

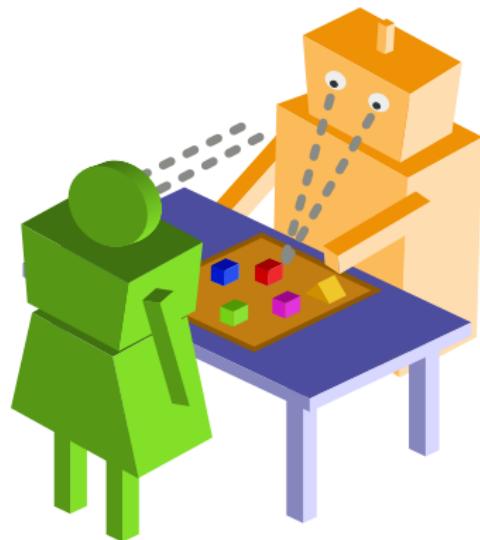
cognition, HRI & data

how to *do* together?

UKRAS19 – 24th Jan. 2019

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You can download the sources of this presentation here:
github.com/severin-lemaignan/l2tor-symposium2018-technical-challenges-cri

JOINT ACTION WITH A ROBOT?

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

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⇒ **explicit cognitive steps**

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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'?*
- ...

Joint action with a robot?

○○●○○○○○

Data-driven!

○○○○○○○○○○○○

Mining the data

○○○○○○○○○○

DNNs for Social Robotics

○○○○○○○

WE CAN DO A BIT ALREADY

Joint action with a robot?

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HOW DO HUMANS PERFORM TASKS TOGETHER?

Collaborating is a costly socio-cognitive activity.

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...which is closely related to: **be lazy**

First, go for the simple – if possibly ambiguous – actions; and, if
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What does “be lazy” mean for robots?

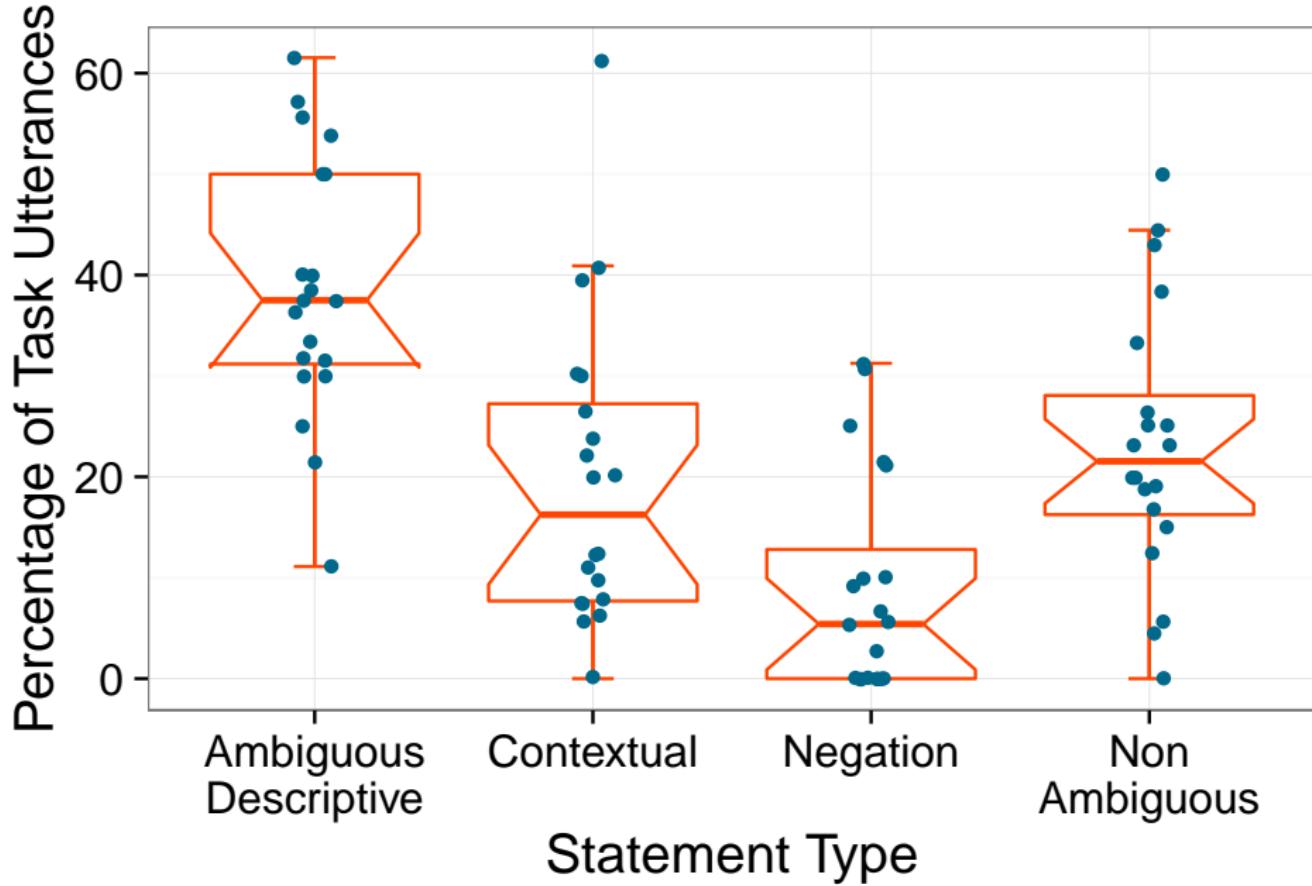
ONE EXAMPLE: GROUNDING OF SPATIAL LANGUAGE



Ambiguities arise easily when describing spatial scenes.

How do we solve them?





SURFACE ALIGNMENT; GROUNDING CRITERION

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

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- ⇒ we typically only reach *partial (or surface) alignment* – full alignment is usually not required

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

IN SOCIAL HUMAN-ROBOT INTERACTION

- These mechanisms are unfortunately often ill-defined, and particularly difficult to turn into equations (or controllers, in our case)
- no close-form equation of social interactions ⇒ data-driven approaches?

TOWARDS THE DATA-DRIVEN STUDY OF SOCIAL DYNAMICS

Joint action with a robot?

oooooooooo

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○●oooooooooooo

Mining the data

oooooooooooo

DNNs for Social Robotics

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DATA!

If we want to use machine learning, we need data (relevant to child-robot interactions in a learning environment).

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...a task that exhibits:

- complex social dynamics
- open, underspecified situations
- natural interactions
- rich semantics
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while being...

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

FREE PLAY

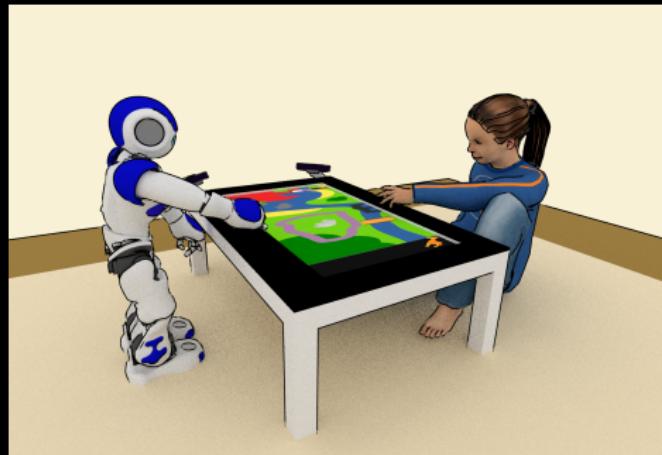
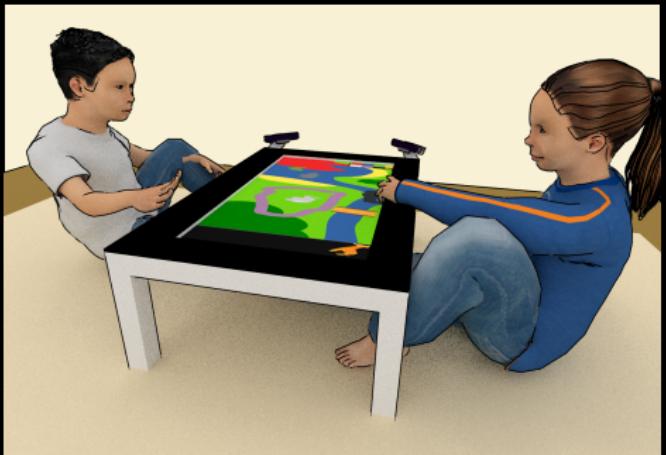
“Just play! Enjoy yourselves!”

- **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**

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



FREEPLAY SANDOX IN A NUTSHELL

A task that exhibits...

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- the **task engagement**
are the participants 'on task' or not?

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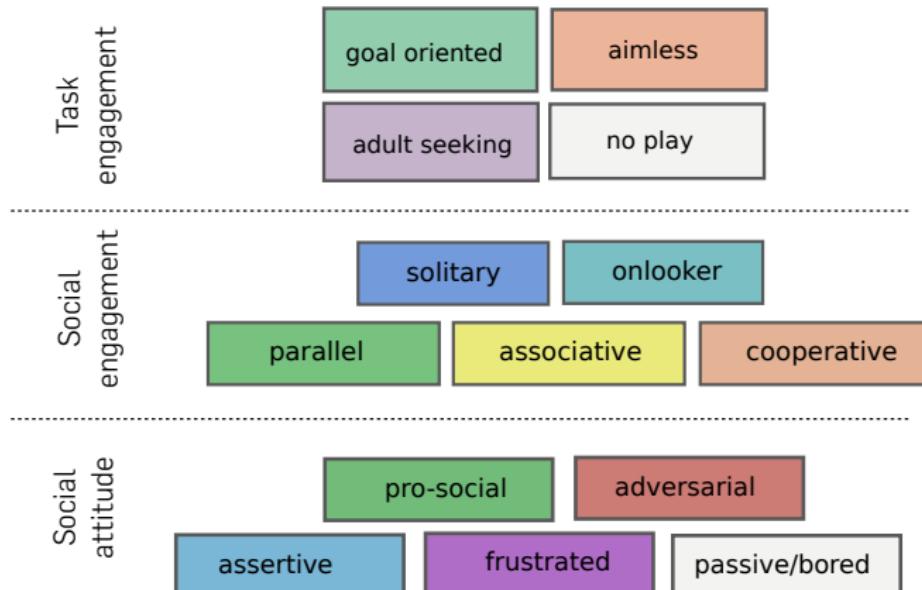
→ **paradigm for socio-cognitive investigation**

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; \approx 2TB
- average duration of freeplay interactions: 24min in child-child condition; 19min in child-robot condition



13000+ ANNOTATIONS



Joint action with a robot?

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Mining the data

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DNNs for Social Robotics

ooooooo

TWO BASELINES



child - non-social robot



child - child

richness of social interactions

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TWO BASELINES



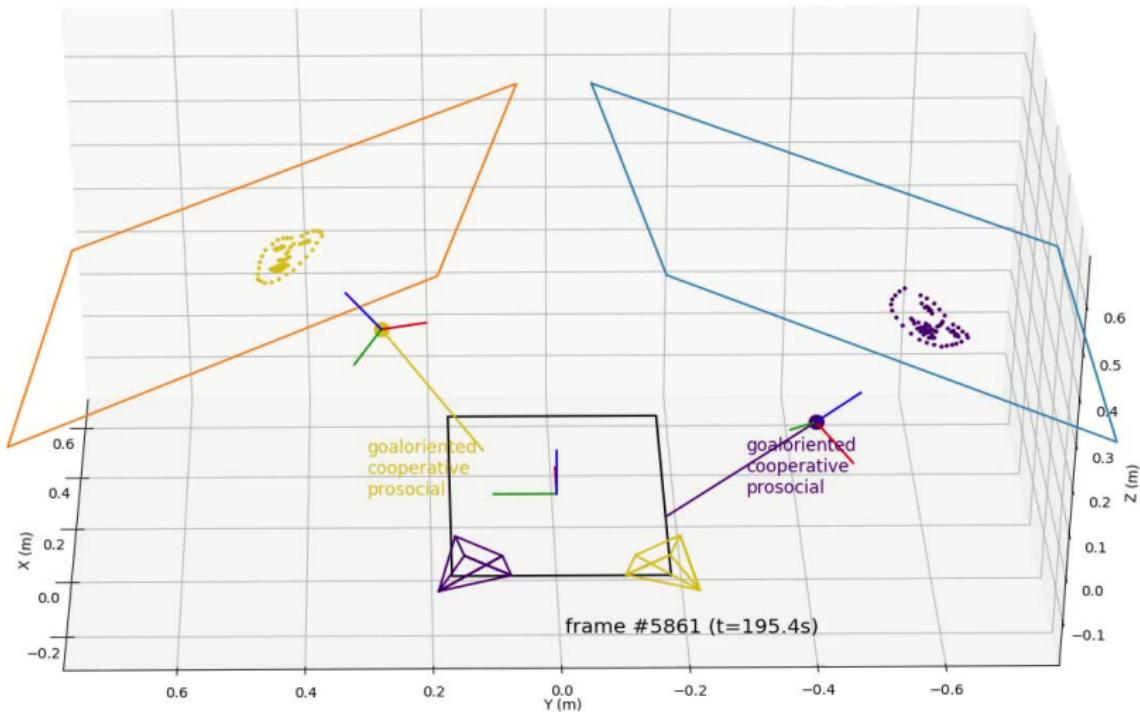
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your next
socio-cognitive
model

child - child

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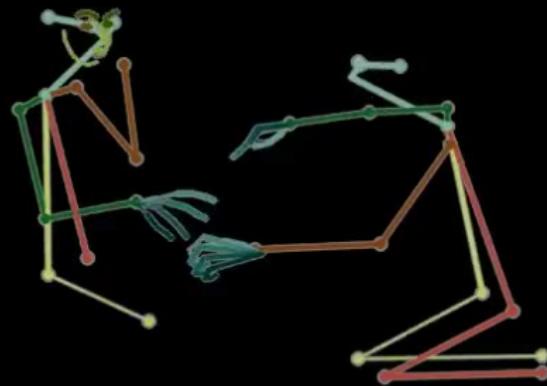
LARGEST OPEN DATASET OF NATURAL SOCIAL INTERACTIONS

Anonymised version (7.2GB) available on-line.
Grab it now!

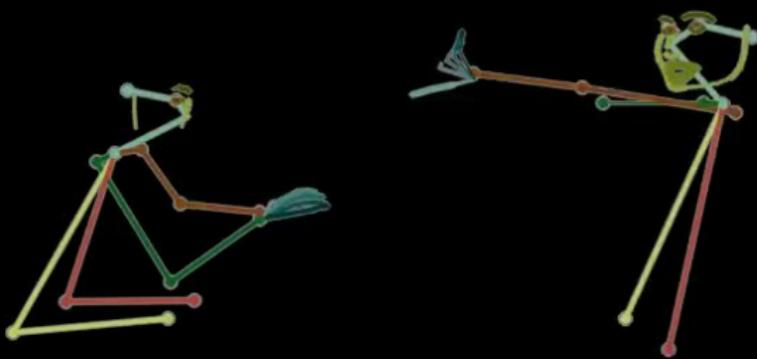
freeplay-sandbox.github.io

Open data! Hosted on EU's **zenodo**

MINING THE DATA











Page 1 of 4.

How much do you agree with the following statements?

The children were competing with one another.

Strongly Disagree

Disagree

Not Sure

Agree

Strongly Agree

200 participants, 4 clips each, on MTurk

The child on the left was sad.

Strongly Disagree

Disagree

Not Sure

Agree

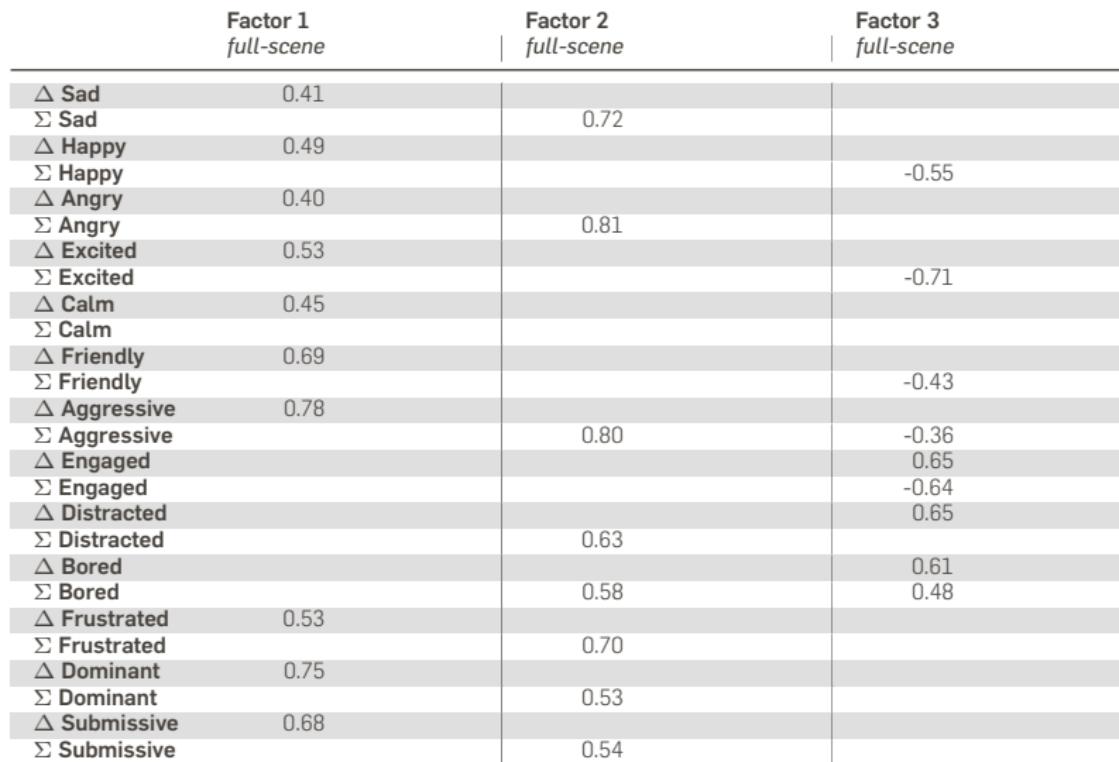
Strongly Agree

	pptID	condition	age	gender	leftSad	rightSad	leftHappy	rightHappy	leftAngry	rightAngry	...	leftDistracted	rightDistracted	leftBored	rightBored
0	186	2	30	Female	1	1	4	4	2	1	...	2	2	1	2
1	186	2	30	Female	3	4	2	2	3	3	...	3	4	3	3
2	186	2	30	Female	3	4	2	2	2	2	...	3	4	3	3
3	186	2	30	Female	3	3	2	3	2	3	...	3	4	3	3
4	94	1	23	Male	1	1	3	3	1	1	...	1	1	2	1
5	94	1	23	Male	1	1	2	2	1	3	...	1	0	1	1
6	94	1	23	Male	2	1	2	2	1	1	...	4	1	4	1
7	94	1	23	Male	1	1	3	3	1	1	...	1	1	1	1
8	155	2	28	Male	0	2	1	1	4	3	...	0	4	3	2
9	155	2	28	Male	0	3	0	0	3	0	...	3	0	4	1
10	155	2	28	Male	3	0	4	2	2	0	...	0	4	4	1
11	155	2	28	Male	0	3	4	4	3	2	...	2	4	2	0
12	156	2	29	Female	0	0	3	3	0	0	...	0	0	0	0
13	156	2	29	Female	1	3	1	1	1	3	...	0	0	0	0
14	156	2	29	Female	0	0	4	4	0	0	...	3	0	0	0
15	156	2	29	Female	0	2	3	2	0	0	...	3	0	0	0
16	157	2	31	Male	0	0	4	3	0	1	...	0	1	0	1
17	157	2	31	Male	0	0	3	2	0	0	...	0	1	1	1
18	157	2	31	Male	1	0	2	3	0	0	...	0	1	0	1
19	157	2	31	Male	1	1	3	2	1	1	...	1	3	1	0

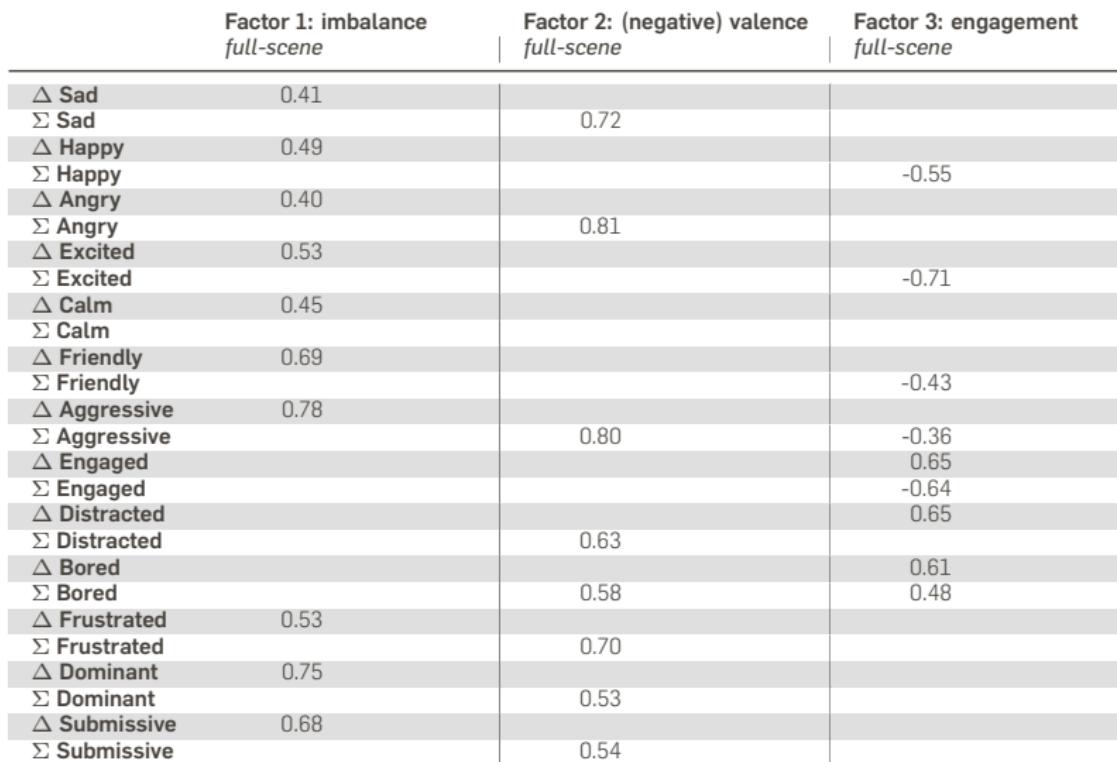
pptID	condition	age	gender	diffSad	sumSad	diffHappy	sumHappy	diffAngry	sumAngry	...	diffDistracted	sumDistracted	diffBored	sumBored	...
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For each construct, calculate Δ and Σ

EFA: EXPLORATORY FACTOR ANALYSIS



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	Factor 1: imbalance <i>full-scene</i>	mov.-alone	Factor 2: (negative) valence <i>full-scene</i>	mov.-alone	Factor 3: engagement <i>full-scene</i>	mov.-alone
△ Sad	0.41	0.52				
Σ Sad			0.72	0.53		0.49
△ Happy	0.49	0.53		-0.51	-0.55	
Σ Happy						
△ Angry	0.40	0.62		0.81	0.85	
Σ Angry						
△ Excited	0.53	0.63				
Σ Excited					-0.71	
△ Calm	0.45	0.63		-0.45		
Σ Calm						
△ Friendly	0.69	0.56		-0.60	-0.43	
Σ Friendly						
△ Aggressive	0.78	0.79				
Σ Aggressive			0.80	0.72	-0.36	
△ Engaged		0.39			0.65	0.52
Σ Engaged					-0.64	-0.64
△ Distracted					0.65	0.63
Σ Distracted			0.63			0.82
△ Bored		0.44			0.61	0.54
Σ Bored			0.58		0.48	0.83
△ Frustrated	0.53	0.61				
Σ Frustrated			0.70	0.69		
△ Dominant	0.75	0.81				
Σ Dominant			0.53	0.52		
△ Submissive	0.68	0.72		0.54		
Σ Submissive						

Joint action with a robot?

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Mining the data

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DNNs for Social Robotics

ooooooo

THREE CONSTRUCTS TO RULE THEM ALL



Interaction imbalance

Interaction valence

Engagement

DEEP LEARNING OF SOCIAL
INTERACTIONS?

Attitude: passive

Social engag.: onlooker

Task engag.: no play

Attitude: passive

Social engag.: solitary

Task engag.: goal oriented



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

WHAT DOES THAT MEAN FOR CRI & LEARNING?

- We can reduce the socio-cognitive cost of collaboration by relying as much as possible on **implicit (sub-conscious) social mechanisms**



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- The robot needs to learn to recognise and interpret those social cues, hidden within complex social dynamics (in real-time!)

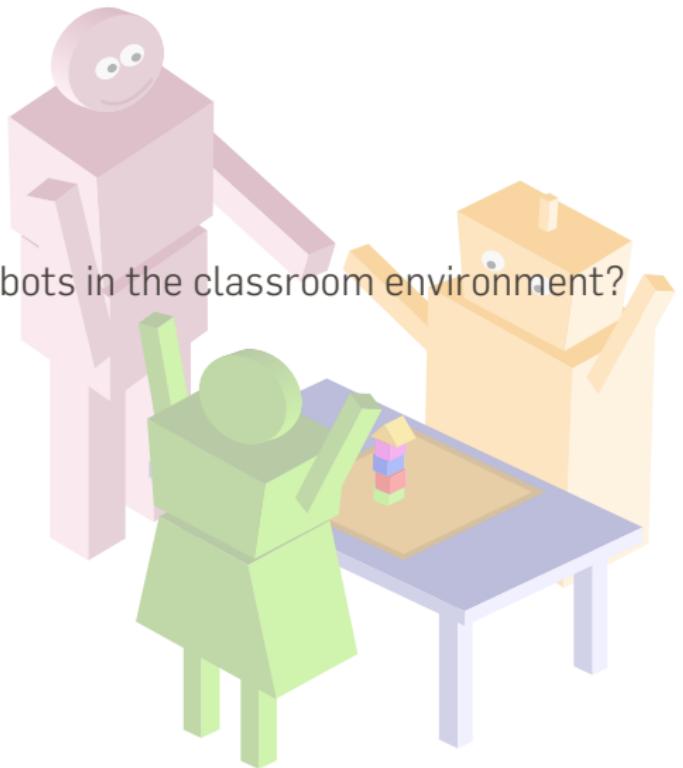
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- We have some raw material. Time to process it together!

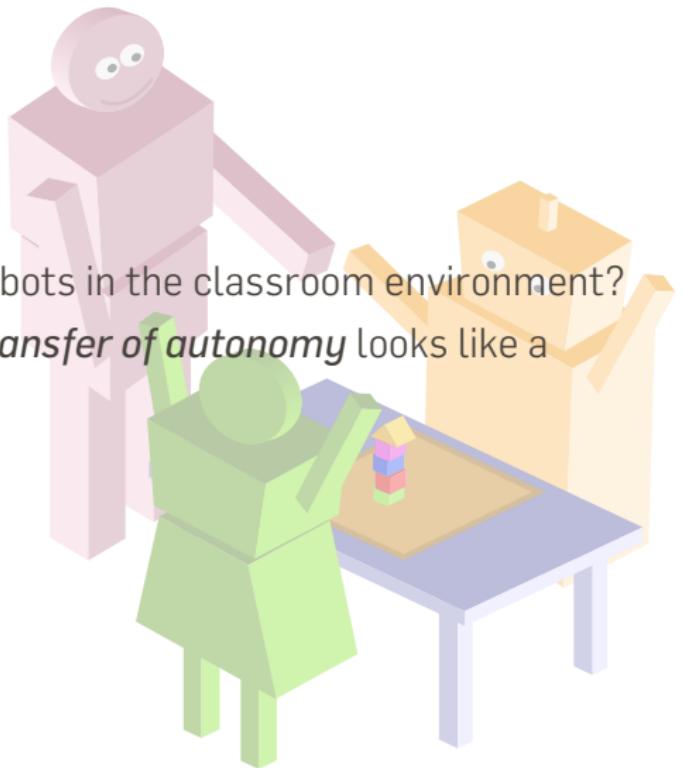
In summary:

- Integration of *social* robots in the classroom environment?



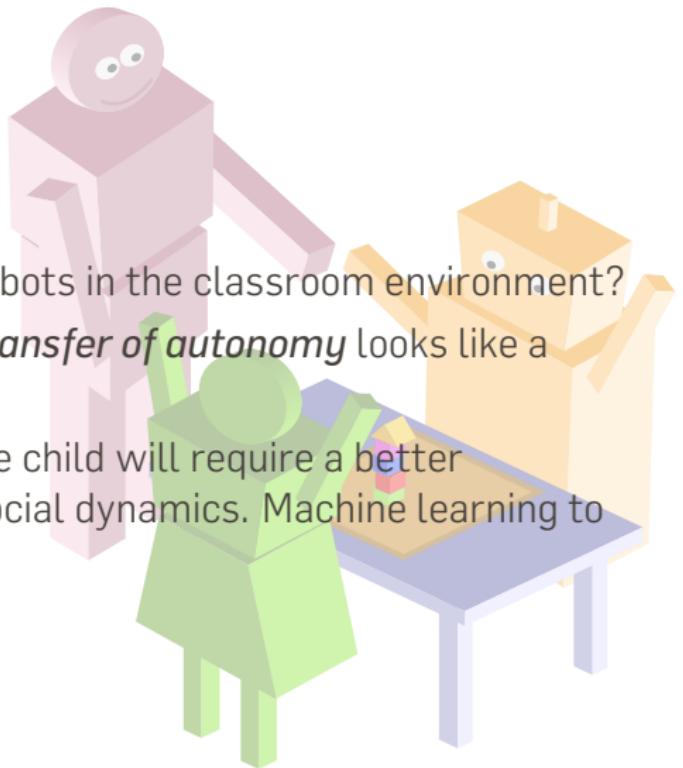
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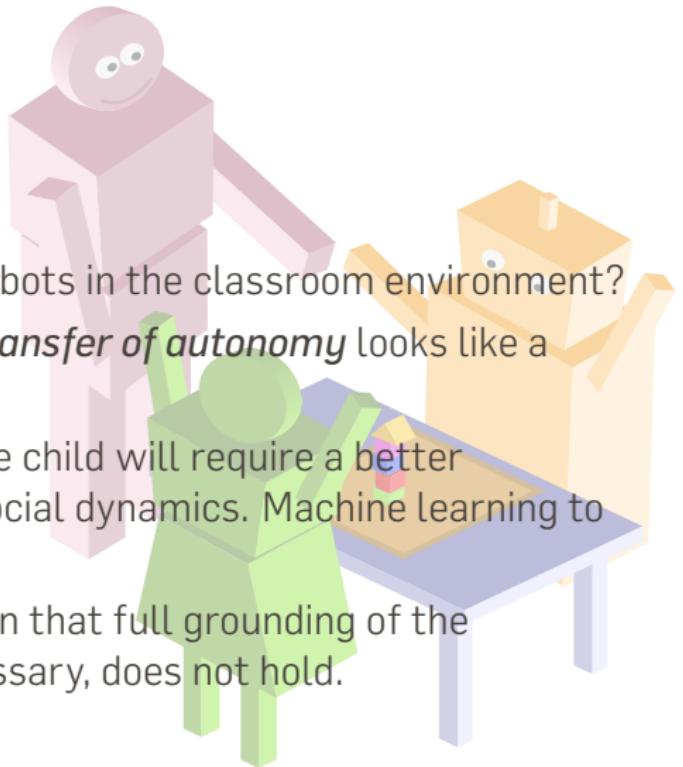
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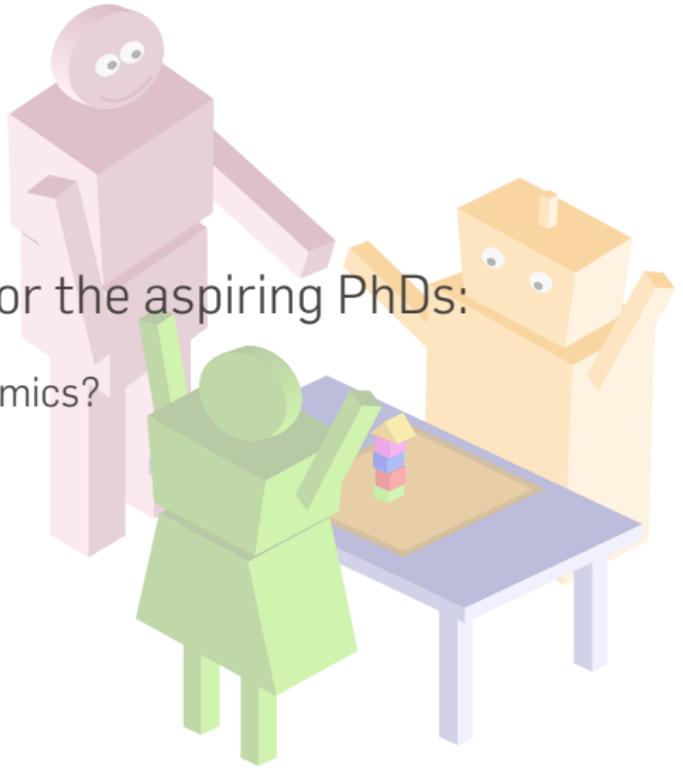
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- Integration of *social* robots in the classroom environment?
- Role of the teacher? *Transfer of autonomy* looks like a promising lead.
- *Doing together* with the child will require a better understanding of the social dynamics. Machine learning to the rescue?
- ...but the old assumption that full grounding of the communication is necessary, does not hold.



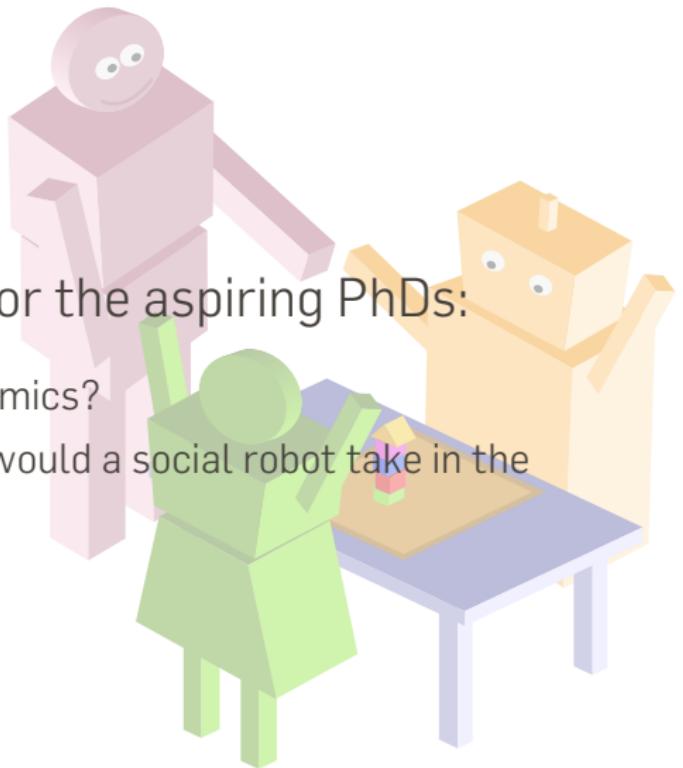


Two open questions for the aspiring PhDs:

- What about group dynamics?

Two open questions for the aspiring PhDs:

- What about group dynamics?
- Over time, what place would a social robot take in the classroom?





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**

How et al. **Behavior recognition for humanoid robots using long short-term memory**, IJARS 2016 → *LSTM to recognise Nao behaviours*

Shiarlis et al. **Acquiring Social Interaction Behaviours for Telepresence Robots via Deep Learning from Demonstration**, IROS 2017

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- **Behavioural sequences recognition**
How et al. **Behavior recognition for humanoid robots using long short-term memory**, IJARS 2016 → *LSTM to recognise Nao behaviours*
Shiarlis et al. **Acquiring Social Interaction Behaviours for Telepresence Robots via Deep Learning from Demonstration**, IROS 2017

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

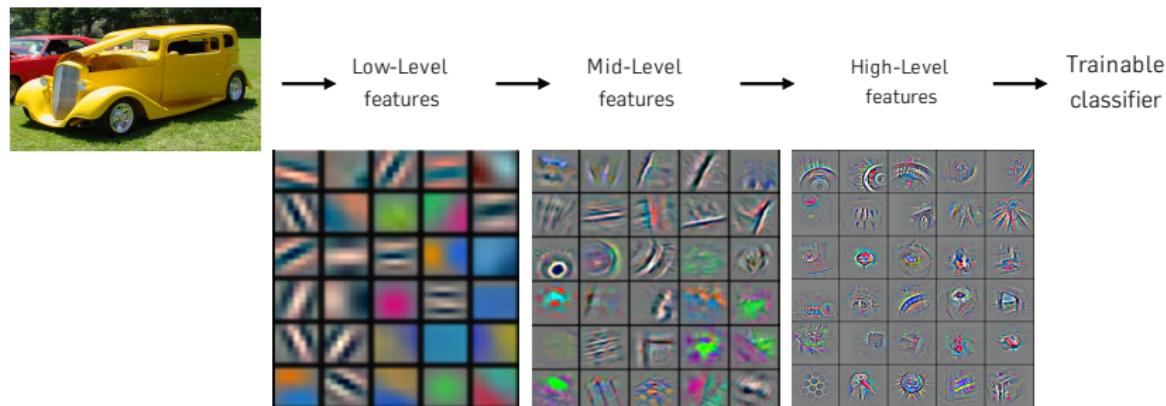
Joint action with a robot?
oooooooooo

Data-driven!
oooooooooooo

Mining the data
oooooooooo

DNNs for Social Robotics
○○●○○○○

DEEP NETWORKS ≡ BLACK BOXES?



Joint action with a robot?
oooooooooo

Data-driven!
oooooooooooo

Mining the data
oooooooooo

DNNs for Social Robotics
oo●ooo

DEEP NETWORKS ≡ BLACK BOXES?



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

WHAT DID WE RECORD?

Domain	Type	Details
child × 2	audio	16kHz, mono, semi-directional
	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...	