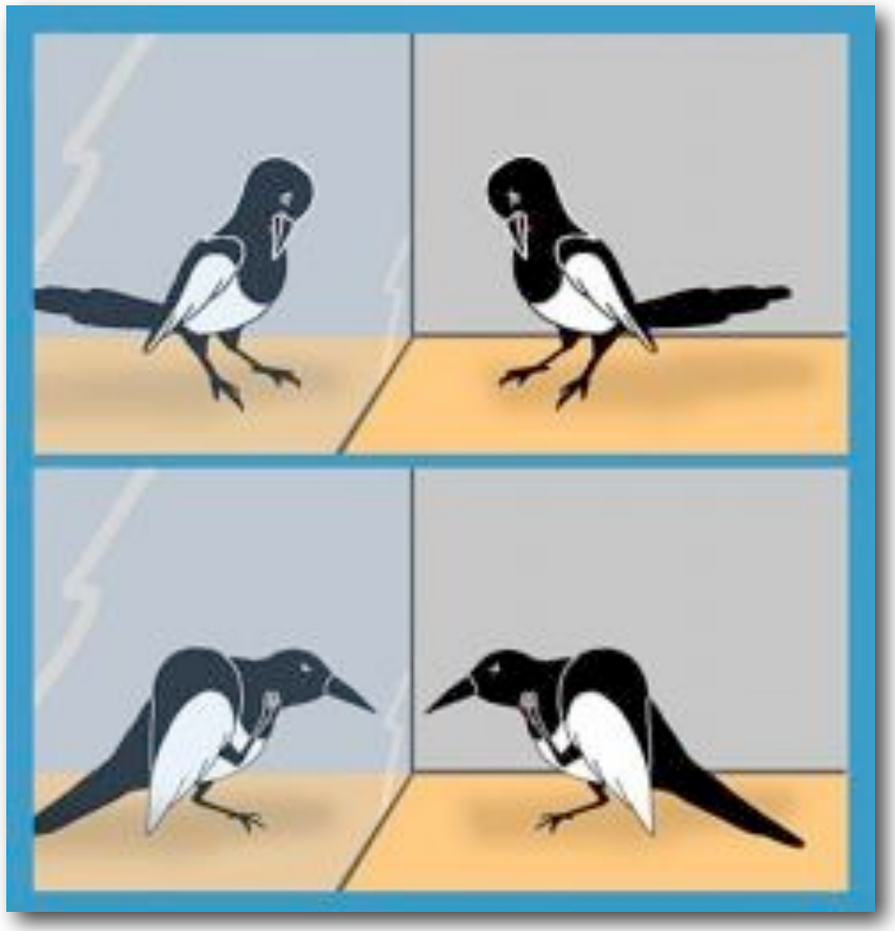
- body image: system of perceptions, attitudes and beliefs towards own body

- body schema: system of sensorimotor capacities that constantly regulate posture and movement

self-recognition

- mirror test: red dot or transparent dot applied to infant‘s face
- touch mirror or own face?
  human infants: around the age of 18 months
- body schema, body image?

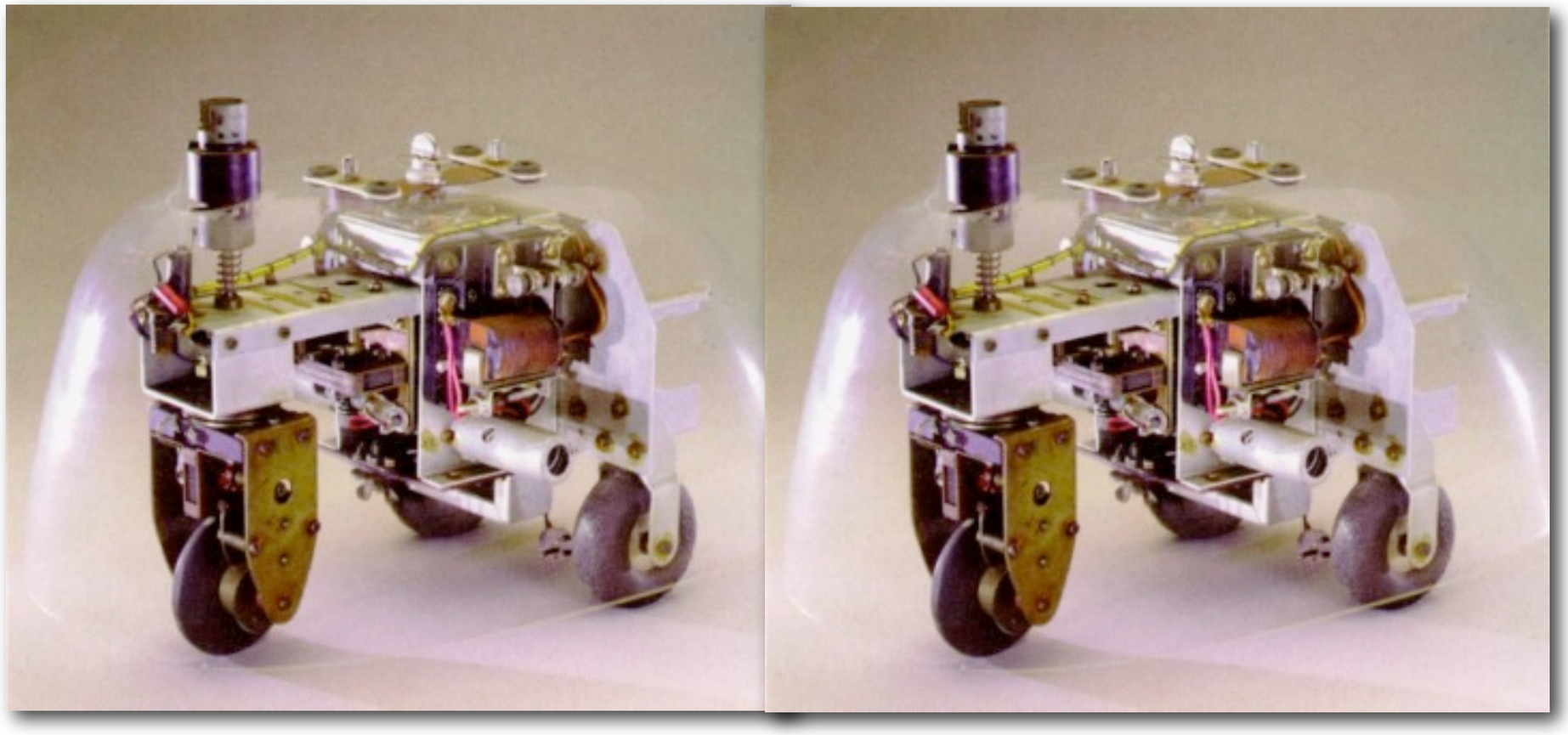
self-recognition



mirror test with magpies

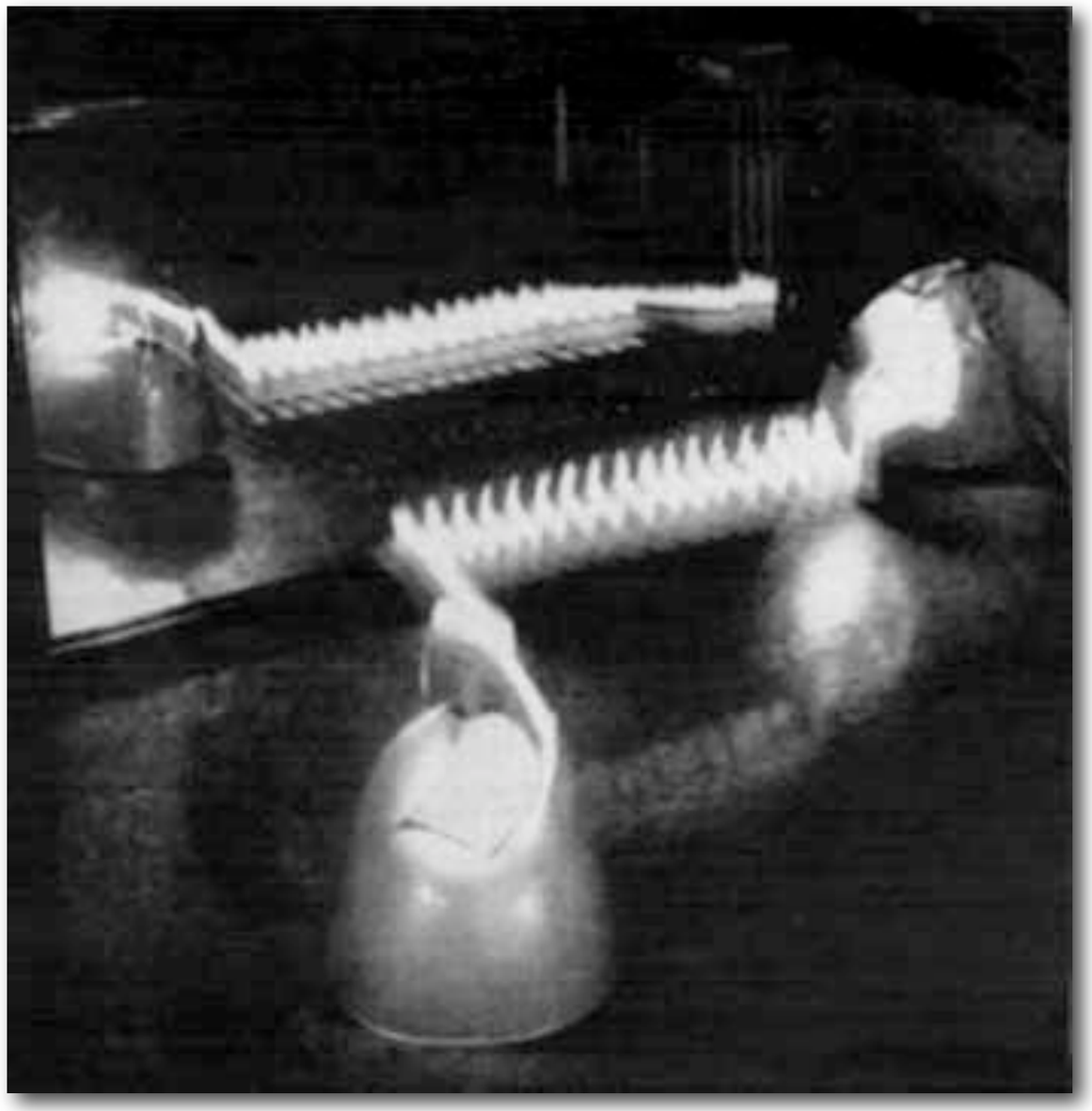
Video 5

First interactive robots



Grey Walter's tortoises

self-recognition



Elsie watching
herself in the mirror

self-recognition?

mirror experiment
with Nao

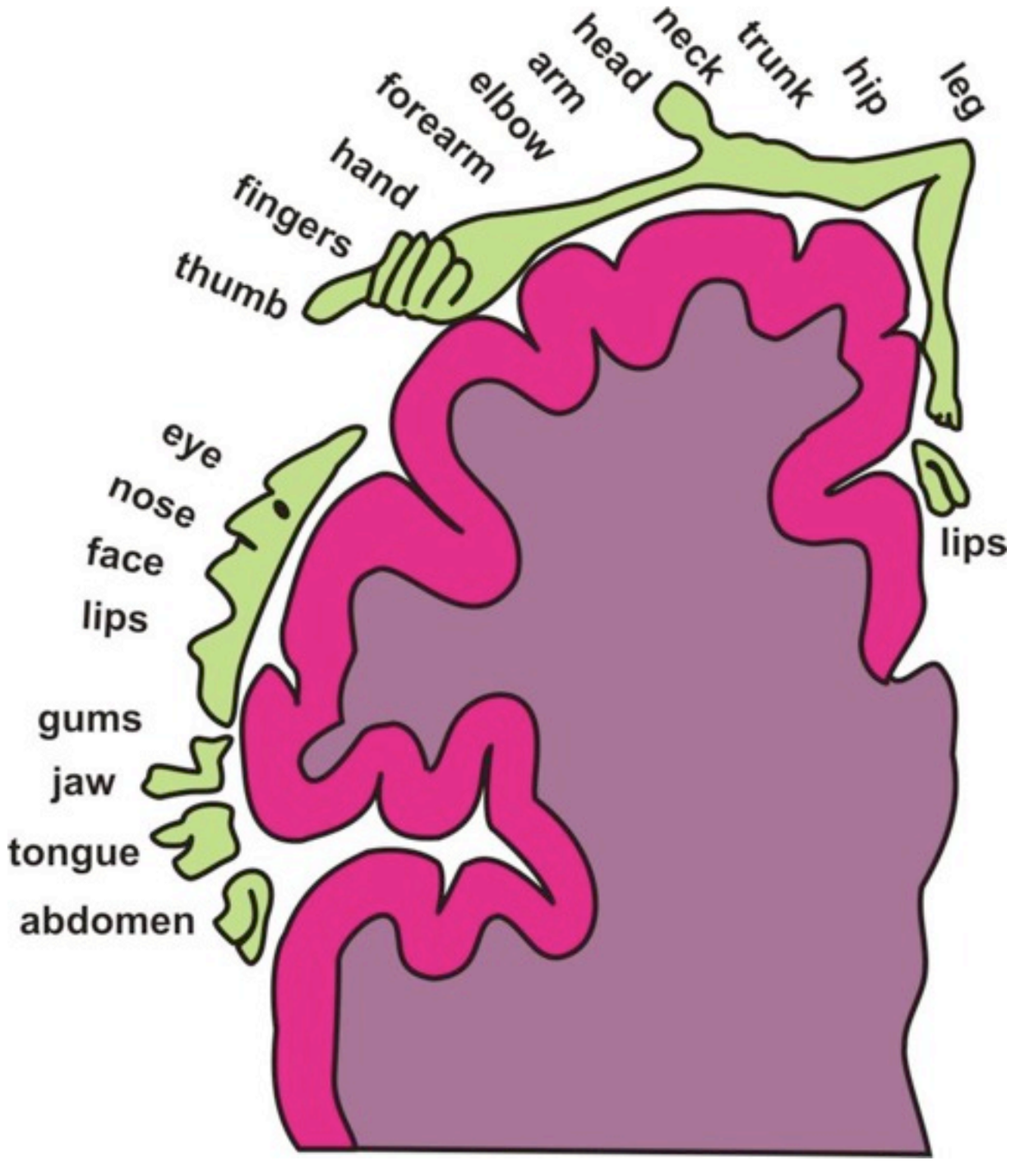
prerequisites for imitation learning

observed behaviour - experienced behaviour

body maps

- inspired by somato-sensory maps in human cortex

- dynamic and short term representation of body and behaviour



Maps based on Information Distances

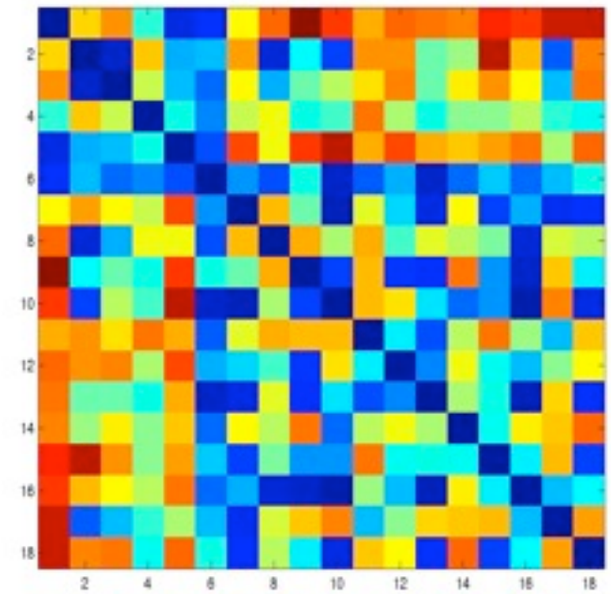
- informationally close sensors are also close on the map
- maps function as body schema

Hafner, V.V. and Kaplan, F. (2008), Interpersonal Maps: How to Map Affordances for Interaction Behaviour, In: E. Rome et al. (Eds.): Affordance-Based Robot Control, LNAI 4760, pp. 1-15, Springer-Verlag Berlin Heidelberg

Information distance method

Information distance:

$d(X_j,X_i) = H(X_j|X_i) + H(X_i|X_j)$

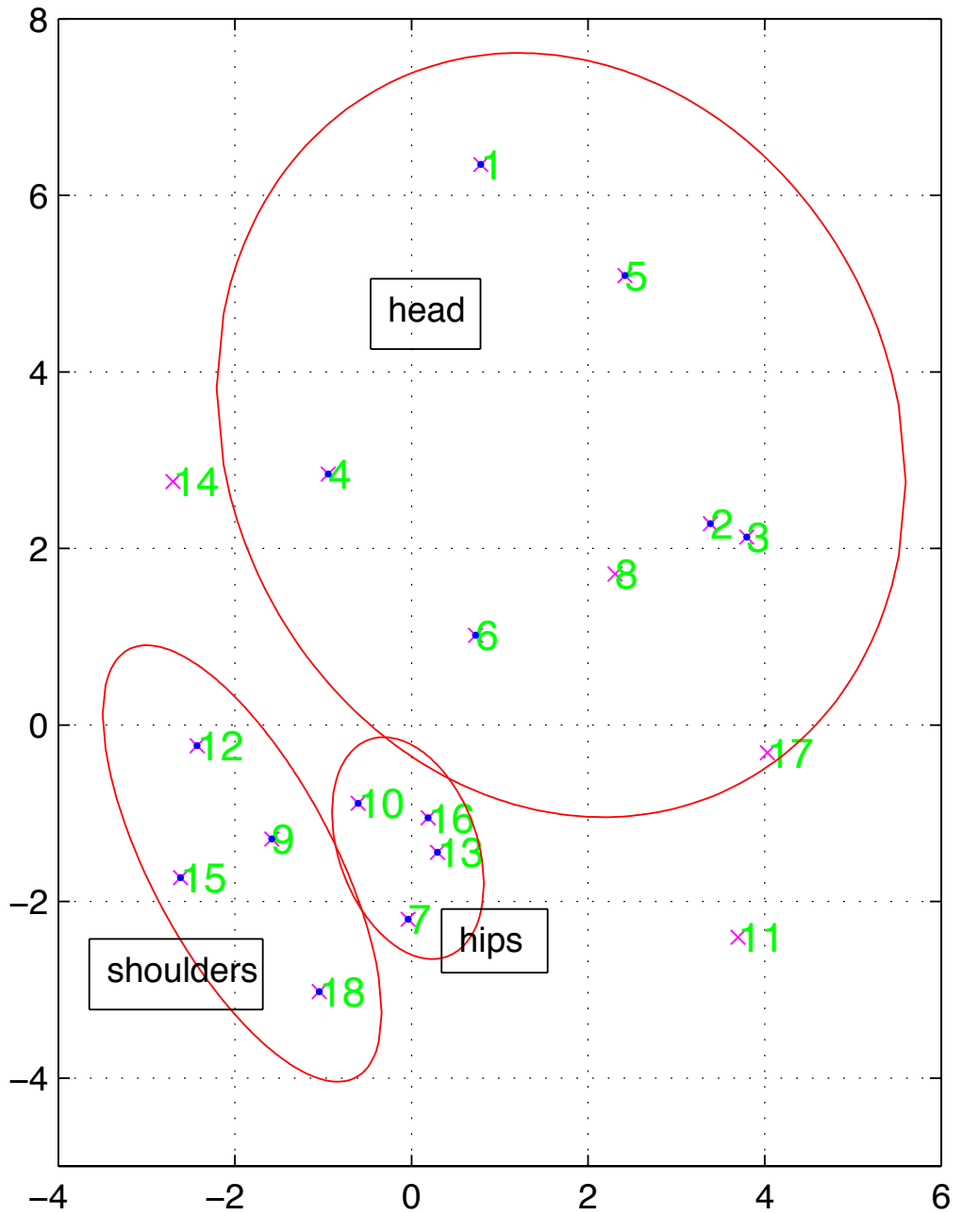


advantage: metric properties

- symmetry d(a,b) = d(b,a)
- d(a,b) = 0 iff a,b recoding equivalent
- triangle inequality $d(a,c) \leq d(a,b)+d(b,c)$

body maps

informationally close sensors are also close on the map

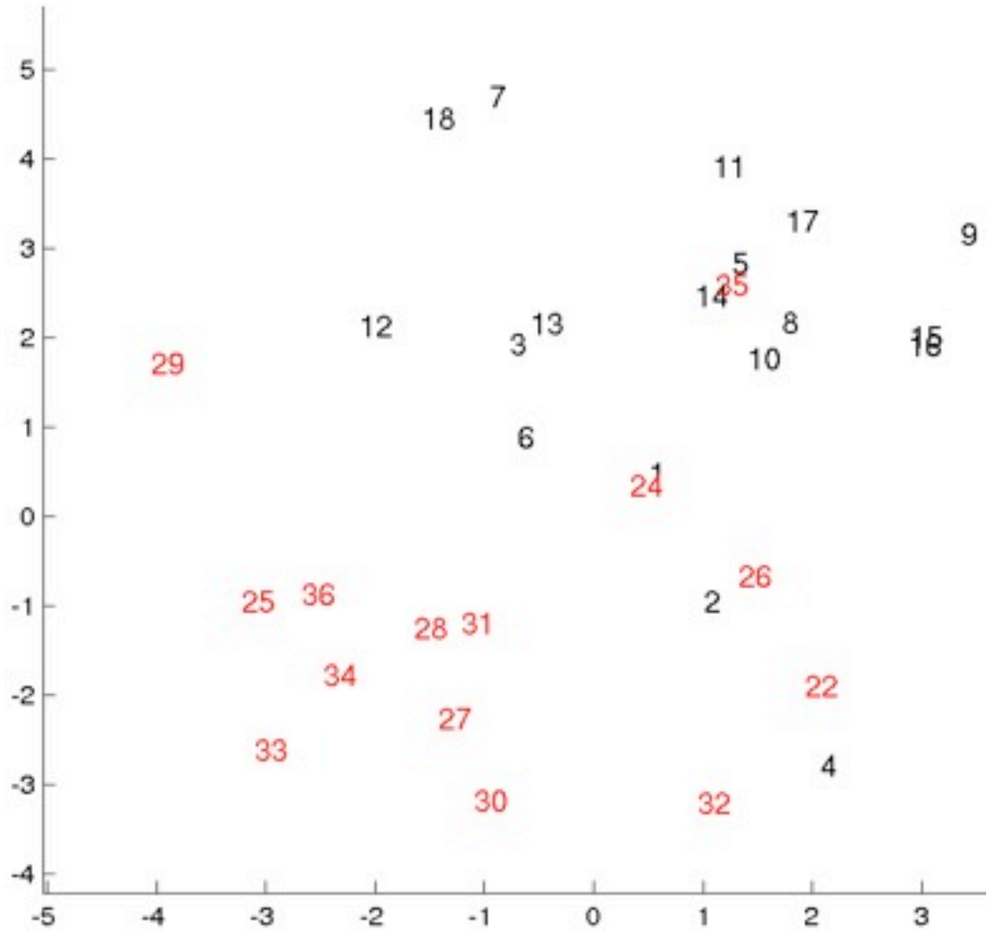


with F. Kaplan

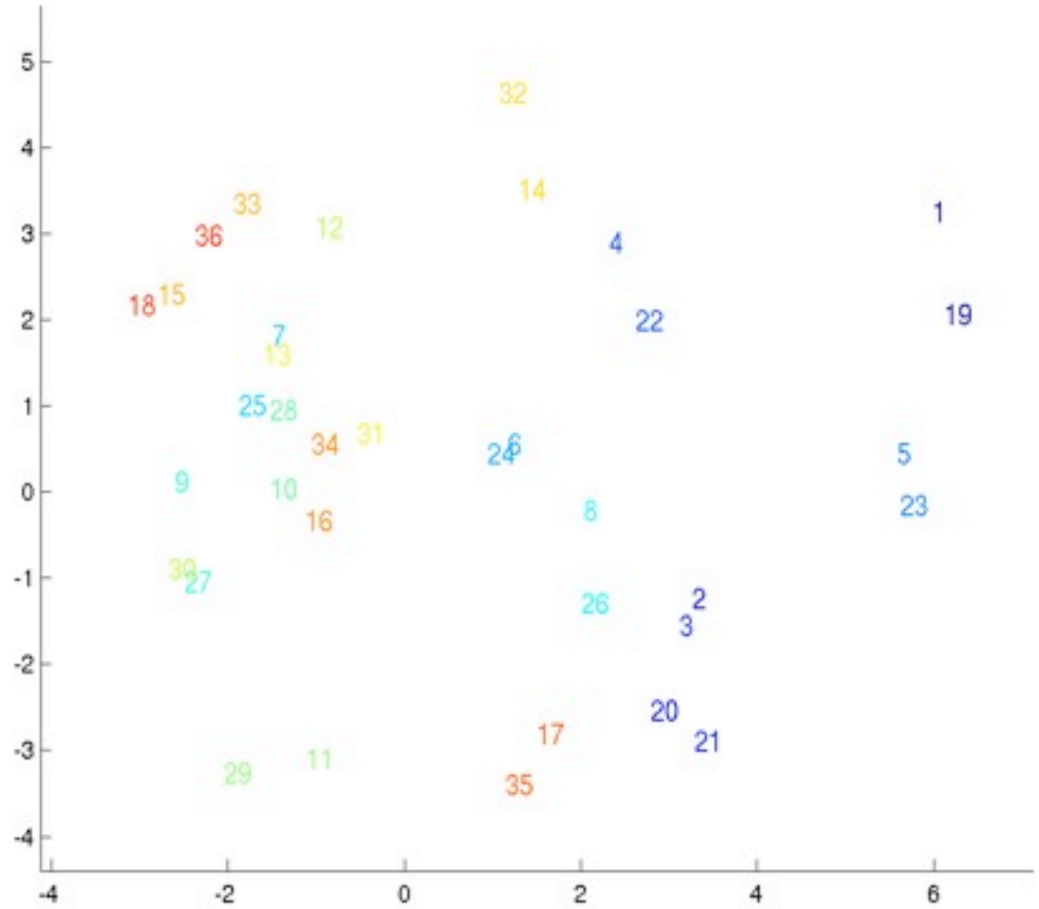
Interpersonal Maps

temporary representation
for interaction behaviour

Interpersonal Maps



No Imitation

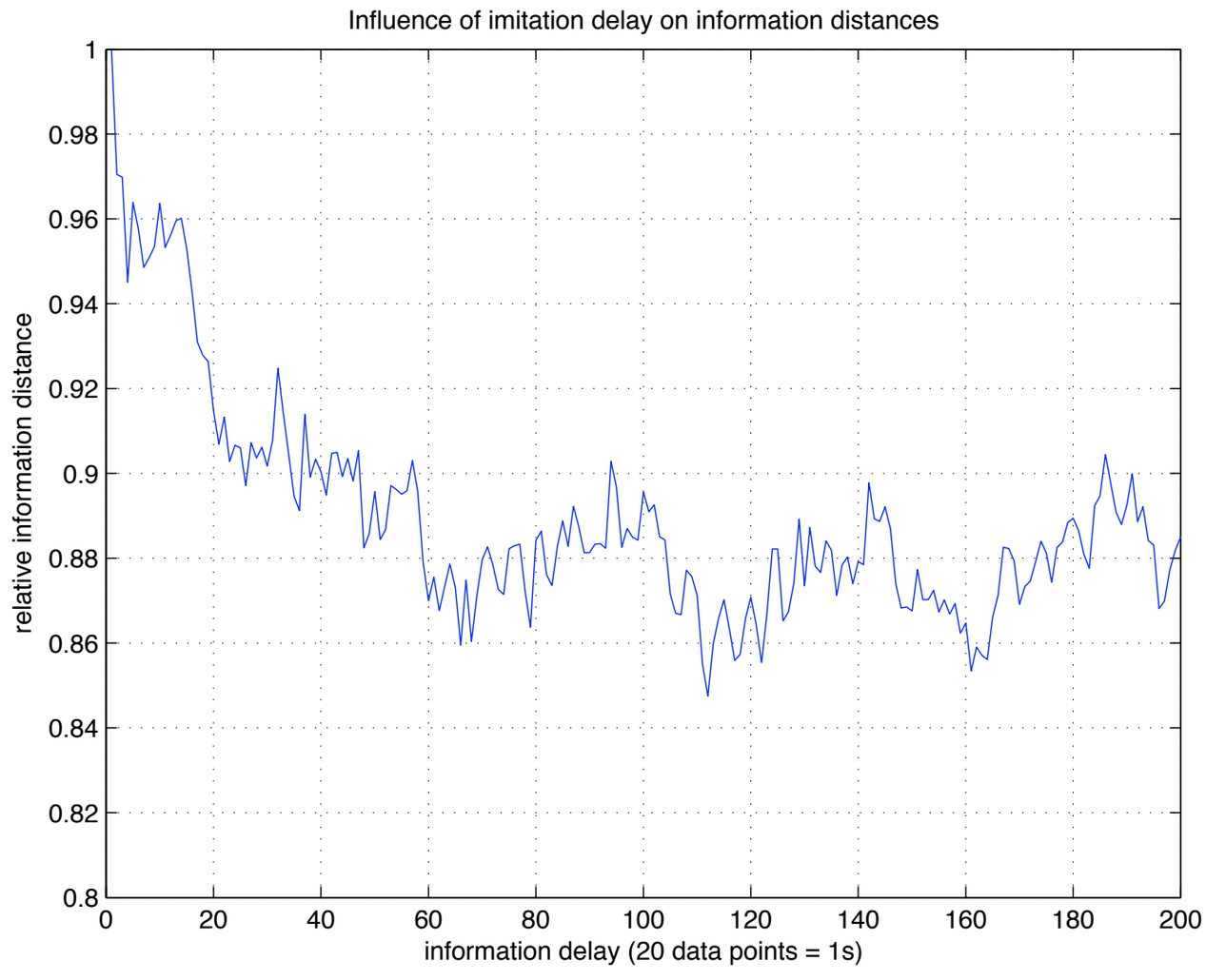


Imitation (delay 0.5s)

Imitation Delay

A_1	A_2
A_3	A_4

c=(A1+A4)/(A2+A3)

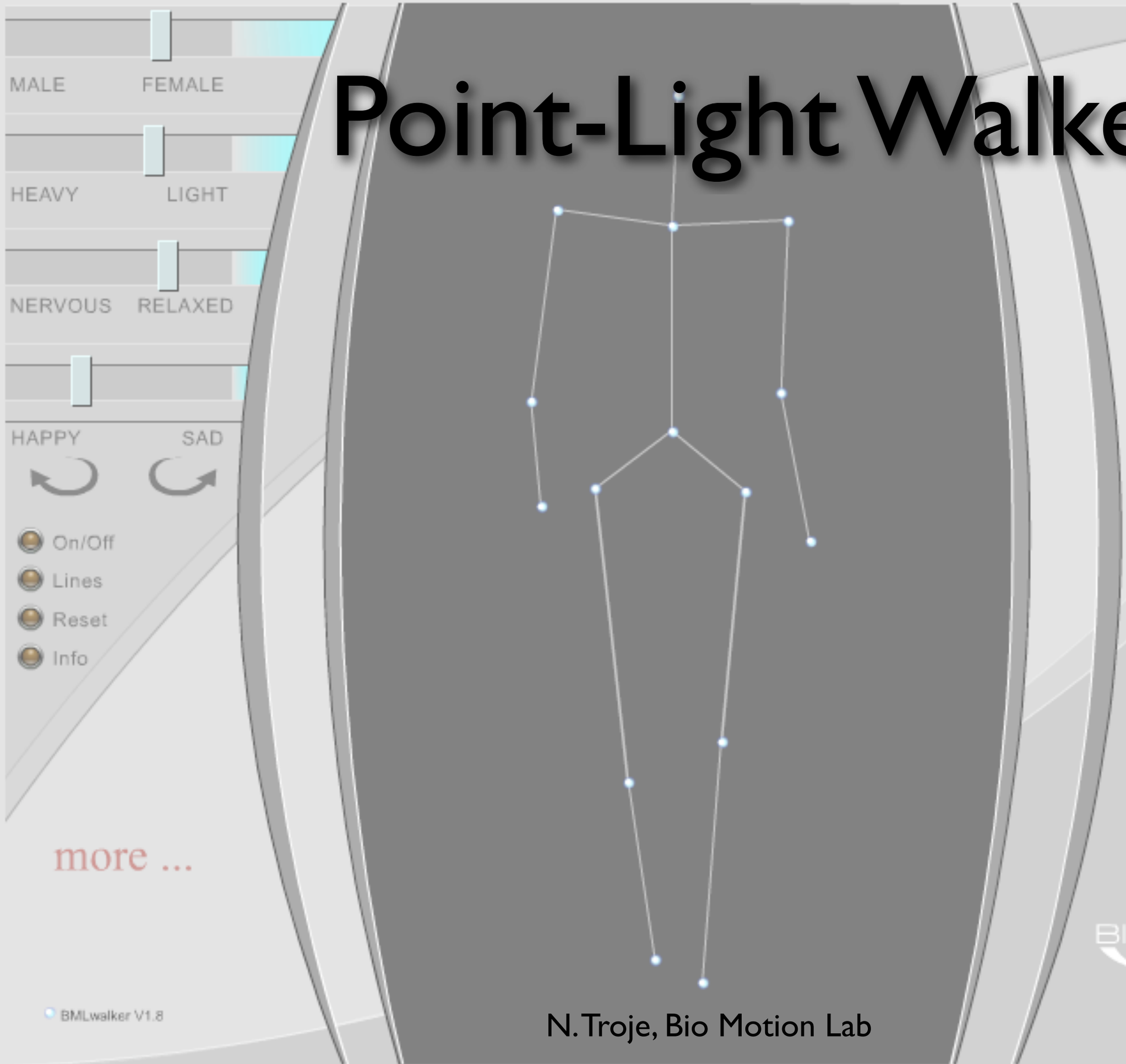


behaviour recognition

People are very successful at this skill.

Point-Light Walker

Demo 1

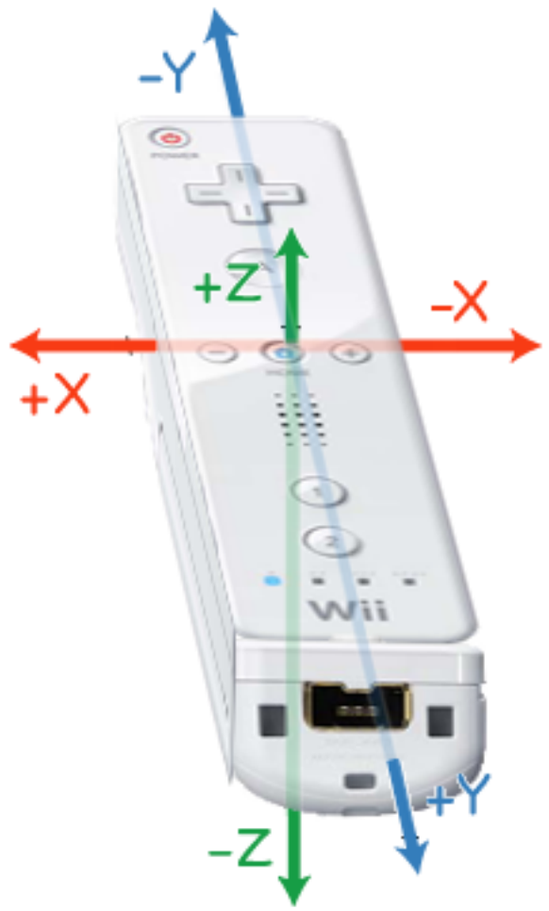


N. Troje, Bio Motion Lab

http://www.biomotionlab.ca/

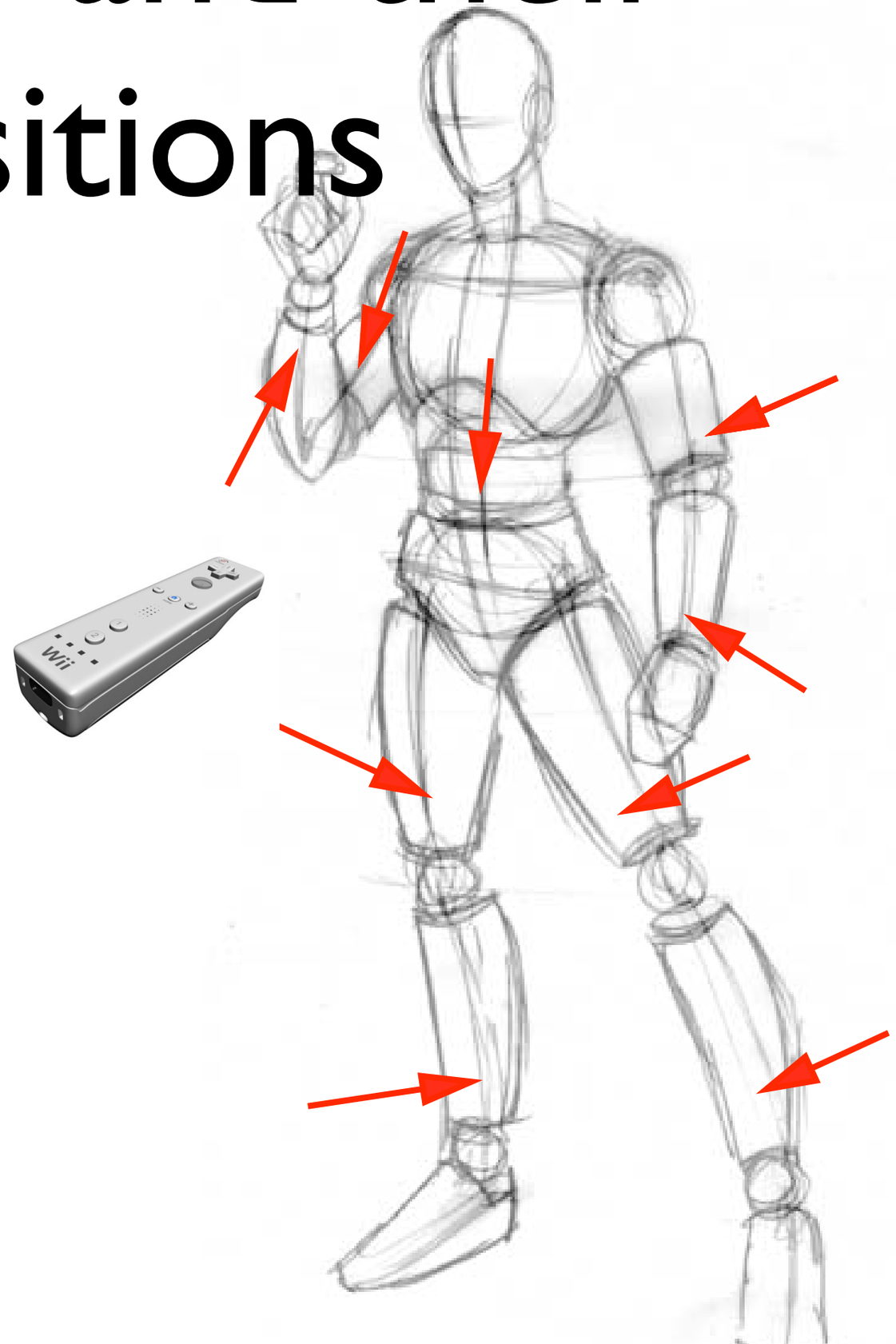
Information lies in the dynamics

- Accelerometer data
- Nintendo Wiimotes



Sensors and their positions

- 9 WiiMotes
- 100 Hz
- 3 axes acc.



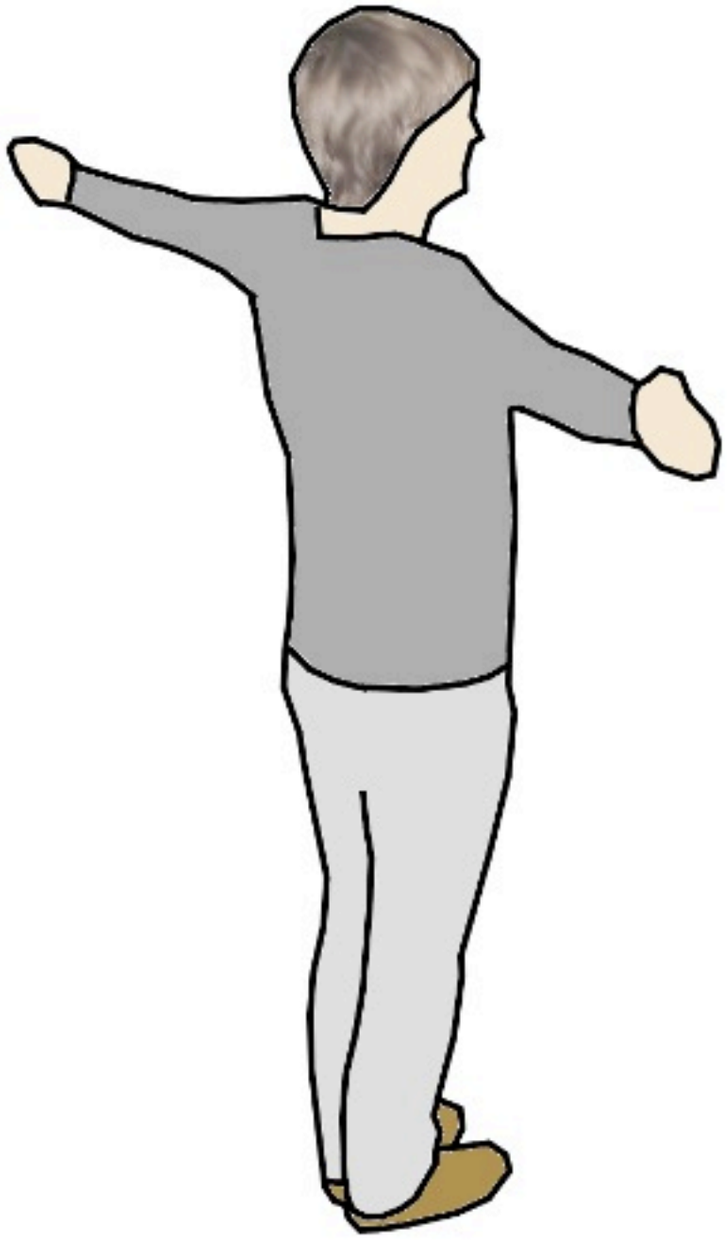
Experimental setup

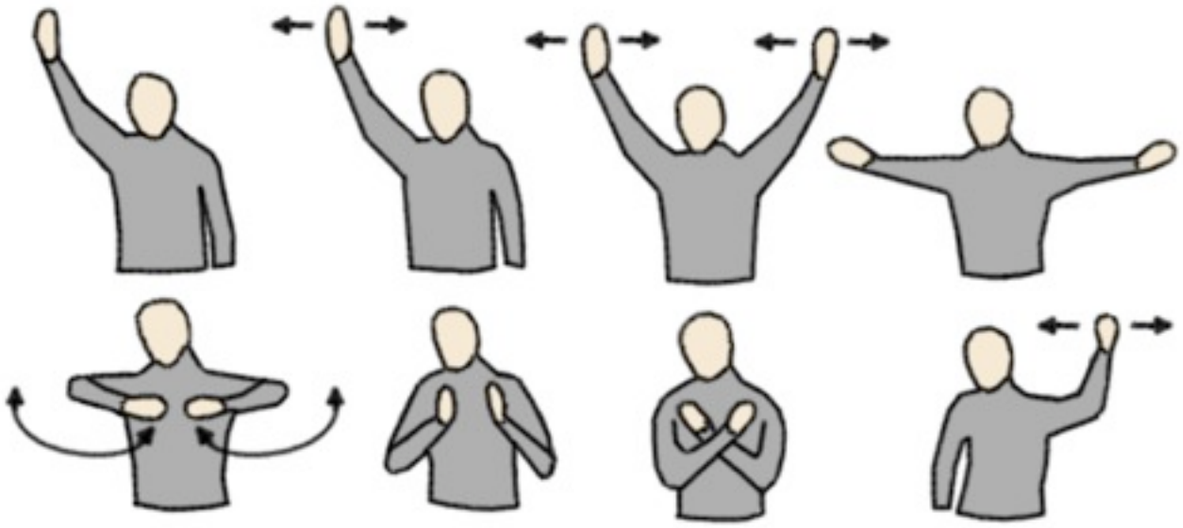
- 4 persons
- 5 gaits (walking, running, going upstairs, going downstairs, walking backwards)
- four recordings of 3 seconds each for each combination of person and gait

Results

- behaviour and person can be recognised purely from these data
- now: body maps for mapping vision and proprioceptive data

Dynamic visual gesture recognition in HRI





with F. Bertsch

Throwing project

with Prof. W. Sommer, Dept. of Psychology, HU Berlin

Setup

Diods

1,16 m
16/10

Resolution:
Horizontal: 1280
Vertical: 800

1,10 m

3 m

EEG measurements, preparatory activation, CNV (Grey Walter)

INTRO

- EU project on interactive robotics
- Behaviour and intention recognition (Guido Schillaci)
- Dynamic gesture analysis (Sasa Bodiroza)

http://introbotics.eu/

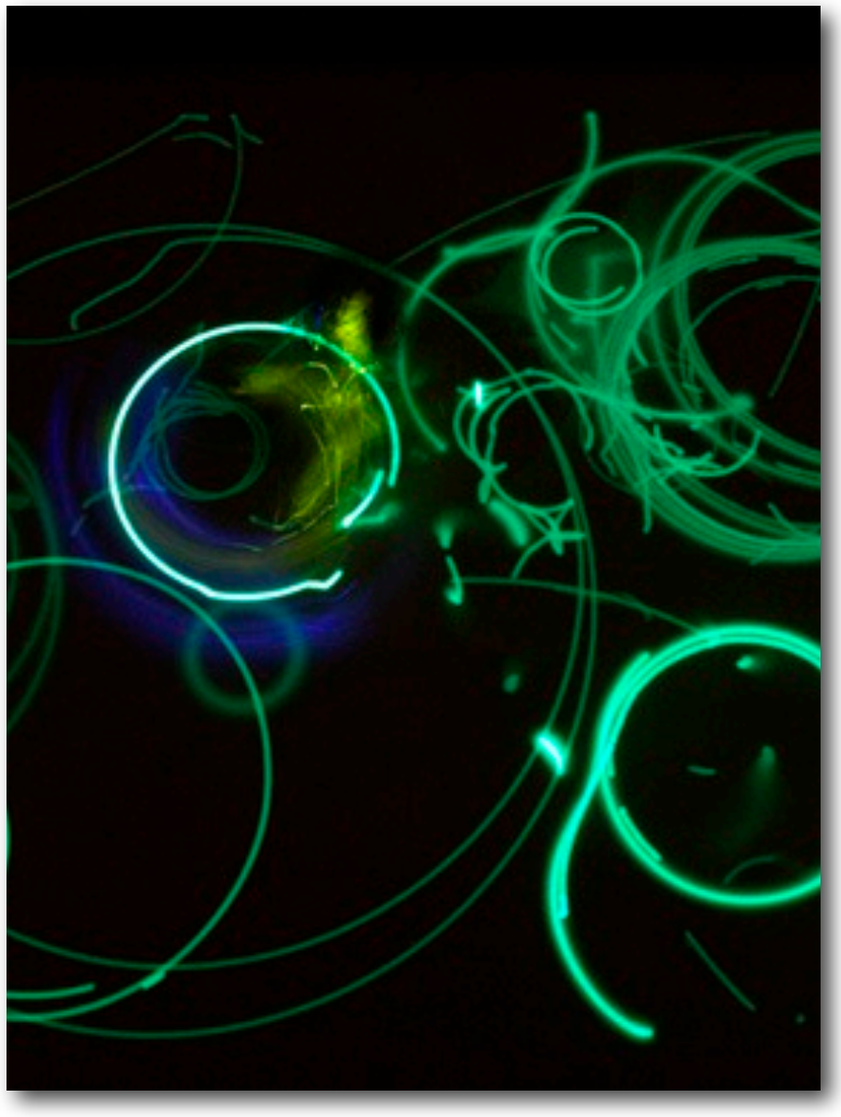
Bio-inspired Navigation

agricopter

http://agricopter.de/

Collective Intelligence

- Cognition from interaction
- simple rules - complex behaviour
- emergence



LumiBots by Mey Kronemann

embodiment

- interaction as prerequisite for cognition
- using these embodied approaches, one day we might understand human cognition

Thank you for listening.

Special thanks to

Ferry Bachmann, Guido Schillaci, Sasa Bodiroza, Siham Al-Rikabi, Christian Blum, Thomas Krause, Heinrich Mellmann, Annika Dix, Carsten Huhn, Romy Frömer, Michael Schulz, Mathias Müller, Oswald Berthold, Katja Gerasymova, Florian Bertsch, Mey Kronemann.

http://koro.informatik.hu-berlin.de/

Information Metric

- Entropy

$$H(X_i) = -\sum_{x_i} p(x_i) \log_2 p(x_i)$$

- Conditional Entropy

$$H(X_j|X_i) = -\sum_{x_i} \sum_{x_j} p(x_i, x_j) \log_2 p(x_j|x_i)$$

- Information Distance [Crutchfield, 1990]:
  $d = H(X_j|X_i) + H(X_i|X_j)$

2D representation

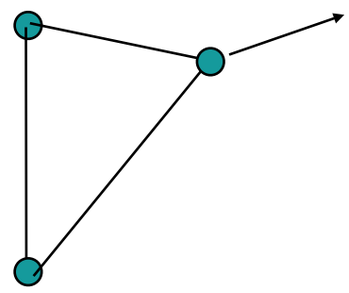
Relaxation Algorithm [Kuipers & Pierce, 1997]

1. The force f_i on each point $\mathbf{p_i}$ is computed as:

$$f_i = \sum f_{ij}$$

where

$$f_{ij} = (||\mathbf{p_i} - \mathbf{p_j}|| - d(X_i, X_j))(\mathbf{p_j} - \mathbf{p_i})/||\mathbf{p_j} - \mathbf{p_i}||$$

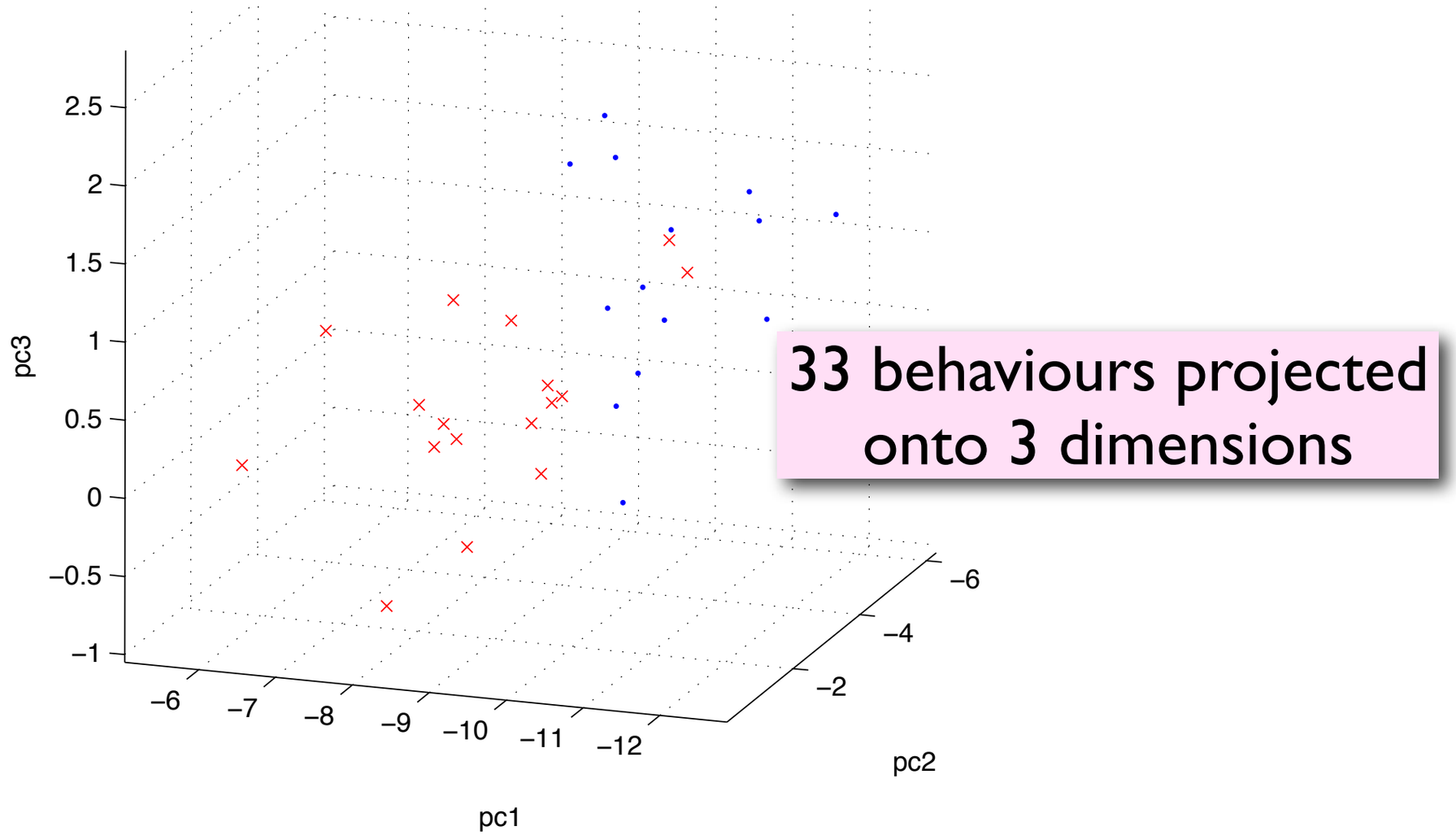


2. Each point $\mathbf{p_i}$ is moved according to the force f_i:

$$\mathbf{p_i} = \mathbf{p_i} + \eta f_i$$

where $\eta = 1/n$.

Behaviour classification



33 behaviours projected onto 3 dimensions

walking vs. non-walking behaviours