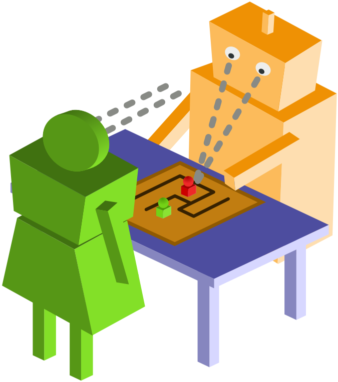
You can download the sources of this presentation here:
github.com/severin-lemaignan/presentation-codesign

brl

UWE Bristol | University of the West of England

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

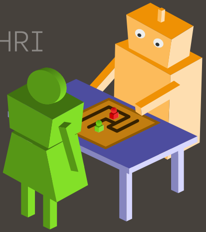
social situation assessment

joint action

ROS4HRI

natural language processing

REAL-WORLD SOCIAL AUTONOMY



DATA-DRIVEN HRI

learning of social policies

large datasets

theory of mind

group dynamics

human-in-the-loop ML

experimental robotics

robotics for learning

CHILD-ROBOT INTERACTION

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;

SOCIAL ROBOTICS

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SOCIAL ROBOTICS

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- Real-world algorithmic robustness;

SOCIAL ROBOTICS

Major scientific challenges:

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- Real-world algorithmic robustness;
- 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

LET SET OURSELVES A CHALLENGE

Design & run a study with:

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

LET SET OURSELVES A CHALLENGE

Design & run a study with:

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- a continuous interaction

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Design & run a study with:

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- also including social behaviours & social dynamics

LET SET OURSELVES A CHALLENGE

Design & run a study with:

- a real robot
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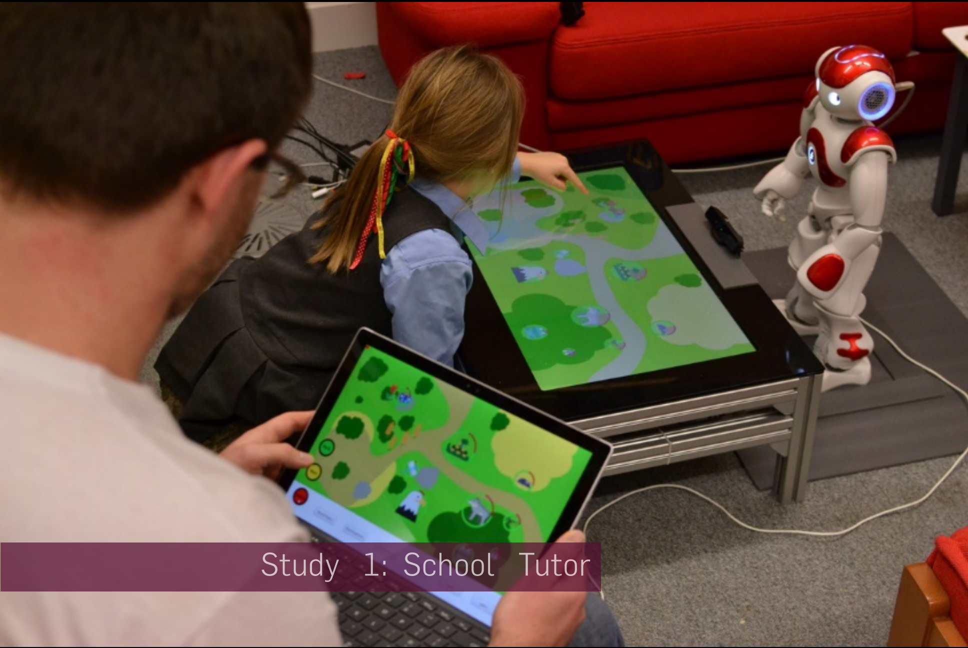
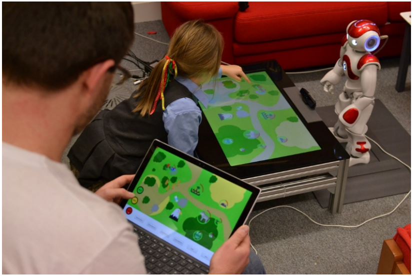
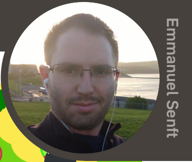
- also including social behaviours & social dynamics
- ...and of course, the robot should be autonomous



Study 1: School Tutor

IRL APPLIED TO SOCIAL ROBOTICS





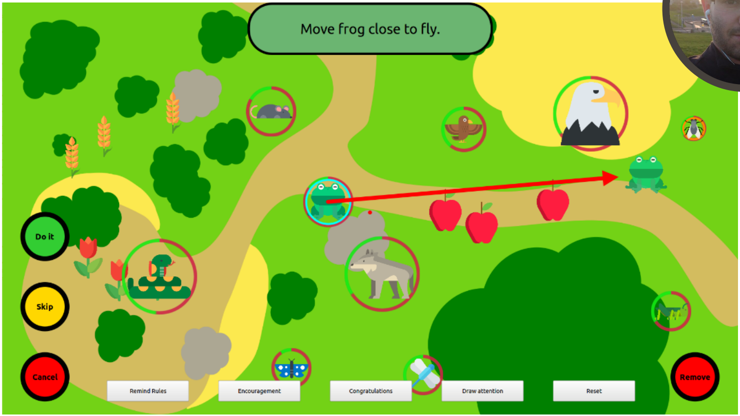
The children plays a game about food chains; the robot learns to guide them (*task-specific action policy*) and encourage them (*social action policy*)

Interactive Machine Learning (IRL) to teach the robot.

$|state| = 210 \; |action\_space| = 655$

[Senft et al. **Teaching robots social autonomy from in situ human guidance** Science Robotics 2019]

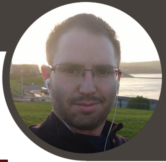
TEACHER'S INTERFACE



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

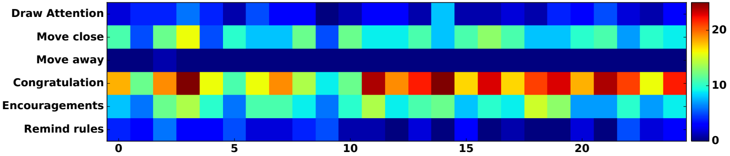
[Senft et al. **Teaching robots social autonomy from in situ human guidance** Science Robotics 2019]

LEARNT ROBOT'S BEHAVIOUR



Emmanuel Senft

Distribution of actions for the 25 children participants:
Supervised



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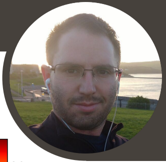

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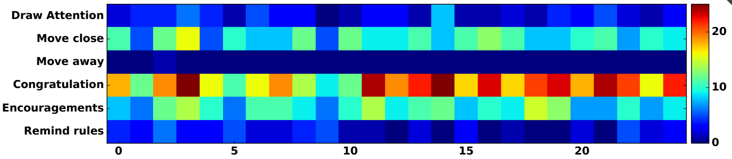
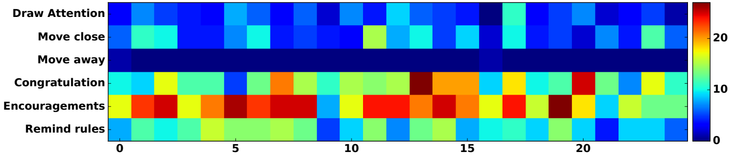


Autonomous

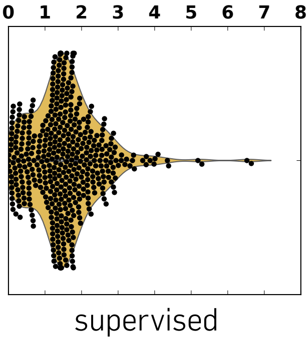


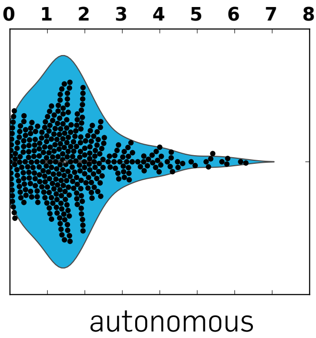
→ the robot personalises its action policies to the child's behaviour.

[Senft et al. **Teaching robots social autonomy from in situ human guidance** Science Robotics 2019]

LEARNT ROBOT'S BEHAVIOUR

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

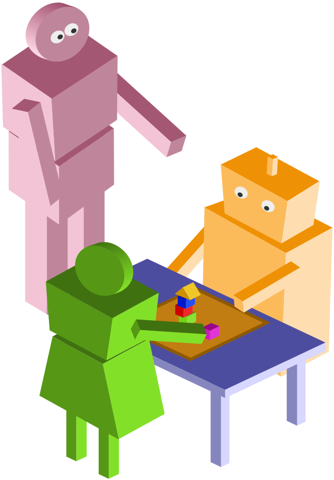




→ the robot has also learnt an appropriate social timing.

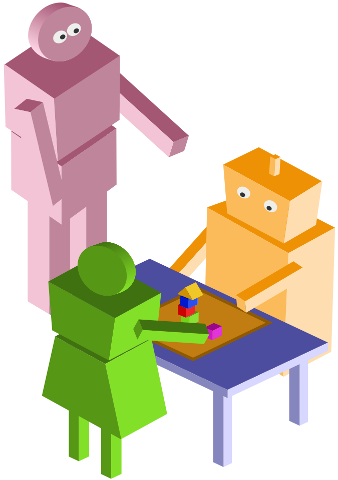
[Senft et al. **Teaching robots social autonomy from in situ human guidance** Science Robotics 2019]

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**)

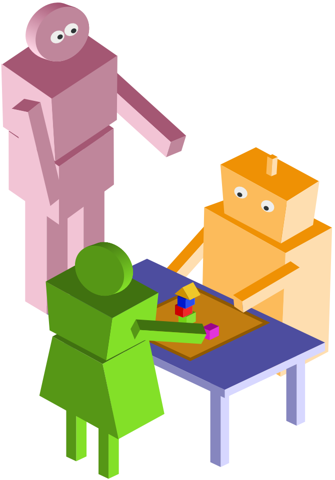
WHAT DOES THAT MEANS FOR THE EXPERT/TEACHER/END-USER?



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?


LifeFitness
Study 2: gym coach

COUCH-TO-5K STUDY

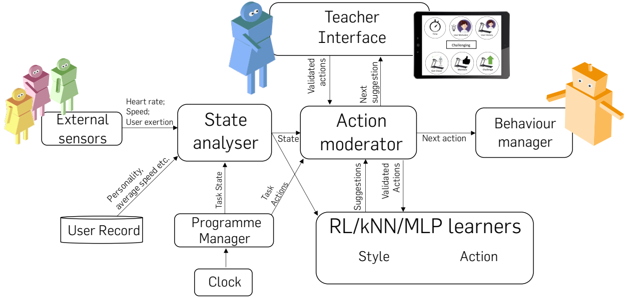

Katie Winkle

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

[Winkle et al. **In-Situ Learning from a Domain Expert for Real World Socially Assistive Robot Deployment** RSS 2020]

COUCH-TO-5K STUDY

Katie Winkle



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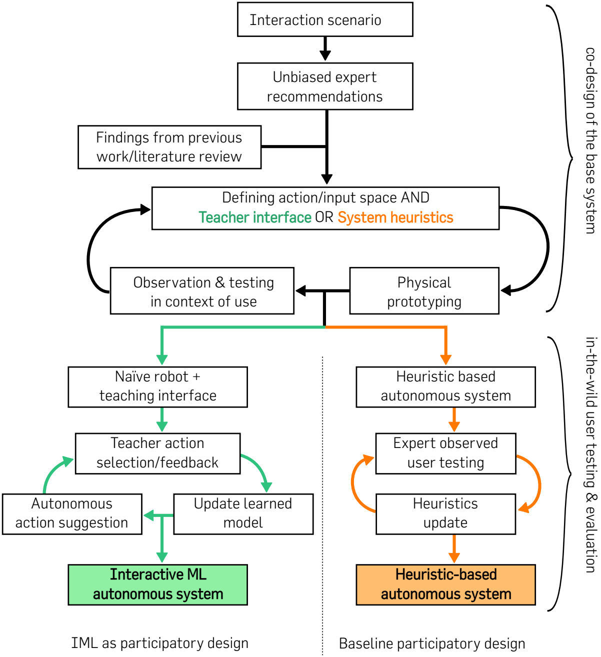
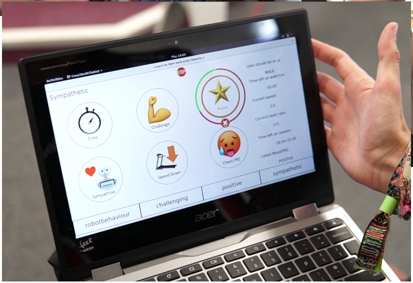

Interaction scenario
Unbiased expert recommendations
Findings from previous work/literature review
Defining action/input space AND
Teacher interface OR System heuristics
Observation & testing in context of use
Physical prototyping
co-design of the base system
Naïve robot + teaching interface
Teacher action selection/feedback
Autonomous action suggestion
Update learned model
Interactive ML autonomous system
Heuristic based autonomous system
Expert observed user testing
Heuristics update
Heuristic-based autonomous system
in-the-wild user testing & evaluation
IML as participatory design
Baseline participatory design

CO-DESIGN FOR REAL-WORLD + LONG-TERM



Katie Winkle

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.**

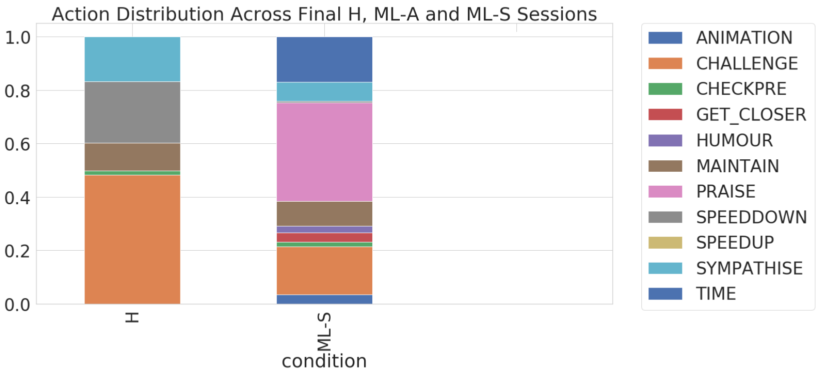
INPUT & OUTPUT SPACES: MOSTLY TASK-SPECIFIC

Full listing of actions as *{action-type, style-modifier}*:

	Social-Supporting Actions								Task Actions		Low Level
	Time	**Social**	**Performance**	**Reward**	**Check User**	**Animation**	**Get Closer**	**Back Off**	**Run**	**Walk**	**Eye Colour**
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



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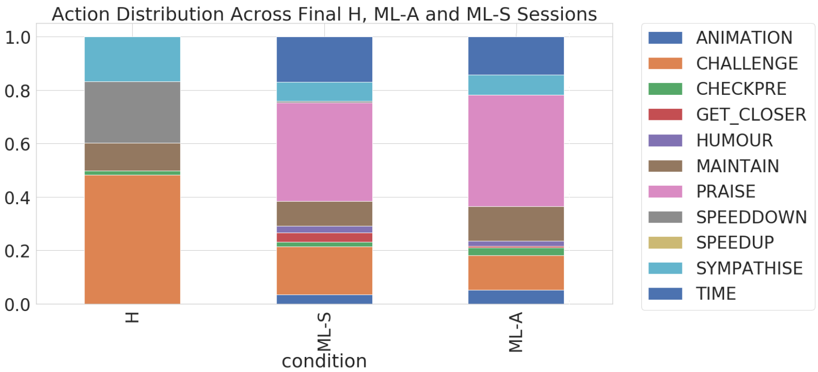
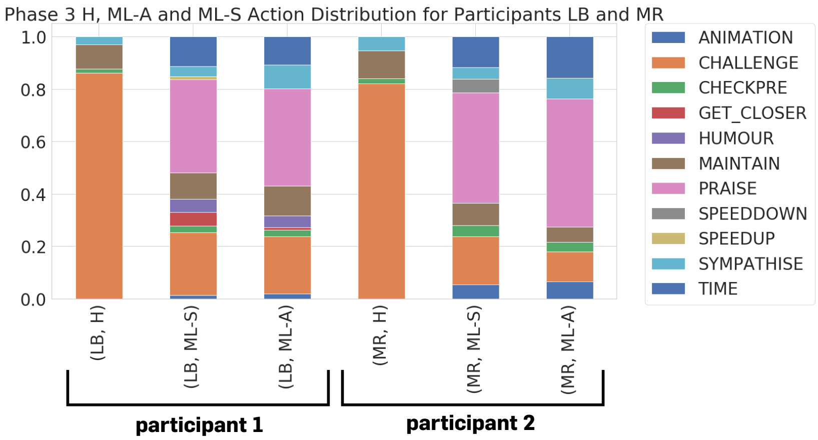


(another nail in the expert systems coffin!)

[Winkle et al. **In-Situ Learning from a Domain Expert for Real World Socially Assistive Robot Deployment** RSS 2020]

LEARNT POLICIES



[Winkle et al. **In-Situ Learning from a Domain Expert for Real World Socially Assistive Robot Deployment** RSS 2020]

BAILAR objectives:

"Endowing robots with learning and behavioral adaptation abilities is a key objective for enabling natural and efficient human-robot interaction, especially in the areas of assistive robotics."

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

[Senft at al. **SPARC: Supervised progressively autonomous robot competencies**, ICSR 2015;
Winkle, Senft, Lemaignan **LEADOR: End-to-End Participatory Design of Autonomous Social Robots** FrontiersIn 2021 (to appear)]

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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

[Senft at al. **SPARC: Supervised progressively autonomous robot competencies**, ICSR 2015;
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LET'S REVISIT OUR CHALLENGE

Studies with...

- ✓ real robots

LET'S REVISIT OUR CHALLENGE

Studies with...

- ✓ real robots
- ✓ real interactions with humans

LET'S REVISIT OUR CHALLENGE

Studies with...

- ✓ real robots
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- ✓ in the wild

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End of the road:

LET'S REVISIT OUR CHALLENGE

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End of the road:

- ? open-ended, underspecified situations

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- ? close the "interaction loop"

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LET'S REVISIT OUR CHALLENGE

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End of the road:

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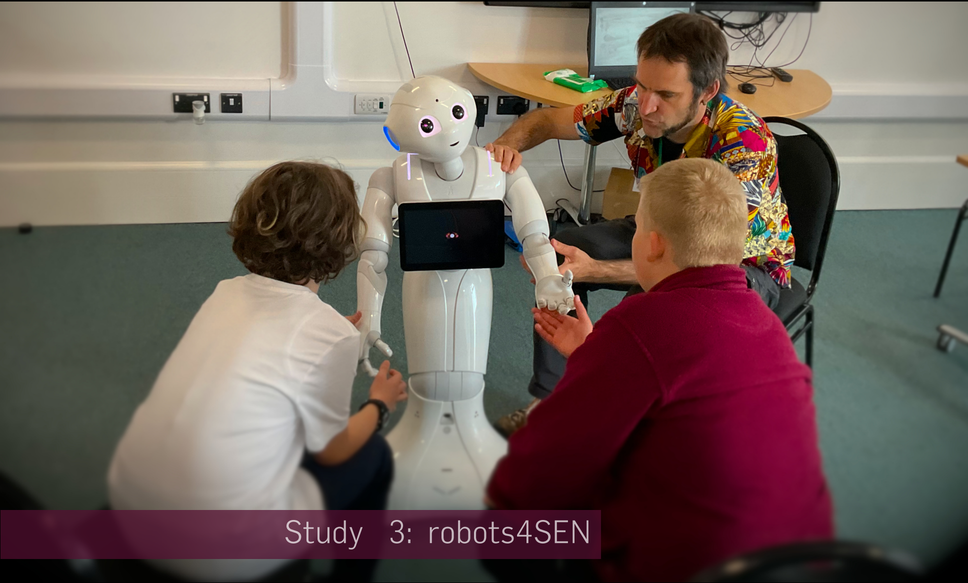
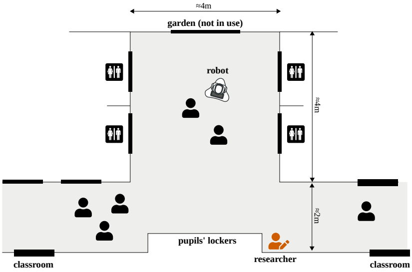
- ? complex social dynamics (incl. groups)
- ? close the "interaction loop"
- ~ sustain long-term autonomous social interactions
- ~ real-world robustness

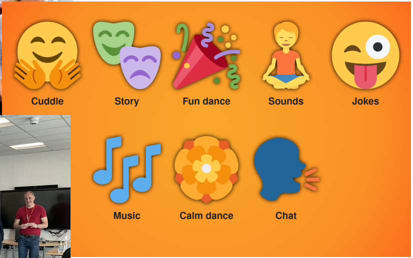


Study 3: robots4SEN

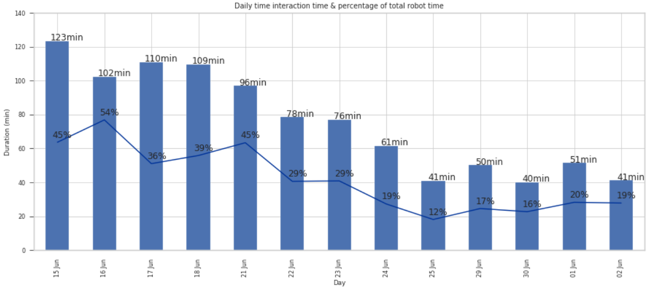
WELL-BEING AND AUTISM

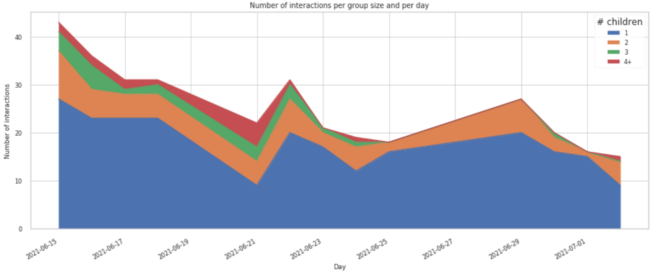


PARTICIPATORY DESIGN WITH AUTISTIC CHILDREN



ENGAGEMENT OVER 3 WEEKS





SOCIAL COMPANIONS TO SUPPORT CHILDREN'S WELL-BEING

- open-ended, underspecified situations
- rich semantics
- complex social dynamics (incl. groups)
- close the "interaction loop"
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But limited autonomy! Interactions child-led!

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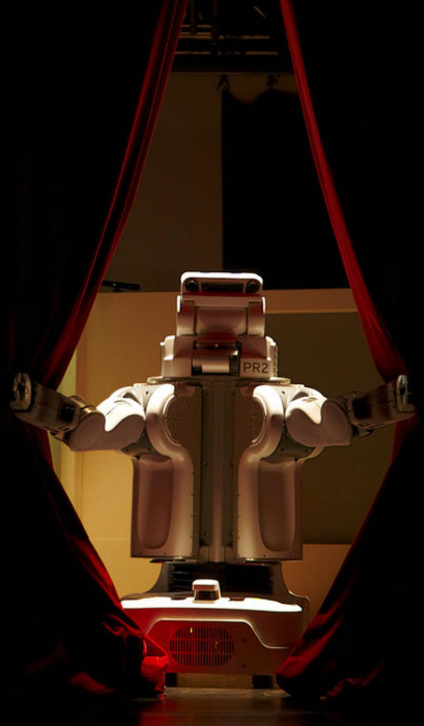
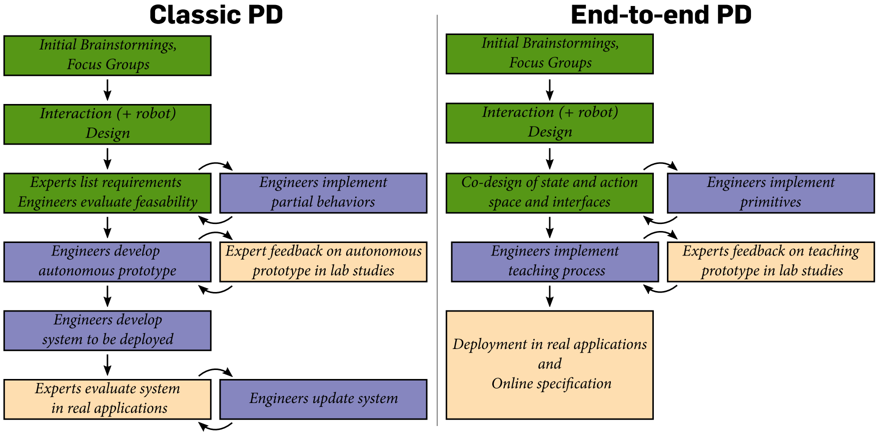
$\Rightarrow$ The next frontier



Thank you!

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


Classic PD
Initial Brainstormings, Focus Groups
Interaction (+ robot) Design
Experts list requirements Engineers evaluate feasability
Engineers implement partial behaviors
Engineers develop autonomous prototype
Expert feedback on autonomous prototype in lab studies
Engineers develop system to be deployed
Experts evaluate system in real applications
Engineers update system
End-to-end PD
Initial Brainstormings, Focus Groups
Interaction (+ robot) Design
Co-design of state and action space and interfaces
Engineers implement primitives
Engineers implement teaching process
Experts feedback on teaching prototype in lab studies
Deployment in real applications and Online specification