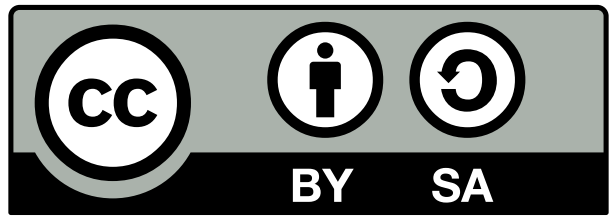
joint action: what's underneath the models?

bringing implicit social dynamics into the picture

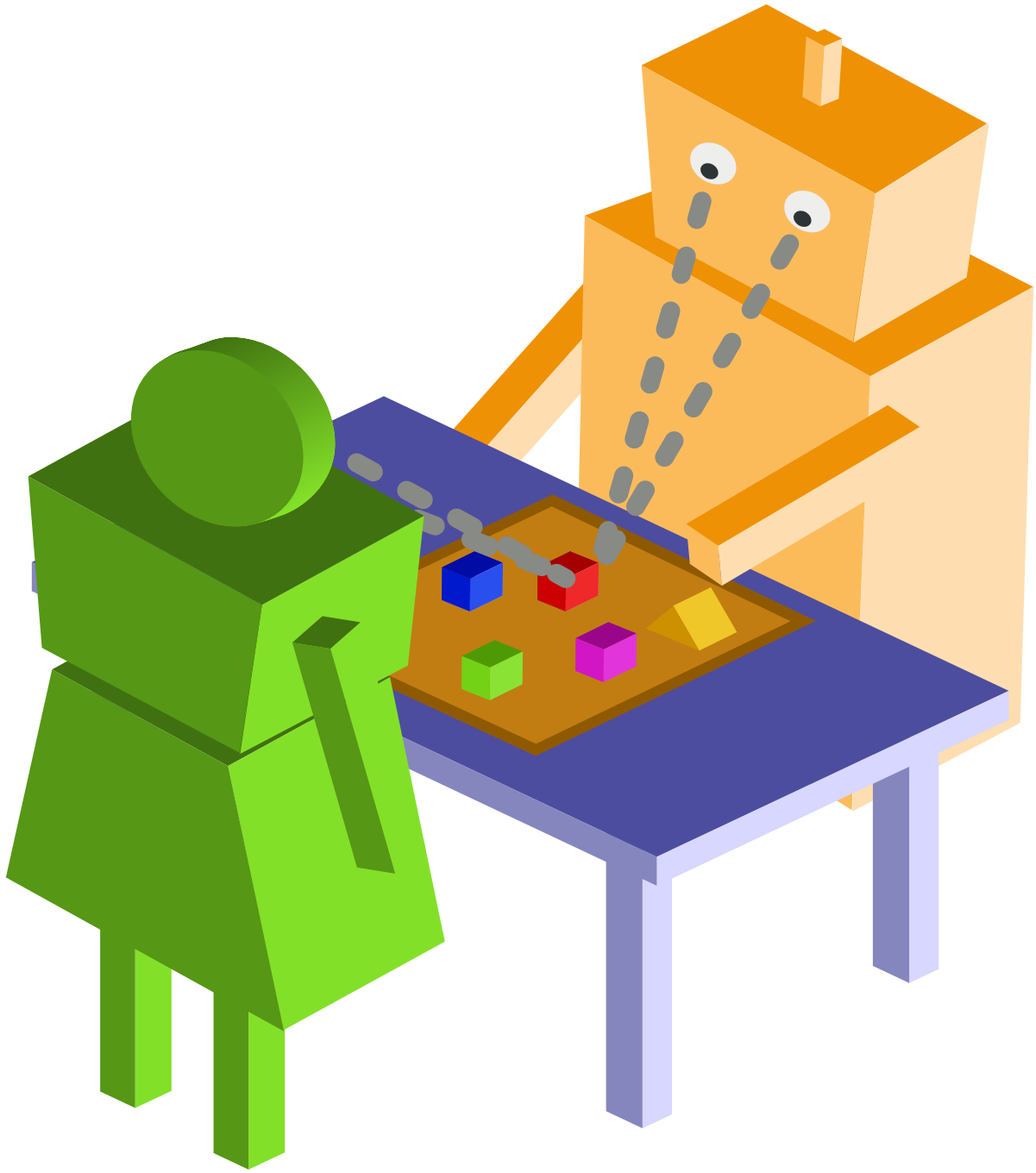
towards a framework for joint action@RSS18 – 29 Jun. 2018

Séverin Lemaignan

Bristol Robotics Lab University of the West of England



You can download the sources of this presentation here:
github.com/severin-lemaignan/rss2018-data-driven-joint-actions



MODEL-BASED JOINT ACTION

1. establish a joint goal
2. plan for the robot
3. plan for the human in order to build a set of priors
4. execute the robot plan
5. monitor progress of the partner towards the goal

[Lemaignan et al. **Artificial Cognition for Social Human-Robot Interaction: An Implementation** Artificial Intelligence 2017]

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⇒ **explicit cognitive steps**

...hard ones, though:

- *how to communicate/agree on goals & plans?*
- *what about the human's own plans?*
- *monitoring/recognising error situations*
- *what to do when we're going 'off track'?*
- *...many more!*

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HOW DO HUMANS PERFORM TASKS TOGETHER?

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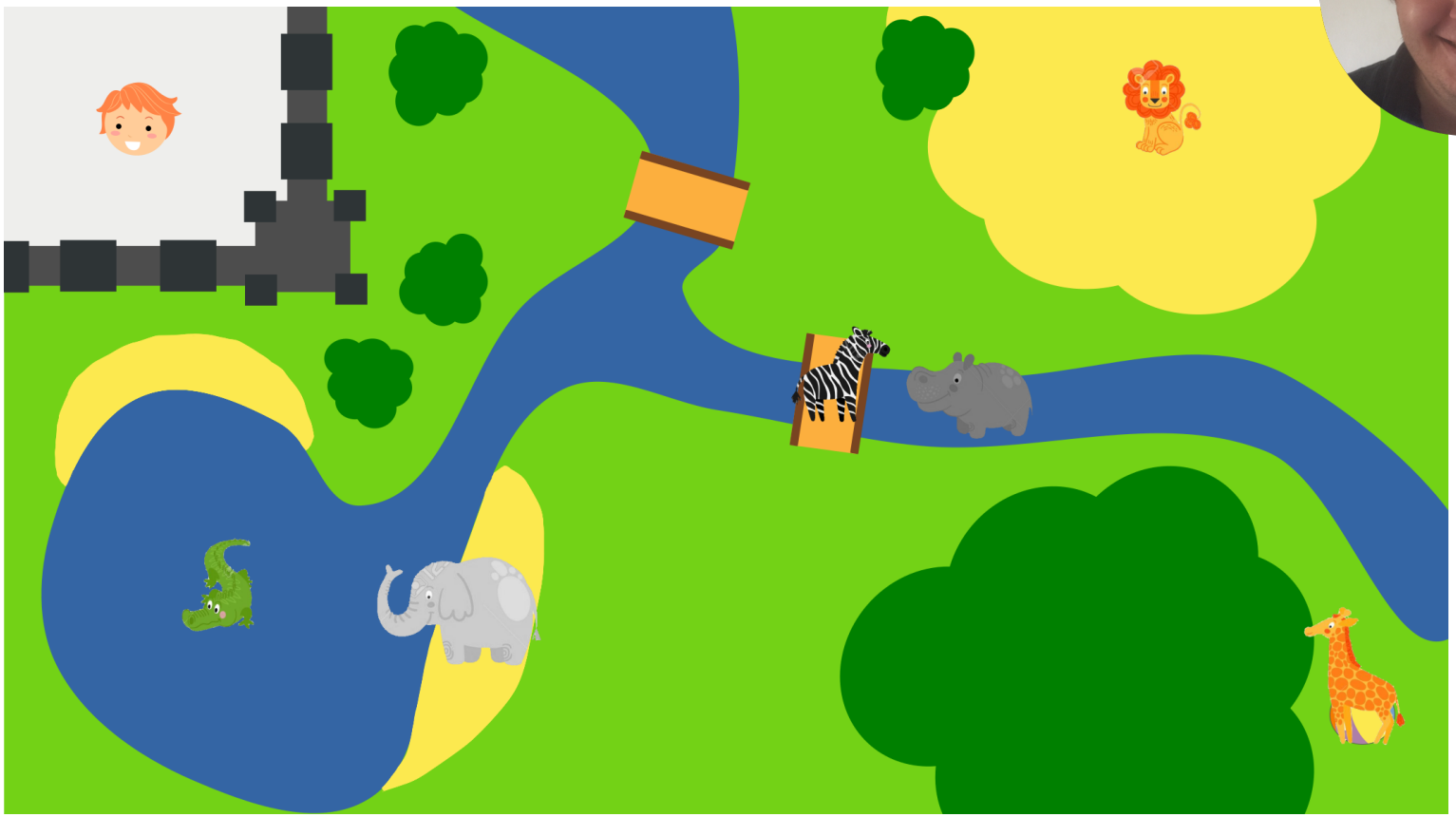
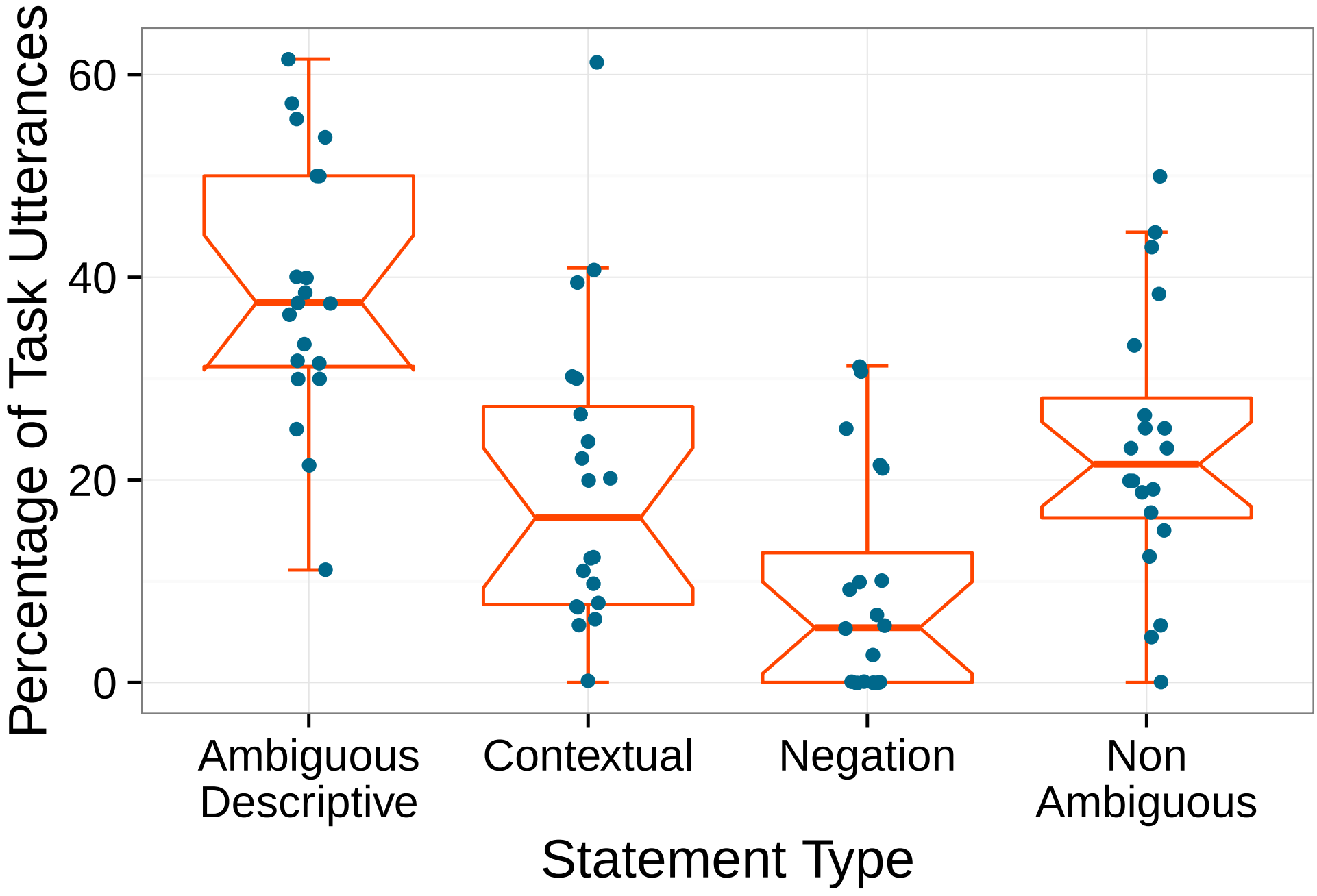
What does "be lazy" mean for robots?

ONE EXAMPLE: GROUNDING OF SPATIAL LANGUAGE



Ambiguities arise easily when describing spatial scenes.

How do we solve them?


Percentage of Task Utterances
60
40
20
0
Ambiguous Descriptive
Contextual
Negation
Non Ambiguous
Statement Type

SURFACE ALIGNEMENT; GROUNDING CRITERION

Psycholinguistics provides a lot of the foundational work on these questions.

- ***Communication is a dynamic social process***: the partner often to signal missing/misunderstood informations

[Clark and Wilkes-Gibbs, ***Referring as a collaborative process***, Cognition 1986
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- **do we need a high-level Theory of Mind at all?**

[Clark and Wilkes-Gibbs, ***Referring as a collaborative process***, Cognition 1986
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IN SOCIAL HUMAN-ROBOT INTERACTION

Well studied in communication (cf back-channeling)

Can we expand this line of thought to sHRI in general?

Most of our social and behavioural alignment comes from sub-conscious social mechanisms:

- entrainment (coupling),
- mimicry,
- implicit turn-taking,
- joint attention
- ...and others

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- implicit turn-taking,
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- ...and others

Can we model & generate them?

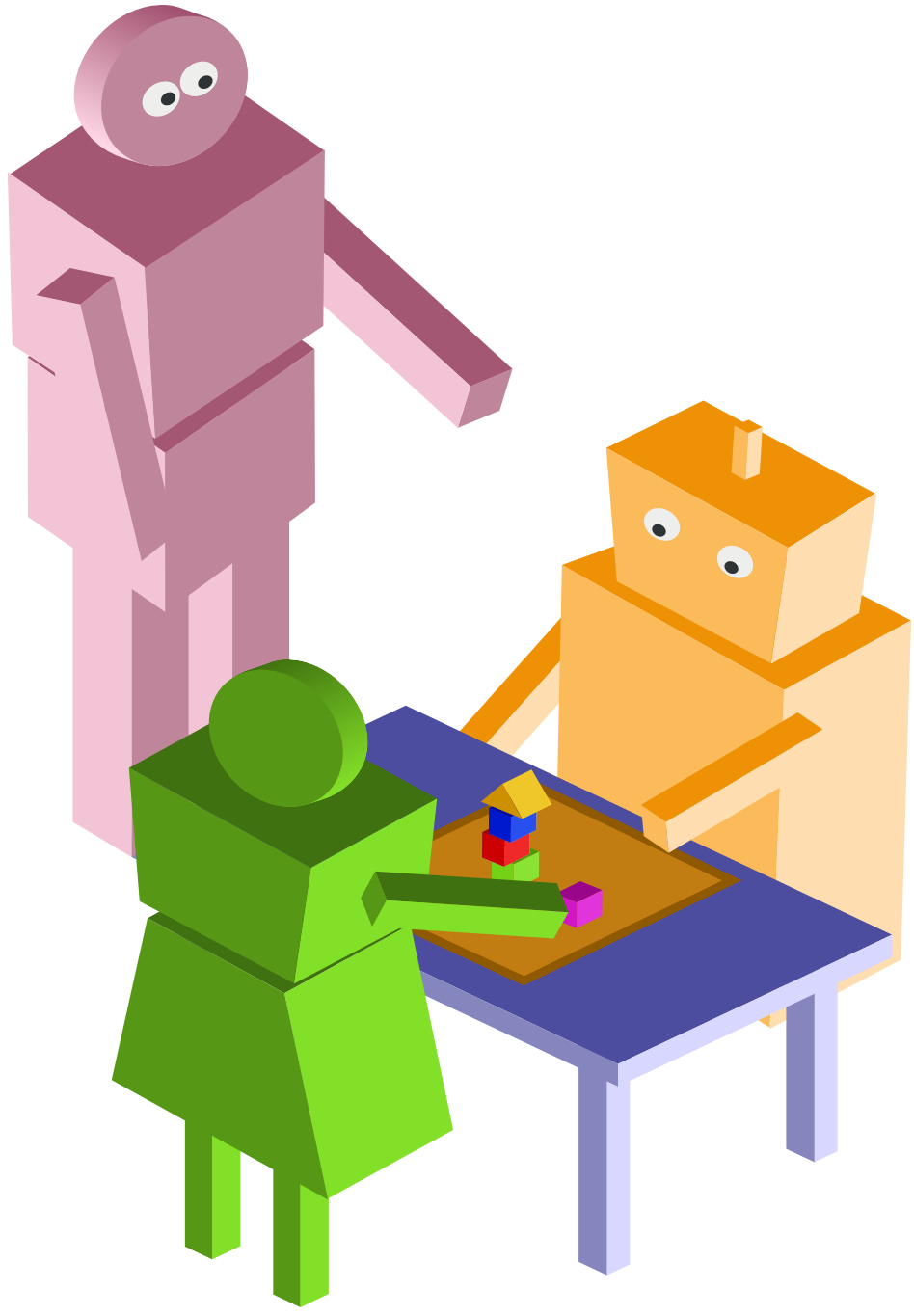
THE PROBLEM

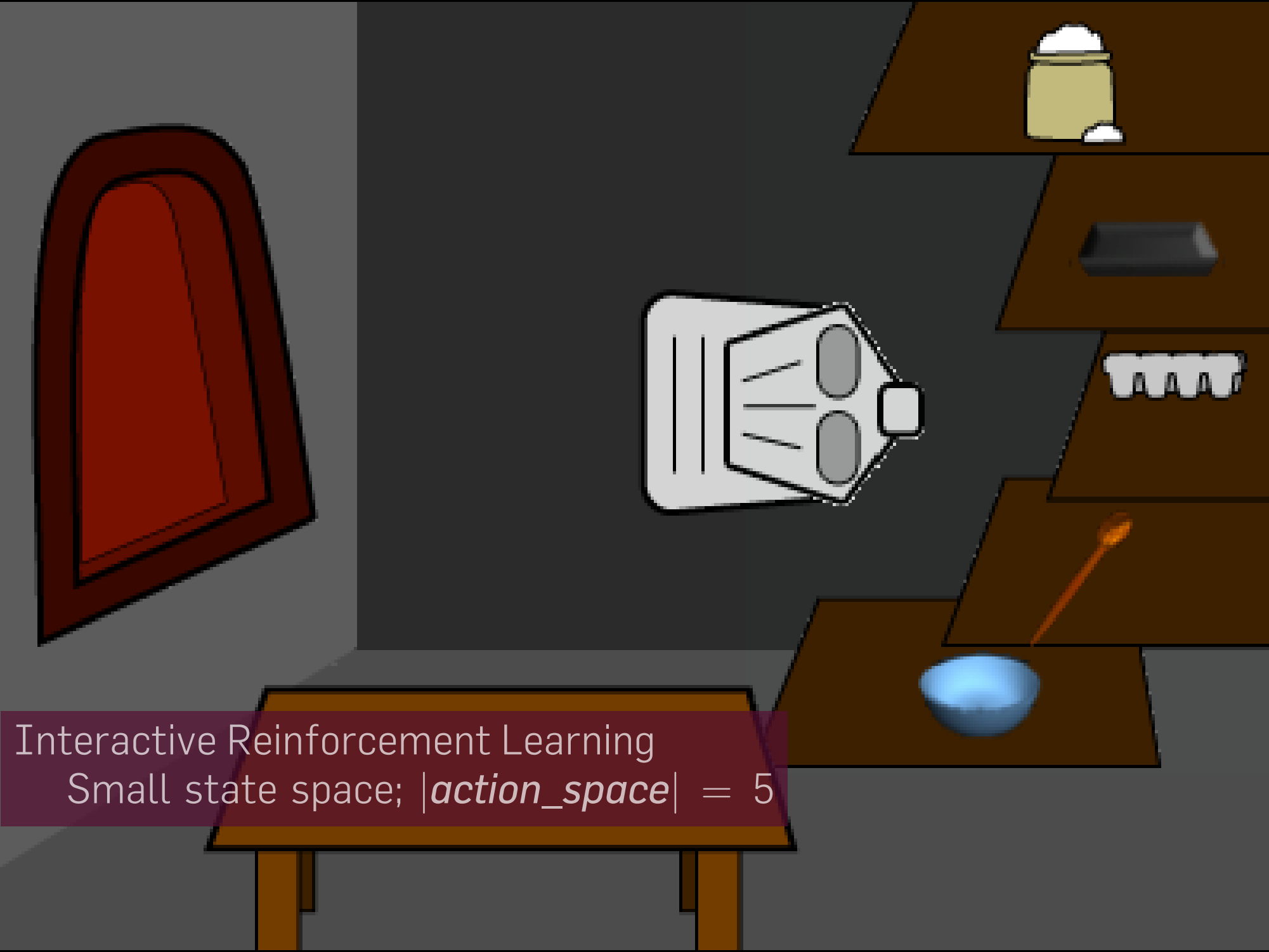
- These mecanisms are unfortunately often ill-defined, and particularly difficult to turn into equations (or controllers, in our case)
- not close-form equation of social interactions $\Rightarrow$ data-driven approaches?

2 INSTANCES

- SPARC: transfering social skills from a human expert to an autonomous robot
- PInSoRo: learning to recognise complex social situations from child-child interactions

LEARNING SOCIAL AUTONOMY FROM HUMANS




Interactive Reinforcement Learning
Small state space; |action_space| = 5

...WELL, WELL...

Can we tackle much more complicated cases?

- real robot?

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

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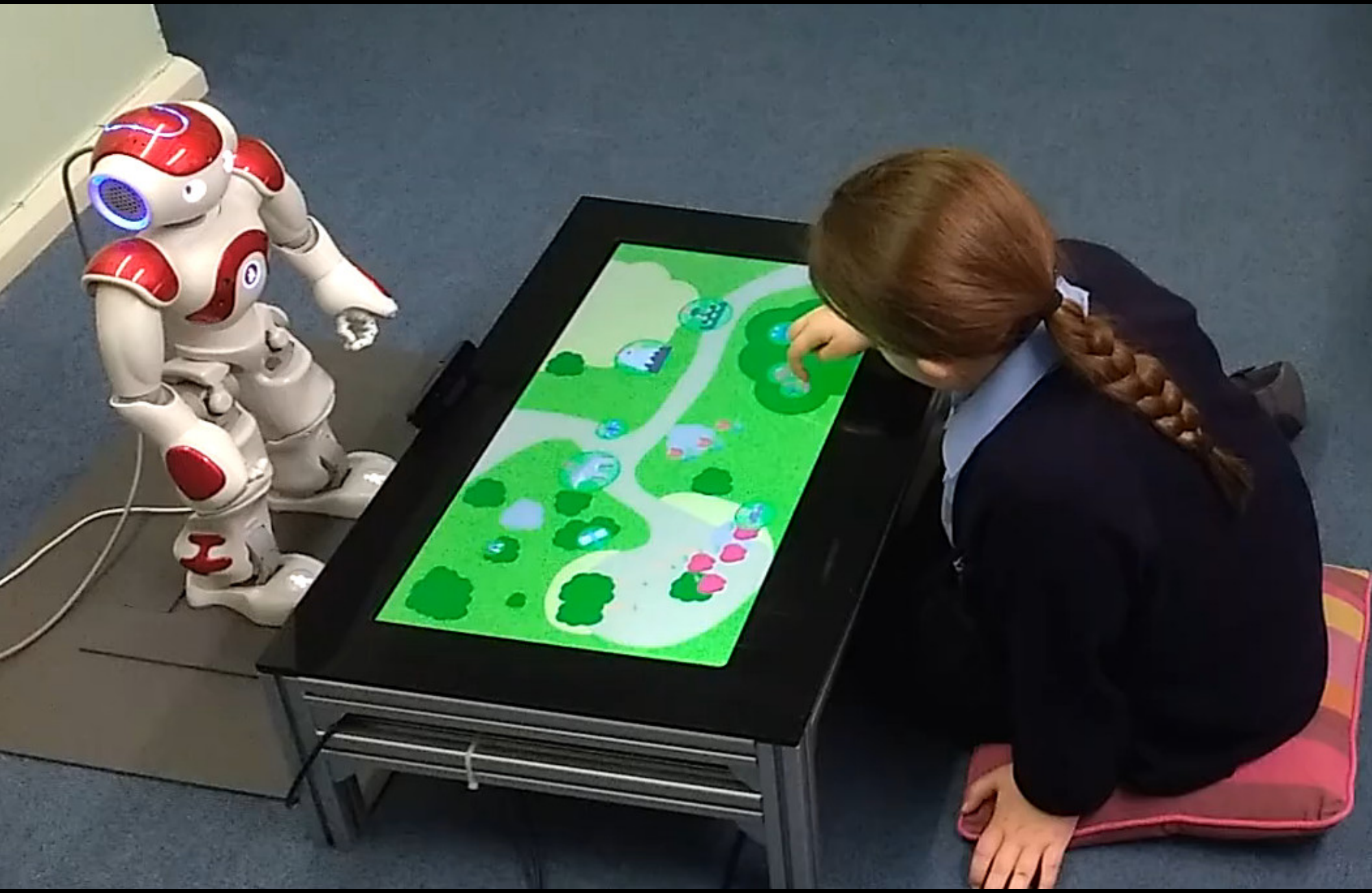
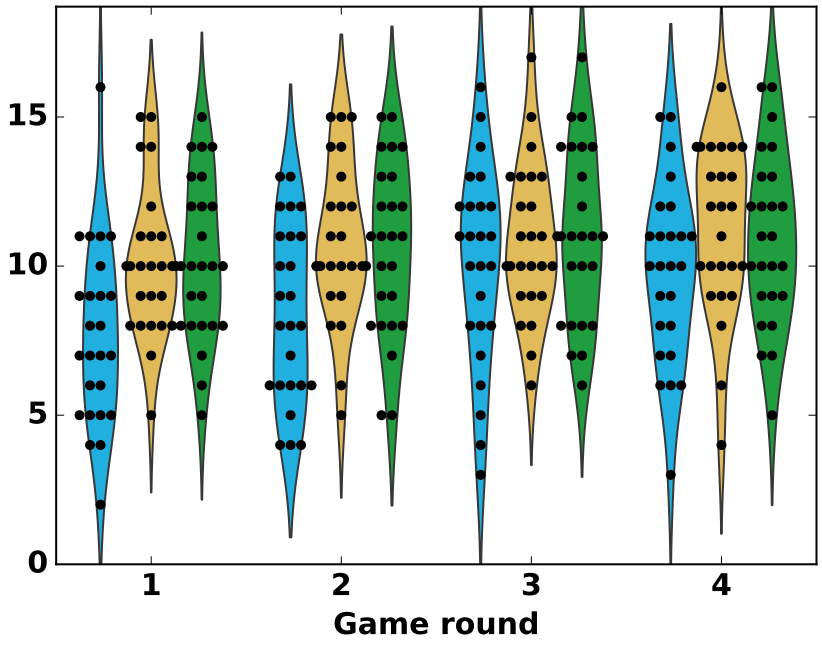
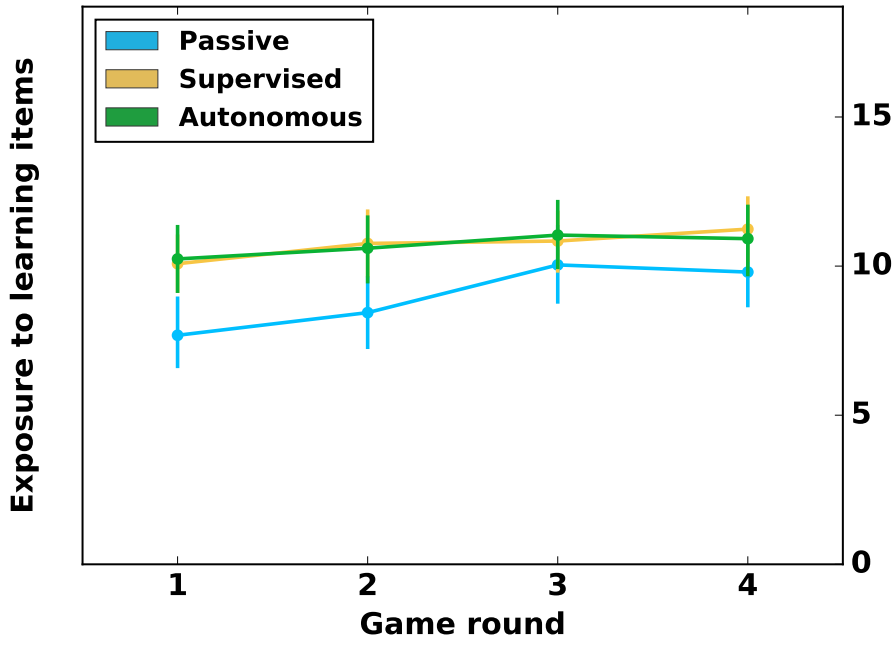
- real interaction (...with a human!)?
- continuous interaction?
- more realistic task (state vector & action space)?
- also including social behaviours?



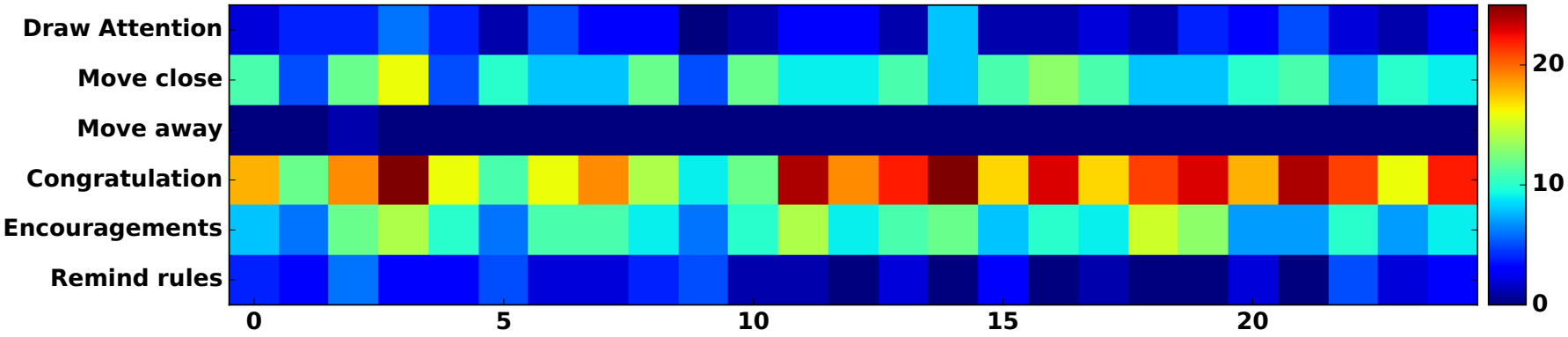

$state \in [0.;1.]^{210}$ $|action\_space| = 655$

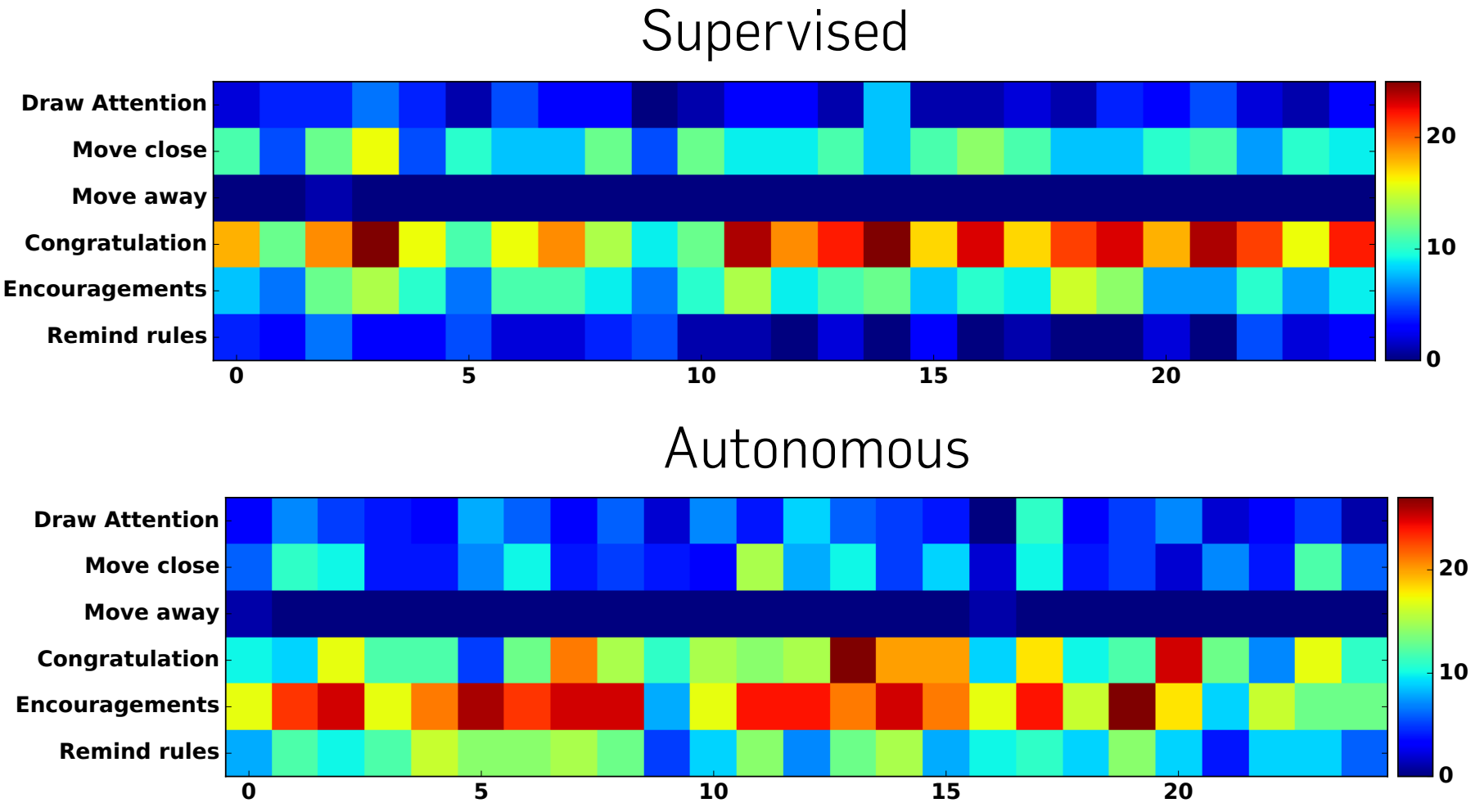




Learning-related game actions

Supervised


Draw Attention
Move close
Move away
Congratulation
Encouragements
Remind rules
0
5
10
15
20
20
10
0


Supervised
Draw Attention
Move close
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0
5
10
15
20
0
10
20
Autonomous
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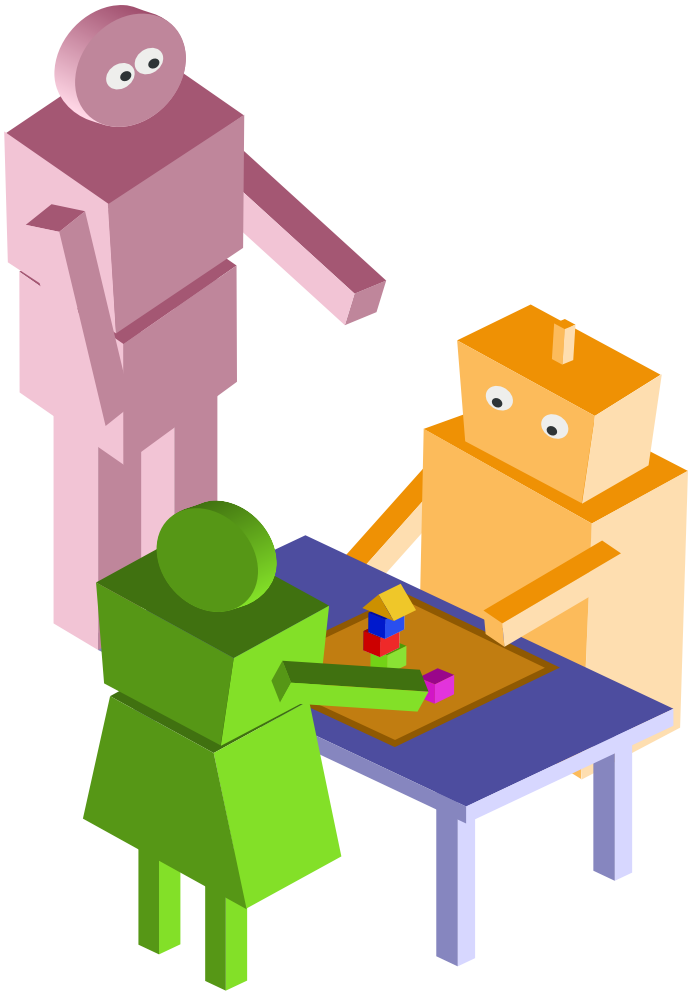
0
5
10
15
20
0
10
20

TAKE-HOME MESSAGE FOR JOINT ACTION



- this example is about tutoring, however **progressively transferring autonomy** is a general principle
- it works well for relatively high-dimensional problems
- it also works for **social behaviours**

WHAT ABOUT MORE SUBTLE SOCIAL DYNAMICS?

TO STUDY SOCIAL DYNAMICS, WE NEED...

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A **task**!

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...that exhibits:

- complex social dynamics
- open, underspecified situations
- natural interactions
- rich semantics
- interplay of many socio-cognitive functions

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while being...

- reproducible/replicable experimental procedure
- clear quantitative metrics
- practical

FREE PLAY

"Just play! Enjoy yourselves!"

- **rich set of cognitive and social dynamics**; importance of motivation/drive; **uncertain and unexpected situations**
- what is the right action policy? Focus instead on the **social policy**

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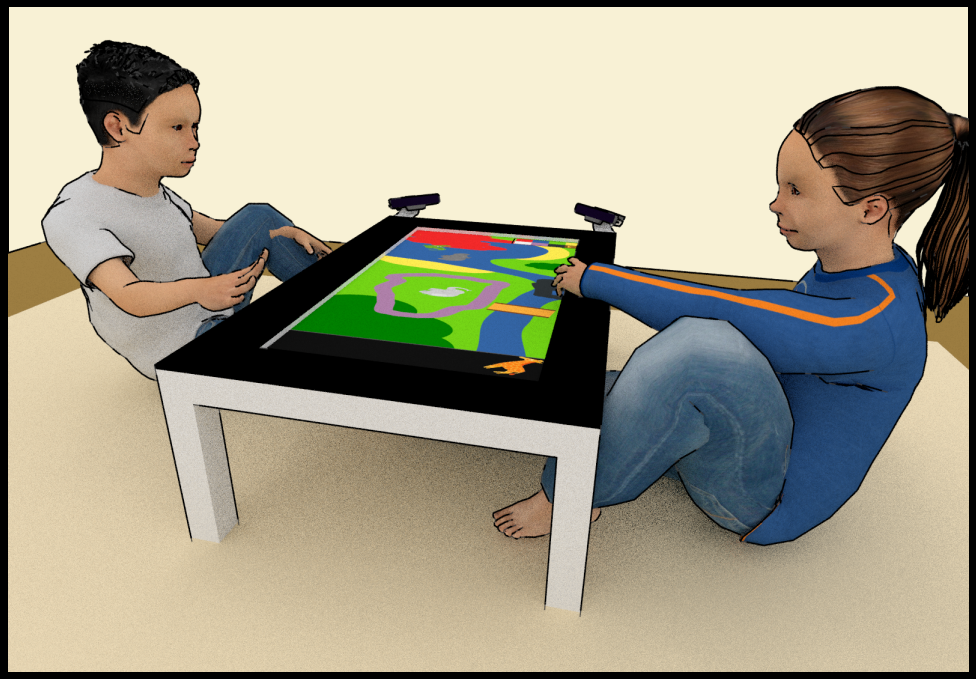
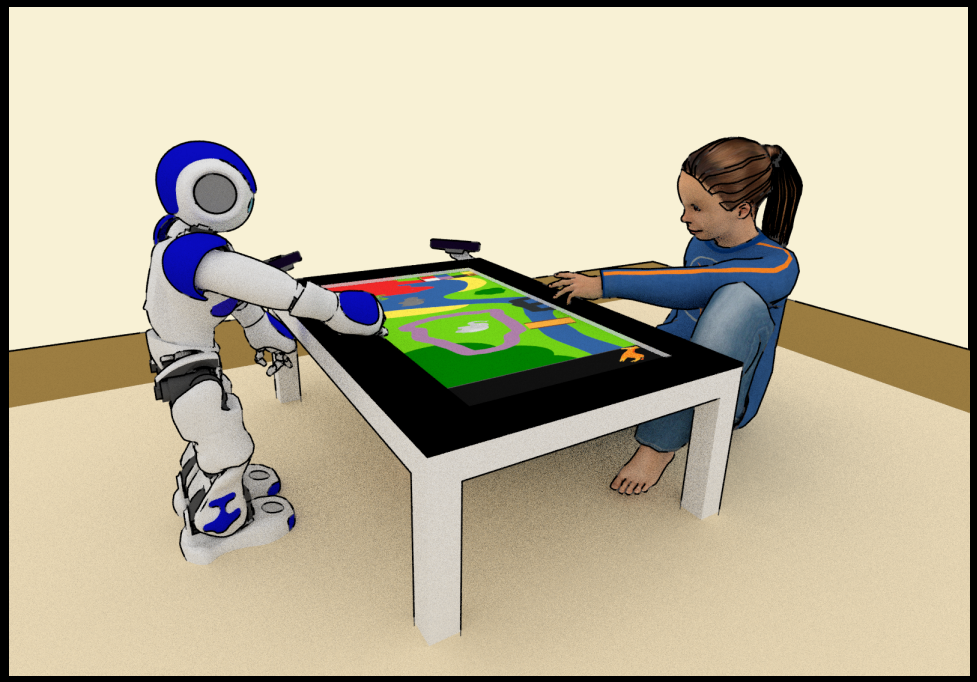
- focus on children
- with a little bit of scaffolding & framing





THE PINSORO DATASET

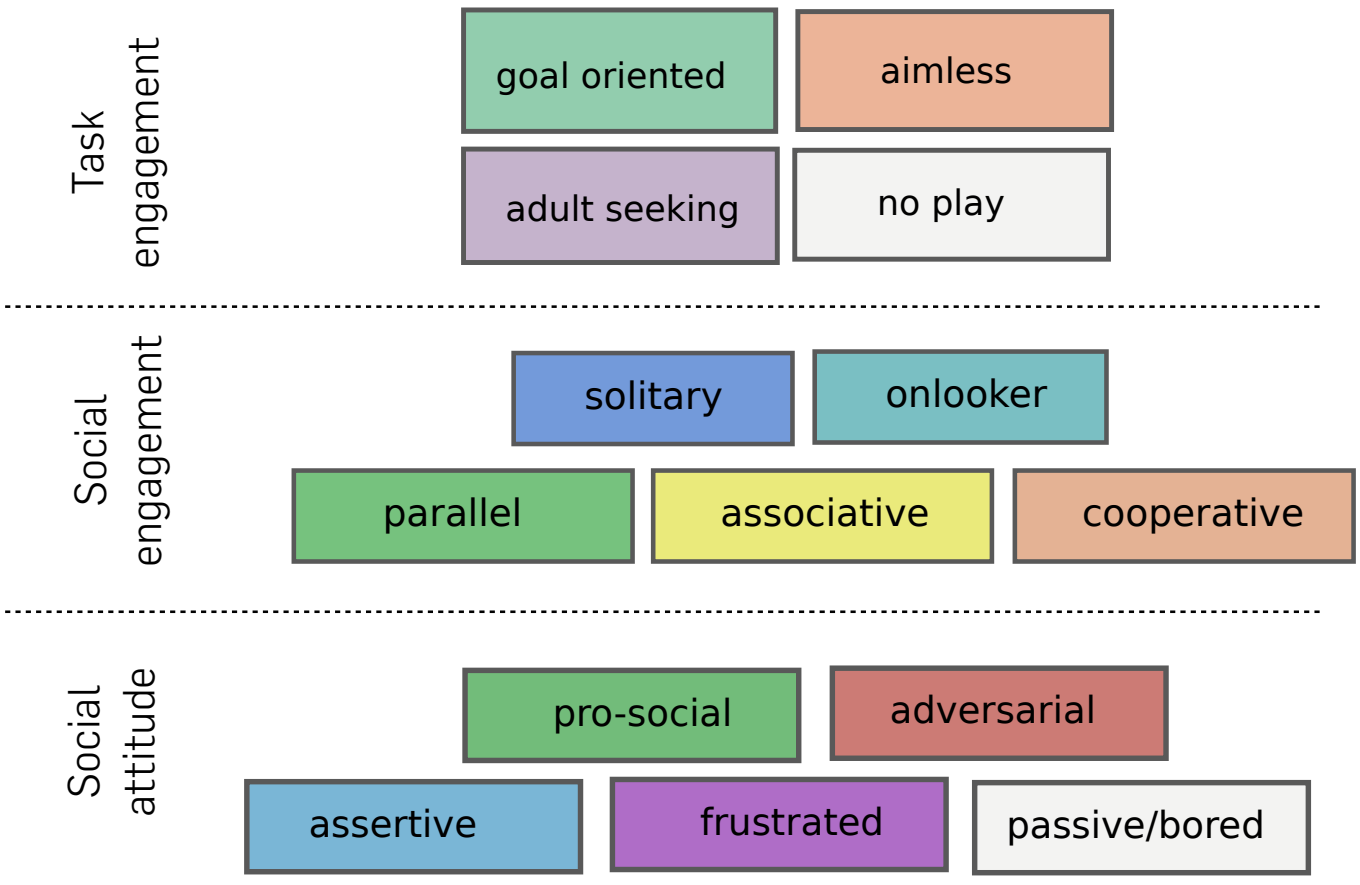
- 120 children, 4 to 8 years old
- 75 interactions
  - 90 children playing with another child,
  - 30 playing with a robot
- About 45h+ of recordings; 2M+ frames; ≈ 2TB
- average duration of freeplay interactions: 24min in child-child condition; 19min in child-robot condition

Large open dataset: **freeplay-sandbox.github.io**

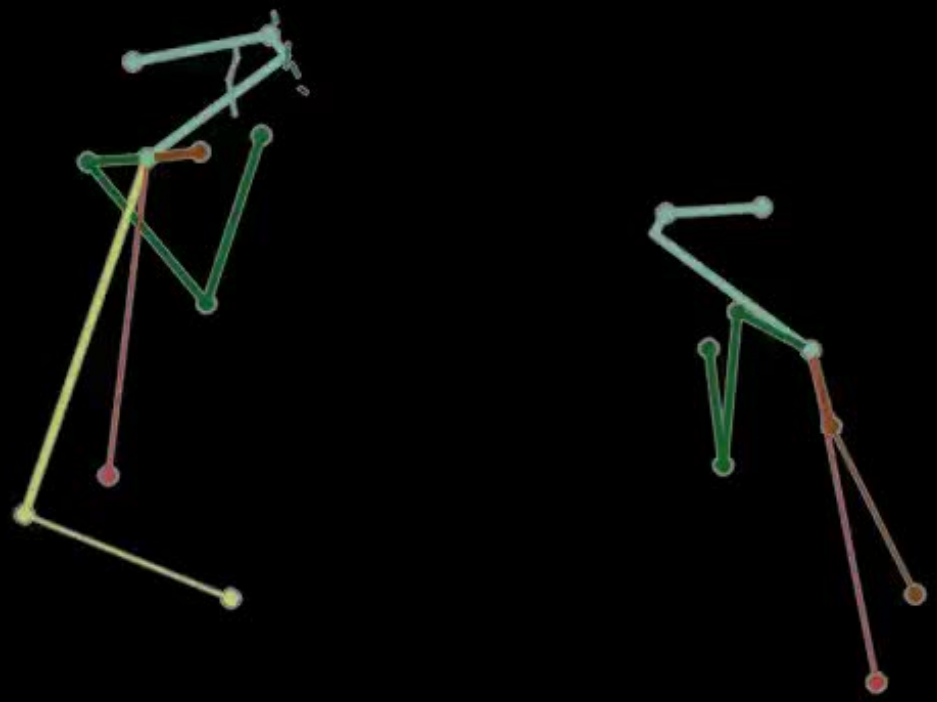
WHAT DID WE RECORD?

Domain	Type	Details
child × 2	audio	16kHz, mono, semi-direction
	face (RGB)	qHD (960x540), 30Hz
	face (depth)	VGA (640x480), 30Hz
	facial features	70 2D points, 30Hz
	skeleton	15 2D points, 30Hz
	hands	20 x 2 2D points, 30Hz
environment	RGB	qHD (960x540), 29.7Hz
touchscreen	background drawing (RGB)	4Hz
	touches	6 points multi-touch, 10Hz
	items position and orientation	(x,y,theta), 10Hz
annotations	timestamped annotations of social behaviours	
+ post-process	optical flow, audio features	
	facial action units...	

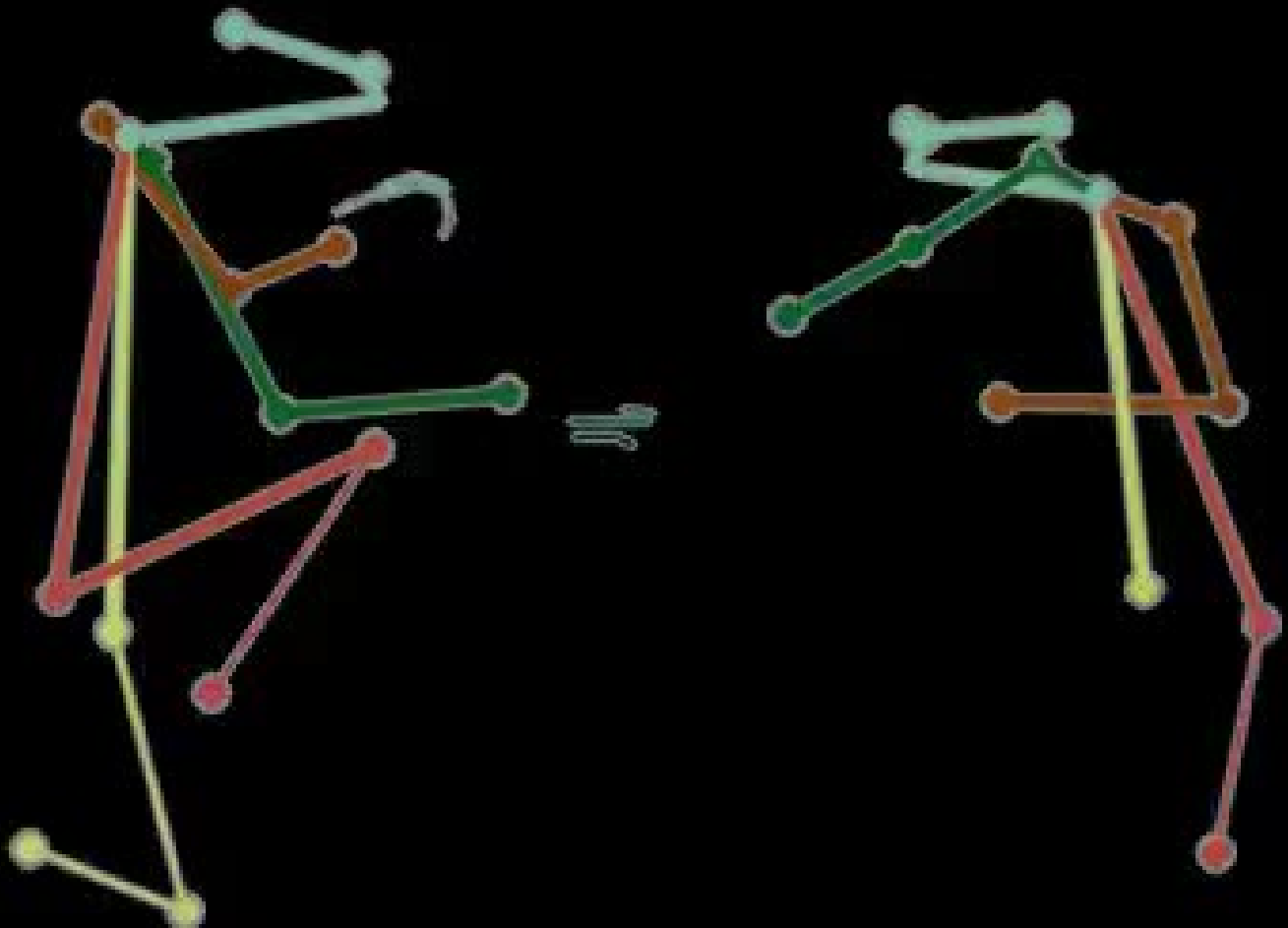
13000+ ANNOTATIONS



TOWARDS DATA-DRIVEN SOCIAL DYNAMICS?



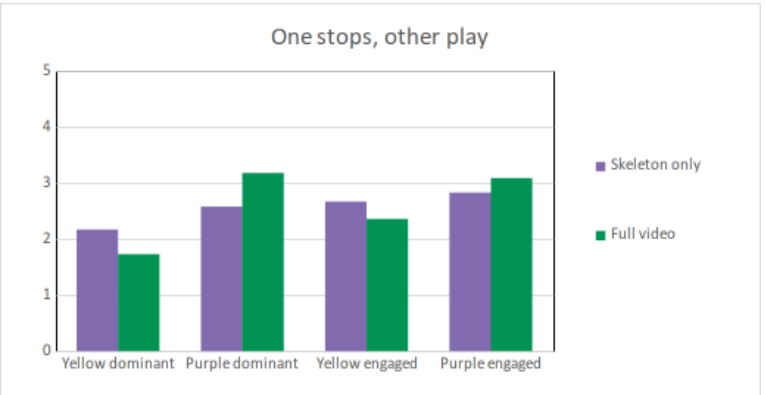

FIRE
EXIT



WHAT DO YOU SEE?

20 30-secs clips with a range of social situations; 200 participants on m-turk.

t-test between skeleton only and full video-streams show no difference in perception for the vast majority of the 11 tested constructs (cooperative, competitive, friendly, sad, engaged,...).



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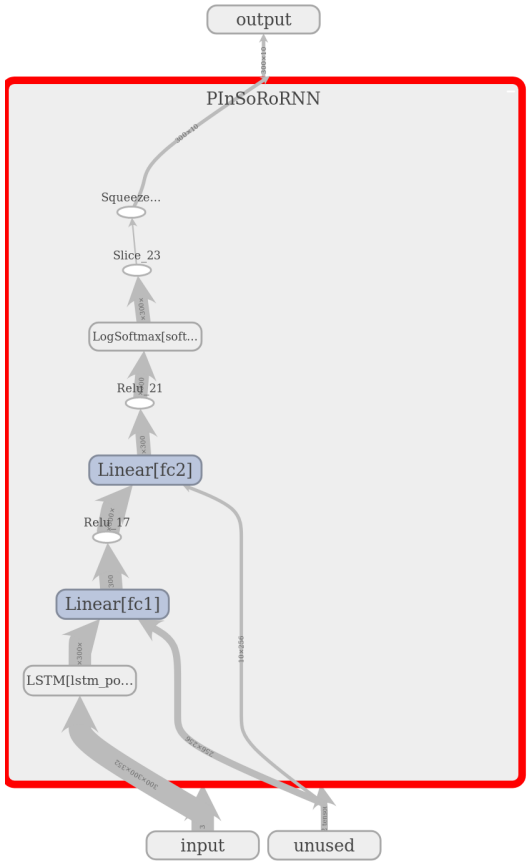
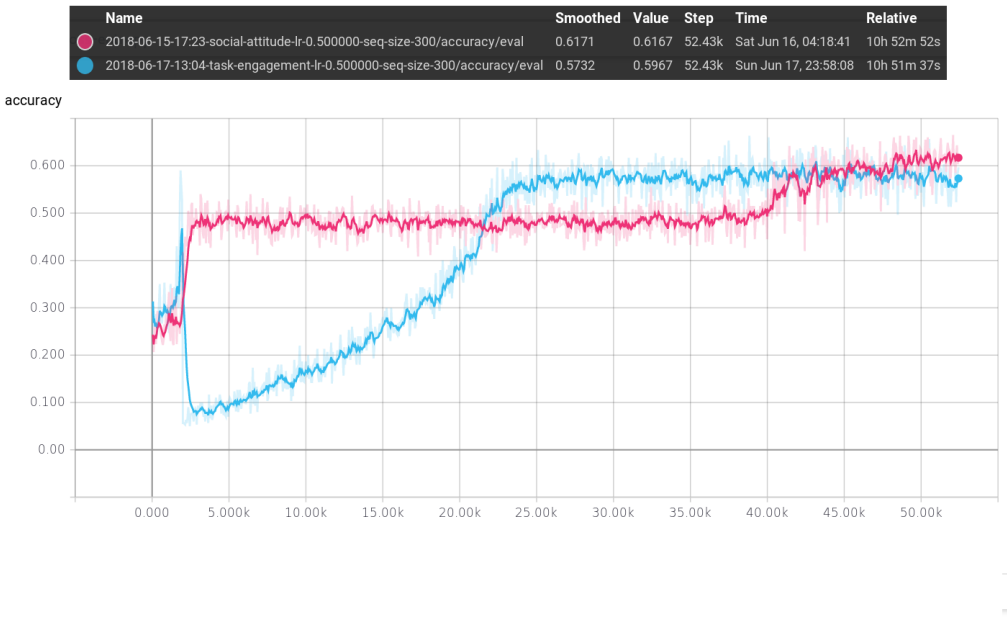
$\Rightarrow$ **30-secs long sequences of body postures and facial landmarks of dyads should be sufficient to recognise a social situation**

DATA CRUNCHING GOING ON!





pytorch; trained on 10 epochs x 2M datapoints; **WIP!!**

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Real-time identification by the robot of...

- the **task engagement**

  is my partner 'on task' or not?

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Social behaviours; Social dynamics: **generation as well!**

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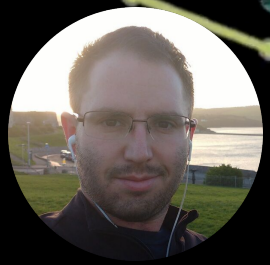
- (do not be scared of ambiguous/partially defined instructions!)
- however, **communication dynamics** & the **recognition of grounding errors** should be research priorities
- **how does that relate to the higher-level concept of 'theory of mind'?**

Attitude: pro-social

Social engag.: parallel play

Task engag.: goal oriented



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Thank you!

SOME MORE STUFF

SOME BUILDING BLOCKS EXISTS

- **Multi-modal fusion**

  e.g. Noda et al. **Multimodal integration learning of robot behavior using DNN**, Robotics and Autonomous Systems 2014

- **Behavioural sequences recognition**

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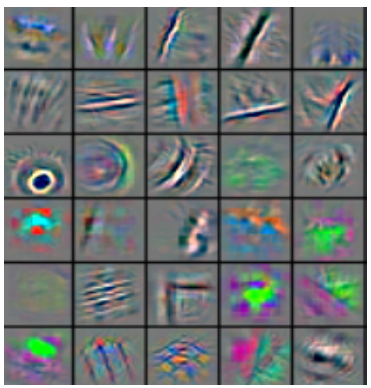
DBSoC: Deep Behavioural Social Cloning – LfD + CNNs + LSTM

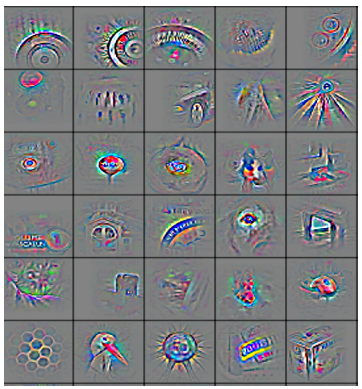
Two tasks for a telepresence robot:

1. position itself in a (dynamic) group of persons
2. follow 2 persons

DEEP NETWORKS ≡ BLACK BOXES?

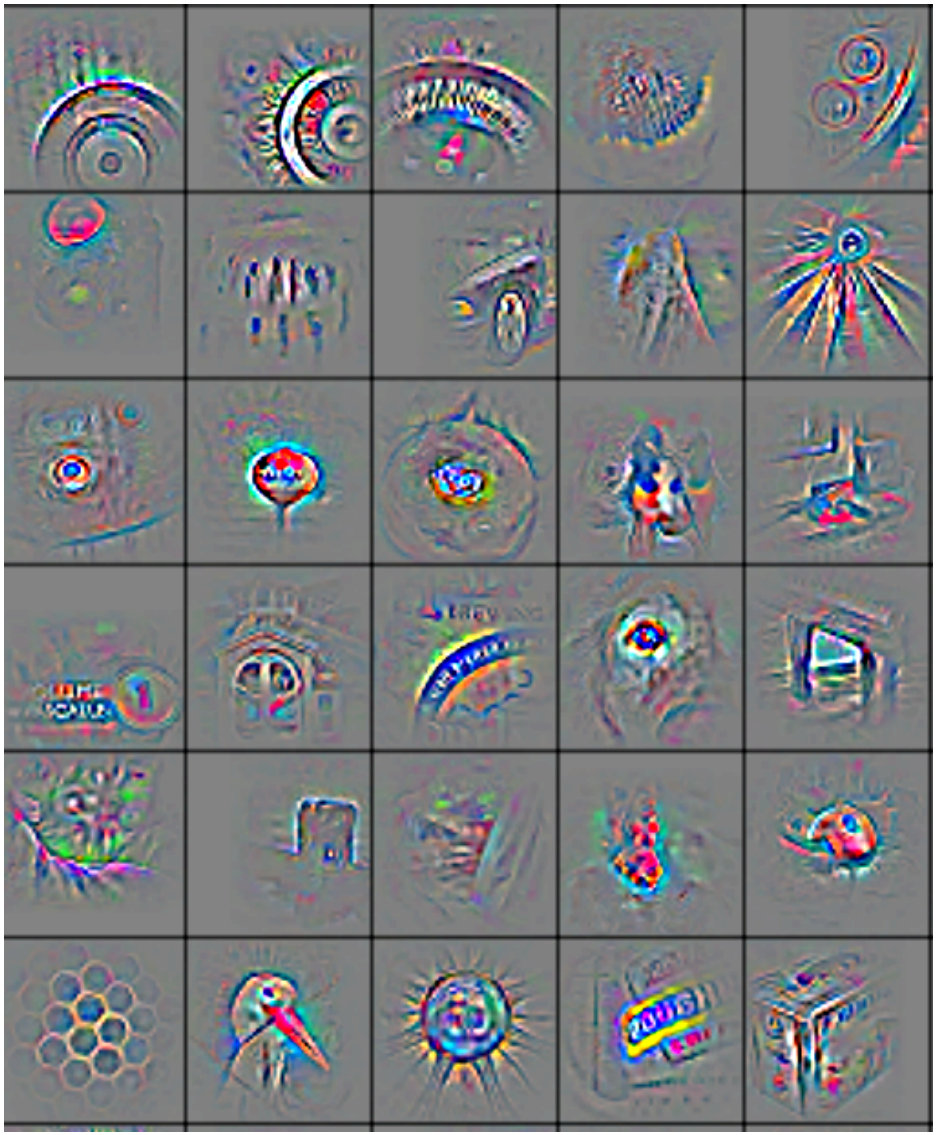
→ Low-Level features → Mid-Level features → High-Level features → Trainable classifier





[taken from a NIPS2015 tutorial by Geoff Hinton, Yoshua Bengio & Yann LeCun]

DEEP NETWORKS ≡ BLACK BOXES?



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