Challenges for benchmarking when working with people and robots

Kerstin Dautenhahn

Adaptive Systems Research Group

University of Hertfordshire

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University of Hertfordshire

The Robot as a Companion Paradigm

Def: A Companion is an agent that

a) makes itself 'useful', i.e. is able to carry out a variety of tasks in order to assist humans

b) behaves socially, i.e. possesses social skills in order to be able to interact with people in a socially acceptable manner.

Note, a) and b) imply a long-term perspective:

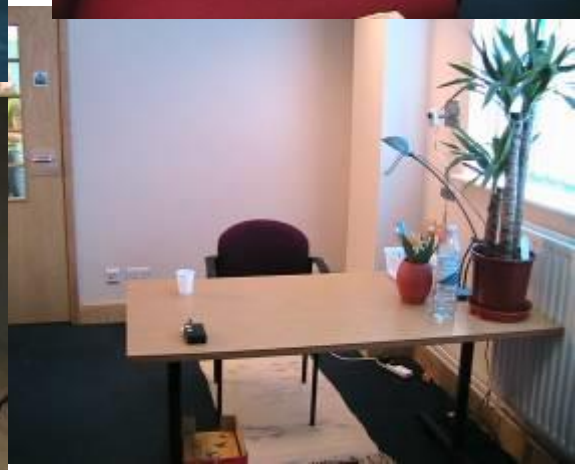
- repeated interactions
- need for learning and adaptation
- potential for relationships, but does not assume that people “bond” with robots (friend vs. assistant/butler)

Home companions:
Types of assistance

- Investigating robots as **home companions** providing assistance as
  - **cognitive prosthetics** (memory aid, e.g. reminding user of appointments etc.)
  - **physical assistance** (carrying objects for user with restricted mobility, fetch-and-carry)
  - **social assistance, mediator** (entertainment context where user can play with remotely located other person via the computer and the companion robot)

Where do we carry out our HRI experiments?
Ecologically valid environments

Laboratory Settings: Simulated Living Room- Experimental Setup



Robots in the Robot House I

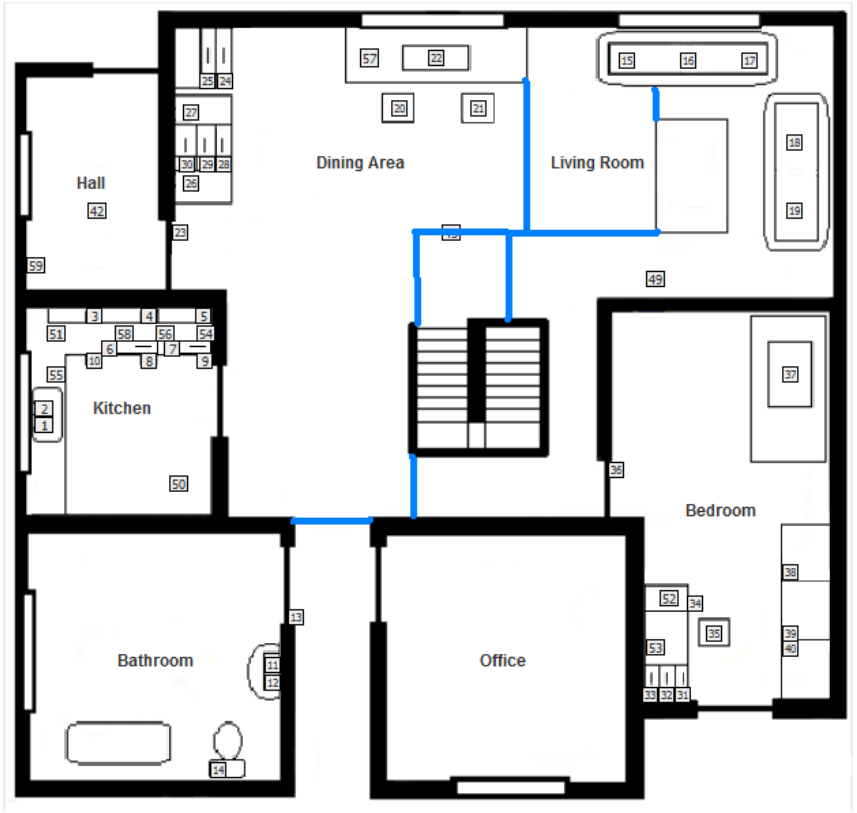
Robot House II (since 2008)

Sunflower (UH, designed by K.L. Koay)

Care-O-Bot® 3 (Fraunhofer IPA)

Robot House

- Smart home including different types of robots
- Sensor network
  - Detect electricity usage of devices
    - Fridge door open
    - Door bell
    - Etc.
  - Dozens of pressure/contact sensors/temperature etc.
    - Open fridge door
    - Setting down on sofa
    - Opening drawers
    - Etc
  - Two omnidirectional ceiling cameras



Care-O-Bot

Database

Sensor State, Context State, Abstract State, User and Object locations

Context Evaluation

Taught or Programmed Behaviours (<precondition><actions><postconditions>

3 Level Architecture

Deliberation

Sequencer (Priority Based Pre-emptive)

Planner (HTN)

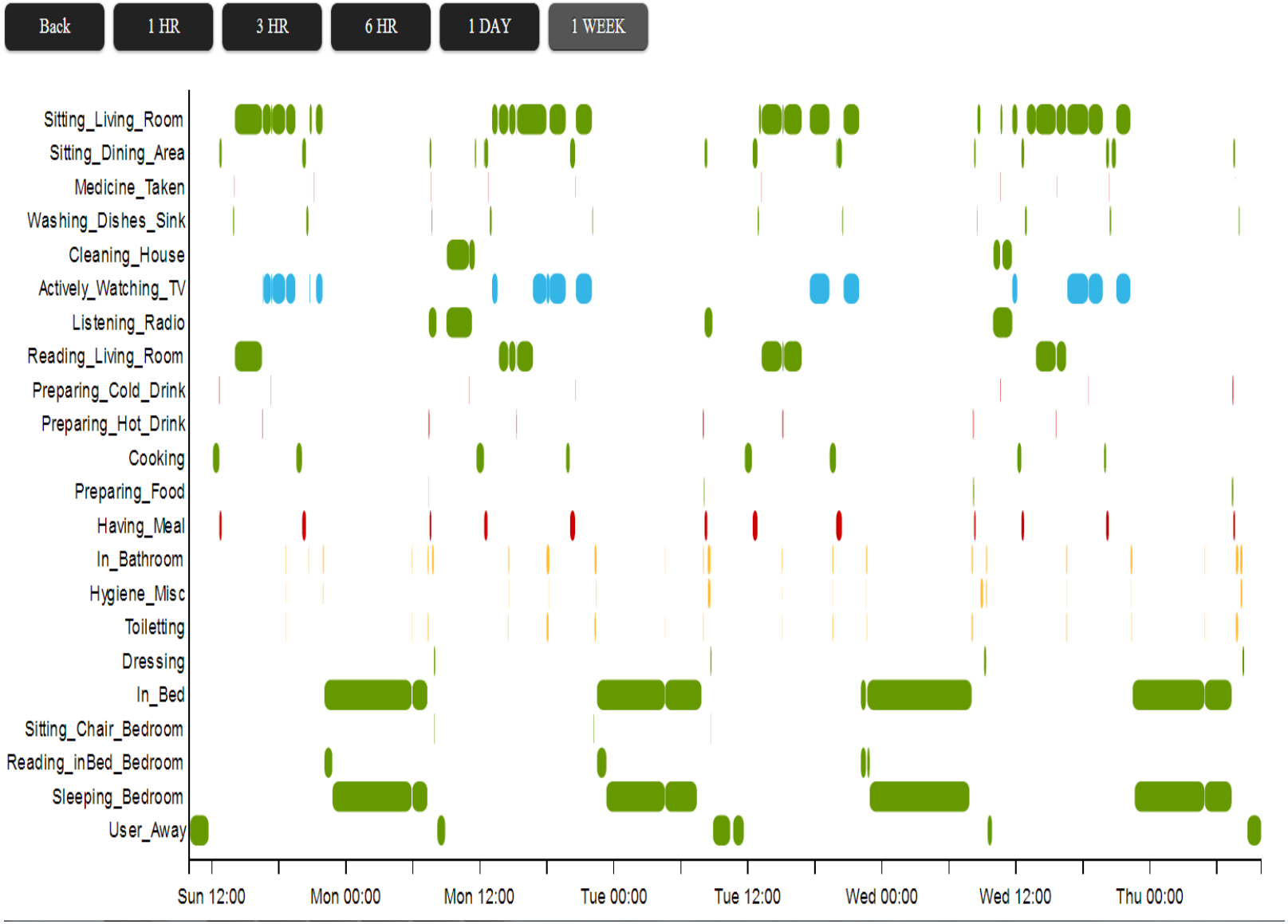
Execution/Reaction

Navigation (ROS navigation/SLAM)

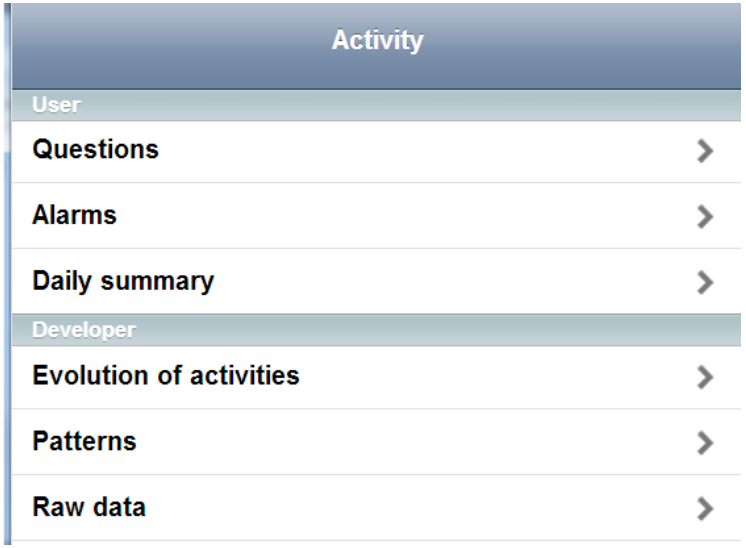
Arm (Inverse Kinematics)

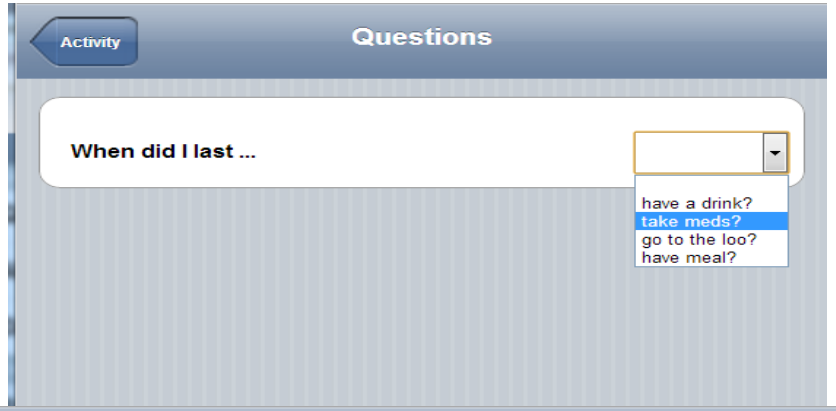
Tray/Torso/Eyes

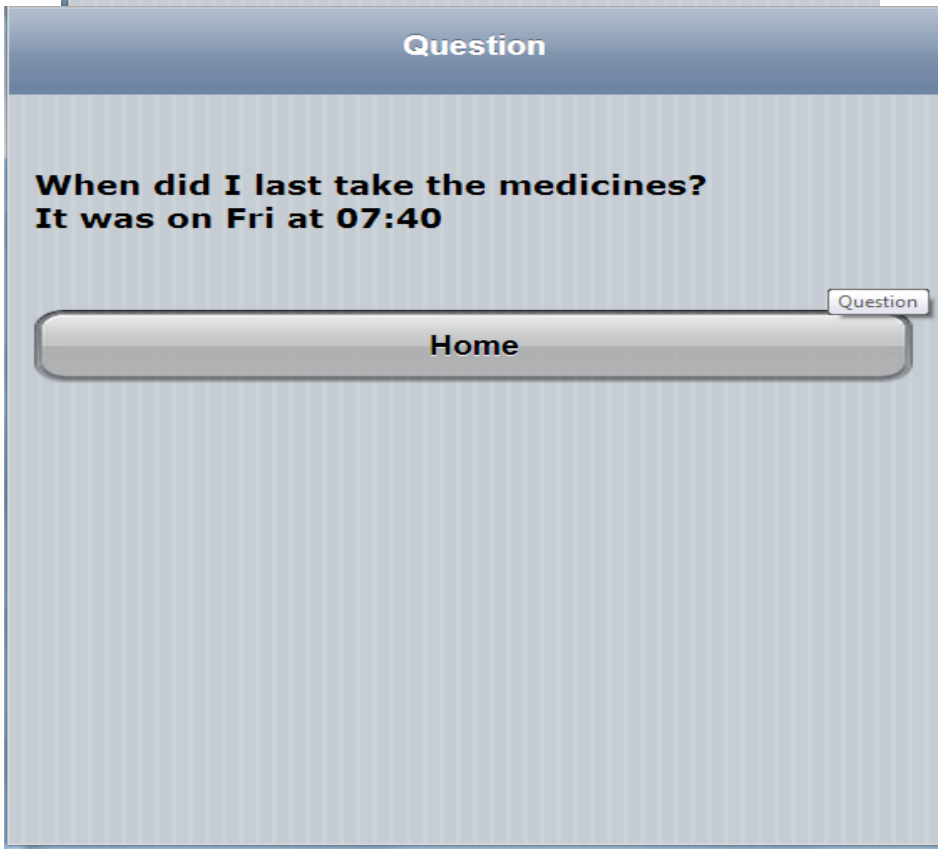
1 Week of Activity



Questions on Activity







- *New EPSRC Infrastructure award affords new robots (Fetch, Sawyer, care-o-bot 4, Pepper) to make the Robot House 2.0 available to industry and academics in UK and abroad for smart home and autonomous robot evaluations*

HRI methodologies
Alternatives to live studies?

Wizard(s) of Oz

Dautenhahn (2007a), Woods et al. (2007), Koay et al. (2006)

Gould et al, 1983; Dahlbäck et al., 1993; Maulsby et al,. 1993

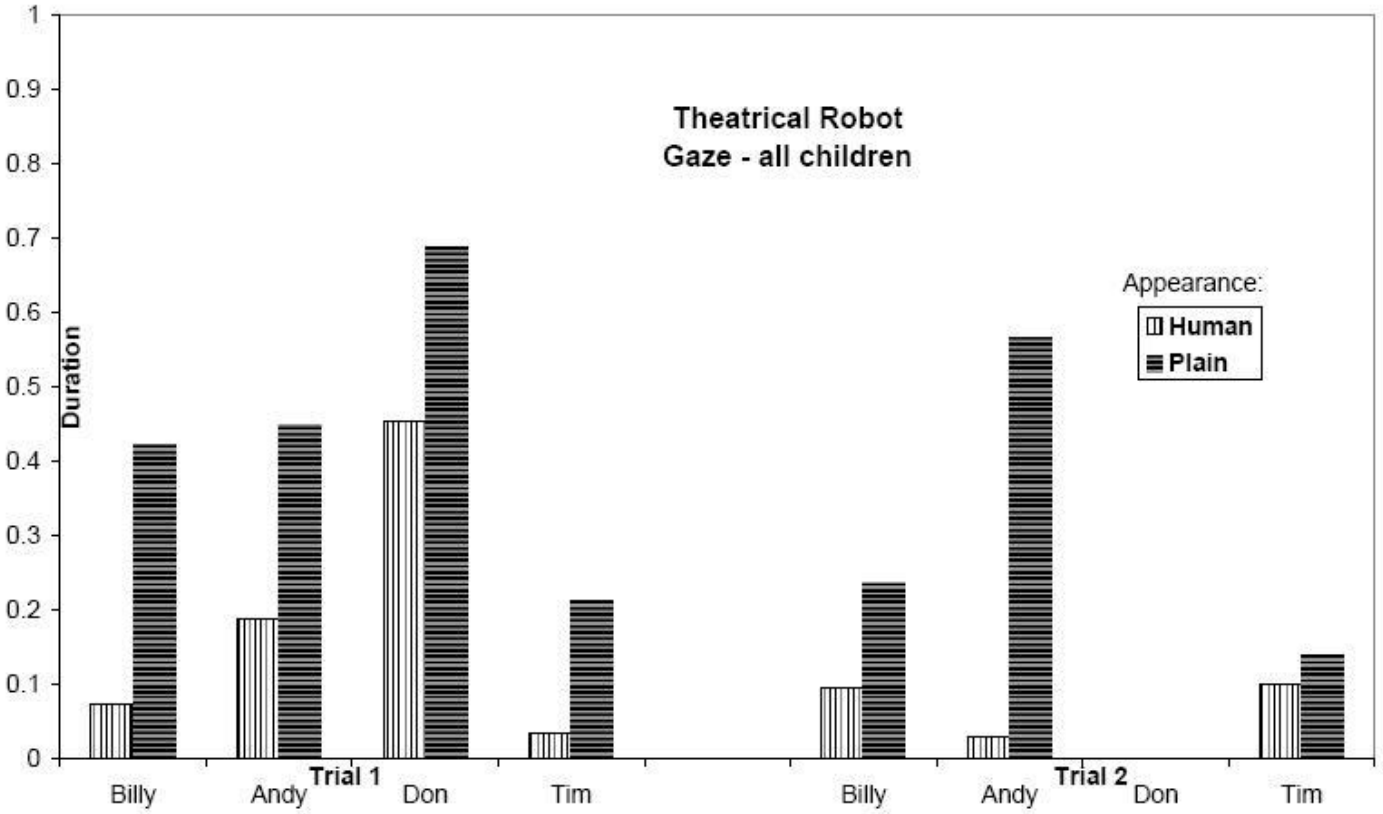
Theatrical Robot

b)

c)

Robins et al. (2004)

Robins et al. 2004

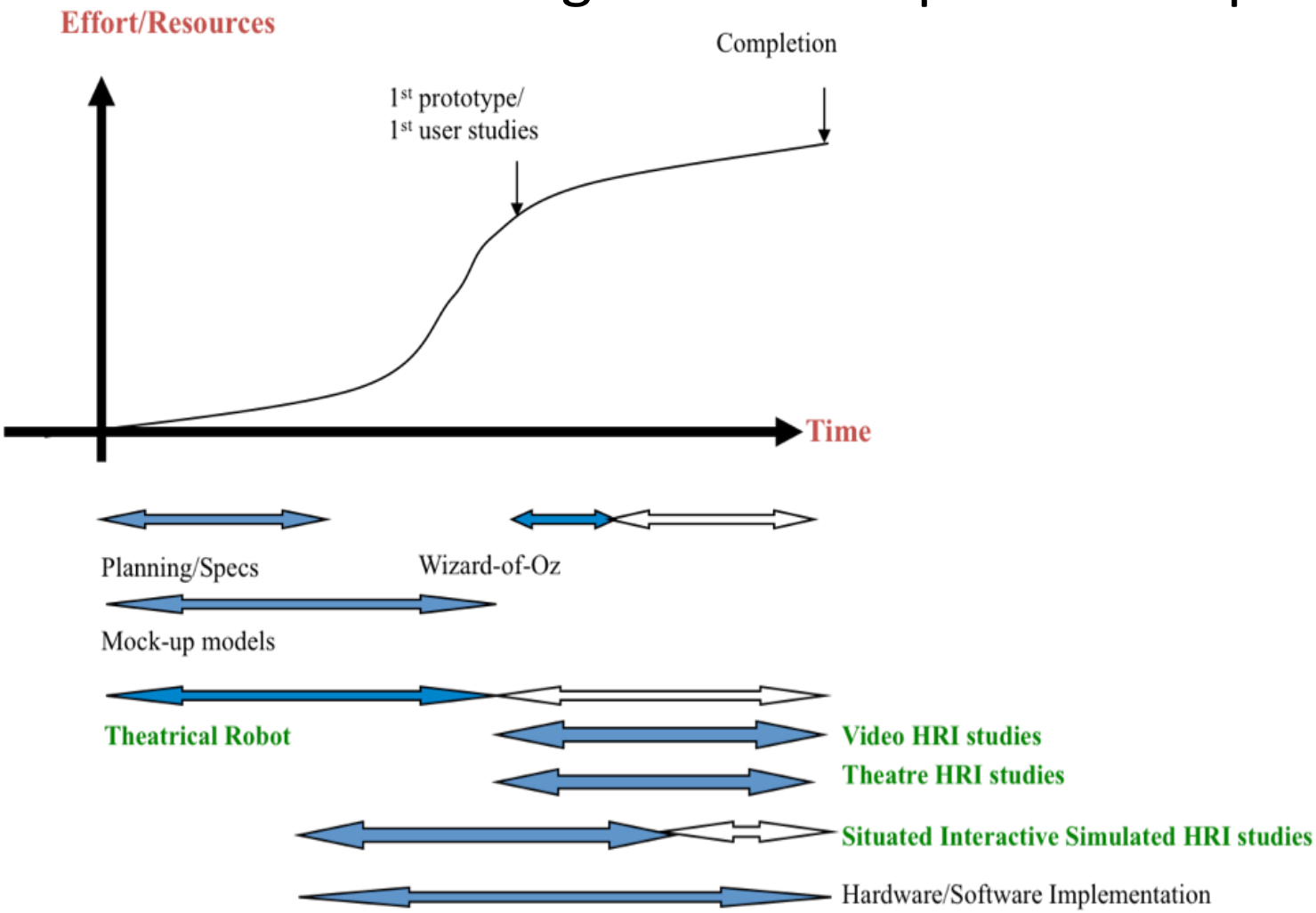


Theatre-based HRI (THRI)

- Found in HCI, e.g. Iacuccui and Kuuti, 2002; Newell et al., 2006
- Applied to HRI
  - Michael Leonard Walters, Kheng Lee Koay, Dag Sverre Syrdal, Anne Campbell, Kerstin Dautenhahn. (2013) Companion robots for elderly people: using theatre to investigate potential users' views. Proceedings IEEE RO-MAN 2013, The 22nd International Symposium on Robot and Human Interactive Communication. Gyeongju, Korea. Publisher: IEEE. August 26-29, 2013
  - Dag Sverre Syrdal, Kerstin Dautenhahn, Michael Leonard Walters, Kheng Lee Koay, Nuno Otero (2011) The Theatre methodology for facilitating discussion in human-robot interaction on information disclosure in a home environment. Proceedings RO-MAN 2011, 20th IEEE International Symposium on Robot and Human Interactive Communication, Atlanta, Georgia, USA - 31 July - 3 August 2011, 479 - 484
  - Amiy R. Chatley, Kerstin Dautenhahn, Mick L. Walters, Dag S. Syrdal, and Bruce Christianson (2010) Theatre as a Discussion Tool in Human-Robot Interaction Experiments - A Pilot Study. Proceedings The Third International Conference on Advances in Computer-Human Interactions ACHI 2010, February 10-16, 2010 - St. Maarten, Netherlands Antilles, IEEE Press, pages 73 - 78. The paper has been selected (together with 13 other papers) to receive a best papers diploma of the conference.

THRI in a care home

Typical development time line of HRI robots, showing different experimental paradigms



Kerstin Dautenhahn (2013) Human-Robot Interaction. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "The Encyclopedia of Human-Computer Interaction, 2nd Ed.". Aarhus, Denmark: The Interaction Design Foundation

Iterative development for HRI

- Note, there are typically several iterations in the development process (not shown in the diagram), since systems may be improved after feedback from user studies with the complete prototype.
- Also, several releases of different systems may result, based on feedback from deployed robots after a first release to the user/scientific community.

Strength and weaknesses

	Situatedness of interaction	Embodied nature of interaction	Ecological validity	Contingency of interaction	Resource efficiency	Sample size	Realism of interaction/ Outcome-relative fidelity
TR	+++	+++	+	+++	+++	-	-
VHRI	+	-	++	-	++	+++	-
THRI	++	-	++	-	++	+++	+
SISHRI	+++	-	+++	+++	+++	-	+
Live HRI	+++	+++	+++	+++	-	-	+++

- weak
+ limited
++ good
+++ excellent

TR (Theatrical Robot), VHRI (Video-based HRI), THRI (Theatre-based HRI), SISHIR (Situated Interactive Simulated HRI), Live HRI.

- Resource efficiency means that experiments need to yield relevant results quickly and cheaply (in terms of effort, equipment required, person months etc.).
- Outcome-relative fidelity means that outcomes of the study must be sufficiently trustworthy and accurate to support potentially costly design decisions taken based on the results (Derbinsky et al. 2013).

Video-based HRI

- Presenting videos to individuals or groups
- Comparison of live HRI and video-based HRI found statistically comparable results in a setting where a robot approached a person (Woods et al., 2006a,b).

A robot in the house or office…

- Robot's non-verbal cues in HRI matter
- ….what about a robot's non-verbal behaviour when it is NOT engaged in an interaction (a robot will not interact constantly with people) ???
  - Do people notice?
  - How do they experience it?
- Study with a non-humanoid robot
- Same applies to other work environments etc.

In Good Company? Perception of Movement Synchrony of a Non-Anthropomorphic Robot

Hagen Lehmann, Joan Saez-Pons, Dag S. Syrdal, Kerstin Dautenhahn (2015) In good company? - Perception of movement synchrony of a non-anthropomorphic robot. *PLoS ONE*, Published: May 22, 2015

DOI: 10.1371/journal.pone.0127747

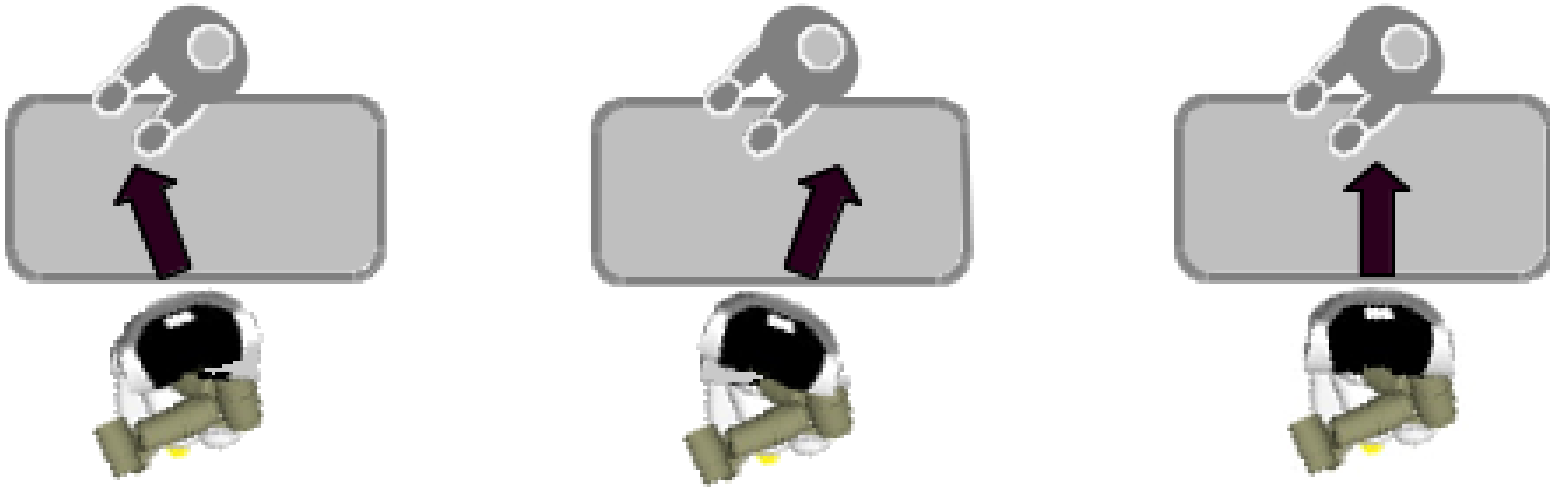
Perception of robotic contingent behaviour

- **Research Questions:**
  - Can contingent gaze behaviour of a non-anthropomorphic robot be perceived as social/"empathic" by users?
  - Does gaze contingency lead to more social, "empathic" and friendly perceptions of robot?
- **Hypotheses**:
  - Positive synchrony (contingent with user behaviour) will be perceived as more social and empathic
  - Negative synchrony will be conceived unfriendly
  - Robot not moving at all will be perceived least friendly/social

Why Gaze Behaviour?

- **Gaze** plays an important role during social interaction, transmitting engagement and intention [e.g. Cook & Smith 1975; Tomasello et al. 2007]
- **Gaze** is a precursor to joint attention, specifically mutual gaze [Farroni 2003, Saito et al. 2010]
- **Gaze** helps to regulate turn-taking [Trevarthan & Aitken 2001, Kleinke 1986]
- Absence of meaningful gaze makes it hard to understand the cues given by an agent [e.g. Garau 2001; Wang & Gratch 2010]

Setup for video study



Flower Arranging with Care-O-bot 3

Experimental Setup: The actor picks up the flowers from the table and arranges them freely into a bouquet

- the actor is sitting in front of a table arranging flowers
- the robot is opposite to the actor and expresses 3 different behaviours
- Three experimental conditions:

C1:

•Positive synchrony

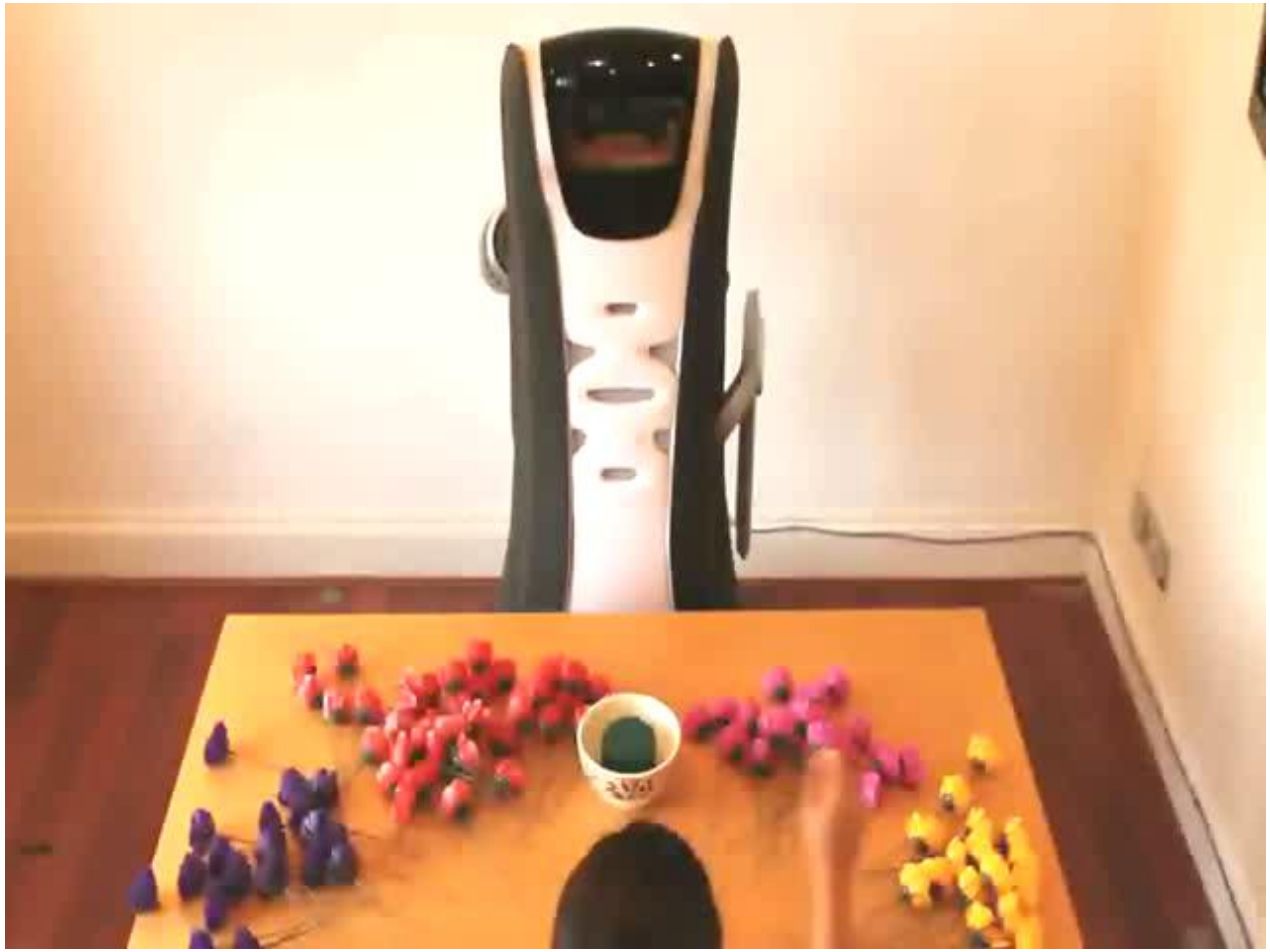
C2:

•Negative synchrony

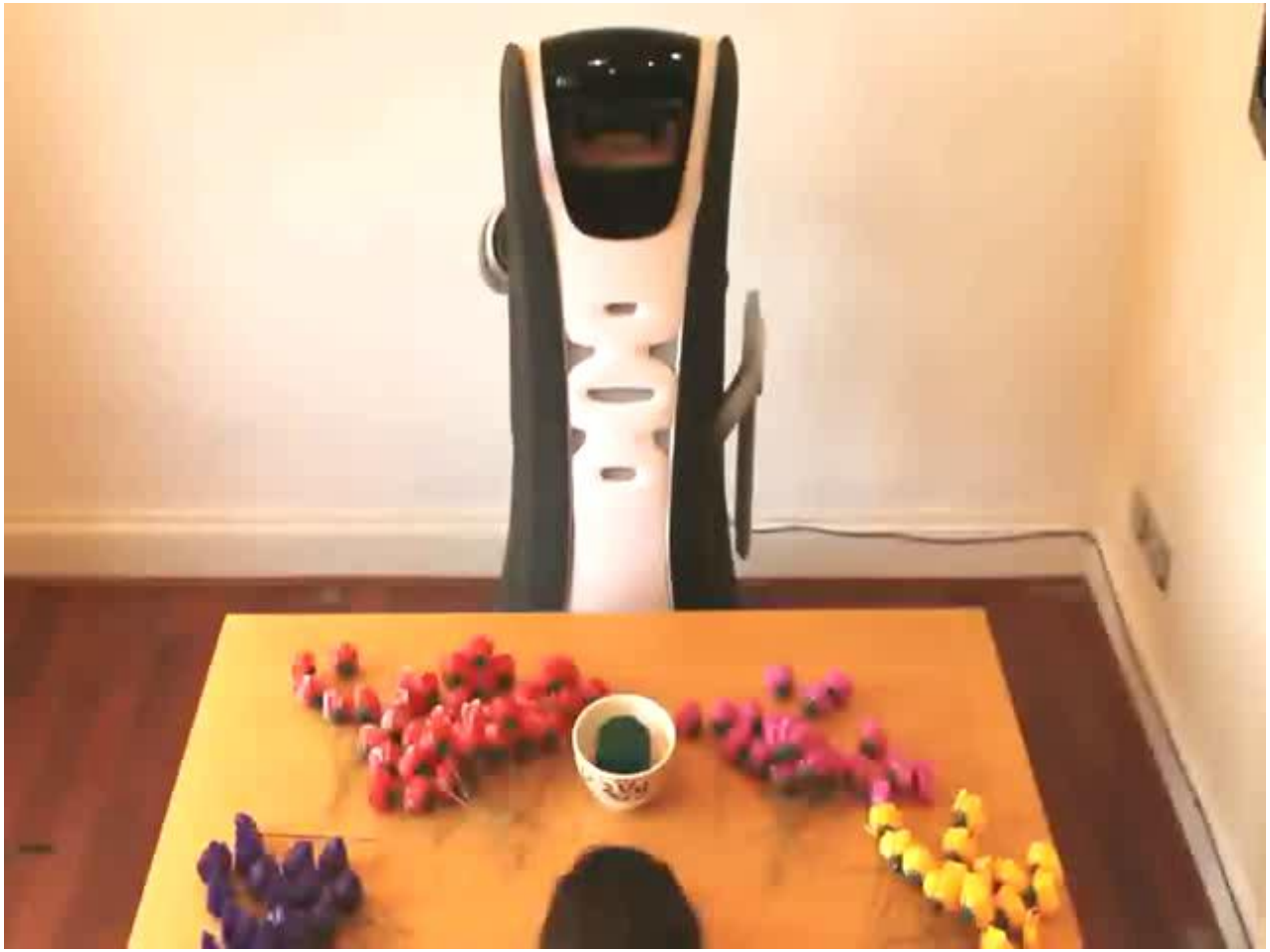
C3: Control

- No movement

C1: Positive Synchrony

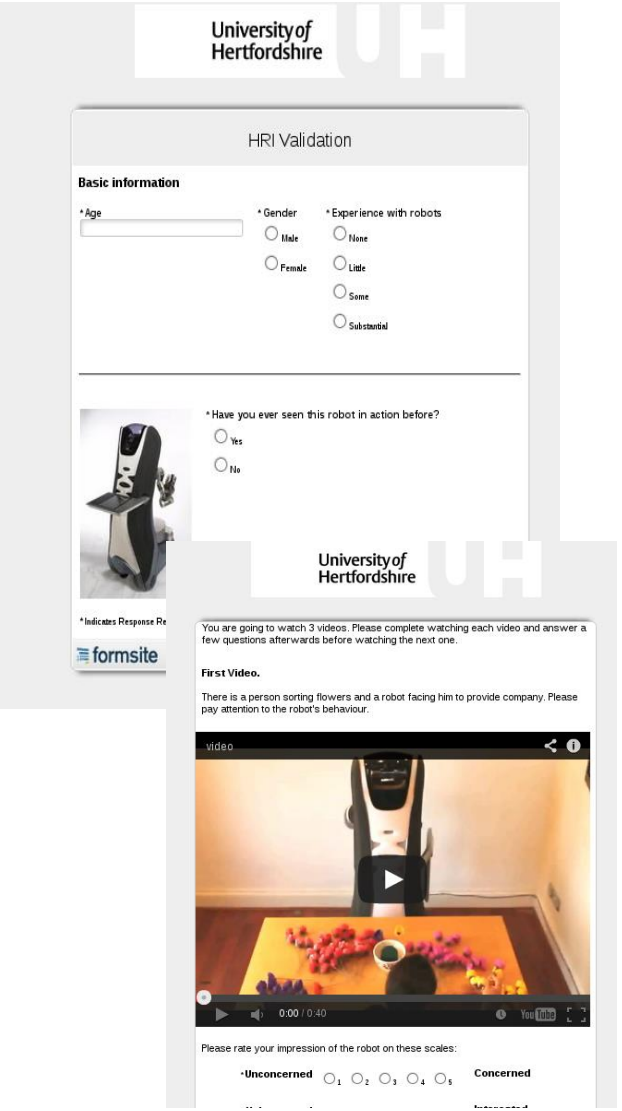


C2: Negative Synchrony



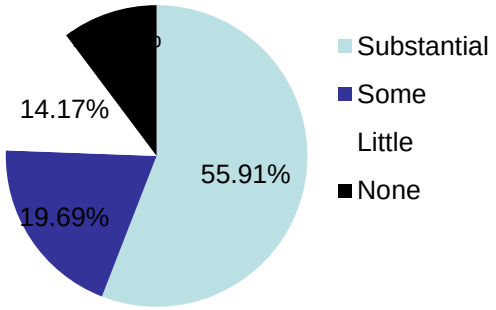
Data collection via Online-Video Survey

- Invitation were sent to different mailing lists (***robotics-worldwide***, ***eu-cognition***, ***euron, PHILOS-L, AIXIA***)
- Videos were presented in random order
- Godspeed Questionnaire subscales III and IV:
  Likeability and Perceived Intelligence
- IOS (Inclusion of Self in Other) questionnaire
- 301 total, 173 complete (57.48%), 46 discarded (26.59%)
- **127** usable responses
- Average age 35 (male 35, female 34)

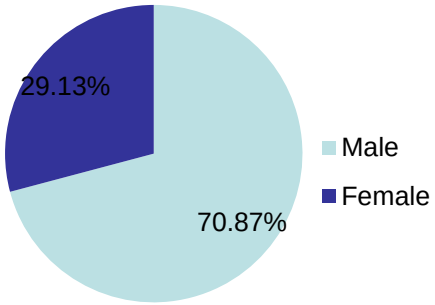


Overview Results

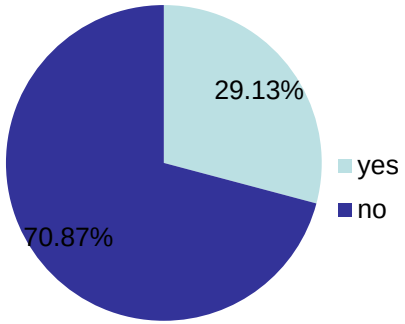
Experience with robots

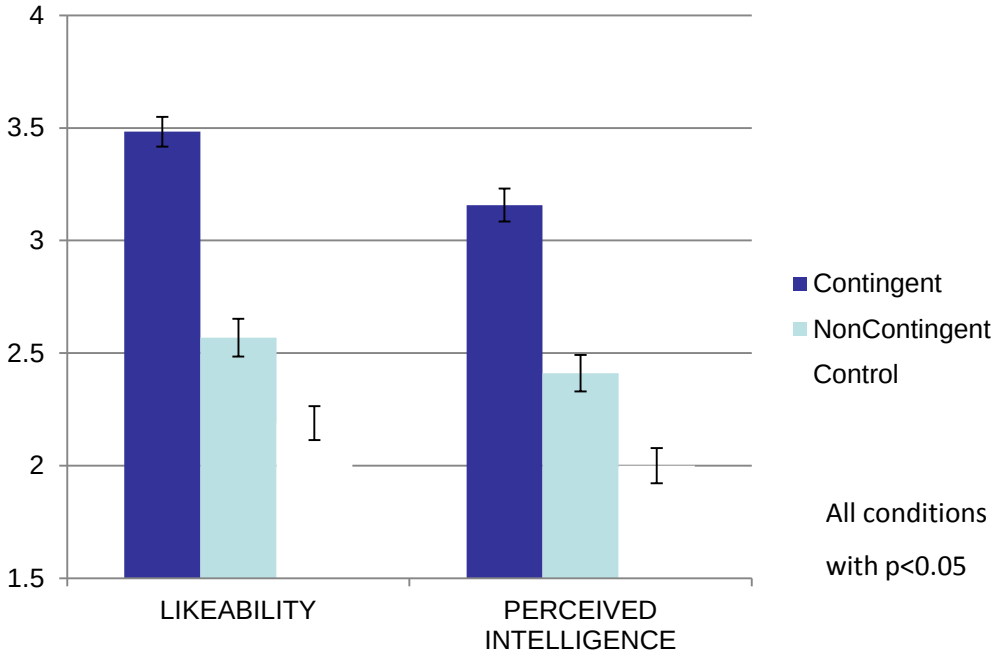


Gender



COB knowledge





- **Significant differences between all conditions**

- No significant difference for:
  - Gender
  - Experienced/non-experienced
  - previous knowledge of COB

Discussion

- Our initial hypotheses have been confirmed

  C1 > C2 > C3

  - People rated positive synchrony (C1) most positive, followed by negative synchrony (C2). The least positive rating was given to the static robot (C3).
  - difference between C2 and C3 confirms that users rate animated artificial agents in general more positive.
  - no gender effects or effects based on prior experience with COB 3 or other robots
  - Contingent gaze behavior can improve people's perception of non-humanoid robot even when not directly interacting with it

KASPAR-building a social robot for robot-assisted therapy (RAT) for children with autism

Autism (ASC)

- Life-long developmental condition
- Impairments in communication, social interaction, imagination and fantasy
- Resistance to change in routine
- Significantly reduced repertoire of activities and interests
- Repetitive and stereotypical behaviour
- Fixation to stable environments

Cf. Diagnostic and Statistical Manual of Mental Disorders, American Psychiatric Association (DSM)

Robot Assisted Play for Children

Starting point: Social interaction with people appears overwhelming, interactions with computers are comfortable

Simple robots provide safe, predictable and enjoyable environment where children can explore and learn about social interaction

Emphasis on **Play**

Ultimate aim **Robot as a Mediator**: improving child-child or child-adult relationships, not child-robot: Robot as a social *Mediator*, not an *Isolator*

Why robots?

- **People are the best teachers of social interaction**, but:
- Simplified, but embodied interaction (less abstract than computers, more “abstract” than people)
- Real-time dynamics of interaction
- “Multi-modal”, full-body interaction, including touch etc.
- Enjoyment during play as the only “reward” (social interaction as positive experience)
- **Providing a safe, enjoyable and non-judgemental environment facilitating learning through play**

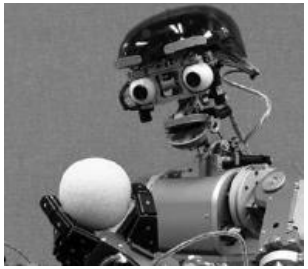
Robot-Assisted Therapy: Research since 1998

- Different robots
- **http://www.aurora-project.com/**
- 6 PhD students, 5 postdocs
- Collaboration with different schools in Hertfordshire, London, Essex, (Netherlands)
- Development of play scenarios, measures, algorithms, and a new humanoid robot: **KASPAR**
- **http://www.kaspar.herts.ac.uk/**

Related work on robot assisted play

KASPAR

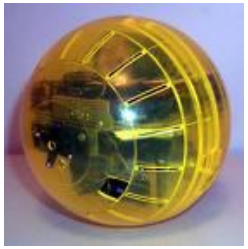
Paro (Wada, Shibata)



Keepon/Infanoid
(Kozima et al.)

IROMEC robot

Huggable
(Breazeal et al.)



Roball (Michaud et al.)

PlayRob (Kronreif et al.)

Probo (Saldien,Vanderborght et al.)

Diehl et al, 2012

…and many more

Focus of UH research

- Robot-assisted **play**
- **Tool** in the hands of therapists/teachers
- Robot as a **social mediator**

Levels of potential benefits

- **Enjoyment** (benefits for child)
- **Engagement** in social interaction with other people (benefits for child/parent/other people)
- Learning and generalising social skills/ **Therapeutic aspects** (life skills, independent living)
  - long-term studies
  - Clinical aspects

Introduce KASPAR: Design Rationale

- Expressive face
- Aesthetic consistency of face
- Child-sized, clothed to be child-friendy
- Specifically designed for interaction with children with autism
- 17 DoF makes a wide range of gestures and facial expressions, as well as simple manipulations such as beating a drum, brush its teeth, comb its hair, eat with a spoon
- Can sign and create a number of expressive poses

Body Language: (Dynamic) Expressions

“sad”

“happy”

“thinking”

“goodbye”

KASPAR modes of operation

- Key pad interface (remote-controlled but as part of the game, known to and used by children)
- Autonomous mode
- Hybrid mode

‘Standardised’ RAT Play Scenarios I

- **Ben Robins, Kerstin Dautenhahn, Ester Ferrari, Gernot Kronreif, Barbara Prazak-Aram, Patrizia Marti, Iolanda Iacono, Gert Jan Gelderblom, Tanja Bernd, Francesca Caprino and Elena Laudanna (2012), Scenarios of robot-assisted play for children with cognitive and physical disabilities. Interaction Studies 13(2), pp. 189-234.**
- Novel set of ten play scenarios for robot assisted play for children with special needs (children with Learning Difficulties, children with Severe Motor Impairment and children with Autism).
- The play scenarios were developed against specific educational and therapeutic objectives that were discussed with panels of experts (teachers, therapists, parents) in various countries, during several user panel meetings for each of the above mentioned target user groups.
- These objectives were classified with reference to the ICF-CY, the International Classification of Functioning – version for Children and Youth.

‘Standardised’ RAT Play Scenarios II

- **Ben Robins, Kerstin Dautenhahn (2014) Tactile Interactions with a Humanoid Robot - Novel Play Scenario Implementations with Children with Autism. International Journal of Social Robotics 6: 397-415.**
- Two novel tactile play scenarios developed for robot-assisted play for children with autism.
- The play scenarios developed against specific educational and therapeutic objectives that were discussed with teachers and therapists.
- These objectives were classified with reference to the ICF-CY, the International Classification of Functioning—version for Children and Youth.

Video removed

Case Study: tactile interaction and emotional expressions

The child started to learn about expressions of being happy and being sad during imitation games with the robot and was later able to convey his feelings to his mother for the first time.

Video removed

Some results from studies with Kaspar

- Teaching imitation and turn-taking skills skills
- Cause and effect games and emotional expressions (“happy”, “sad”)
- Appropriate tactile social interaction
- “if you are happy and you know it…” (naming body parts, singing in a group)
- Teaching child-child collaborative skills
- Teaching about personal hygiene and food

Long-term goals

- Developing a tool for teachers/parents/siblings to assist interaction and communication with a child with autism
- Developing a tool for robot-assisted therapy according to defined developmental and therapeutic needs of individual children
- Current fundraising in parallel to commercial activities

Thank you.

k.dautenhahn@herts.ac.uk