ELTE | FACULTY OF INFORMATICS

ETHOROBOTICS

Beáta Korcsok

DEPARTMENT OF ETHOLOGY
EÖTVÖS LORÁND UNIVERSITY

ELTE | IK
DEPARTMENT OF ARTIFICIAL INTELLIGENCE

BOSCH

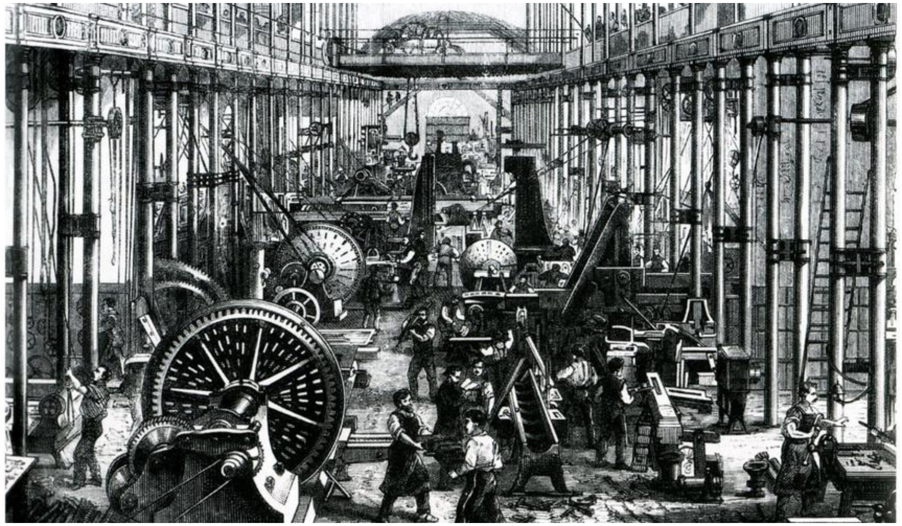
HUN-REN
Hungarian Research Network

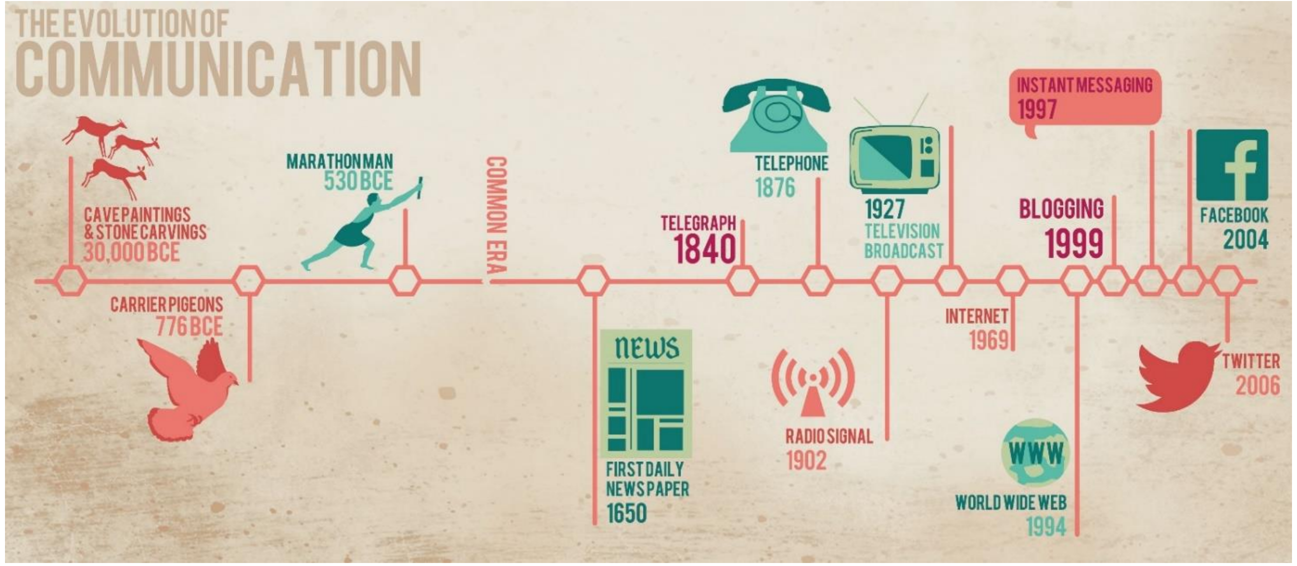
Overview

- Introduction
- Trends in robotics
- Social robots
- Uncanny valley
- Ethorobotics
- Investigation of Human-Robot Interactions

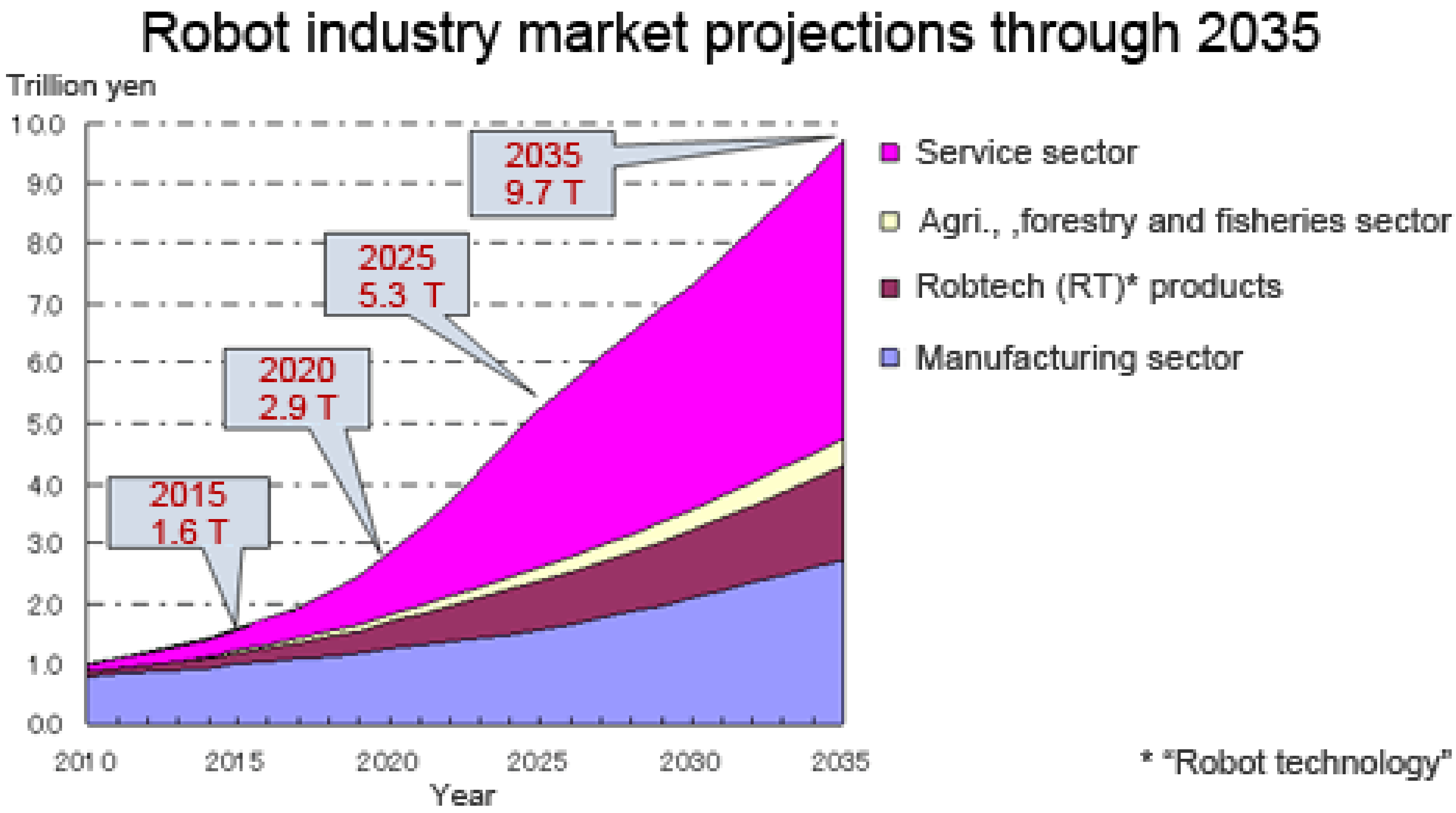
Some slides contain explanations/article excerpts in the Notes section

Human and machine





Robotics trends



Source:
New Energy and
Industrial Technology
Development
Organization
Japan

Who deals with robots?

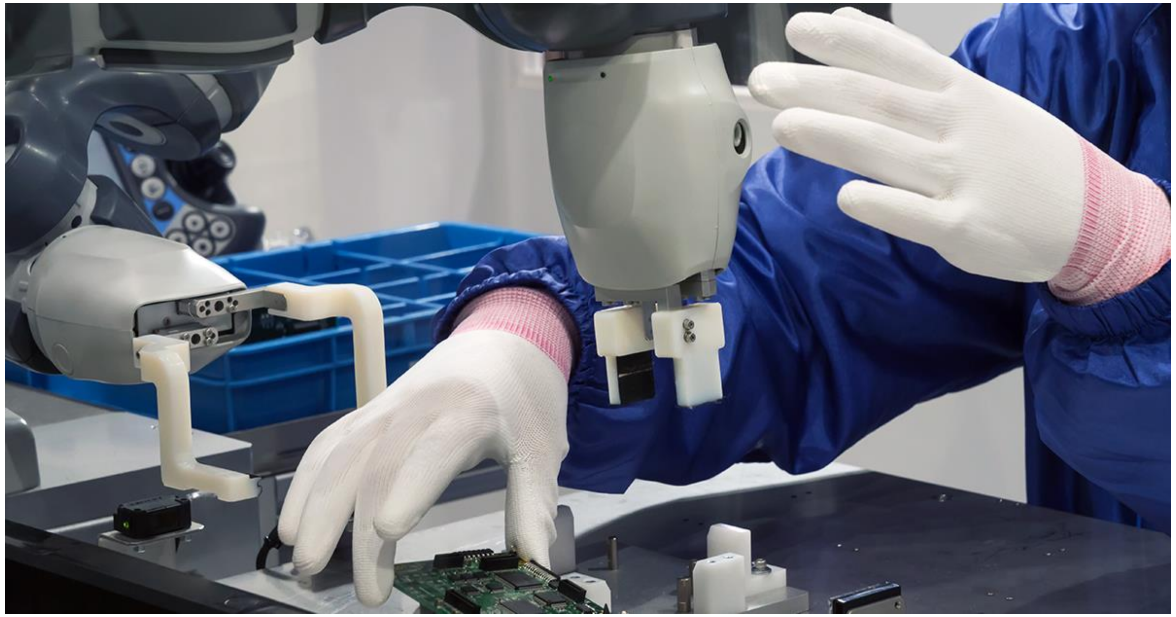
- Classic industrial robots, high-volume production: robot specialists
- Small and medium-sized enterprises, small-volume production: engineers, but not robot specialists
- Medical, research and other applications: not necessarily engineers, but accepting towards new technologies
- Service/assistive robots, e.g. waiter robot, elderly care robot: not necessarily an accepting environment

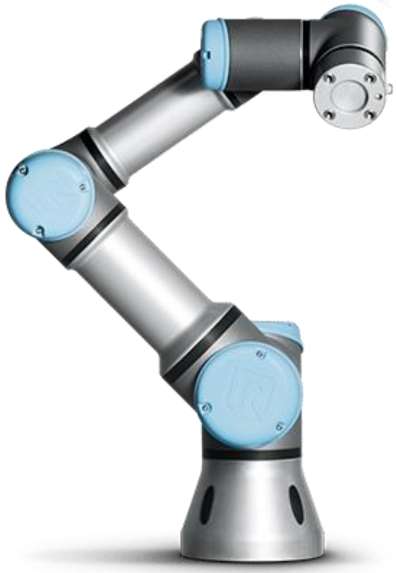
Industrial robots

- In spaces separated from humans
- Controlled environment
- No direct interaction

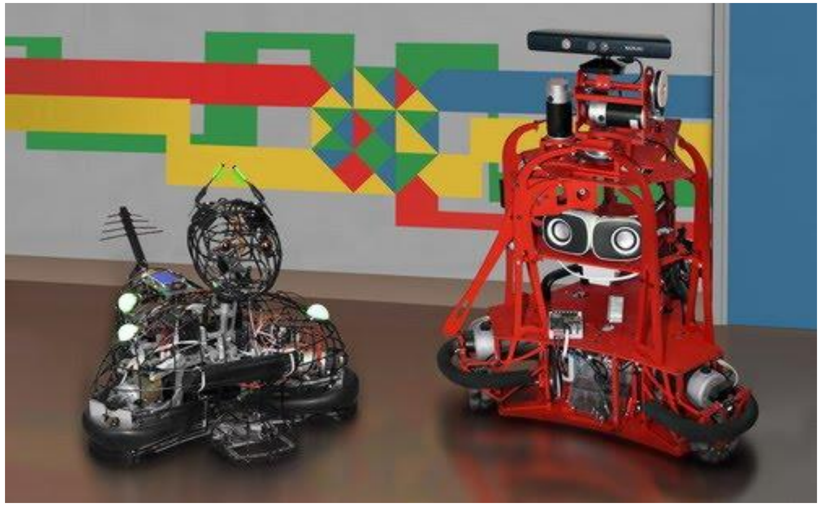
Industrial robots at small and medium-sized enterprises

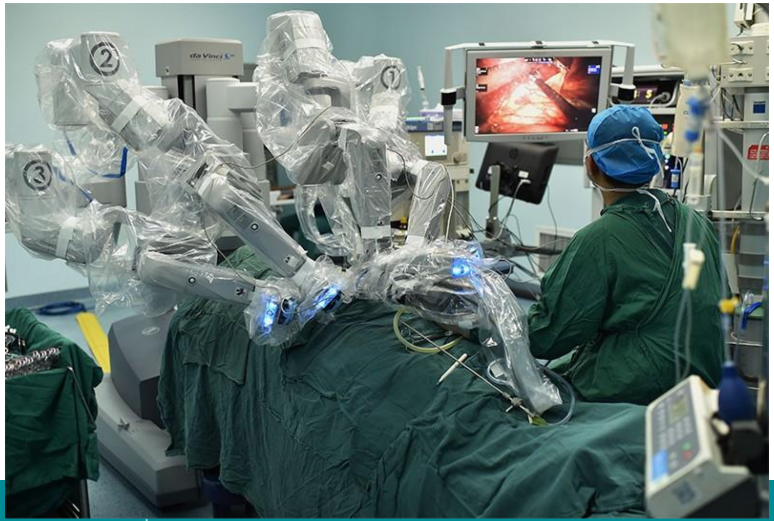
- Varied tasks, frequent task changes
- CoBot: collaborative robots
- Trend: more and more interaction with humans





Medical, research and other applications





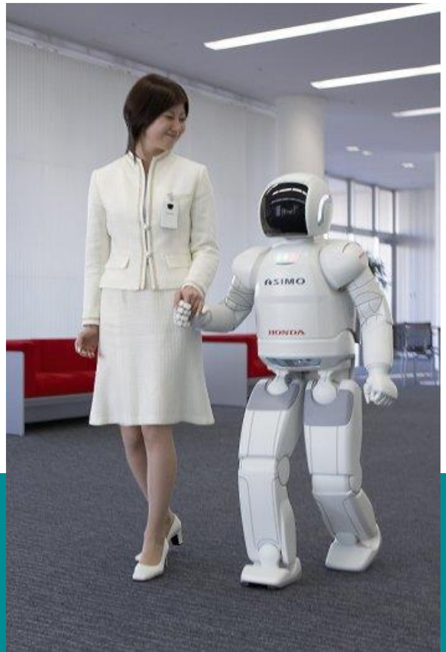
(Bonnet et al., 2016)

Service/assistive robots

Changing challenges

- Industrial robots
  - In factories
  - Executing pre-programmed movements
  - Separated from people

- Social robots
  - In human environments
  - Various tasks
  - Cooperating with people



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Social robots

- Expected to become part of everyday life

- Characteristics:
- Communication, learning, recognizing people, attachment, recognizing/showing emotions

- Application possibilities
- Household, workplace
- Assistive robots: helping the elderly, therapies, developing the social skills of autistic children

General expectations

- Robots have to behave in a way that is acceptable to people
- Have to fit into the human environment
- Appearance and structure that suits both the tasks to be performed and people
- Don't bother people

- Communication:
- A person should not need technological knowledge
- Verbal? Non-verbal?
- But is it good if it talks if it does not understand what it is saying?

Uncanny Valley

- Social robots

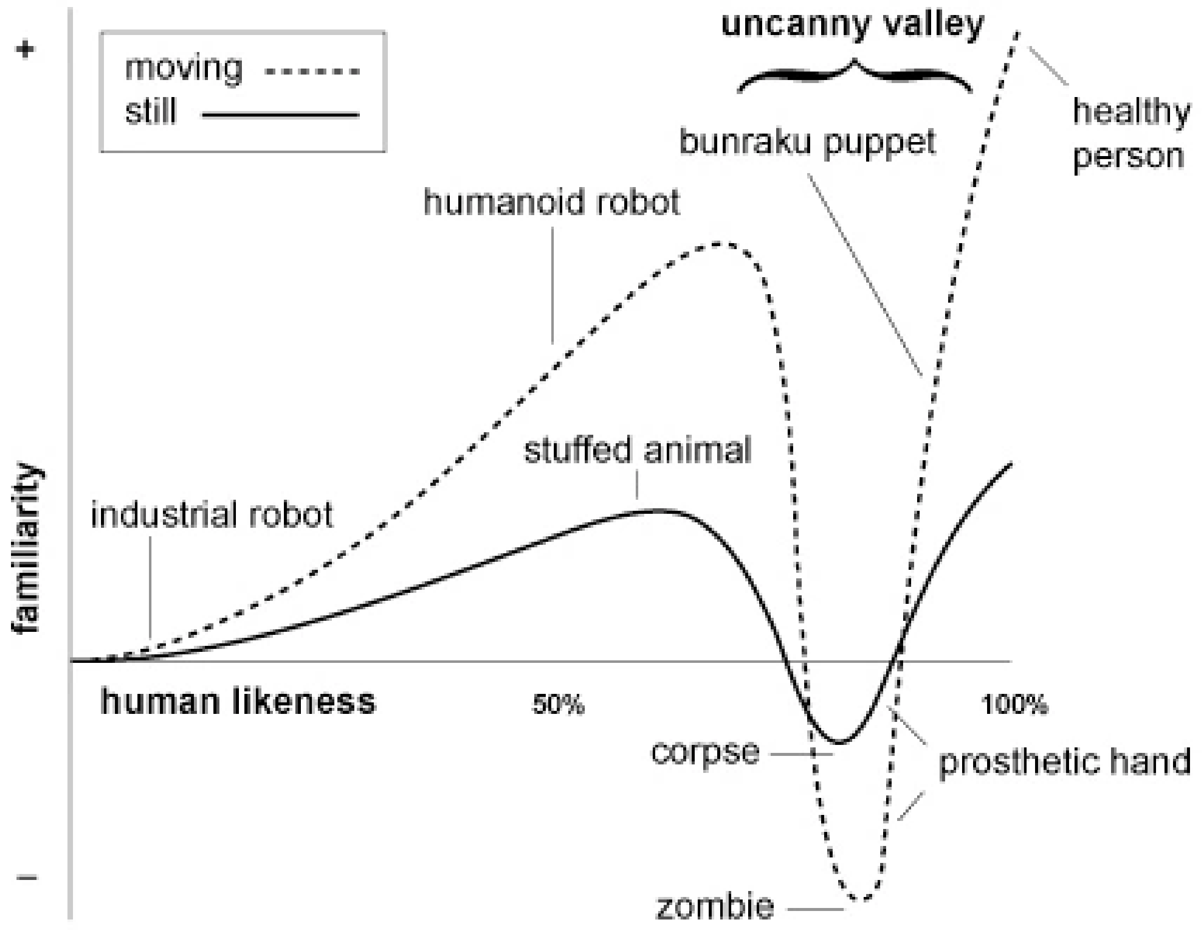
- Why not human?
- Uncanny valley
- Masahiro Mori (1970)
- Functionality:
- Relationship between function and mechanism → capabilities → credibility (Rose et al., 2010, Miklósi et al., 2012)

Uncanny Valley

- Human-like robots?

- The appearance and behaviour of robots can cause aversion if they are too human-like (Masahiro Mori, 1970)

!



Uncanny Valley

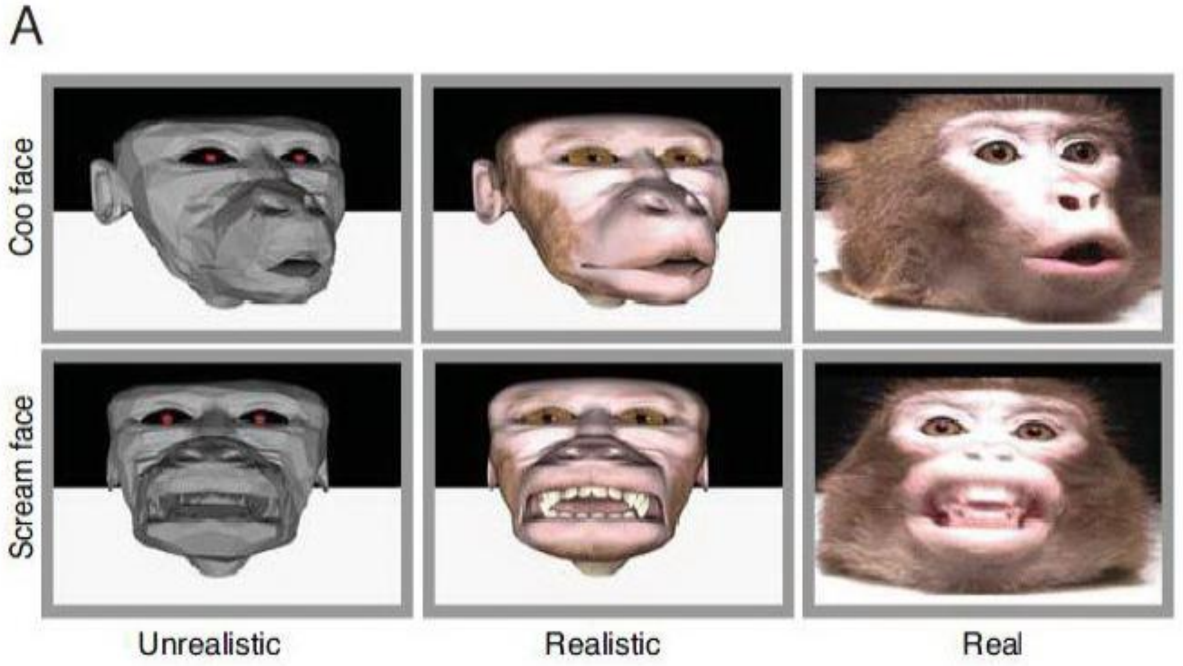
Hiroshi Ishiguro & Geminoid HI-1

Uncanny Valley



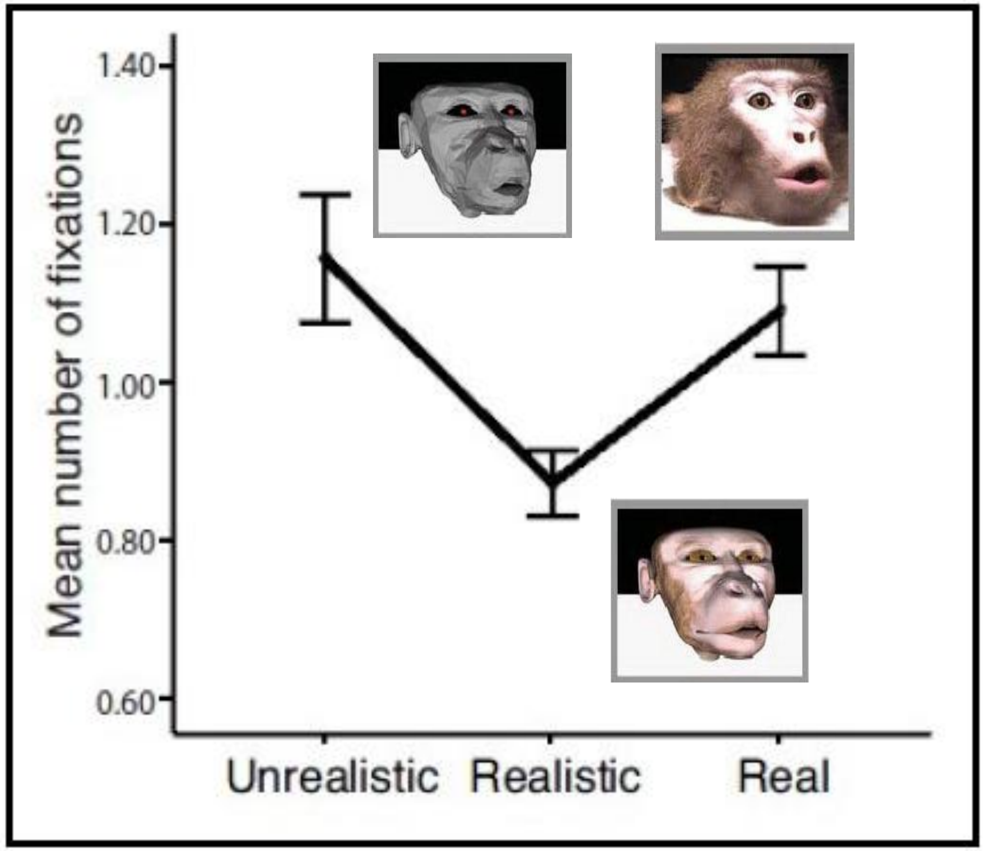

Uncanny Valley

- Evolutionary background?
- Uncanny Valley effect in monkeys (Steckenfinger et al., 2009)
  - Long-tailed macaque (*Macaca fascicularis)*
  - Unrealistic, realistic and real monkey heads on screen



Uncanny Valley

- Macaques looked less at the realistic face than at the others



Uncanny Valley

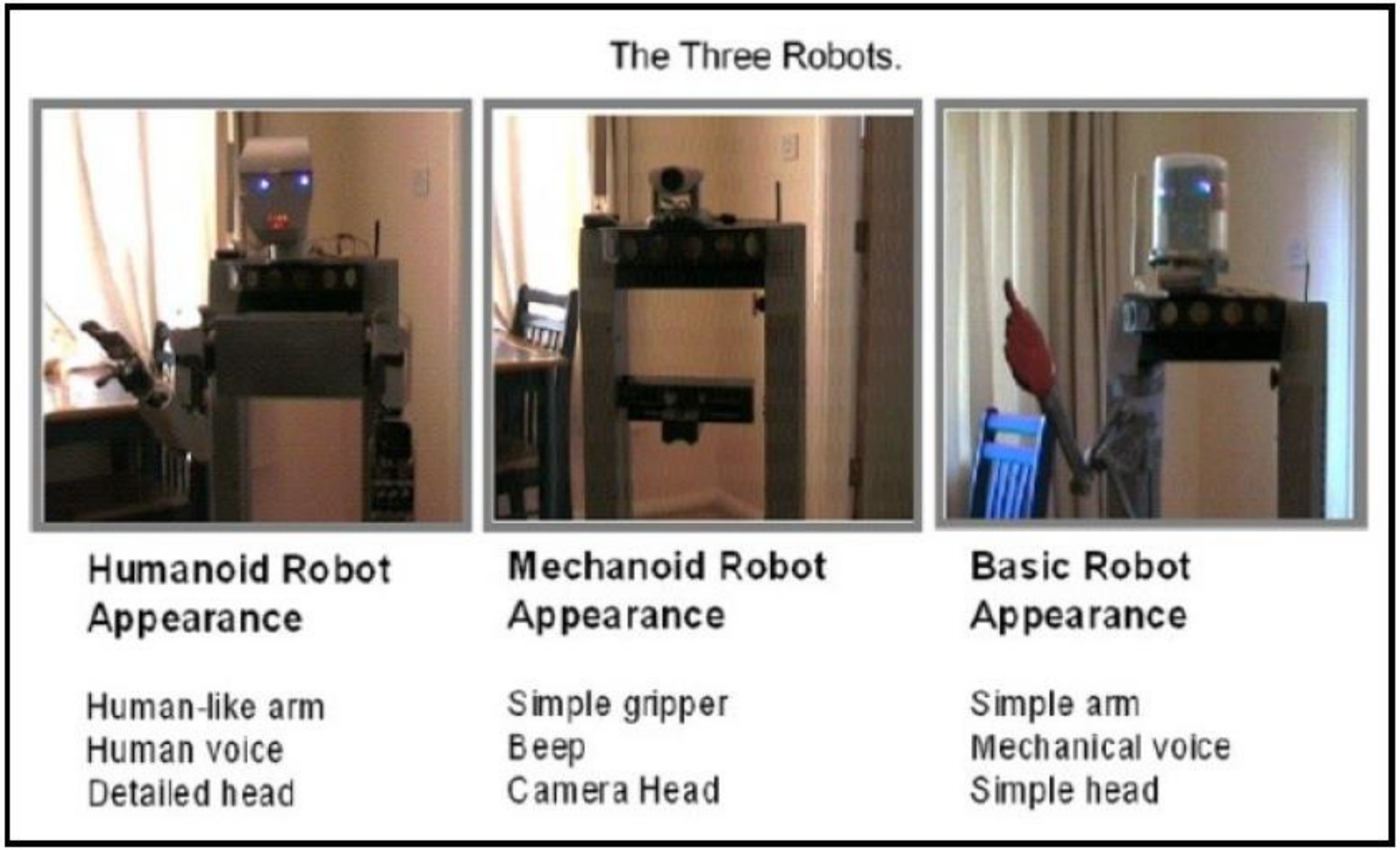
- Uncanny valley effect can be caused by the mechanism of avoiding ill individuals → may have an evolutionary origin in humans

- It was not ruled out in the experiment that the longer viewing time of the unrealistic and real faces was due to fear or curiosity

Uncanny Valley

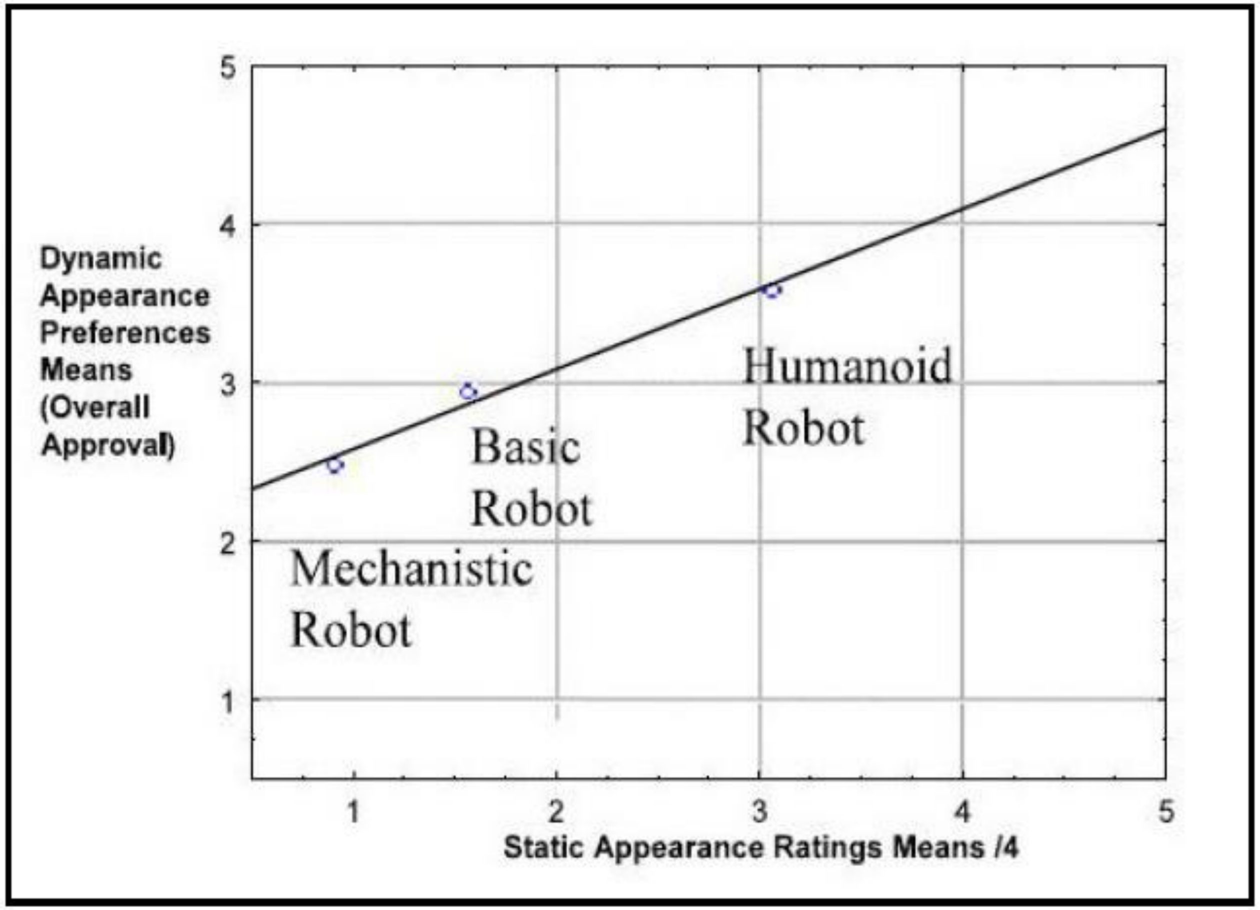
- Preference for the appearance and behavior of different robots
- (Walters et al., 2008)
- Everyday situations were displayed
- Video recordings of human-robot interactions
- 3 types of robots: simple, mechanoid, "humanoid„
- Appearance and behaviour were congruent
- Subjects rated the robots based on the recordings

Uncanny Valley

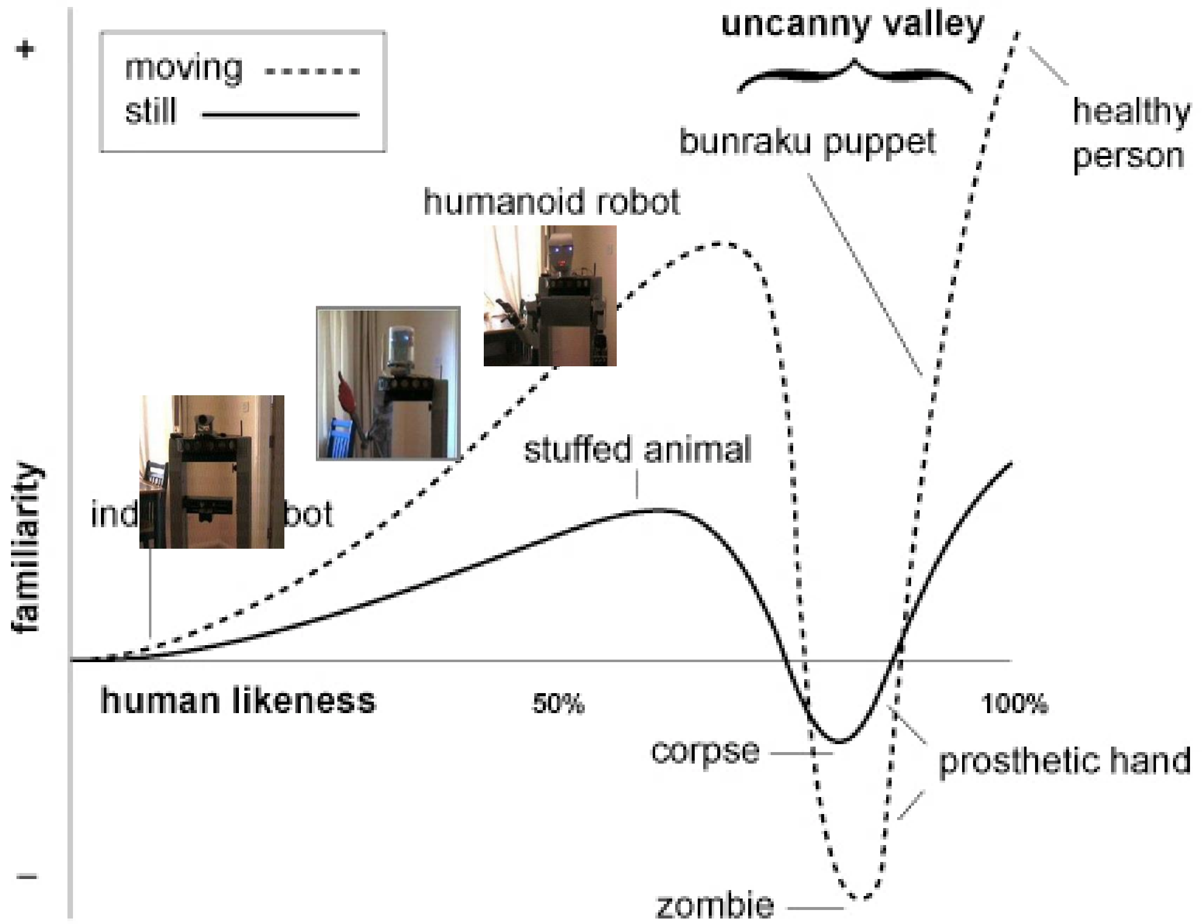


Uncanny Valley

- The mechanoid robot was preferred the least and the humanoid the most



Uncanny Valley



BUT!
The humanoid robot was not human-like enough to fall into the uncanny valley

Uncanny Valley

Bartneck et al.,
2009

- Short interactions with an android or a human
- The results indicate no uncanny valley effect
- But: methodological issues

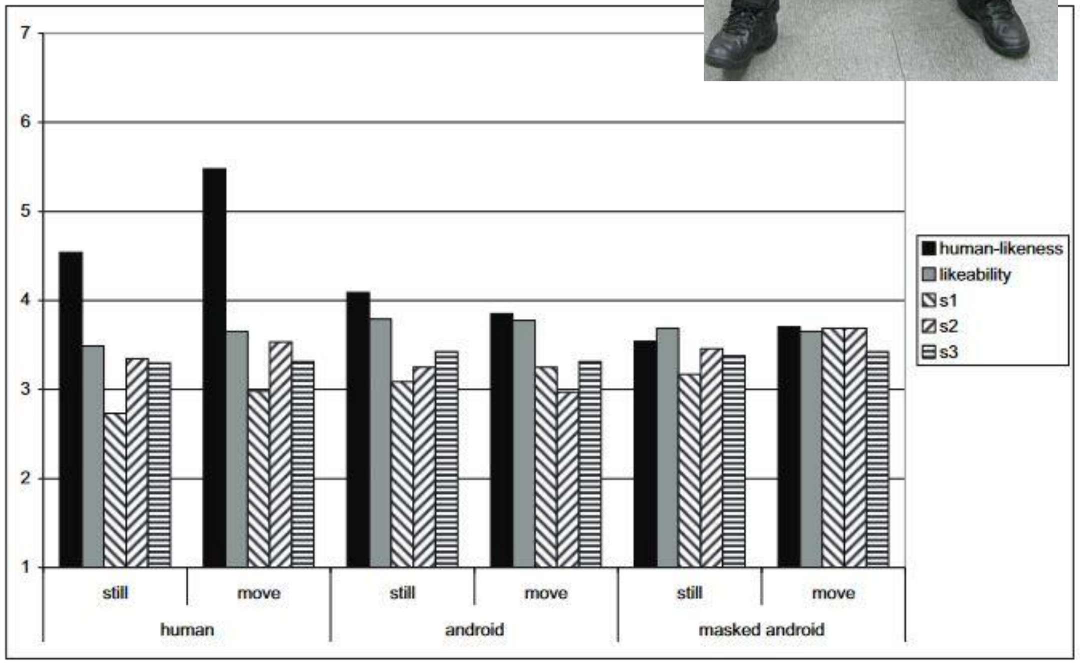
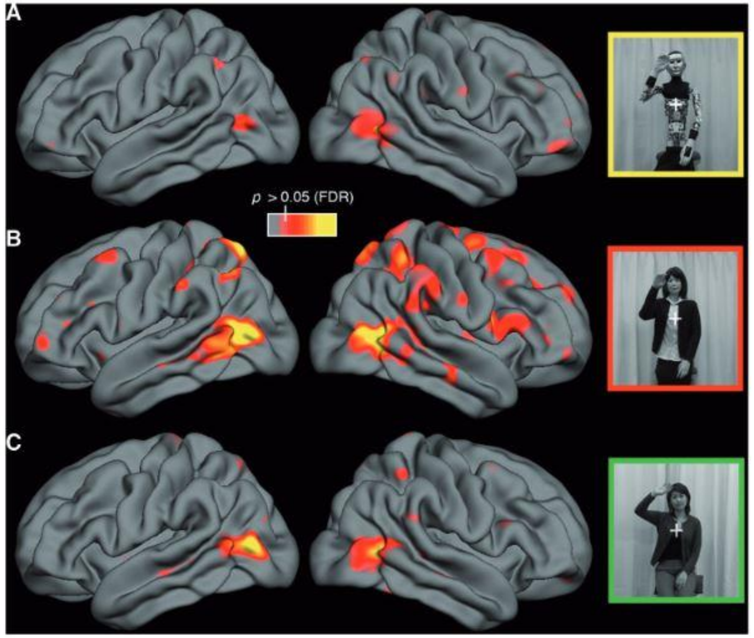


Figure 6: Means of all measurements under all conditions. Human-likeness and likeability were measured on a 7-point scale, while the RAS scales (S1, S2 and S3) were measured on a 6-point scale.

Uncanny Valley

- Humanoid appearance with robotic movement
- fMRI examination
- Video recordings: human, human-like android, machine-like android
- Prediction error: incongruency between the expected movements of the human-like android and its actual robotic movements

Saygin et al., 2011



Uncanny Valley

- **5 main theories** (Zhang et al., 2020)
- Evolutionary psychological explanations:

1. Threat Avoidance Hypothesis: pathogen avoidance; avoiding mortality
2. Evolutionary Aesthetics Hypothesis: aversion to individuals with an unattractive appearance (bilateral symmetry, skin surface quality, proportions of facial features) → health, fertility

!

- Cognitive explanations:

3. Mind Perception Hypothesis: projecting the ability of feeling onto robots
4. Violation of Expectation Hypothesis: expectations of human-like abilities → the robot violates this
5. Categorical Uncertainty Hypothesis: blurred category boundary

Uncanny Valley

- Robots can easily surpass human-likeness
- E.g., 360° cameras → no need to turn around → different gaze behaviours
- Improved „human” or another valley?

Uncanny Valley

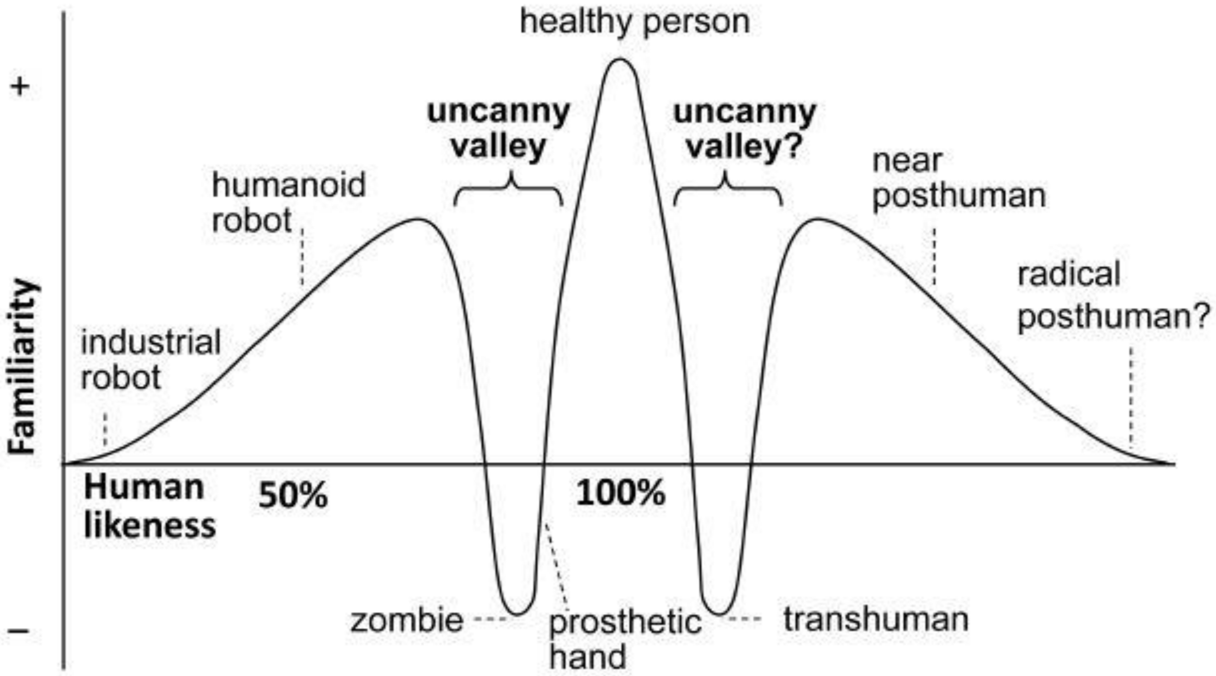


FIGURE 2 | An extended version of Mori's idea by Jamais Cascio (from http://www.openthefuture.com/2007/10/the_second_uncanny_valley.html). The second valley shows a similar effect related to robots evolved *from* perfect humanlike agents, as they become *less* similar to humans – following the path of *trans*-human and, eventually, *post*-human robots. The hill after the valley is when differentiation is strong enough to create a new category.

Cascio, 2007

Avoiding the Uncanny Valley

Miklósi et al., 2017

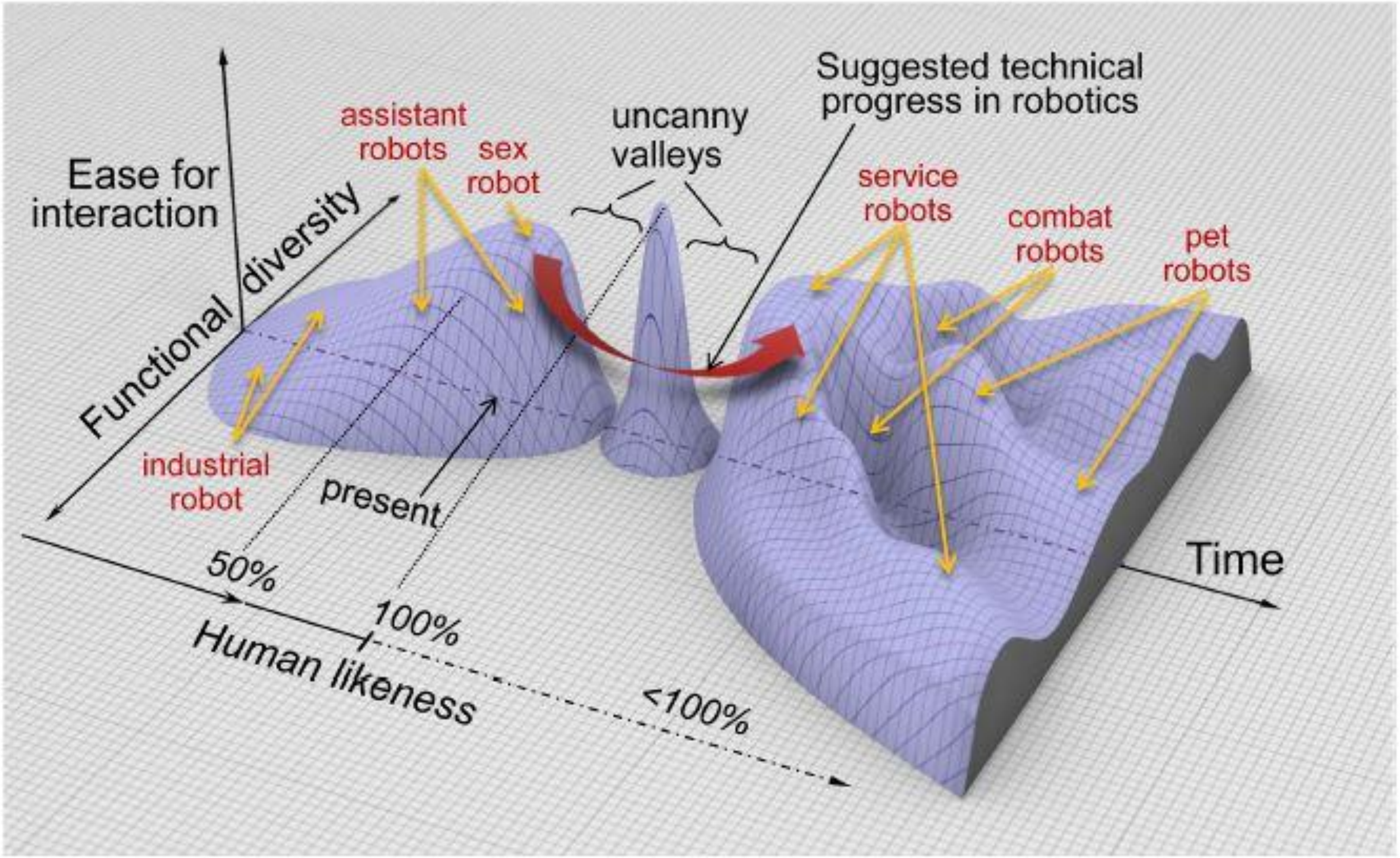


FIGURE 3 | An ethorobotic concept of emerging human-robot interaction. Based on Mori's idea, the present situation and the envisaged progress of social robotics are shown in a three-dimensional space to separate human-likeness, functionality and ease of interaction. After the peak and the second uncanny valley, robots are likely to evolve into a diversity of morphologies and behaviors that, depending on their functions, gradually move away from perfect human likeness. The wide curved arrow indicates the possible detour for social robotics by moving directly from the present state to less humanlike robots with diverse functionality retaining high-level capacity for social interaction with humans. The labels on the terrain are only for informative purposes and do not necessarily refer to actual existing robots.

Uncanny Valley

- So what should social robots be like?
- Embodiment and behaviour aligned with its functions
- Embodiment should not be misleading
- Living creature-like characteristics (but not looking like a specific animal) → considered as a new species
- Bilateral symmetry
- Features that facilitate communication (e.g. separate, rotatable head, "eyes")

Kaspar - University of Hertfordshire's Adaptive Systems Research Group

When the function necessitates human-likeness…

Telenoid R1

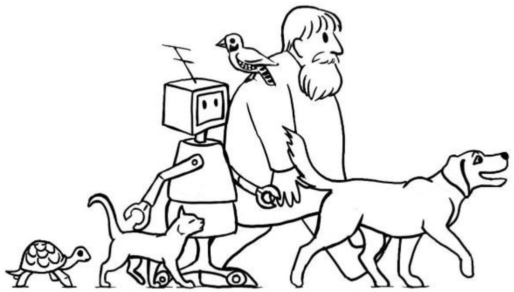
…And when it's not

Telecommunicational tool

Ethorobotics

- Ethology + robotics

- ELTE Ethology Department & BME MOGI Department



MOGI

- HUN-REN–ELTE Comparative Ethology Research Group

Ethology, ethorobotics

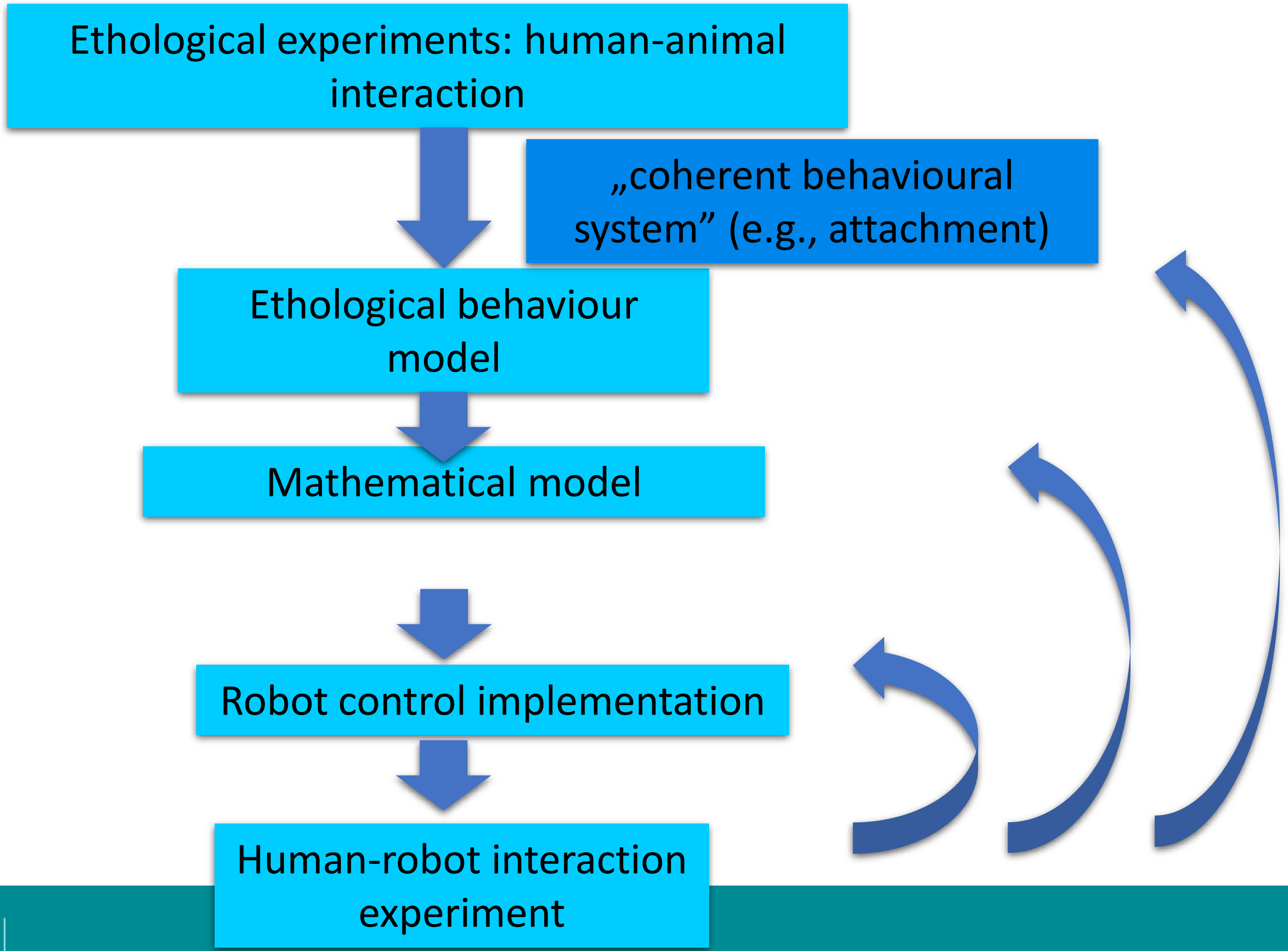
- Behaviour research

- Field observations
- Well-controlled experiments carried out in laboratories
- Evolutionary approach
- Tinbergen's 4 questions: function, mechanism, ontogeny, evolution

- Ethorobotics
- Behavioural models and ethological methods

Jane Goodall

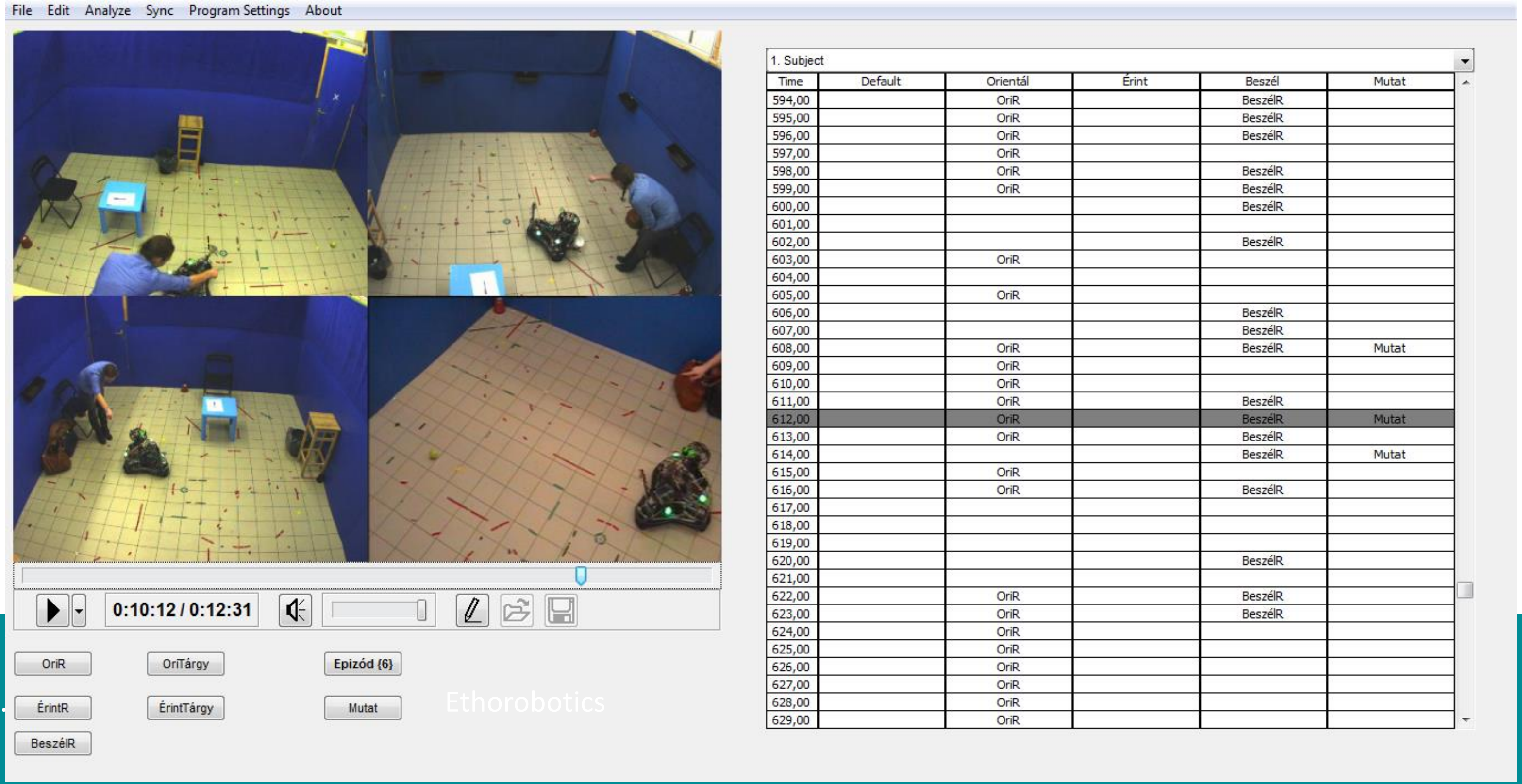
Ethorobotics



Research process - data collection, analysis

- Experiment/observation
- Recording measurements (usually video recordings)
- Behaviour coding
- Data
- Statistics
- Behavioural model

Behaviour coding programs:
Observer
Watcher
Solomon Coder
BORIS



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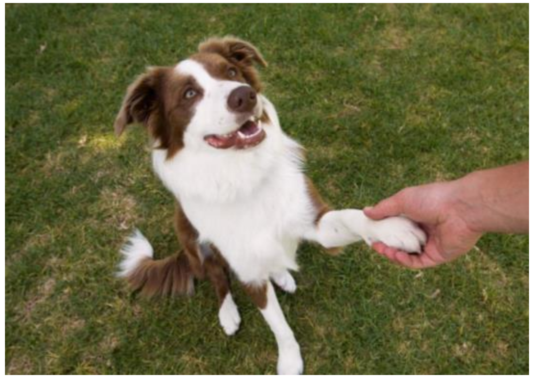
629,00		OriR			

Ethorobotics

- Behaviour models: social animals, e.g., dogs
- During domestication, dogs acquired social skills that helped them to integrate into the human environment (Topál et al., 2009).
- Communication
- Cooperation
- Attachment
- → Help dogs (e.g., guide dogs for the blind)





Ethorobotics - goals

- Determination of basic behavioural elements
- Increasing the acceptability of robots by humans, the success of interactions, and the usability of the robots
- Robot as a new species → function, abilities → appropriate level of social competence

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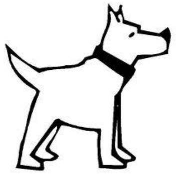
Social competence: „an individual's ability to generate social skills that conform to the expectations of others and the social rules of the group" (Miklósi et al., 2013)



→ Behaviour elements, social skills →

What can they help us with?

- Development of communication signals
- Development of specific behaviours, e.g., leading to a sound source: assistance dogs for the hearing impaired (Koay et al., 2003)
- Characteristics of interactions: proximity seeking, looking at people, activity (Faragó et al., 2014), emotional expression (Korcsok et al., 2020)
- Modeling dog-human attachment (Kovács et al., 2011)

Emotion expressions in artificial agents

- Emotion expressions mostly based on human facial expressions
- Robot faces → Uncanny Valley (Mori, 1970), function?
- Emoticons → static/repetitive, human-specific, visual modality only
- Depends a lot on the structure (facial expressions)
- Human emotionally expressive behaviours are too complex
- A simpler model is needed that can be easily adapted to the function and structure of the agent
- An alternative approach is to design the emotion expressions of artificial agents based on biological/ethological rules (Gácsi et al., 2016)
- Biological approach: dynamic, multimodal, non-species specific, easily adaptable

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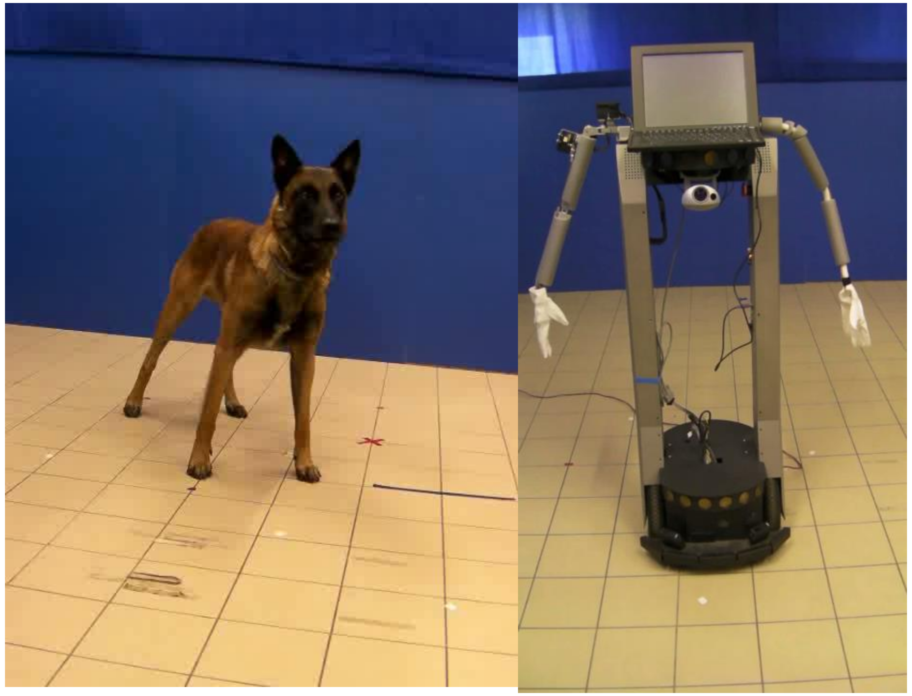
Emotion expression with simple robot embodiment

Fear



Sadness

Gácsi et al., 2016

Emotion expression with simple robot embodiment

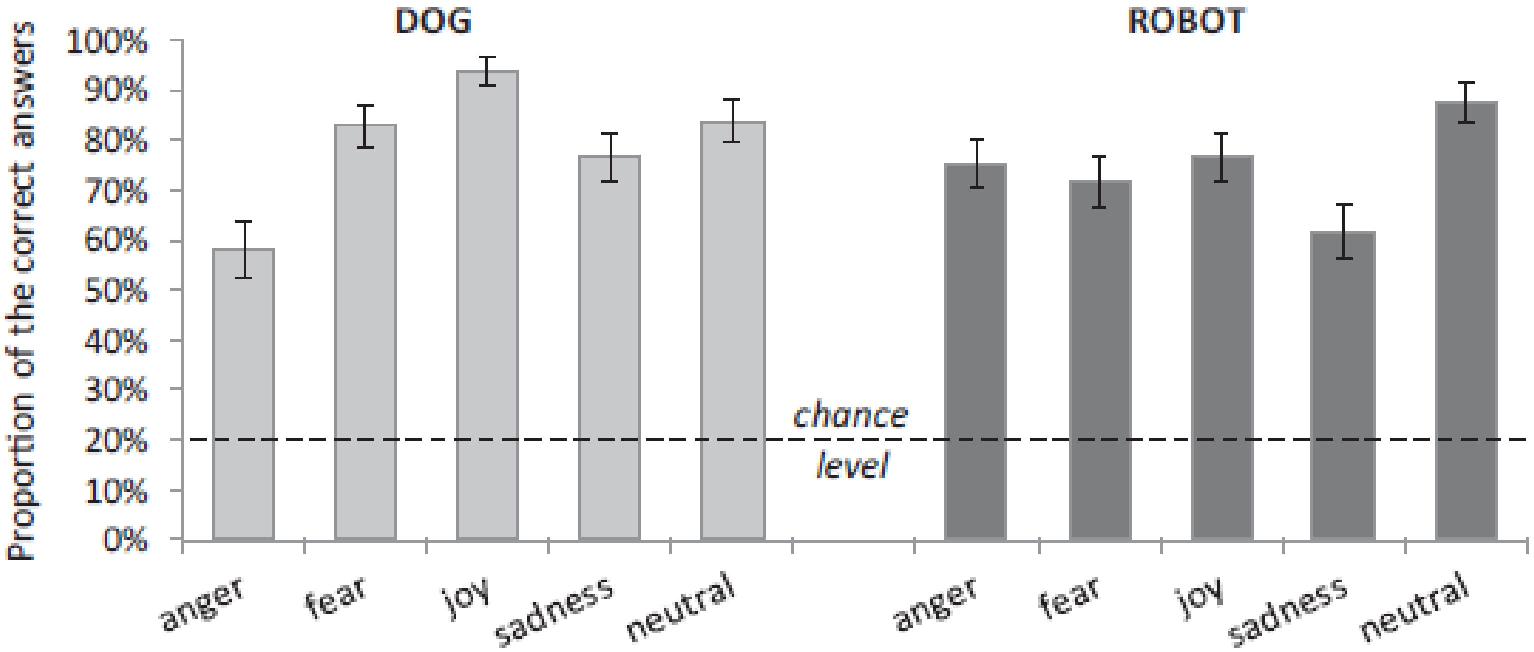


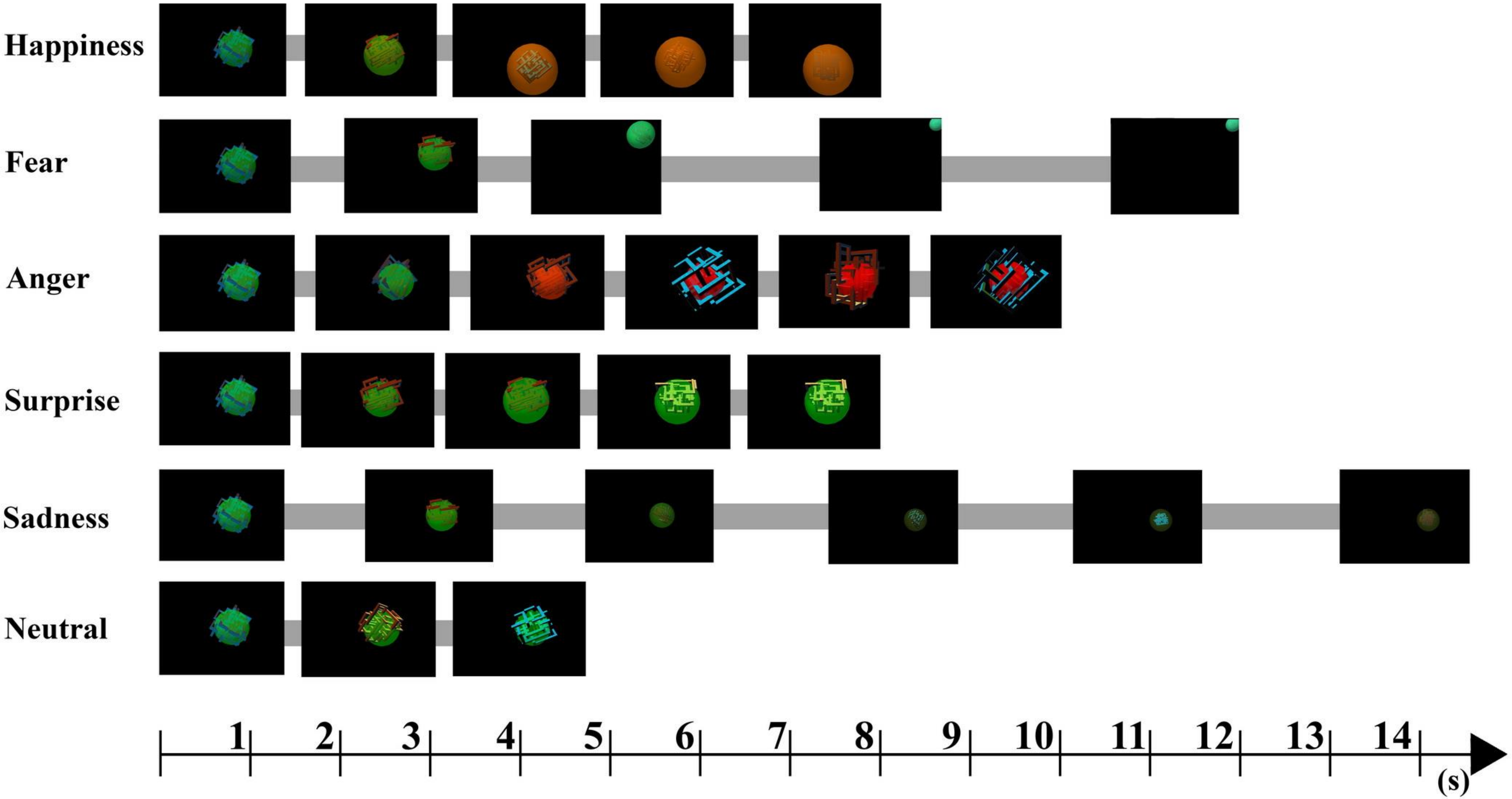
Fig. 3. Percentage of correct answers related to each inner state in the case of the dog and the robot in the multiple-choice part of the questionnaire.

Method

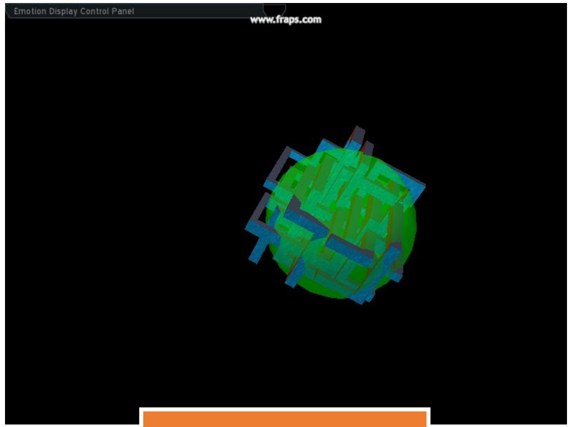
- Agent: abstract form → sphere + grid
- Multiple changeable parameters: colour, size, movement, transparency, direction and speed of rotation
- Multiple questionnaire study (Open-ended questionnaire Q1, Closed-ended questionnaire Q2)
- Subjects: volunteering university students
    - Hungary: N=114 (34♂, 78♀, age 21 ± SD 1.7 years)
    - Japan: N=22 (21♂, 1♀, 22±SD1.1 years)
- 6 short (12-4 s) videos of functionally relevant basic emotions (anger, happiness, sadness, fear, surprise) + neutral state

Korcsok et al., 2018

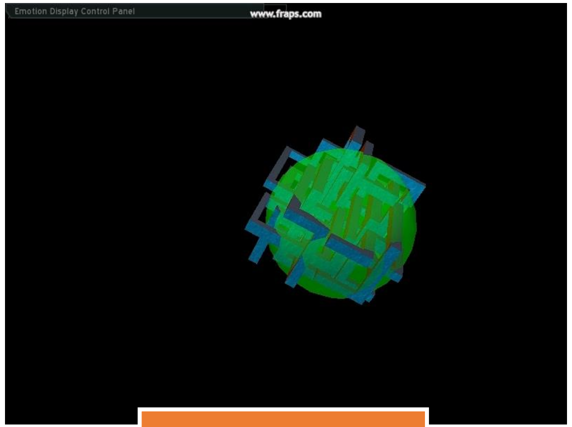
Visual emotion expression



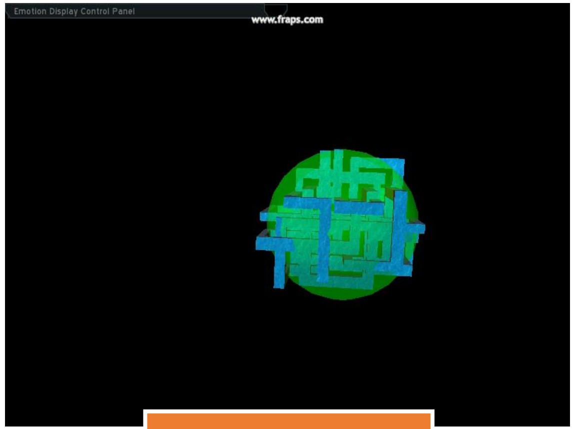
Visual emotion expression



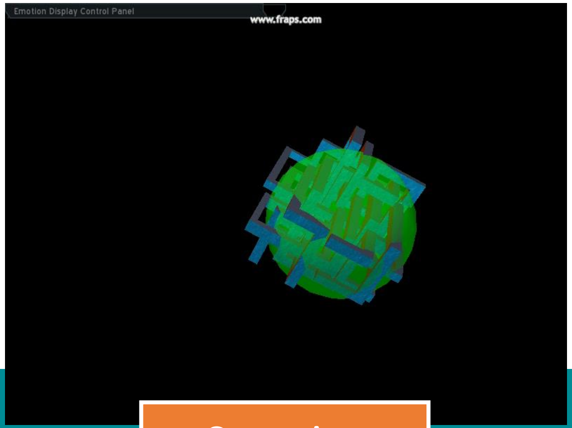
Anger



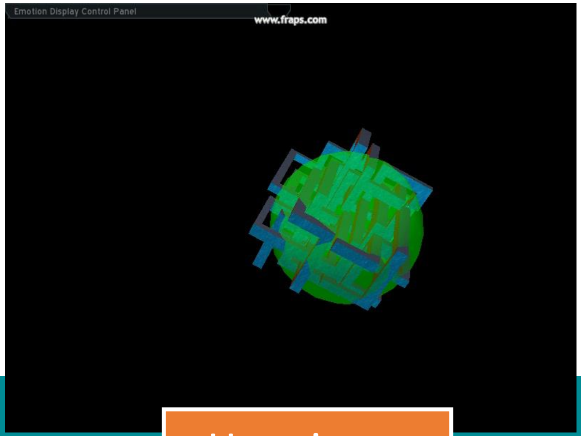
Sadness



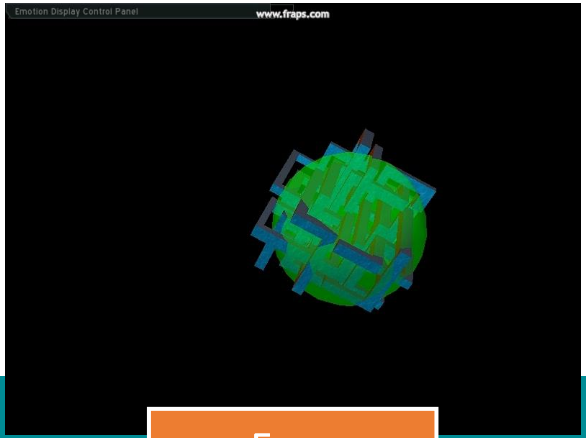
Neutral



Surprise



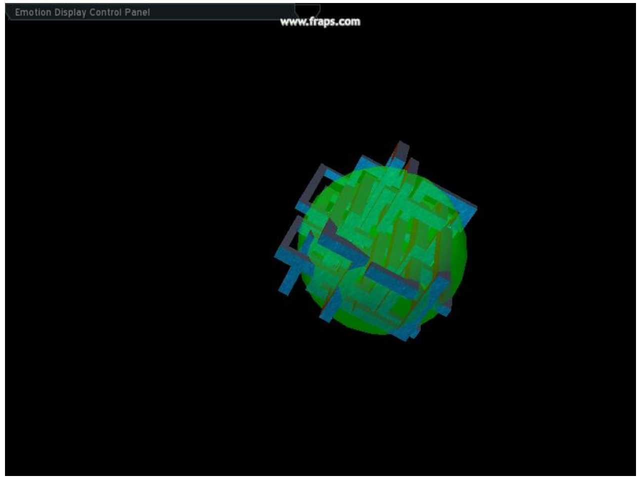
Happiness



Fear

Anger

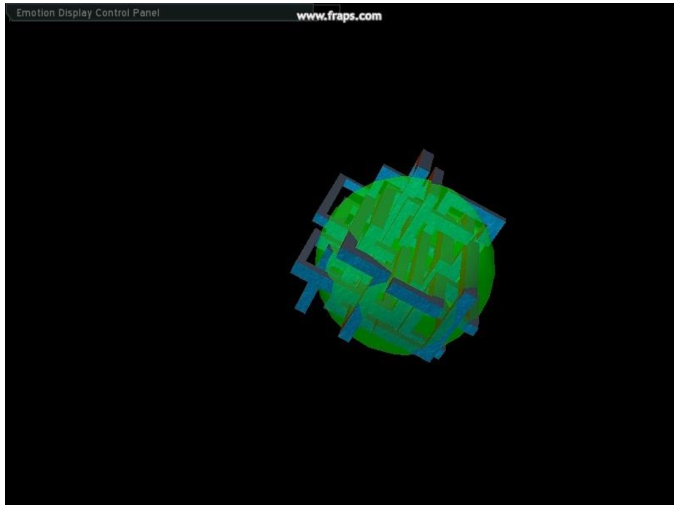
- Threat displays: evolved from behaviours that take place before/during combat
- Showing "weaponry„
- Show larger body size
- Bright colours (e.g. blood saturation or showing pigmented body parts)
- Approach



Anger	Approach/avoidance, intra-specific competition (enemy) Scott and Fredericson, 1951; Evans and Norris, 1996	Vivid colors, size increase, threat displays (showing weaponry) Evans and Norris, 1996; de Boer et al., 2003	Rotation speed increases. Agent moves closer (size increase). Dill, 1978; Nishida et al., 1999; de Boer et al., 2003	Sphere and grid size increase, grid becomes bigger than sphere Scott and Fredericson, 1951; Evans and Norris, 1996; Nishida et al., 1999; de Boer et al., 2003	Sphere becomes red, grid becomes blue Evans and Norris, 1996; Drummond and Quah, 2001; Chen and Fernald, 2011

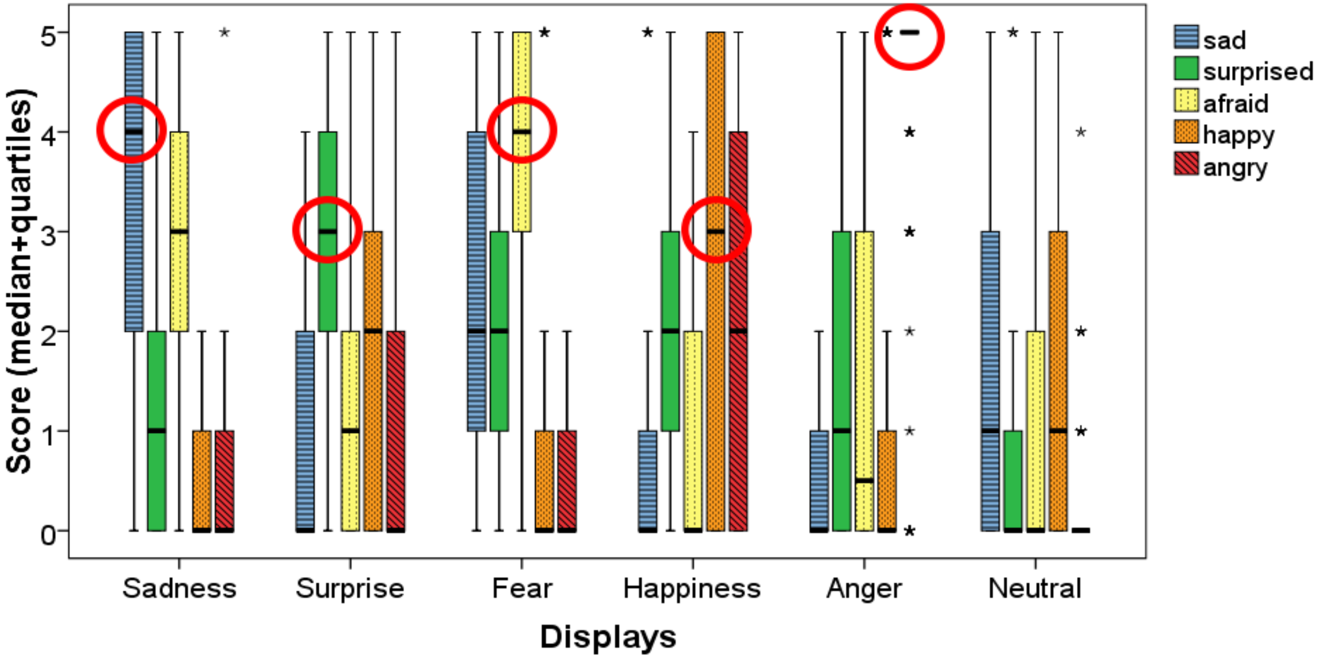
Fear

- Escape
- Fast movement
- Hiding
- Crouching → smaller size
- Faded colours



Fear	Avoidance, escape	Pale colors, size decrease, seeking escape, hiding	Agent moves toward the right upper corner. Rotation speed increases.	Sphere and grid size decrease, sphere becomes bigger than grid	Sphere becomes pale/bright
	Bonenfant and Kramer, 1996; Stankowich and Blumstein, 2005	Dill and Houtman, 1989; Bonenfant and Kramer, 1996; Stankowich and Blumstein, 2005	Dill and Houtman, 1989; Bonenfant and Kramer, 1996; Stankowich and Blumstein, 2005; Rhoades and Blumstein, 2007	Caro, 2005	Conte, 2004; Vianna and Carrive, 2005; Garfinkel and Critchley, 2014

Results – Hungarian



Scores given to the correct emotion differ from all other given scores in the FEAR, ANGER, SURPRISE displays (Friedman test + Wilcoxon signed rank test; *** p<0.001)

	Displays					
Emotions receiving the biggest score	Sadness	Surprise	Fear	Happiness	Anger	Neutral
sad	53,2%	5%	18%	4%	0%	31%
surprised	8%	50%	8%	11%	3%	13%
afraid	31%	9%	59%	8%	6%	10%
happy	4%	26%	13%	47%	11%	44%
angry	4%	10%	3%	30%	79%	1%

Confusion matrix. The grey cells indicate the percentage at which each emotion received the biggest score.

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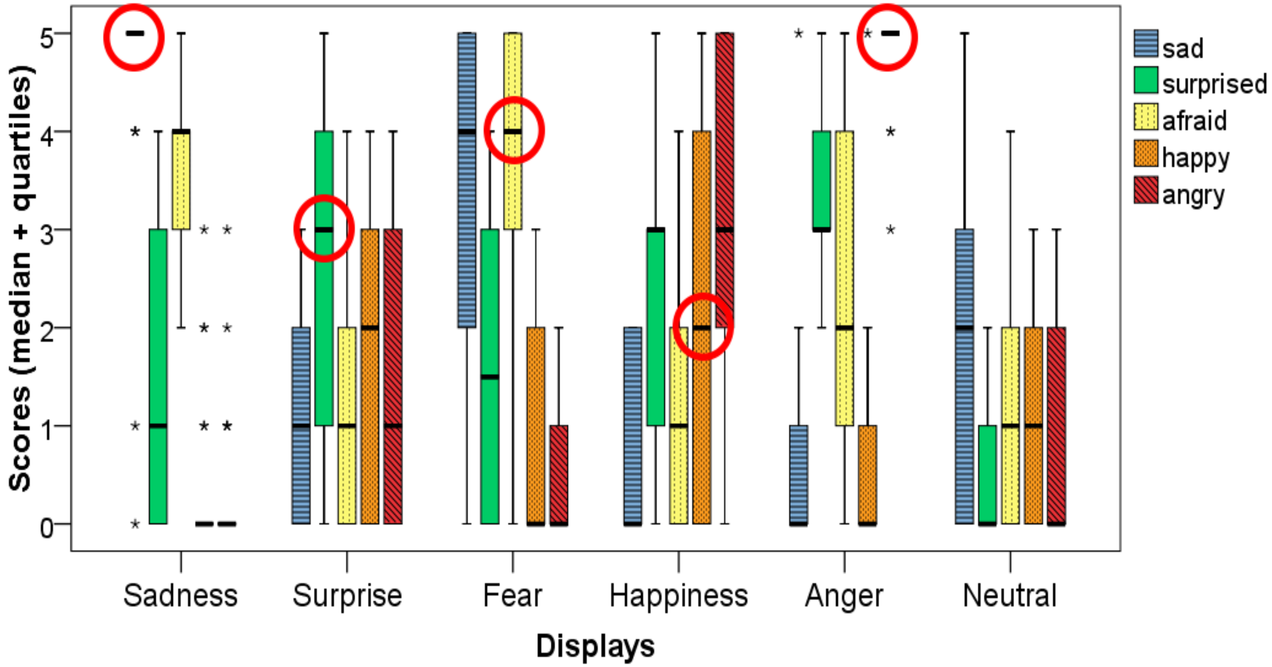
Results – Japanese



Scores given to the correct emotion differ from all other given scores in the Sadness and Anger displays (sad-happy, sad-angry, sad-surprised: $p < 0.001$ sad-afraid: $p = 0.007$) (angry-afraid, angry-happy, angry-sad: $p < 0.001$ angry-surprised: $p = 0.001$) (Friedman test + Wilcoxon signed rank test; *** $p<0.001$)

	Displays					
Emotions receiving the biggest score	Sadness	Surprise	Fear	Happiness	Anger	Neutral
sad	77%	6%	35%	0%	1%	40%
surprised	5%	46%	9%	14%	10%	10%
afraid	18%	8%	47%	7%	3%	21%
happy	0%	32%	10%	28%	1%	21%
angry	0%	8%	0%	51%	85%	7%

Confusion matrix. The grey cells indicate the percentage at which each emotion received the biggest score.

Discussion

- Most participants attributed emotions to the agent's emotionally expressive behaviours
- The most well recognised emotion expression was anger
- People mixed some emotions more easily (happiness → anger, sadness → fear) which had similar behavioural attributes
- Hungarians scored the fear, anger and surprise displays the most correctly, while Japanese scored best with sadness and anger

- Viable alternative for current emotion expressions of artificial agents

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Thank you for your attention!

Korcsok Beáta
korcsokbea@gmail.com

Robot as mediator

Figure 4 Robot as a mediator. The left image shows an autistic child (far end) engaged in a simple imitation game with the robot, showing his skills to another (non-autistic) child. In the right image, the robot *mediates* the interaction between two children with autism who are engaging in a simple imitation game with the robot.

Billard et al., 2006