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You can download the sources of this presentation here:
github.com/severin-lemaignan/presentation-codesign

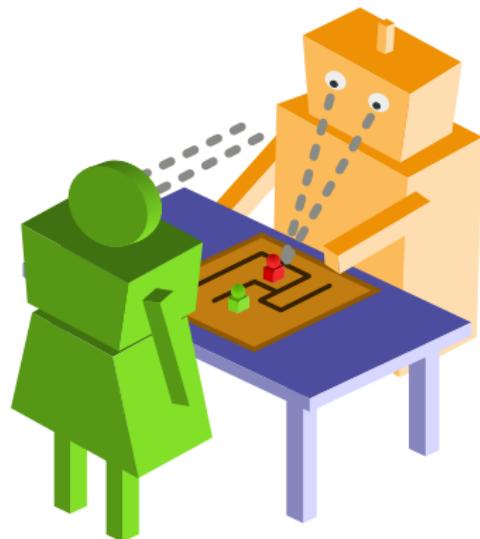
Co-designed head to toe

Towards end-to-end participatory design

RoMAN21 – BAILAR Workshop | 08 Aug 2021

Séverin Lemaignan

Bristol Robotics Lab University of the West of England
(soon PAL Robotics!)



situation assessment

symbolic grounding

symbolic reasoning

SYMBOLIC SOCIAL COGNITION FOR ROBOTS

ontologies

perspective taking

cognitive architectures

social situation assessment

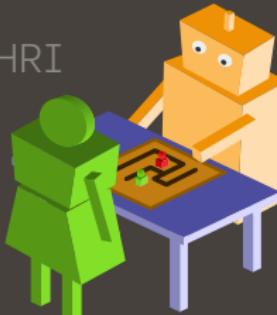
joint action

ROS4HRI

natural language processing

REAL-WORLD SOCIAL AUTONOMY

learning of social policies



DATA-DRIVEN HRI

large datasets

theory of mind

group dynamics

human-in-the-loop ML

robotics for
learning

CHILD-ROBOT INTERACTION

experimental robotics

trust

HUMAN FACTORS

engagement

responsible AI

anthropomorphism

social robotics

participatory design

persuasion

SOCIAL ROBOTICS

Creating interactive robots that are **embedded and understand their (human) social context; generate and adopt appropriate social behaviours; have a positive impact on human society.**

⇒ designing and implementing the **assistant and companion robots** for tomorrow.

⇒ direct impact on ageing society, education, customer service; **major socio-economic challenge**



SOCIAL ROBOTICS

Major scientific challenges:

- Model open-ended, underspecified situations; rich semantics; complex social dynamics;



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Major scientific challenges:

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- Complex ethical landscape;



SOCIAL ROBOTICS

Major scientific challenges:

- Model open-ended, underspecified situations; rich semantics; complex social dynamics;
- Close the interaction loop;
- Understand and sustain long-term autonomous social interactions;
- Real-world algorithmic robustness;
- Complex ethical landscape;
- ⇒ cross-disciplinary & holistic approach required
- ⇒ involve all the stakeholders; participatory approach



LET SET OURSELVES A CHALLENGE

Design & run a study with:

- a real robot

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Design & run a study with:

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- a real interaction (...with a human!)

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- in the wild

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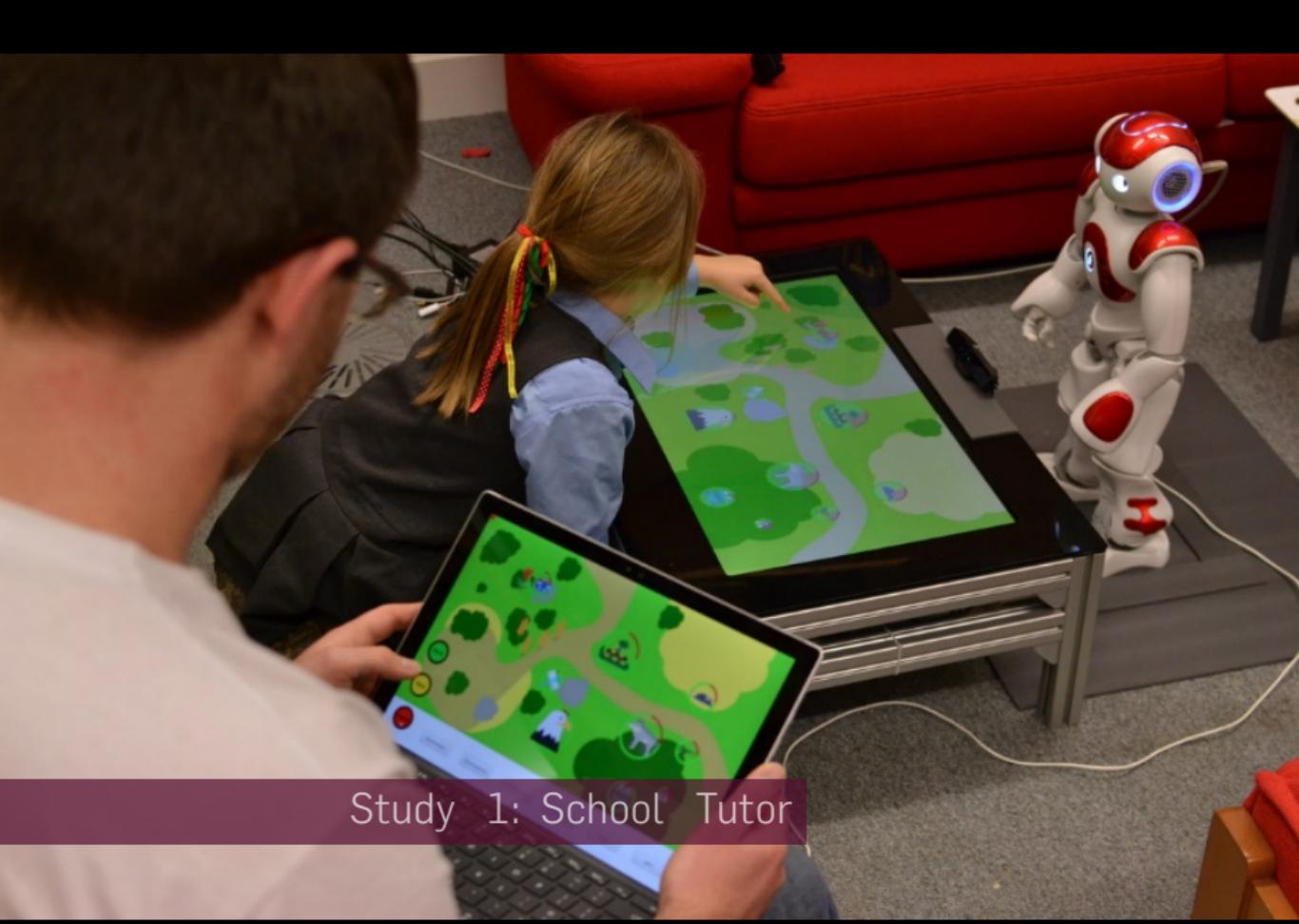
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- also including social behaviours & social dynamics

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Design & run a study with:

- a real robot
- a real interaction (...with a human!)
- a continuous interaction
- a realistic task (large state vector & action space)
- in the wild
- also including social behaviours & social dynamics
- ...and of course, the robot should be autonomous



Study 1: School Tutor

IRL APPLIED TO SOCIAL ROBOTICS



The children play a game about food chains; the robot learns to guide them (*task-specific action policy*) and encourage them (*social action policy*)

Interactive Machine Learning (IRL) to teach the robot.

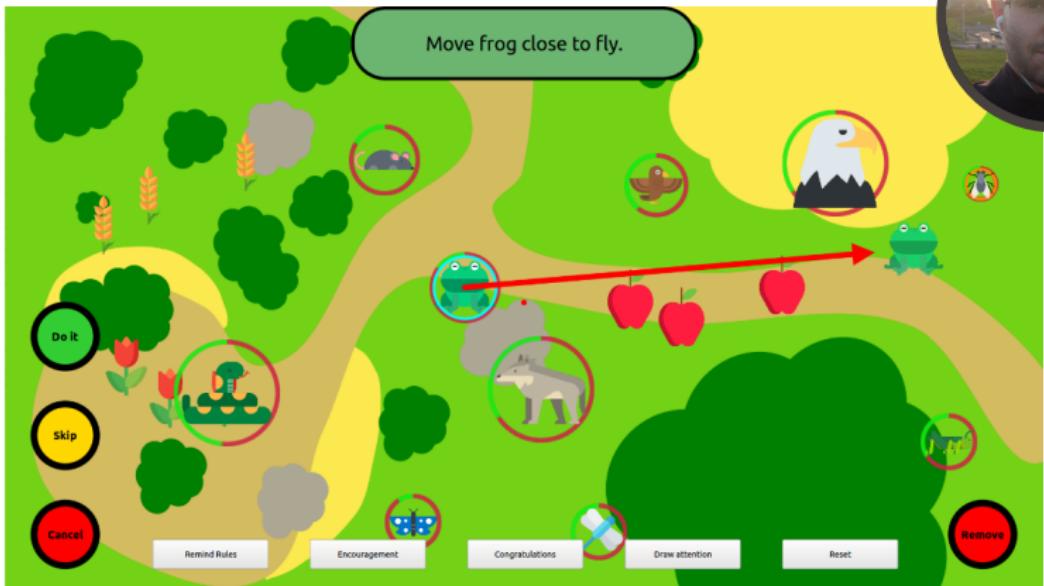
$$|state| = 210 \quad |action_space| = 655$$



TEACHER'S INTERFACE



Emmanuel Sennft



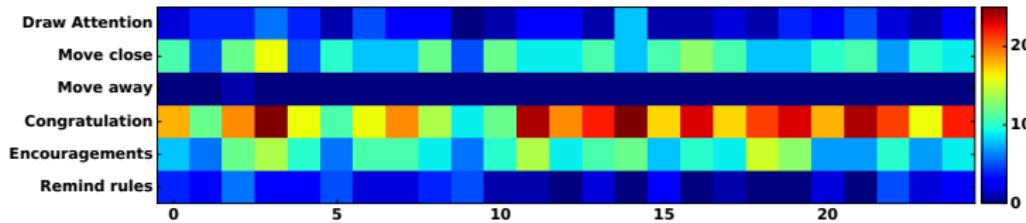
The robot's teacher (an end-user: might be the actual child's teacher) has a tablet interface that mirrors the child one, and adds robot's teleoperation and rewards.

LEARNT ROBOT'S BEHAVIOUR



Emmanuel Sennft

Distribution of actions for the 25 children participants:
Supervised

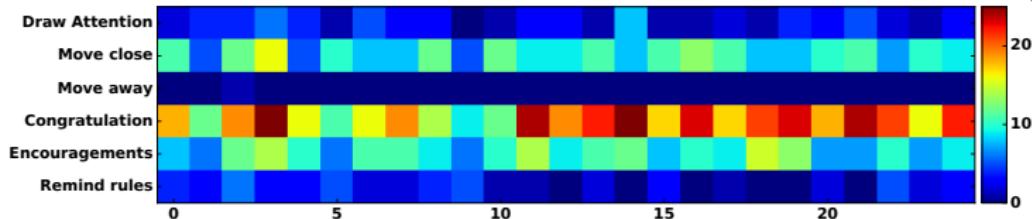


LEARNT ROBOT'S BEHAVIOUR

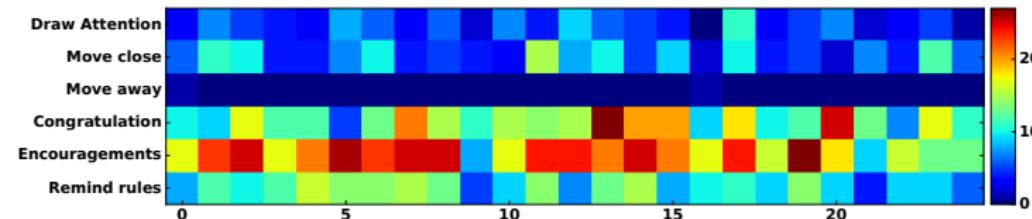


Emmanuel Sennf

Distribution of actions for the 25 children participants:
Supervised



Autonomous

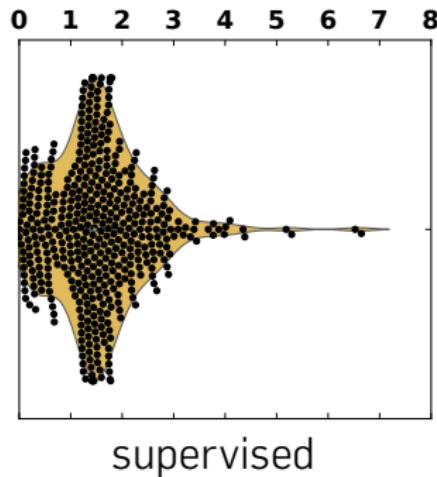


→ the robot personalises its action policies to the child's behaviour.

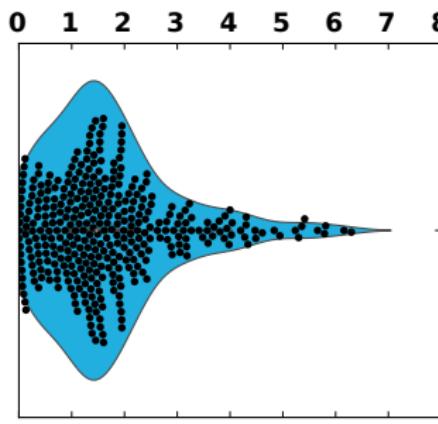
LEARNT ROBOT'S BEHAVIOUR



Time between a child's successful action and a praise:



supervised



autonomous

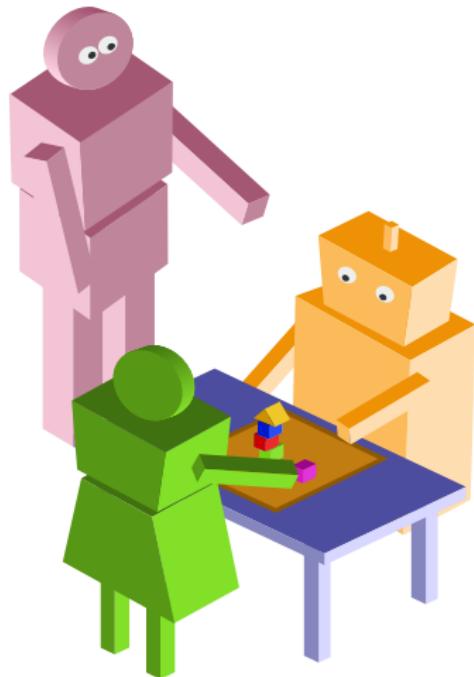
→ the robot has also learnt an appropriate social timing.

WHAT DOES THAT MEANS FOR THE EXPERT/TEACHER-END-USER?



- **Progressively transferring autonomy** demonstrably works in non-trivial tutoring scenarios
- (it also learns some elements of **social behaviours** and **social timing**)

WHAT DOES THAT MEANS FOR THE EXPERT/TEACHER-END-USER?



Key properties:

- **progressive autonomy** yet **transparency** of the behaviour;
- **observability** and possibility to **take over**;
- because the training takes place in-situ, the robot behaviours are **co-constructed** by the teacher and the child
- ⇒ interesting properties from a ethics/responsible AI perspective

WHAT DOES THAT MEANS FOR THE EXPERT/TEACHER-END-USER?



Yet:

- Design of the input state tricky and largely task dependent;
- What about more complex social behaviours?
- Would that sustain long-term interactions?



Study 2: gym coach

COUCH-TO-5K STUDY



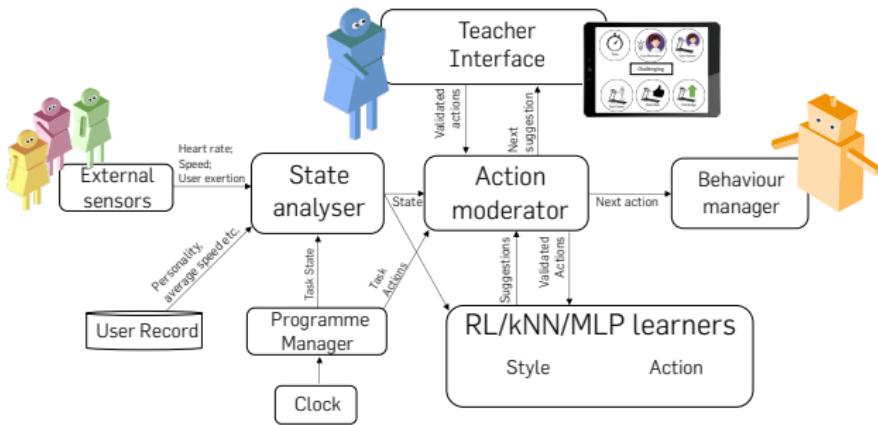
Katie Winkle

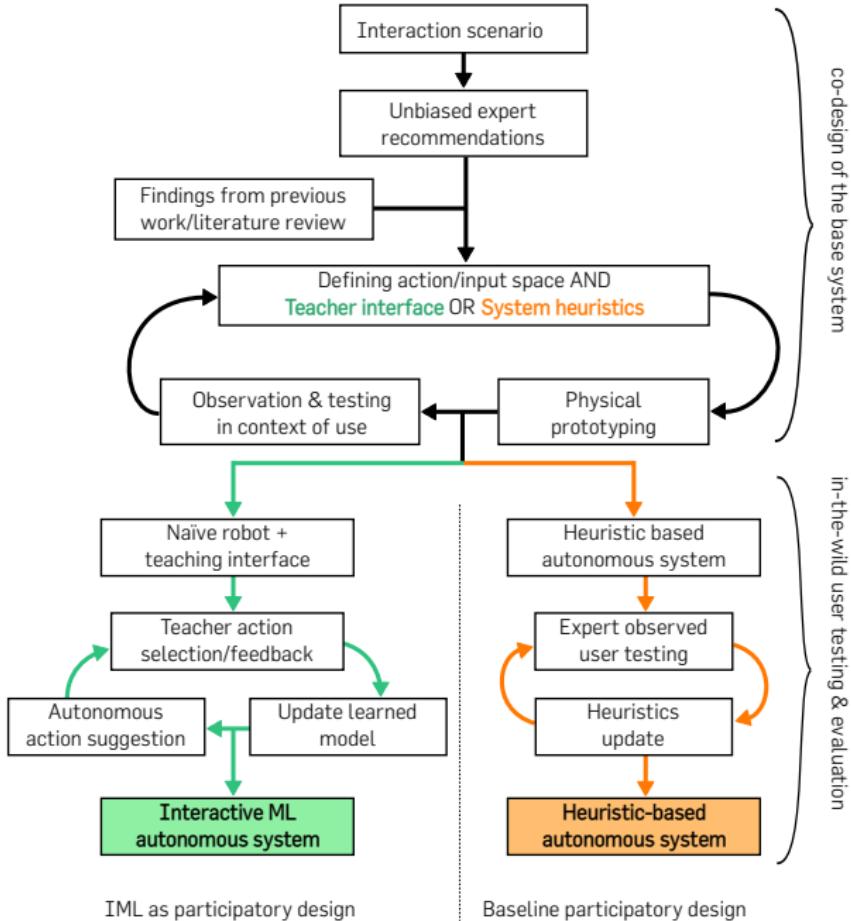
- 9 participants
- 3 months; 27 one-hour sessions per participants
- $|\text{state}| = 20$ $|\text{action_space}| = 11$
- Includes participants' personality (Big-5) as input feature

COUCH-TO-5K STUDY



Katie Winkle





CO-DESIGN FOR REAL-WORLD + LONG-TERM



INPUT & OUTPUT SPACES: MOSTLY TASK-SPECIFIC

Type	Feature	Values	Description
(Dynamic) Task State	Task Action Type	0, 0.5, 1	Whether participant is in warm-up, walk or run
	Session Progress	0-1	Time spent in session/session duration
	Programme Progress	0-1	Time spent on programme/programme duration
	Programme Action Progress	0-1	Time spent on current walk or run action/action duration
	Programme Action Duration	0, 0.5, 1	Current walk/run action length as \leq 3 mins, \geq 20 mins or other
	Time Since Last Action	0-1	Time since last action/60; capped at 1
Dynamic Performance	Relative Speed: Average	0-1	Current speed/(2 x average speed)
	Relative Speed: Best	0-1	Current speed/(2 x personal best speed)
Dynamic Engagement	Heart Rate	0-1	Heart rate/2x resting heart rate capped at 1
	Motivation/Effort	0, 0.5, 1	Self-reported measure in warmup/on check PRE action
	Facial Expression: Lip Pull*	0-1	Normalised action unit returned by OpenFace
	Facial Expression: Mouth Open*	0-1	Normalised action unit returned by OpenFace
Static Engagement	Elaboration level (self)	0-1	Normalised sum of 3 Likert questions
	Elaboration level (expert)	0-1	as above but rated by fitness instructor
	Activity Level	0-1	Likert question response
Static Personality	Extroversion	0-1	Big Five measure normalised with respect to max score
	Agreeableness	0-1	Big Five measure normalised with respect to max score
	Conscientiousness	0-1	Big Five measure normalised with respect to max score
	Emotional Stability	0-1	Big Five measure normalised with respect to max score
	Openness to Experience	0-1	Big Five measure normalised with respect to max score

Features followed by * were ultimately removed due to unreliable detection.

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Features followed by * were ultimately removed due to unreliable detection. **Non-task specific features.**

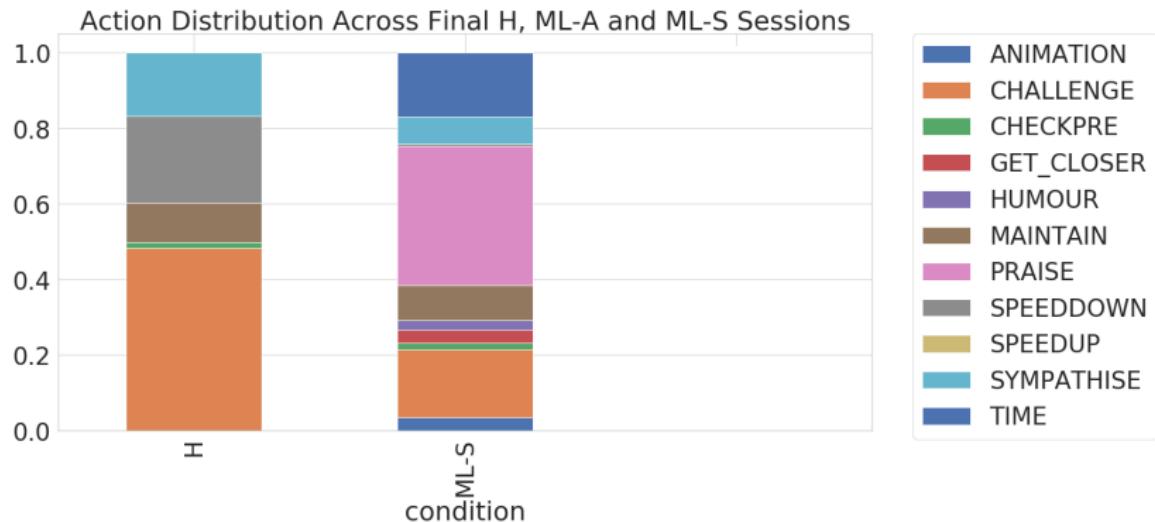
INPUT & OUTPUT SPACES: MOSTLY TASK-SPECIFIC

Full listing of actions as *[action-type, style-modifier]*:

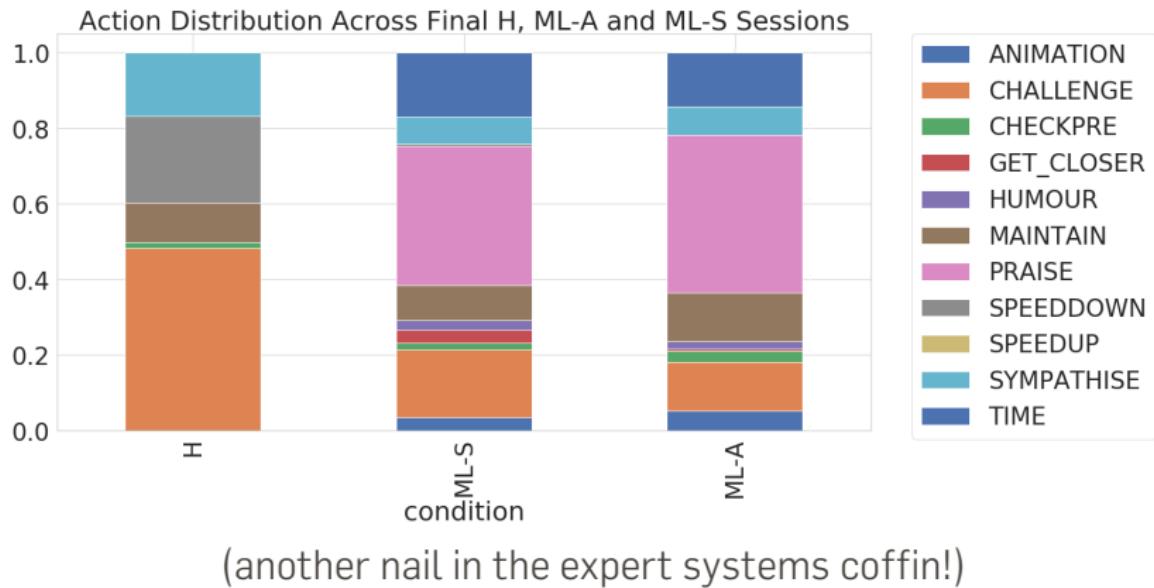
Social-Supporting Actions									Task Actions		Low Level Eye Colour
	Time	Social	Performance	Reward	Check User	Animation	Get Closer	Back Off	Run	Walk	
P	Time	Humour	Maintain	Praise	-	Animation	-	-	Run	Walk	Green
C	Time	Challenge	Speed Up	-	-	-	-	-	Run	Walk	Yellow
S	Time	Challenge Sympathise	Speed Down	Praise	Check PRE	-	-	-	Run	Walk	Blue
N	-	-	-	-	-	-	Get Closer	Back Off	Run	Walk	White

Style modifiers: P = Positive; C = Challenging; S = Sympathetic; N = Neutral.

LEARNT POLICIES

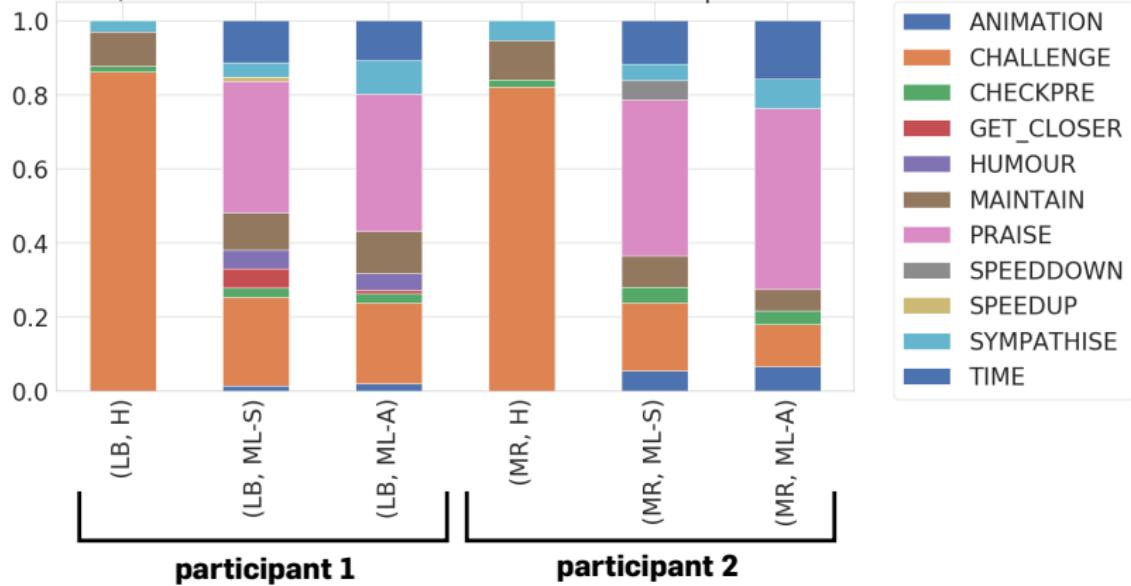


LEARNT POLICIES



LEARNT POLICIES

Phase 3 H, ML-A and ML-S Action Distribution for Participants LB and MR



LEADOR: END-TO-END PARTICIPATORY METHODOLOGY

In retrospect:

- a successful technical solution to replace the wizard;
- but equally important, a **end-to-end** participatory design methodology

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From a technique:

SPARC: Supervised progressively autonomous robot competencies

to a methodology:

LEADOR: Led-by-Experts Automation and Design Of Robots

LET'S REVISIT OUR CHALLENGE

Studies with...

- ✓ real robots

LET'S REVISIT OUR CHALLENGE

Studies with...

- ✓ real robots
- ✓ real interactions with humans

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- ✓ real robots
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End of the road:

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- ② open-ended, underspecified situations

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- ② close the "interaction loop"

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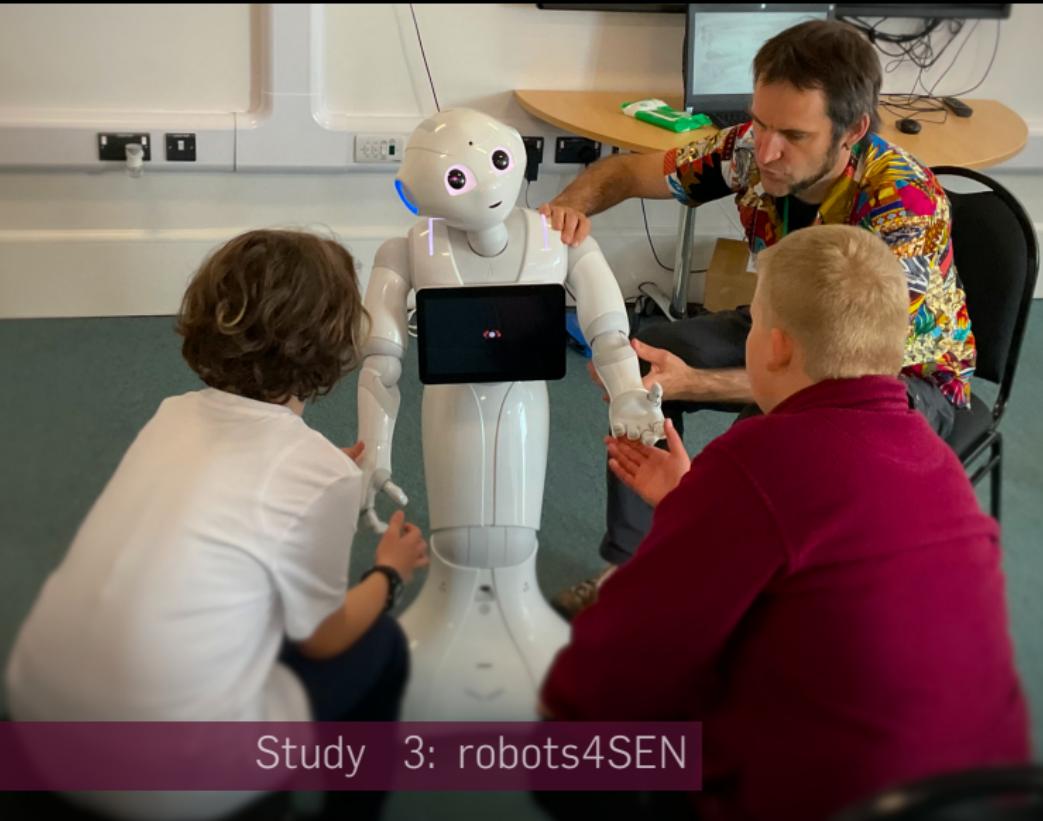
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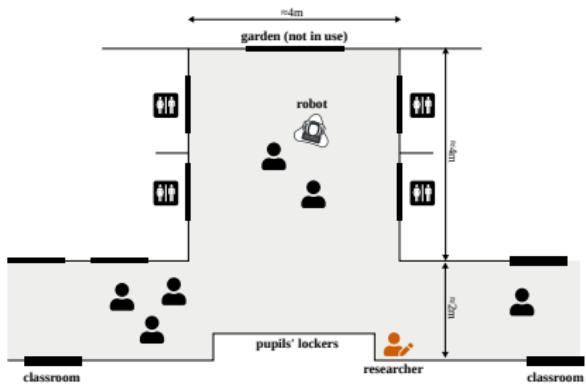
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 - ~ sustain long-term autonomous social interactions
 - ~ real-world robustness

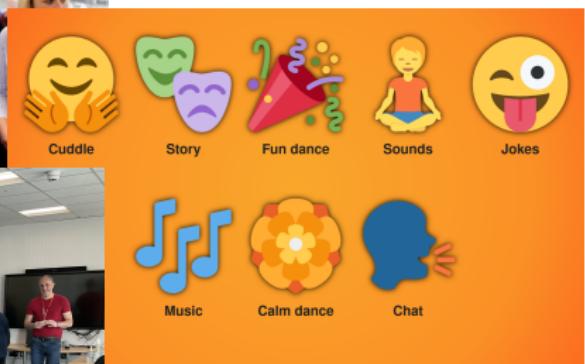


Study 3: robots4SEN

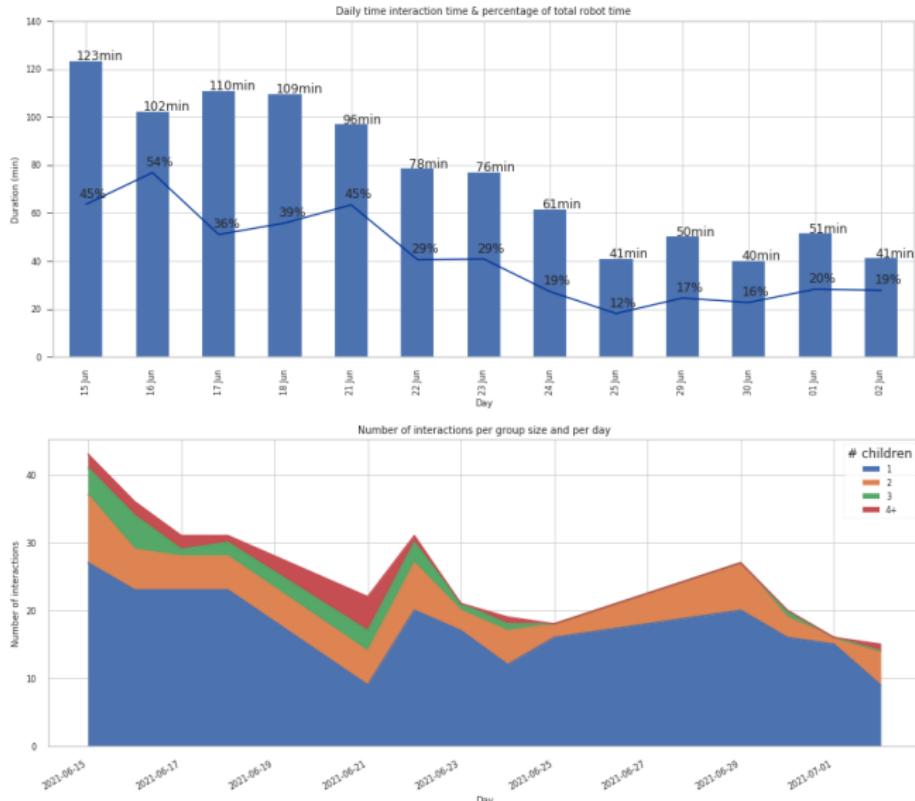
WELL-BEING AND AUTISM



PARTICIPATORY DESIGN WITH AUTISTIC CHILDREN



ENGAGEMENT OVER 3 WEEKS



SOCIAL COMPANIONS TO SUPPORT CHILDREN'S WELL-BEING

- open-ended, underspecified situations
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But limited autonomy! Interactions child-led!

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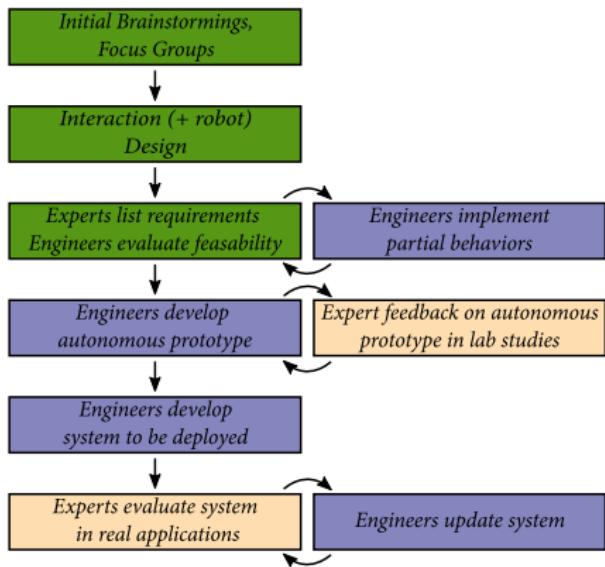
⇒ The next frontier

A PR2 robot is positioned on a stage. It is a two-armed humanoid robot with a white and grey metallic finish. The robot is facing forward with its arms slightly raised and bent at the elbows. The background consists of dark red curtains pulled back to reveal a bright stage area. Stage lights create strong highlights on the robot's body and cast shadows on the curtains.

Thank you!

Get the slides:
github.com/severin-lemaignan/presentation-codesign

Classic PD



End-to-end PD

