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presentation-cognitive-robotics](https://github.com/severin-lemaignan/presentation-cognitive-robotics)

**WITH
PLYMOUTH
UNIVERSITY**



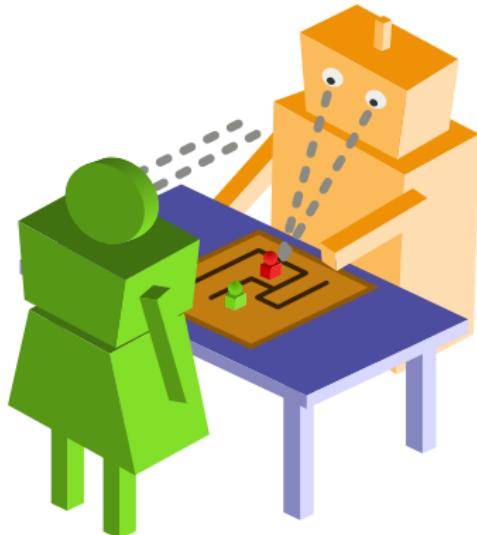
Of Cognition and Social Robots

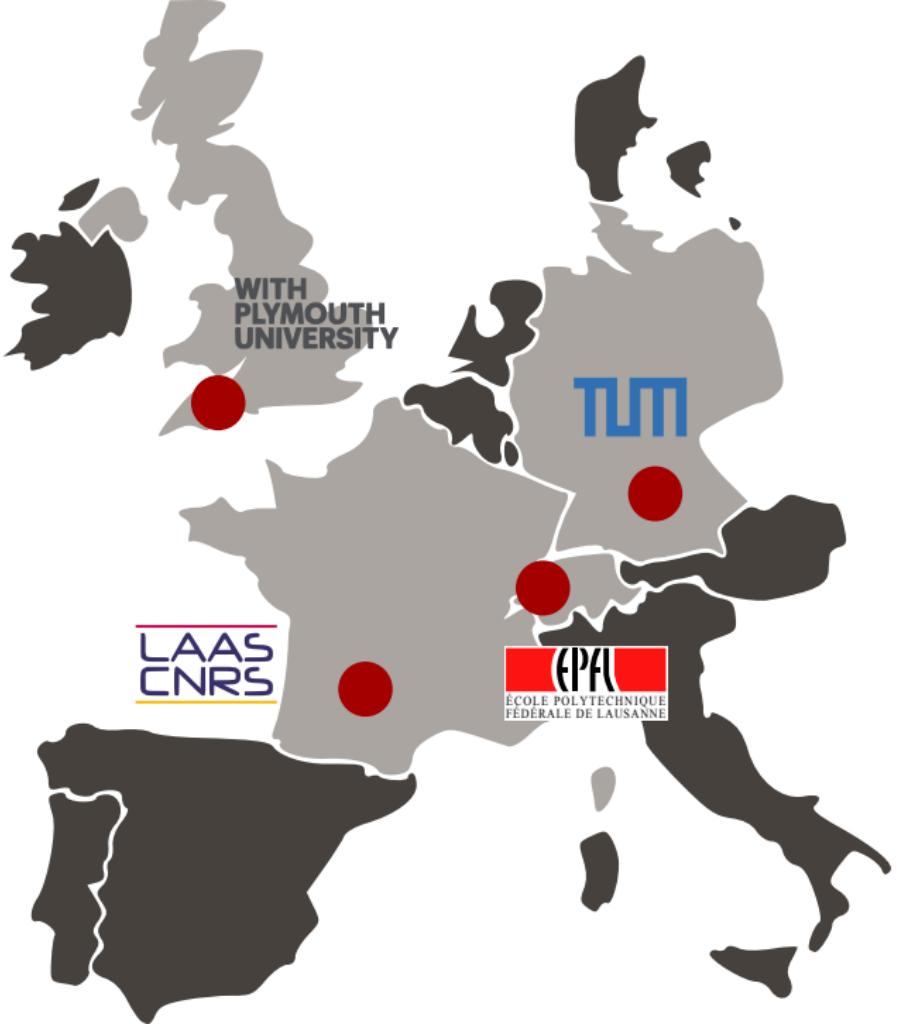
Is “Social Cognition” in HRI just a buzz word?

Bristol Robotics Lab – **May 11, 2016**

Séverin Lemaignan

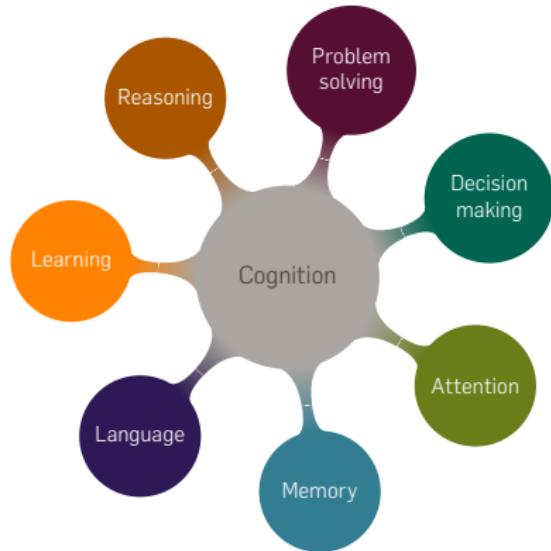
Centre for Robotics and Neural Systems
Plymouth University

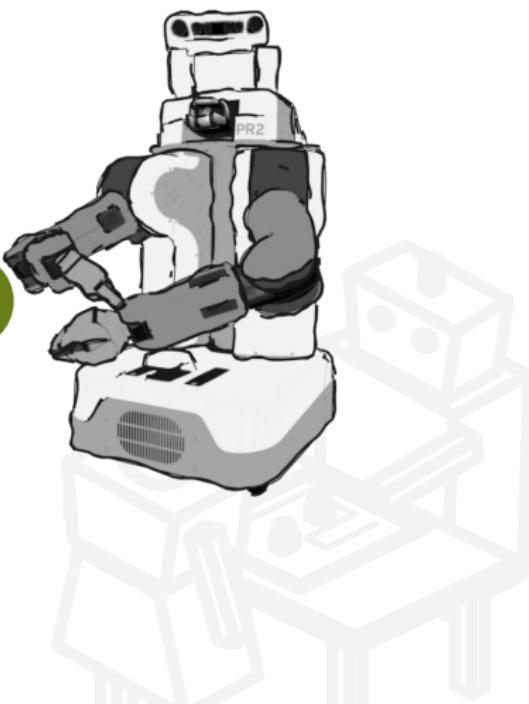


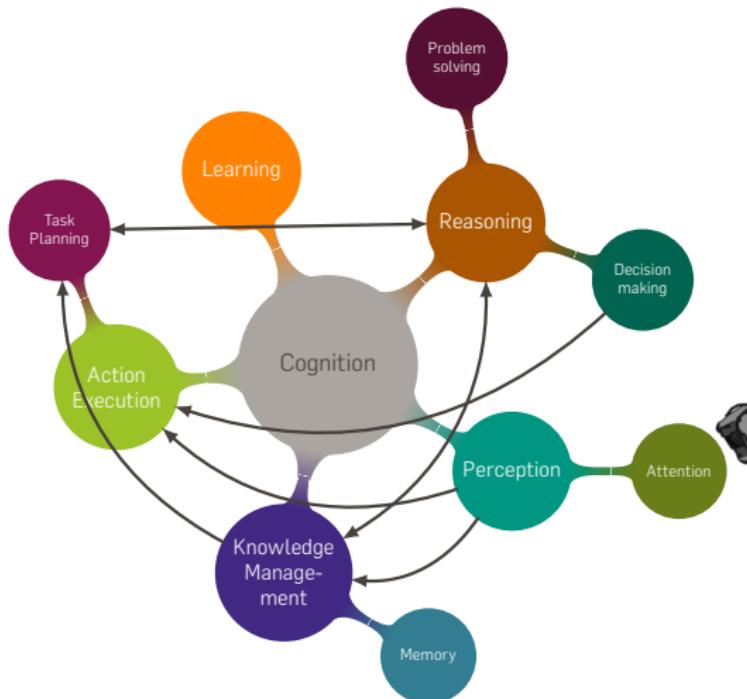


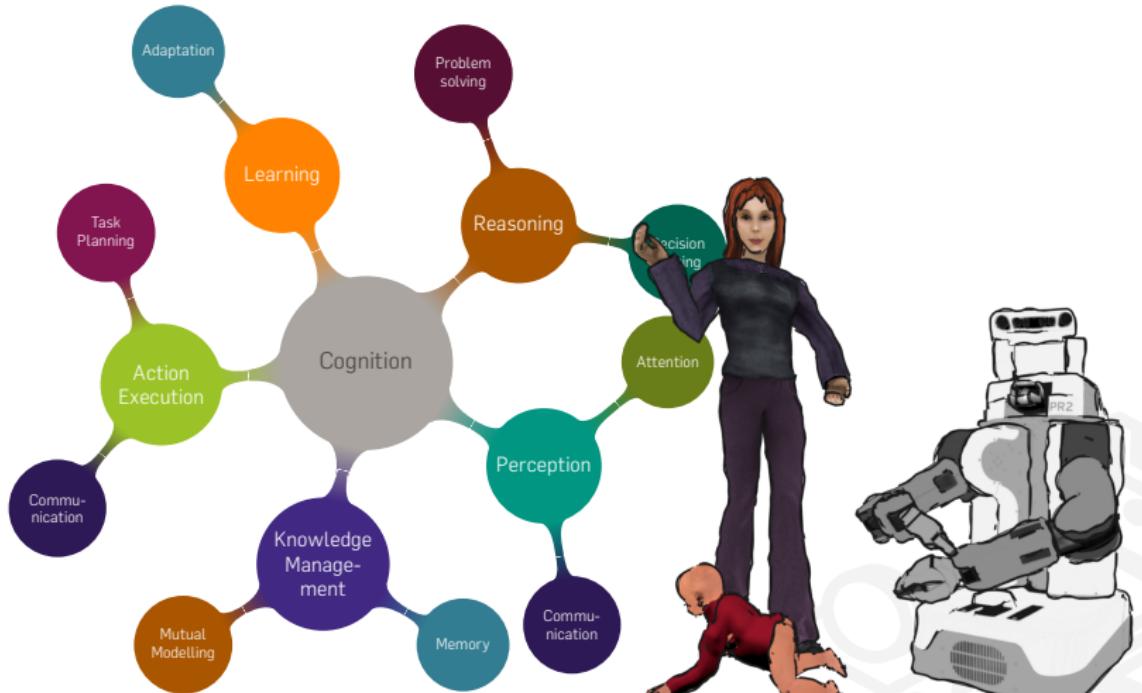
“Cognition is a group of mental processes that includes **attention**, **memory**, producing and understanding **language**, **learning**, **reasoning**, **problem solving**, and **decision making**.”







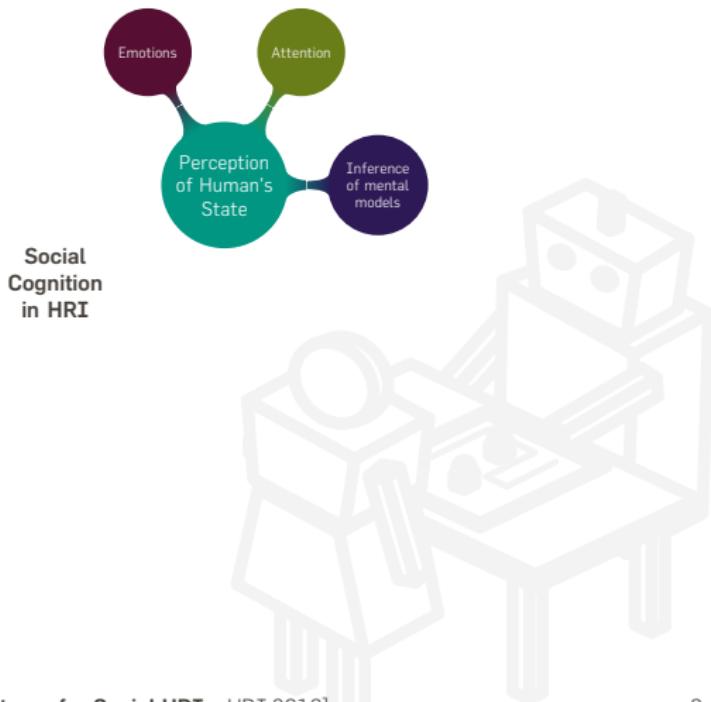






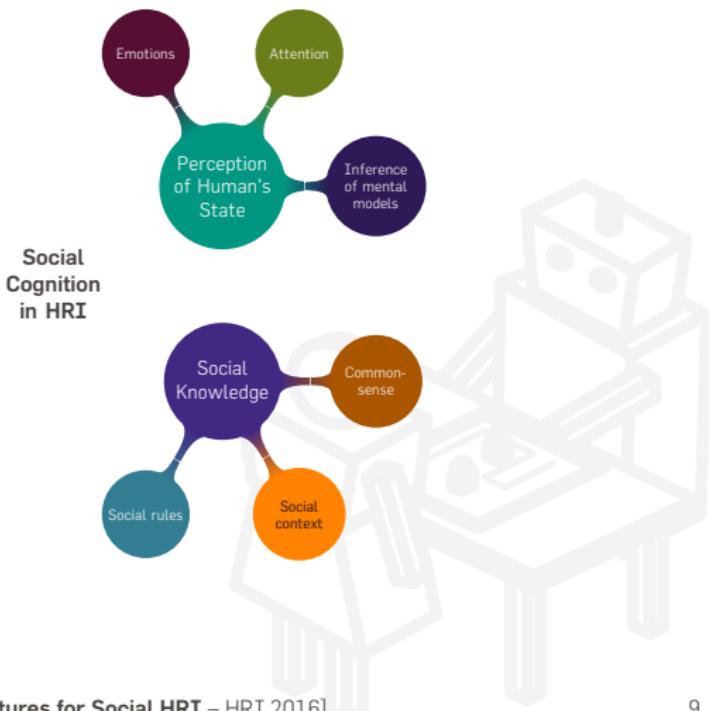


FUNCTIONS FOR SOCIAL COGNITION





FUNCTIONS FOR SOCIAL COGNITION





FUNCTIONS FOR SOCIAL COGNITION





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FUNCTIONS FOR SOCIAL COGNITION

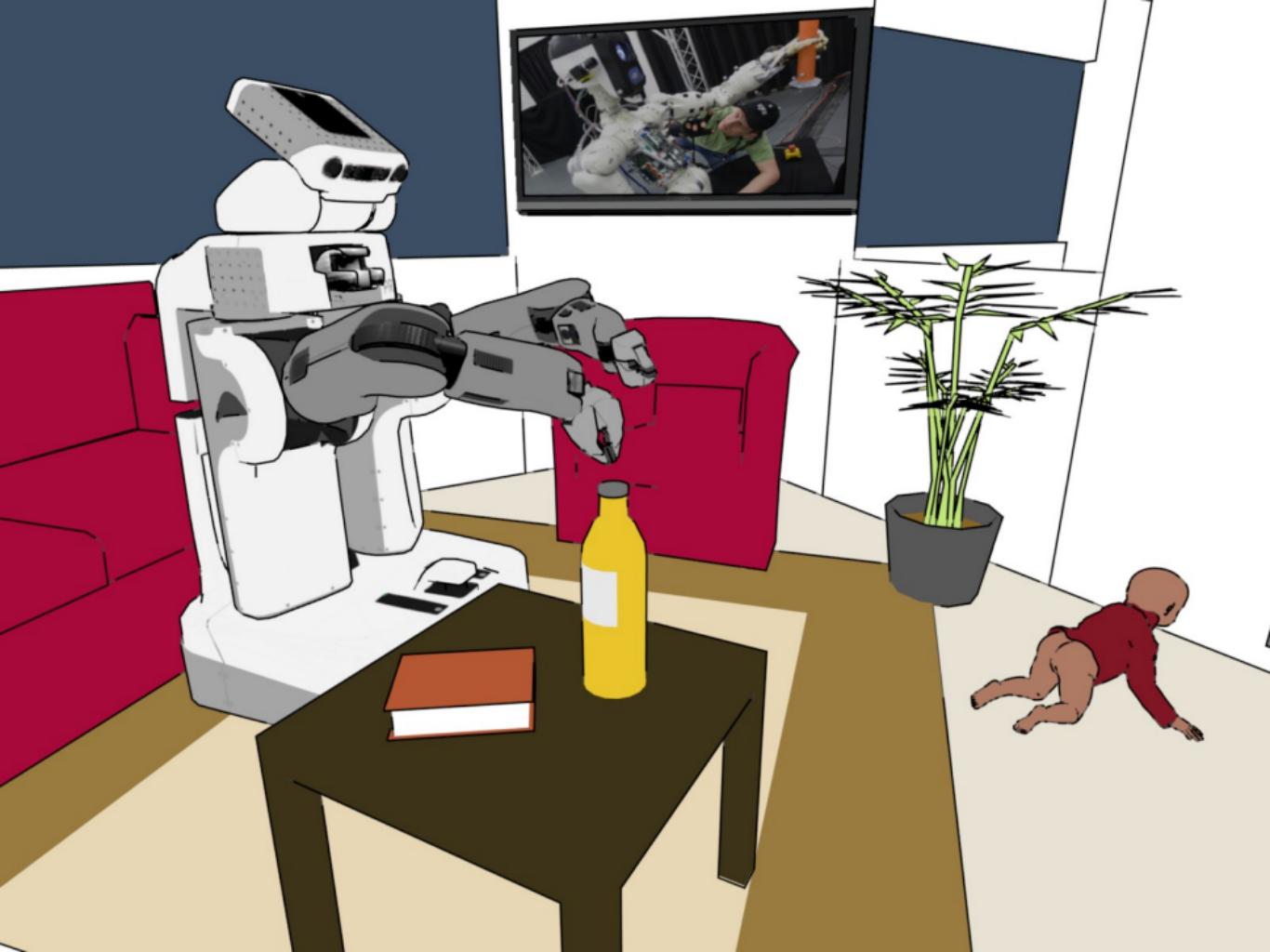


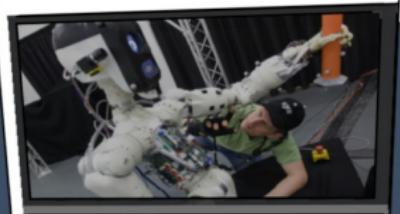
OVERVIEW

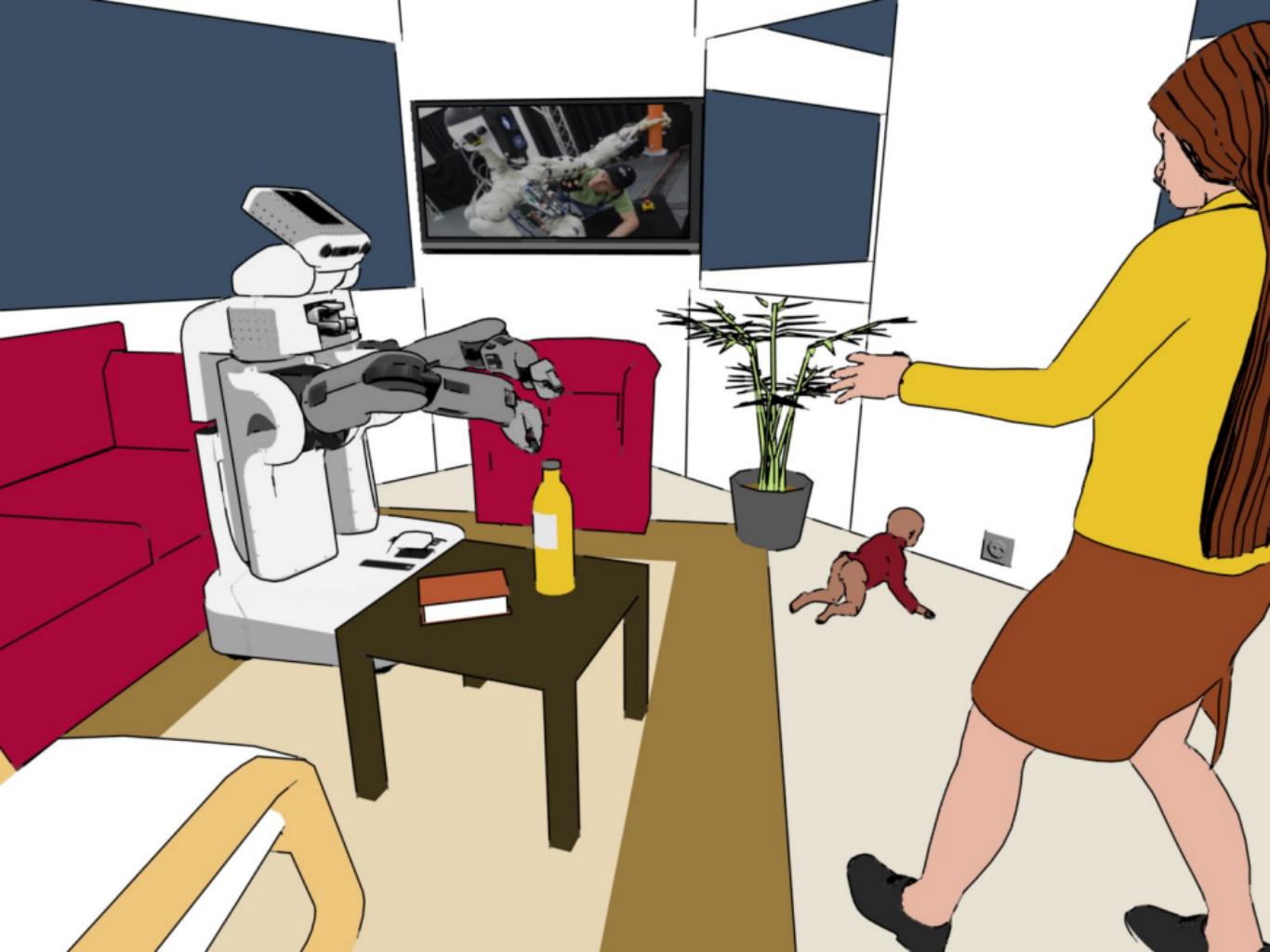
1. The Robot's (Symbolic) World
2. Adding the Human to the Equation
3. Are you still with me?
4. A Summary and Some Ideas

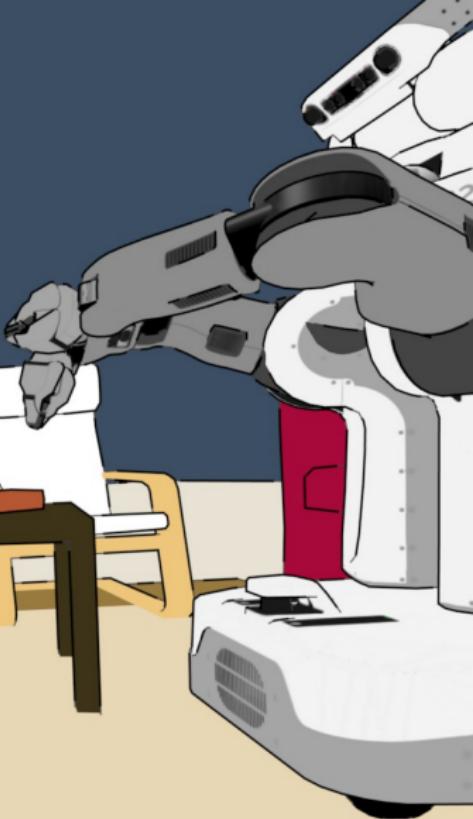
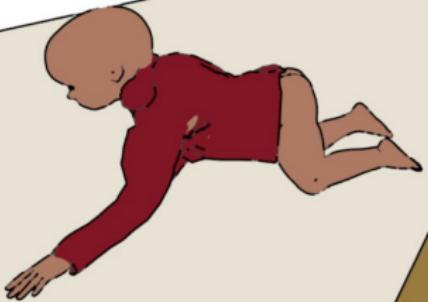


THE ROBOT'S (SYMBOLIC) WORLD



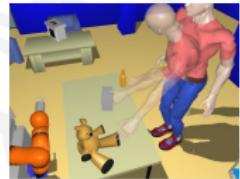
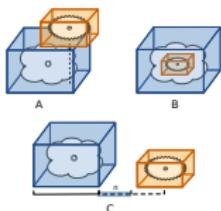
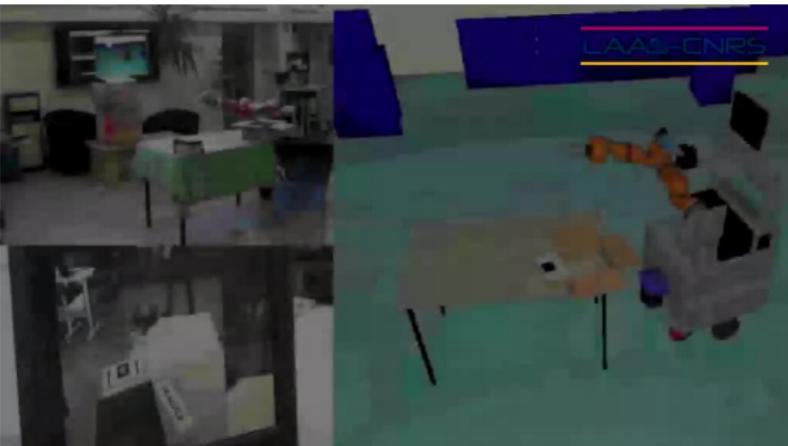




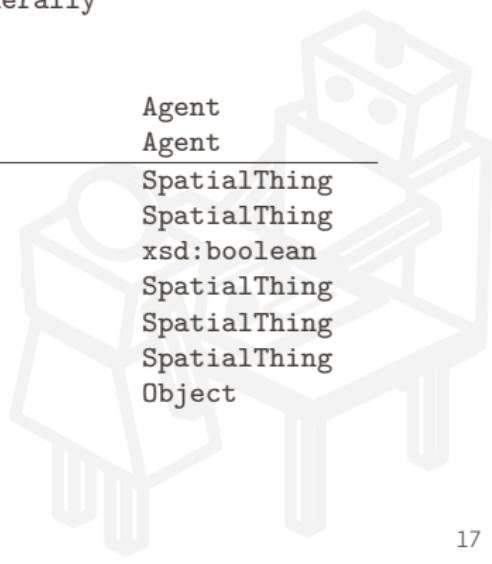




SITUATION ASSESSMENT

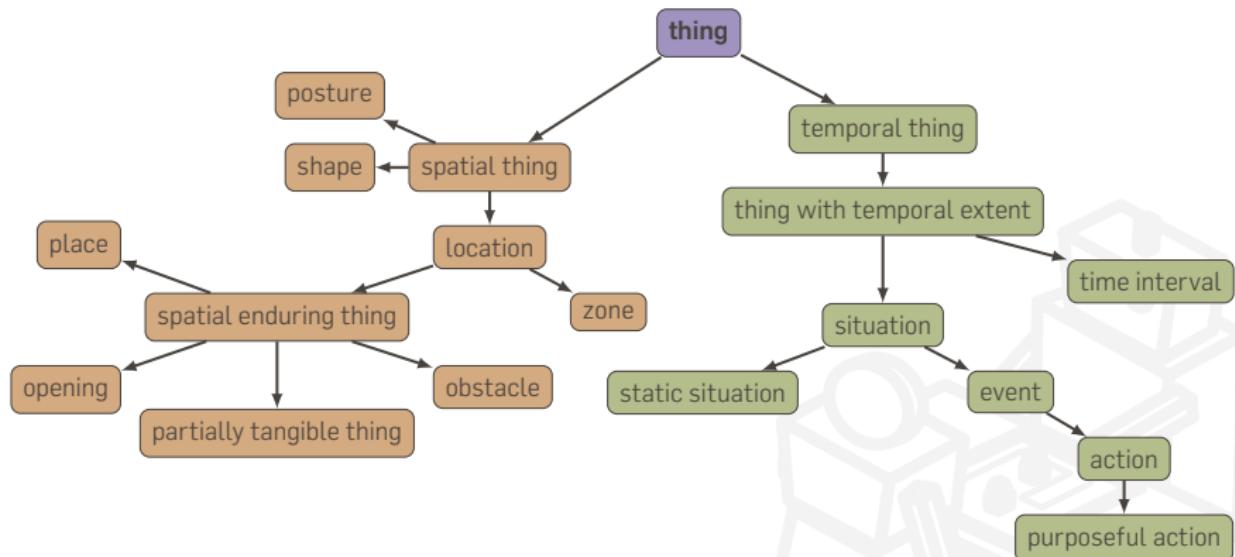


Subject	Predicate	Object
Location	$\text{isAt} \equiv \text{cyc:objectFoundInLocation}$ $\rightarrow \text{isOn} \equiv \text{cyc:above_Touching}$ $\rightarrow \text{isIn}$ $\rightarrow \text{isNextTo}$	Location
Location	$\text{isAbove} \equiv \text{cyc:above-Generally}$	Location
Location	isBelow	Location
Location	$\text{hasRelativePosition}$ $\rightarrow \text{behind} \equiv \text{cyc:behind-Generally}$ $\rightarrow \text{inFrontOf} \equiv \text{cyc:inFrontOf-Generally}$ $\rightarrow \text{leftOf}$ $\rightarrow \text{rightOf}$	Location
Object	cyc:farFrom	Agent
Object	cyc:near	Agent
Agent	looksAt	SpatialThing
Agent	sees	SpatialThing
SpatialThing	isInFieldOfView	xsd:boolean
Agent	$\text{pointsAt} \equiv \text{cyc:pointingToward}$	SpatialThing
Agent	focusesOn	SpatialThing
Agent	$\text{seesWithHeadMovement}$	SpatialThing
Agent	canReach	Object



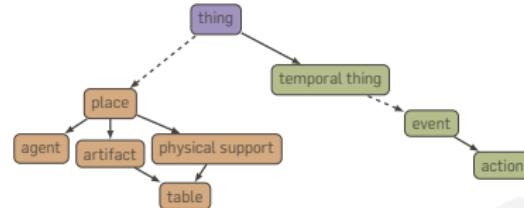
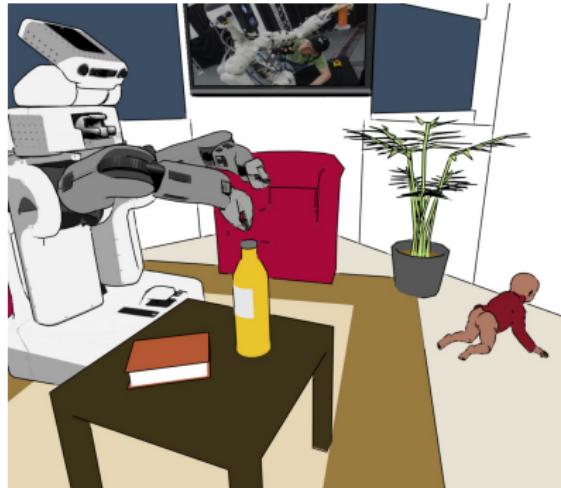


FROM SPATIAL MODEL TO SYMBOLIC MODEL



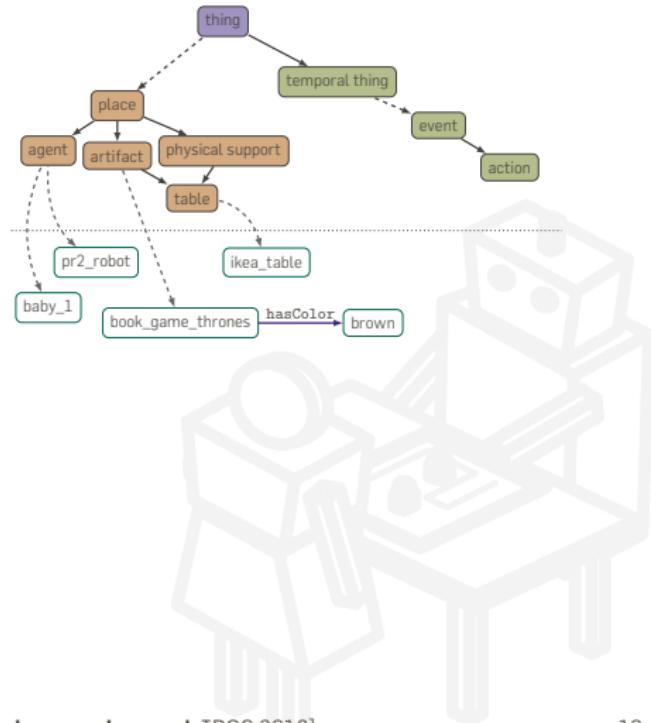
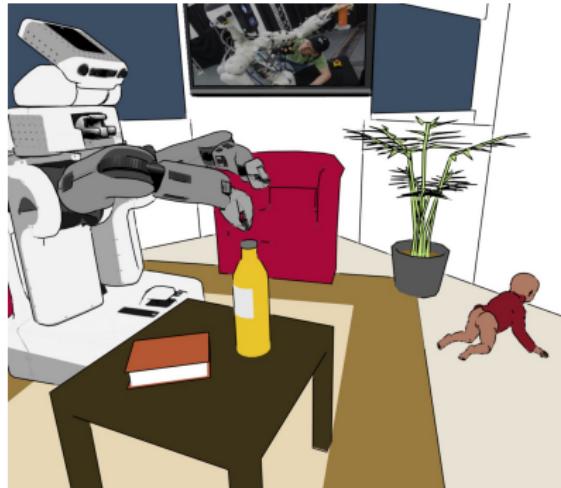


ONLINE INSTANTIATION



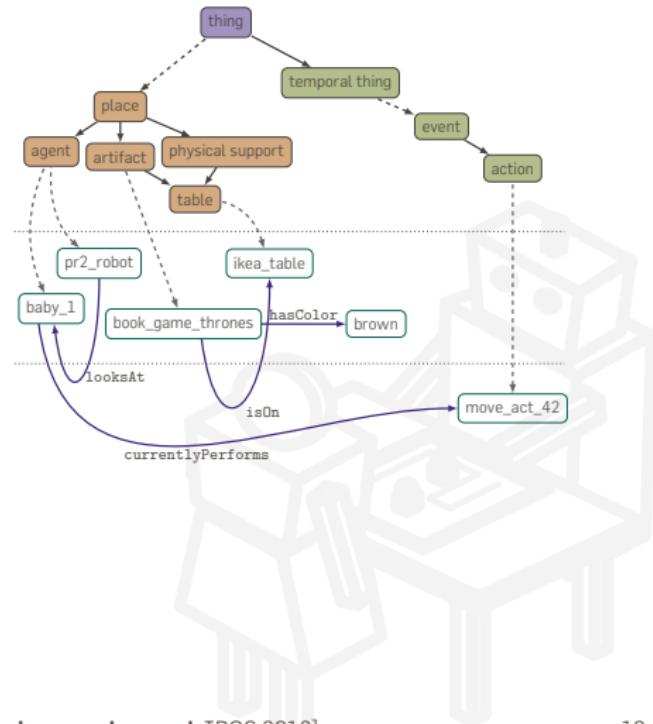
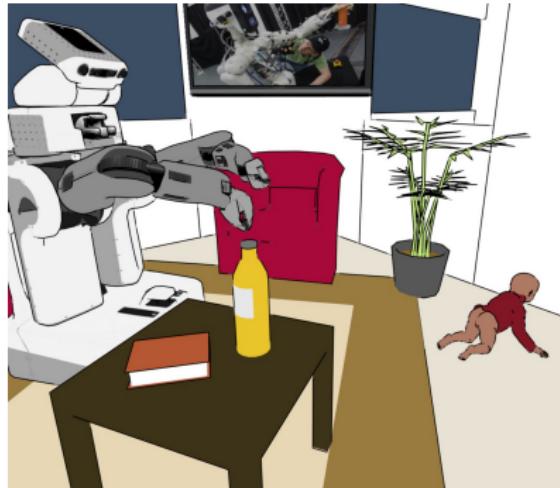


ONLINE INSTANTIATION





ONLINE INSTANTIATION





DIALOGUE GROUNDING

I keep the natural language processing part for the questions, but:

"Give me the book on the table"





DIALOGUE GROUNDING

I keep the natural language processing part for the questions, but:

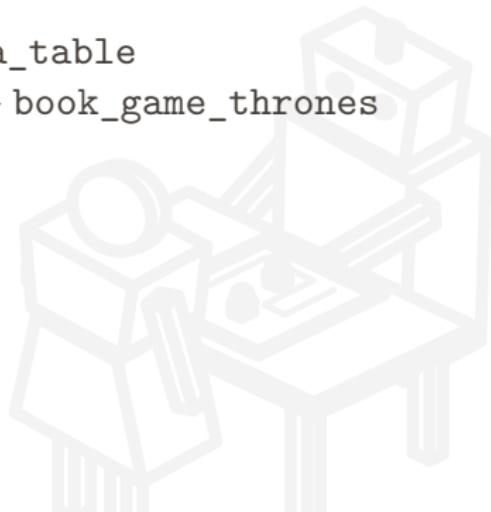
"Give me the book on the table"



me → baby_1

find(?obj type table) → ikea_table

find(?obj type book, ?obj isOn ikea_table) → book_game_thrones





DIALOGUE GROUNDING

I keep the natural language processing part for the questions, but:

"Give me the book on the table"



me → baby_1

find(?obj type table) → ikea_table

find(?obj type book, ?obj isOn ikea_table) → book_game_thrones



baby_1 desires give_act_1,

give_act_1 type Give,

give_act_1 performedBy myself,

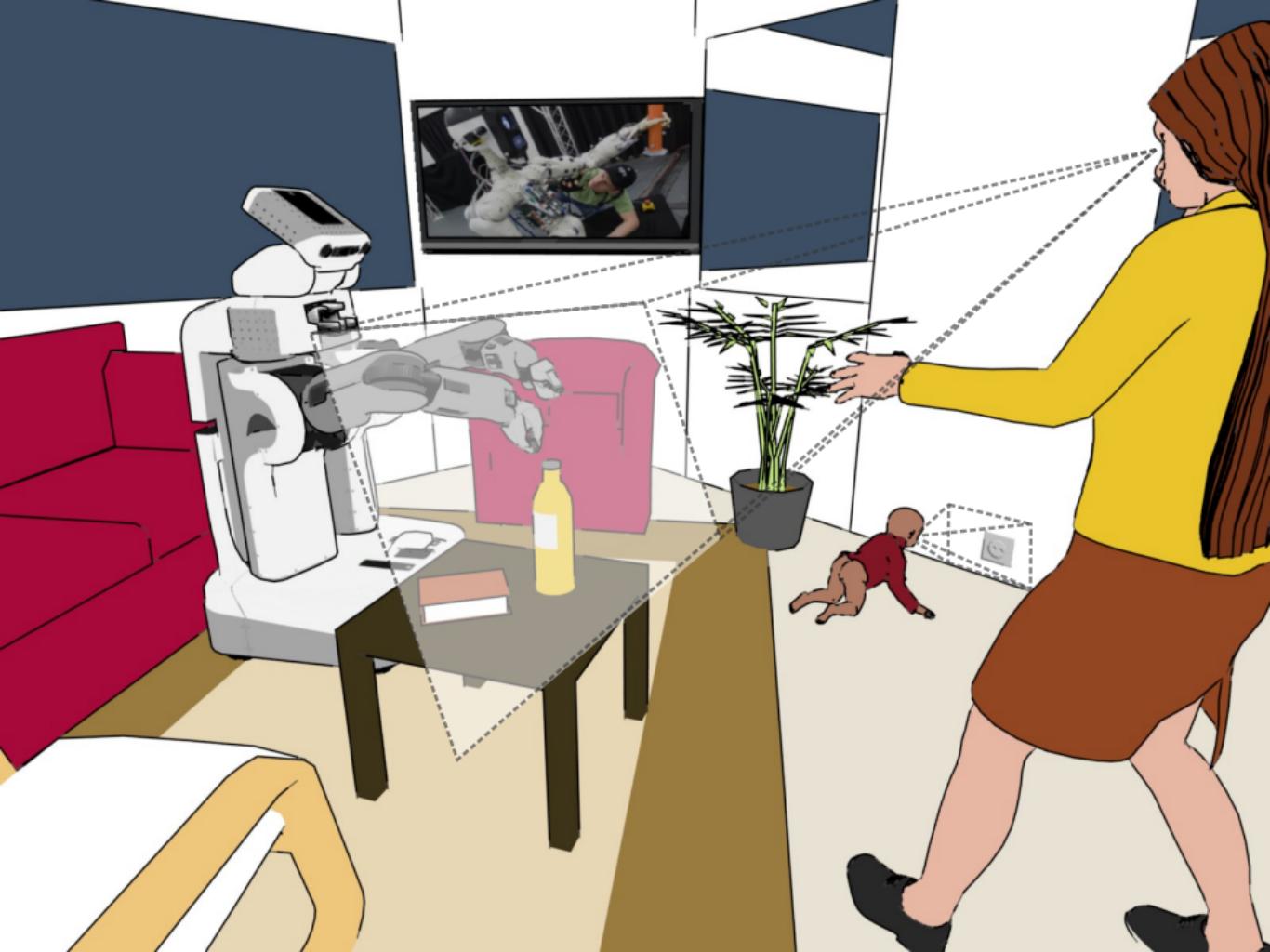
give_act_1 actsOnObject book_game_thrones,

give_act_1 receivedBy baby_1

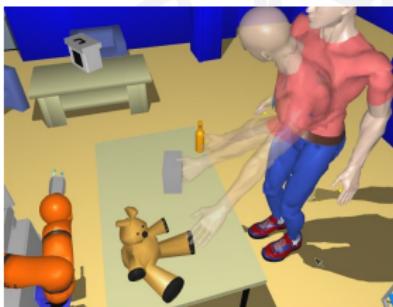
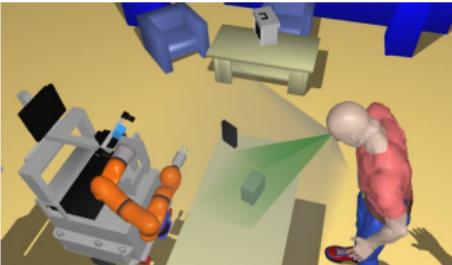
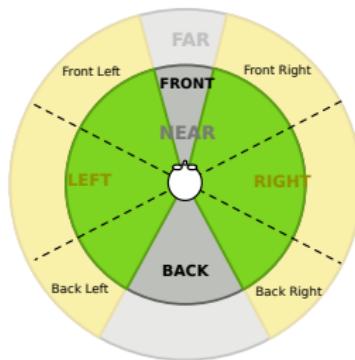
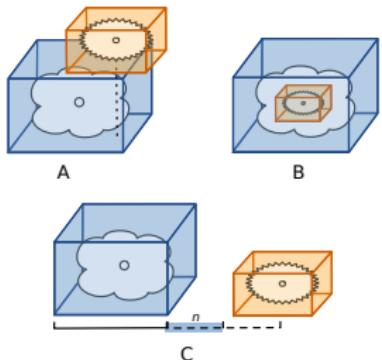
LAAS-CNRS



ADDING THE HUMAN TO THE EQUATION

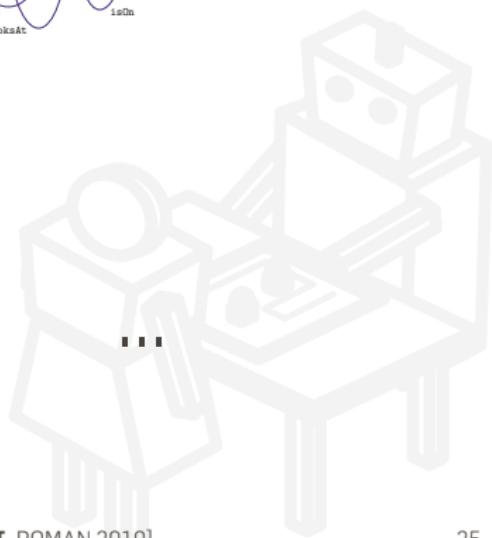
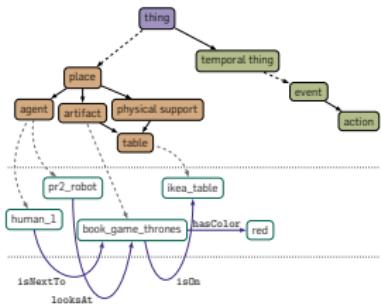
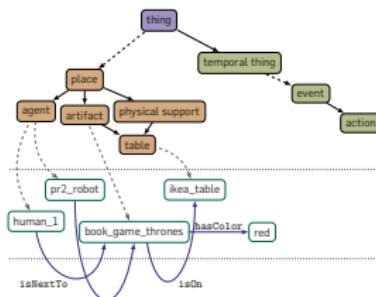
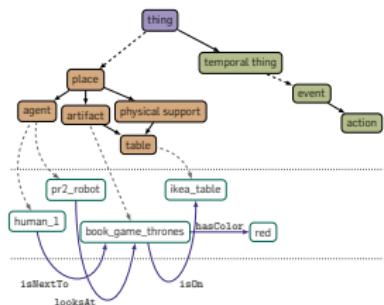


VISUAL PERSPECTIVE TAKING





MULTIPLE SYMBOLIC MODELS

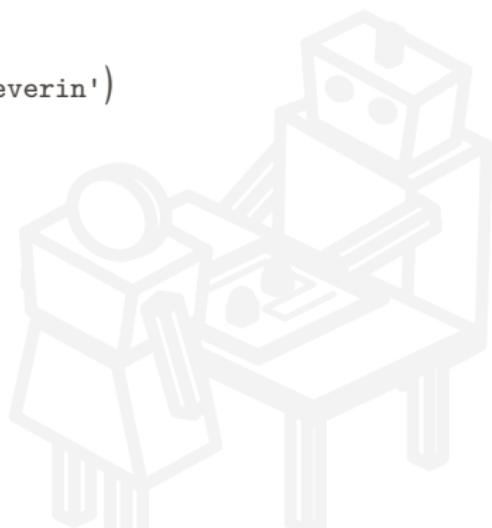




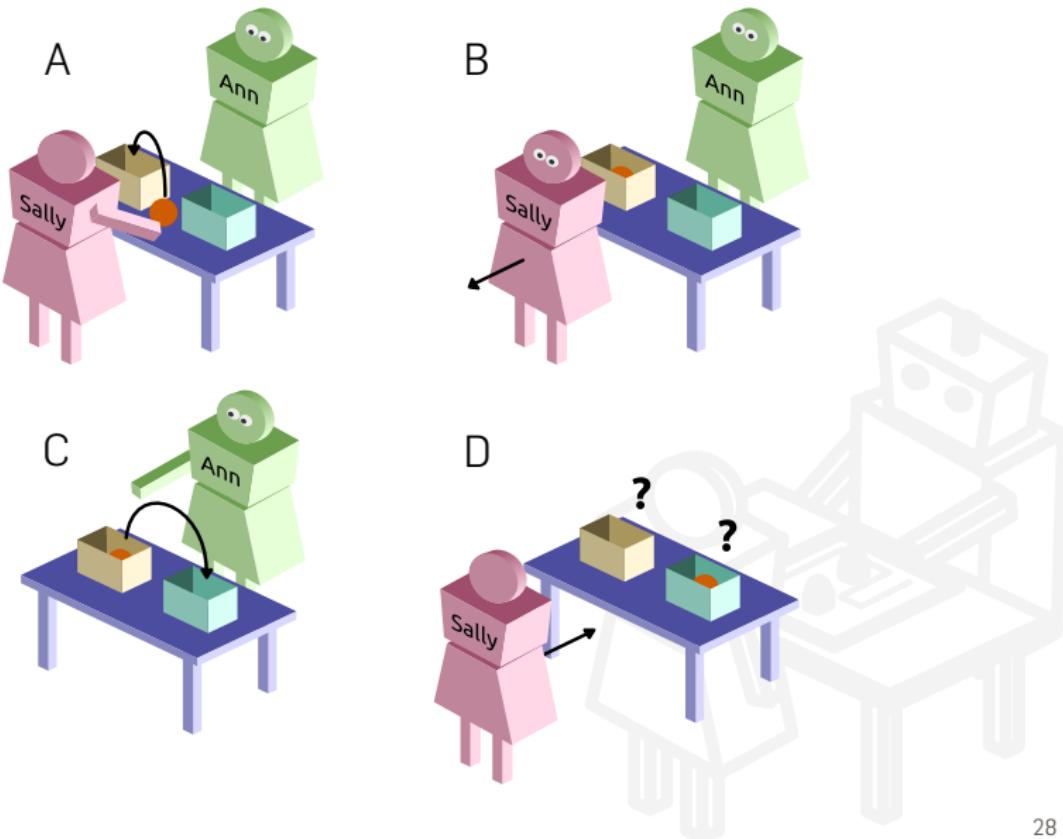
"Give me the can!"



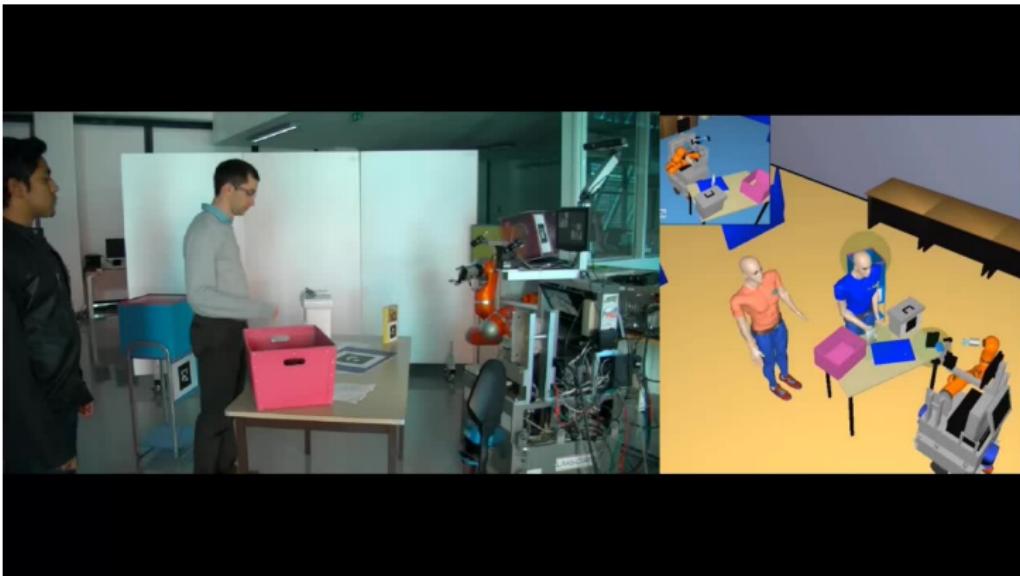
find(?obj type Can, model='severin')

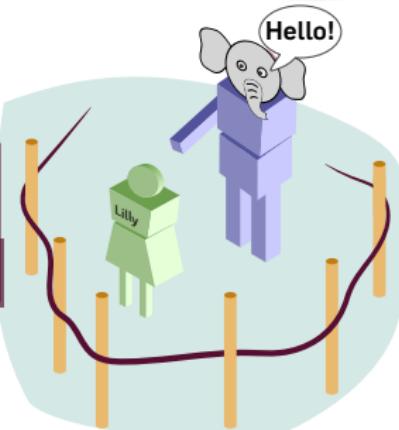
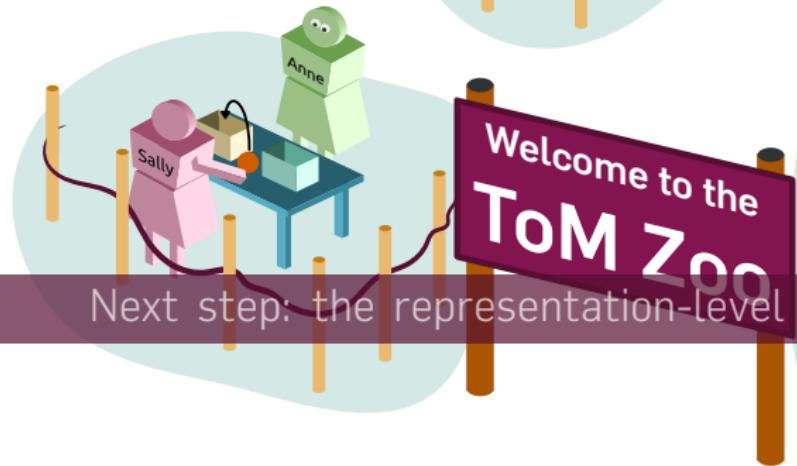
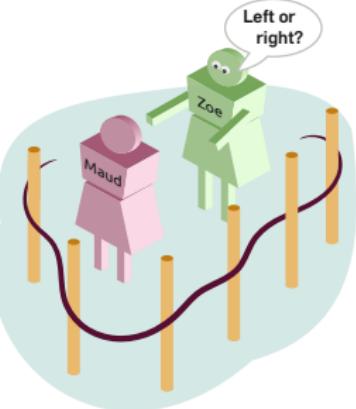
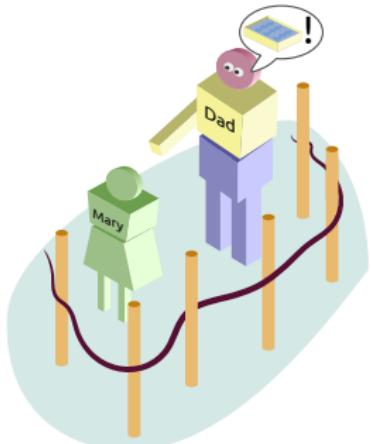


THE FALSE-BELIEF EXPERIMENT



THE FALSE-BELIEF EXPERIMENT



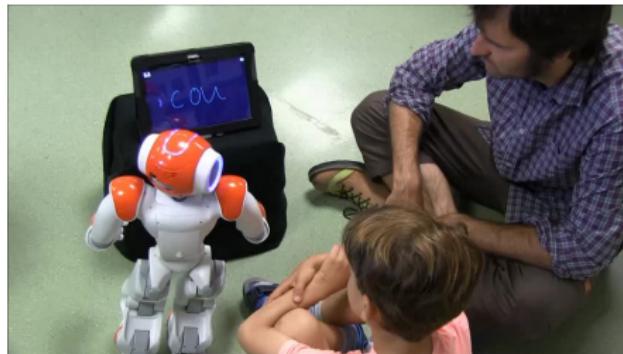


Mind modelling is **mutual**

We can take advantage of it in HRI at fundamental levels



COGNITIVE ENGAGEMENT AND META-COGNITION





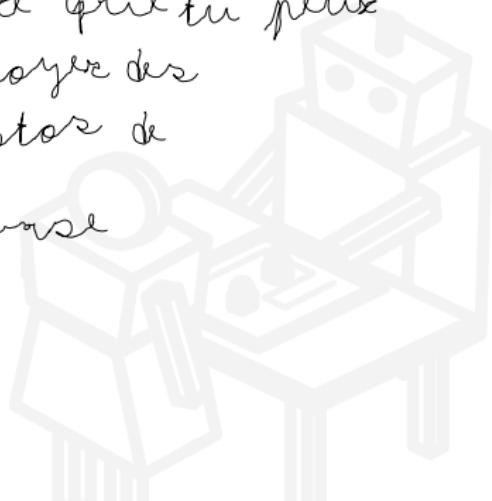
salut mimi
nous persons
que c'est un
corps
est que que tu peu
croire des
photos de
la lise





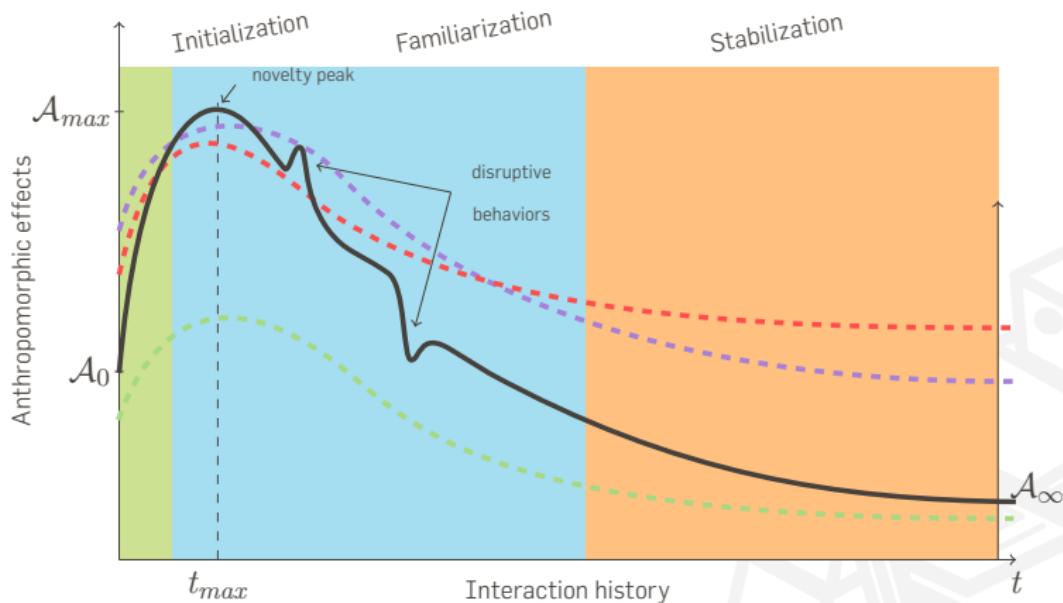
salut mimi
nous persons
que c'est un
corps
est à que tu peux
croire des
photos de
la base

salut mimi
nous persons
que c'est un
corps
est à que tu peux
envoyer des
photos de
la base



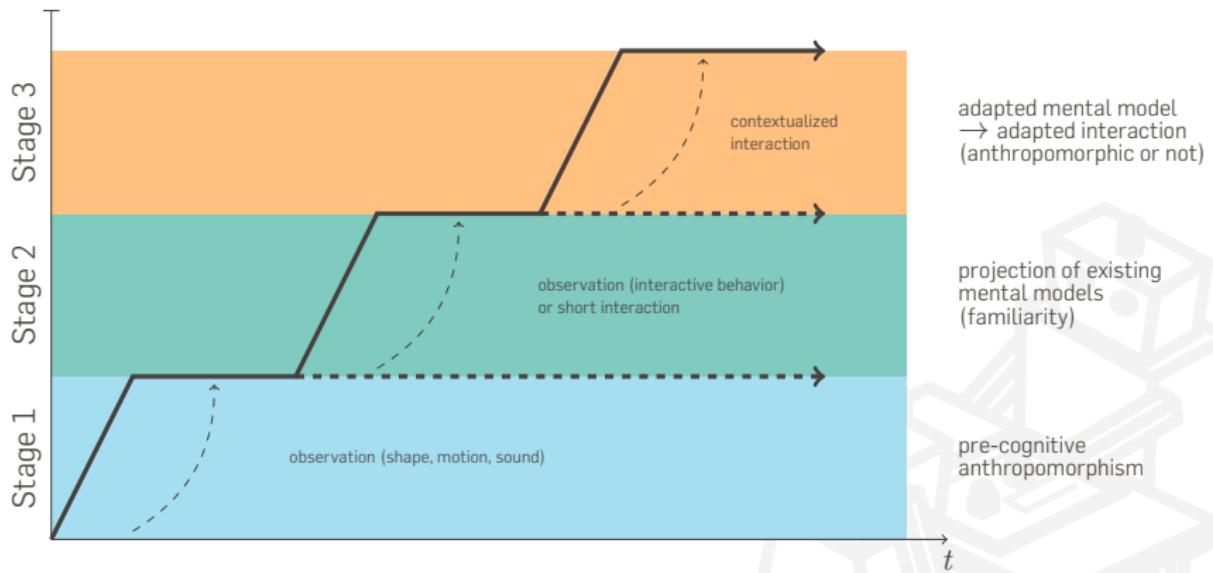
ARE YOU STILL WITH ME?

HOW DO WE PERCEIVE ROBOT OVER TIME?

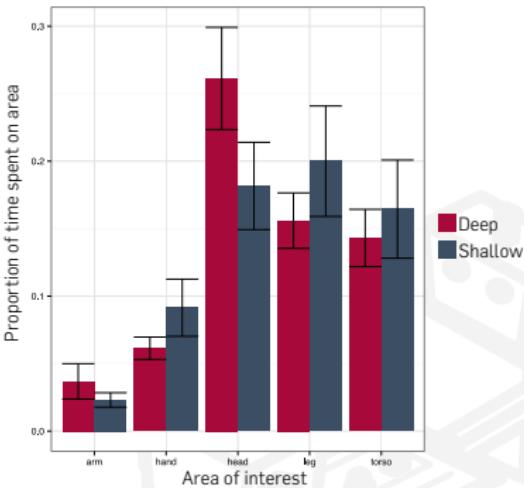




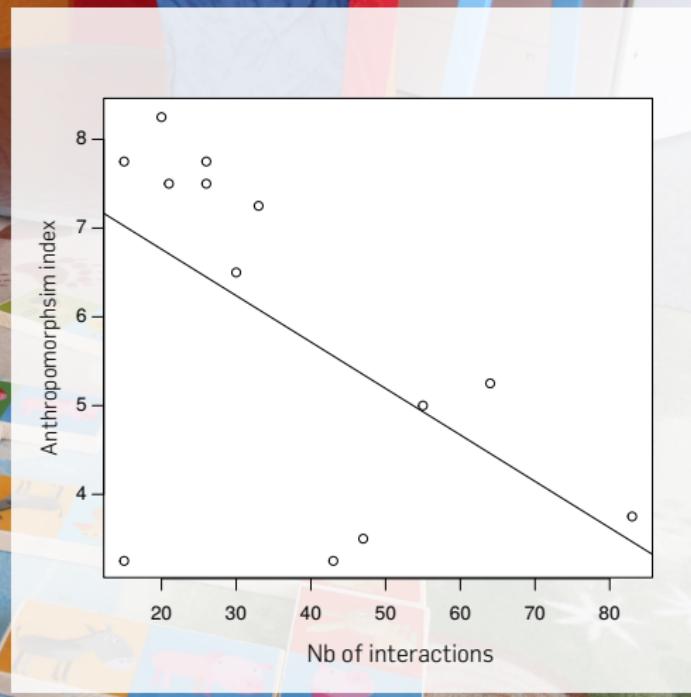
COGNITIVE INTERPRETATION?



COGNITIVE CONTEXT AND ANTHROPOMORPHISM



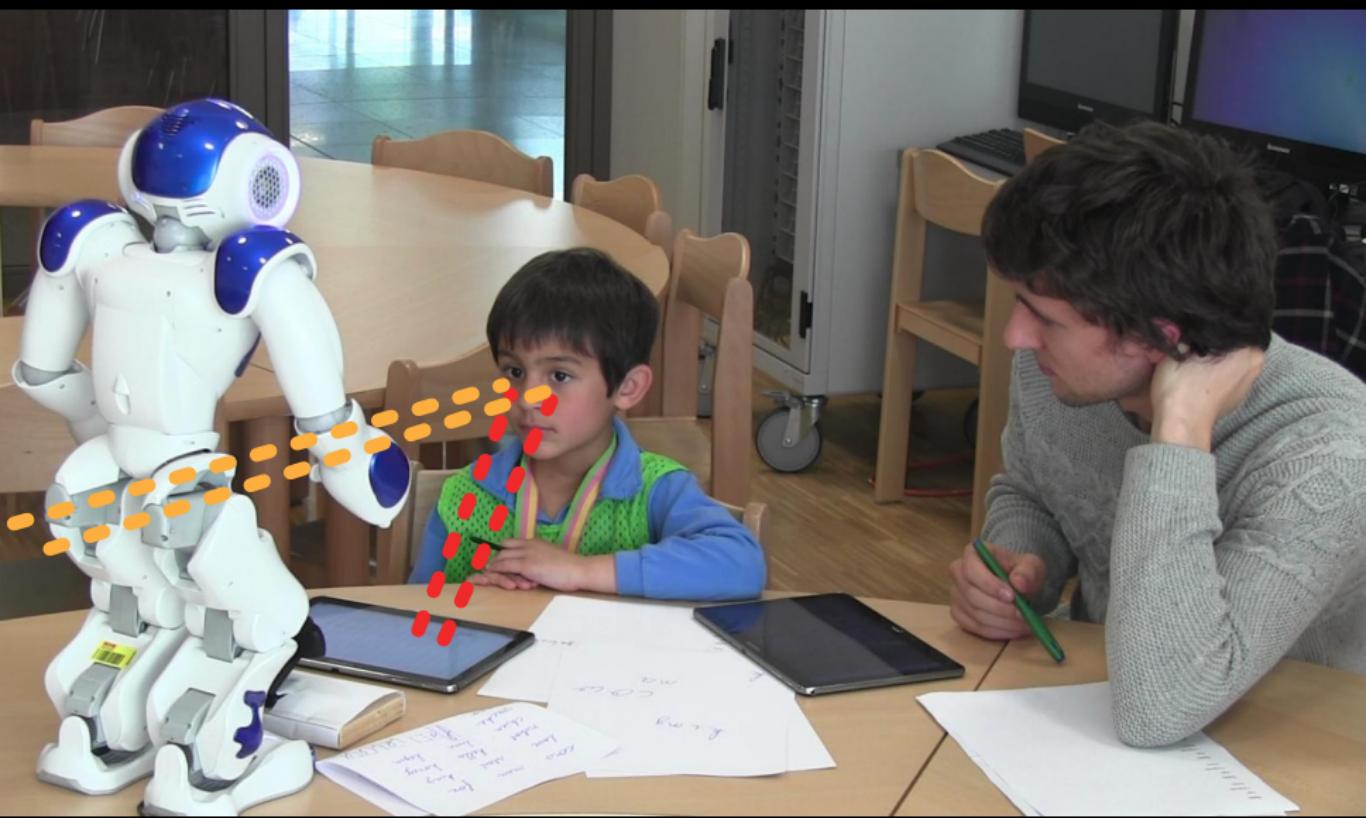
ANTHROPOMORPHISM != ENGAGEMENT

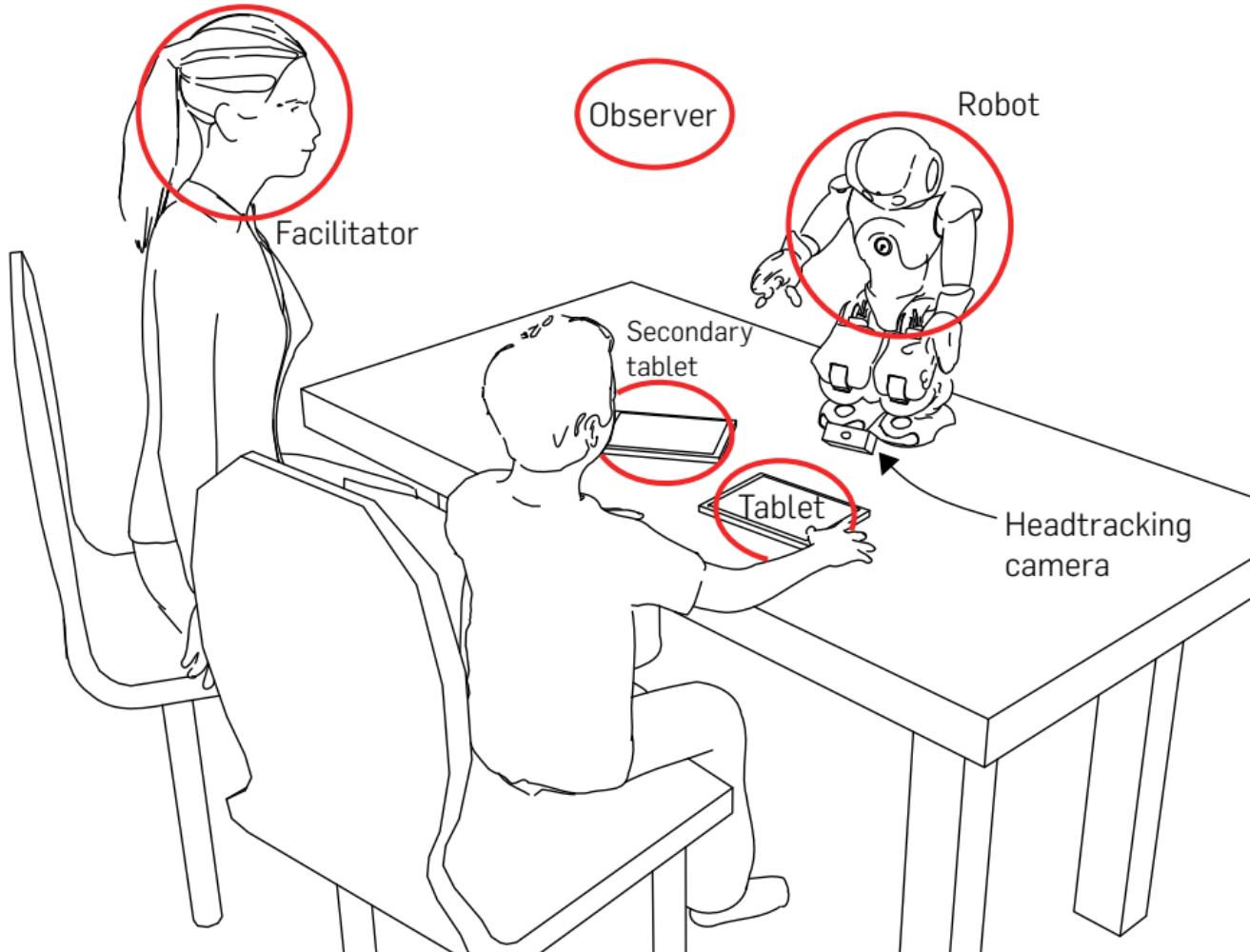


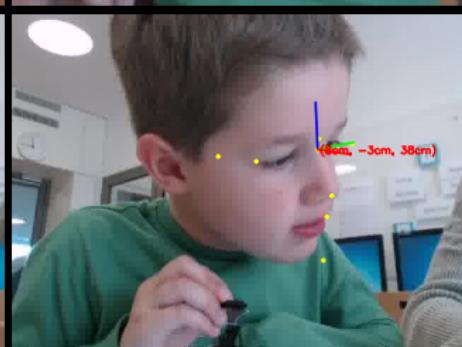
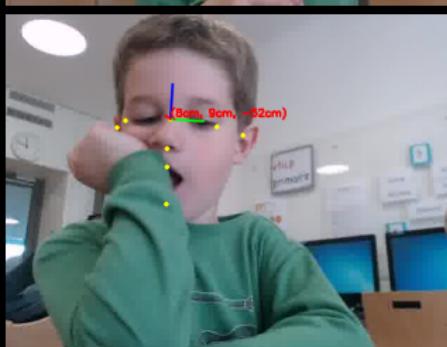
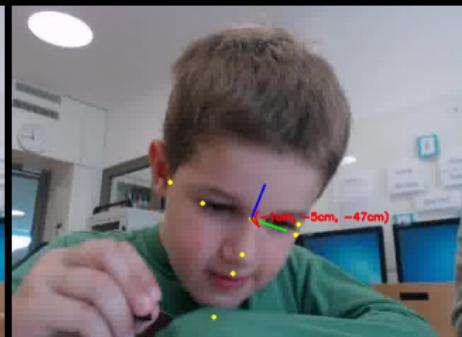
Can we make the assessment of engagement **practical?**





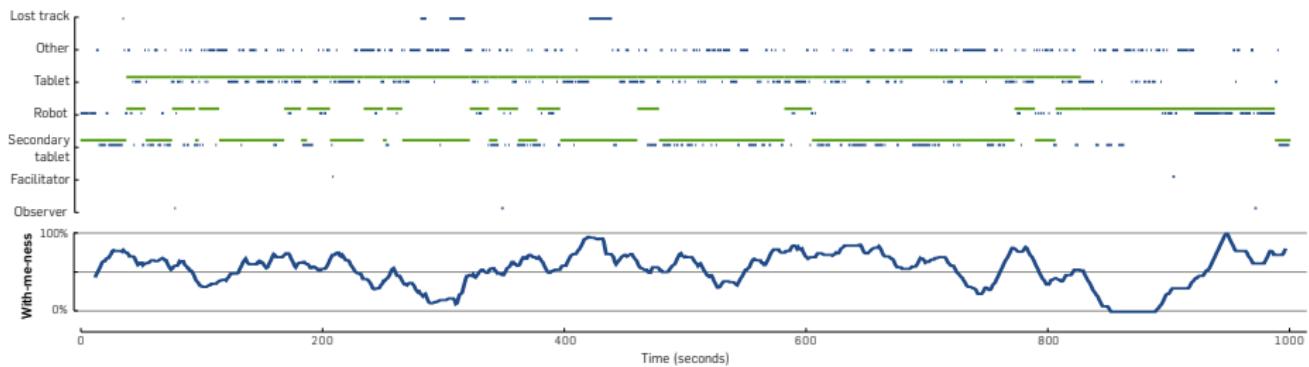








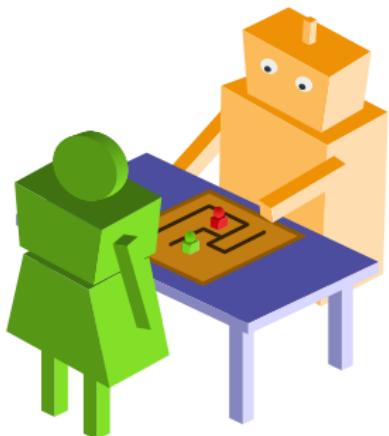
WITH-ME-NESS



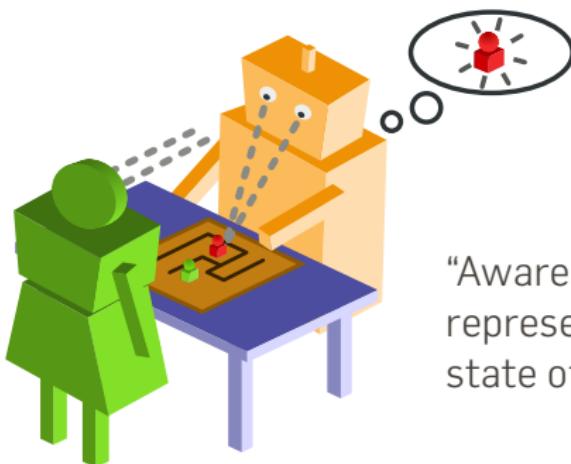
A SUMMARY AND SOME IDEAS



ATTENTION, AWARENESS, ALIGNMENT



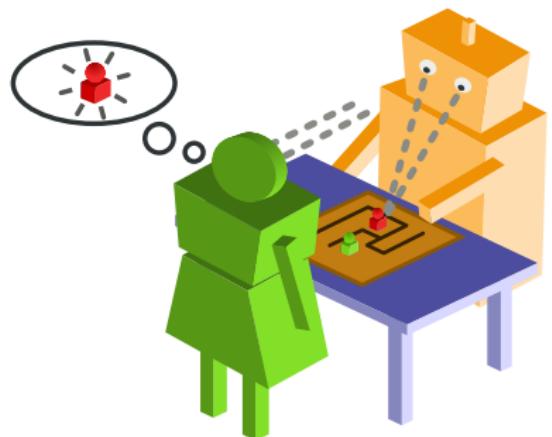
ATTENTION, AWARENESS, ALIGNMENT



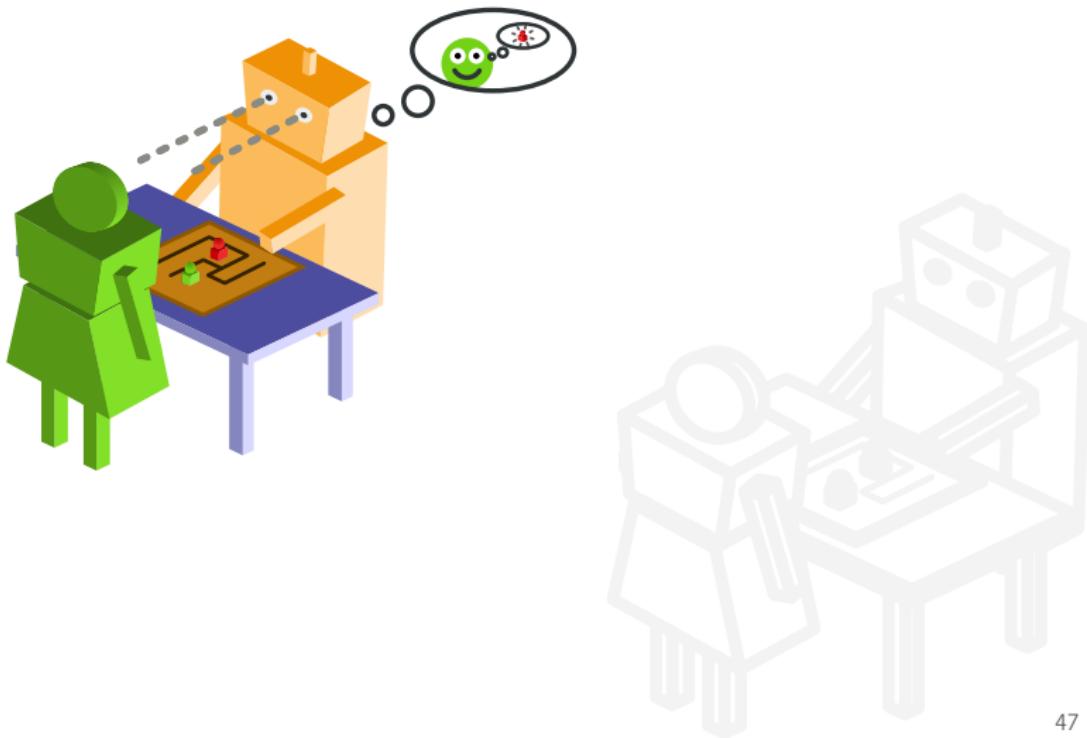
"Awareness is a construct that represents the attentional state of a brain"

[Graziano **Consciousness and the Social Brain** – 2013]

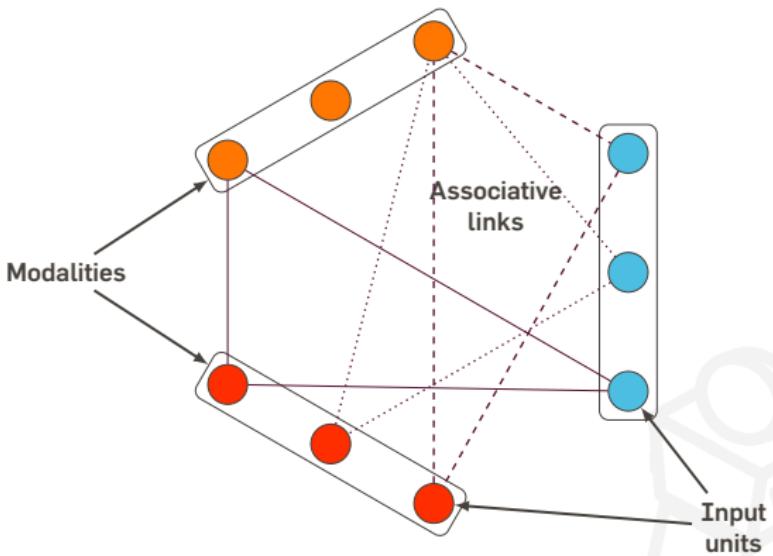
ATTENTION, AWARENESS, ALIGNMENT



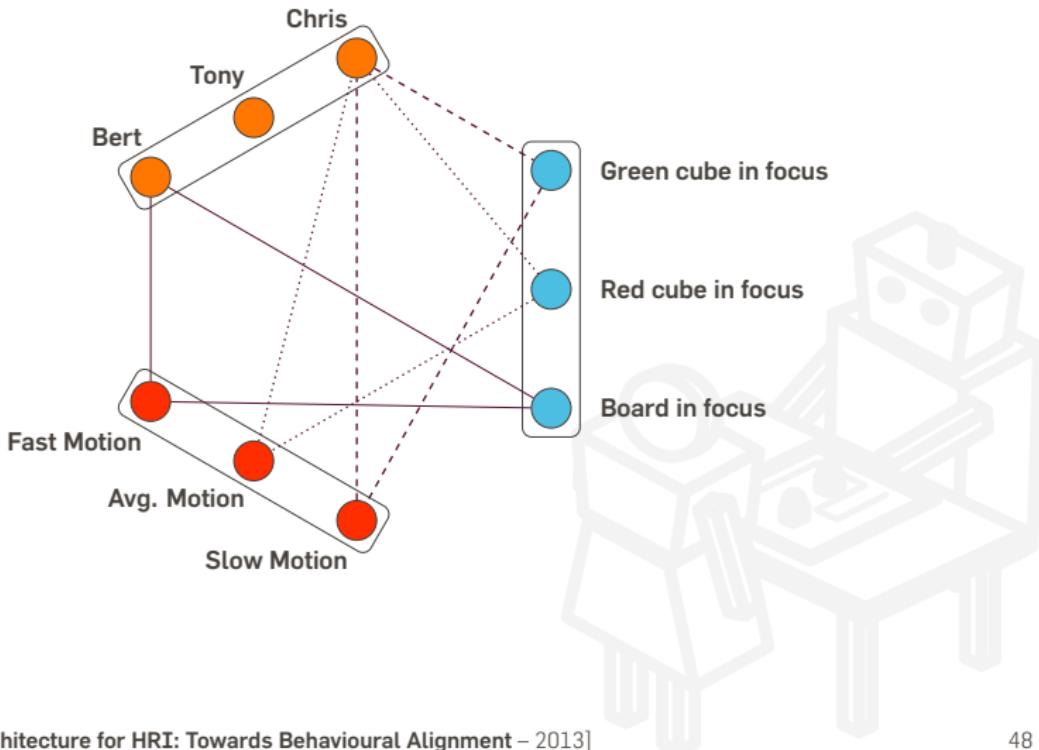
ATTENTION, AWARENESS, ALIGNMENT



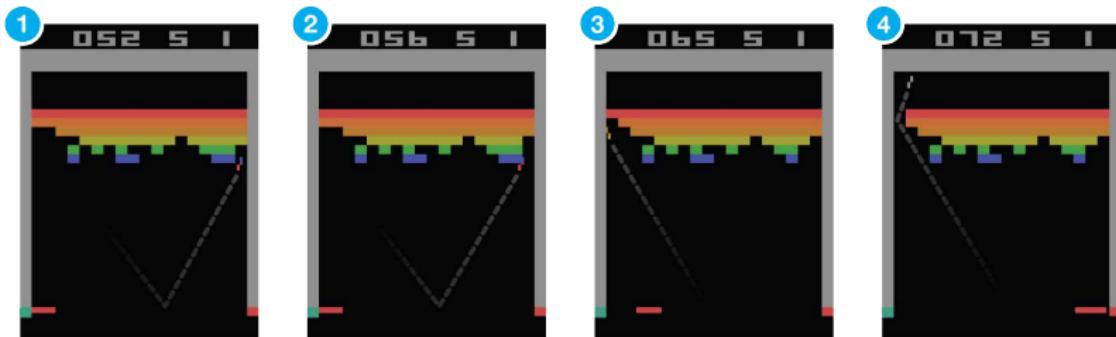
ASSOCIATIVE MEMORY



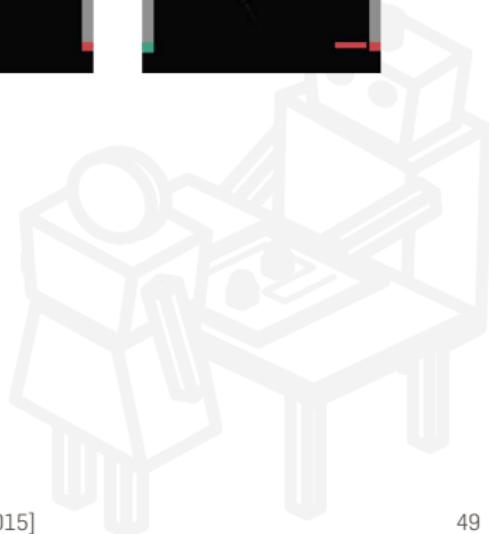
ASSOCIATIVE MEMORY



LEARNING COMPLEX BEHAVIOURS



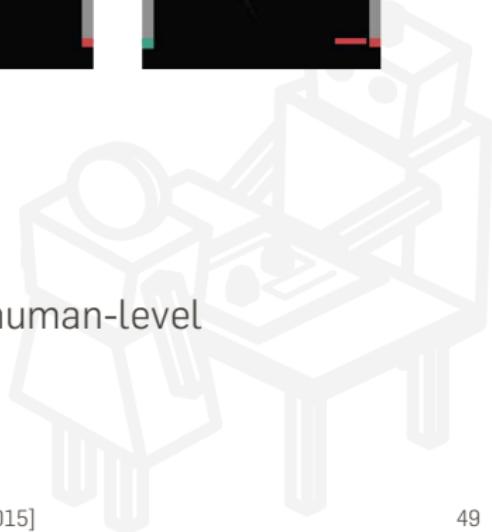
- Inputs: raw screen image + score
- from the outside, looks like planning



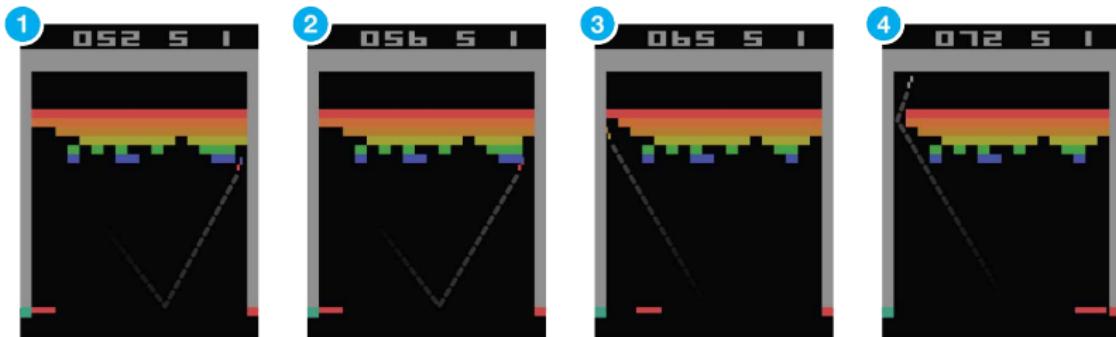
LEARNING COMPLEX BEHAVIOURS



- Inputs: raw screen image + score
- from the outside, looks like planning
- ~~1.000.000~~ **500** games to play a good human-level



LEARNING COMPLEX BEHAVIOURS



- Inputs: raw screen image + score
- from the outside, looks like planning
- ~~1.000.000~~ **500** games to play a good human-level

Could we also learn social dynamics?

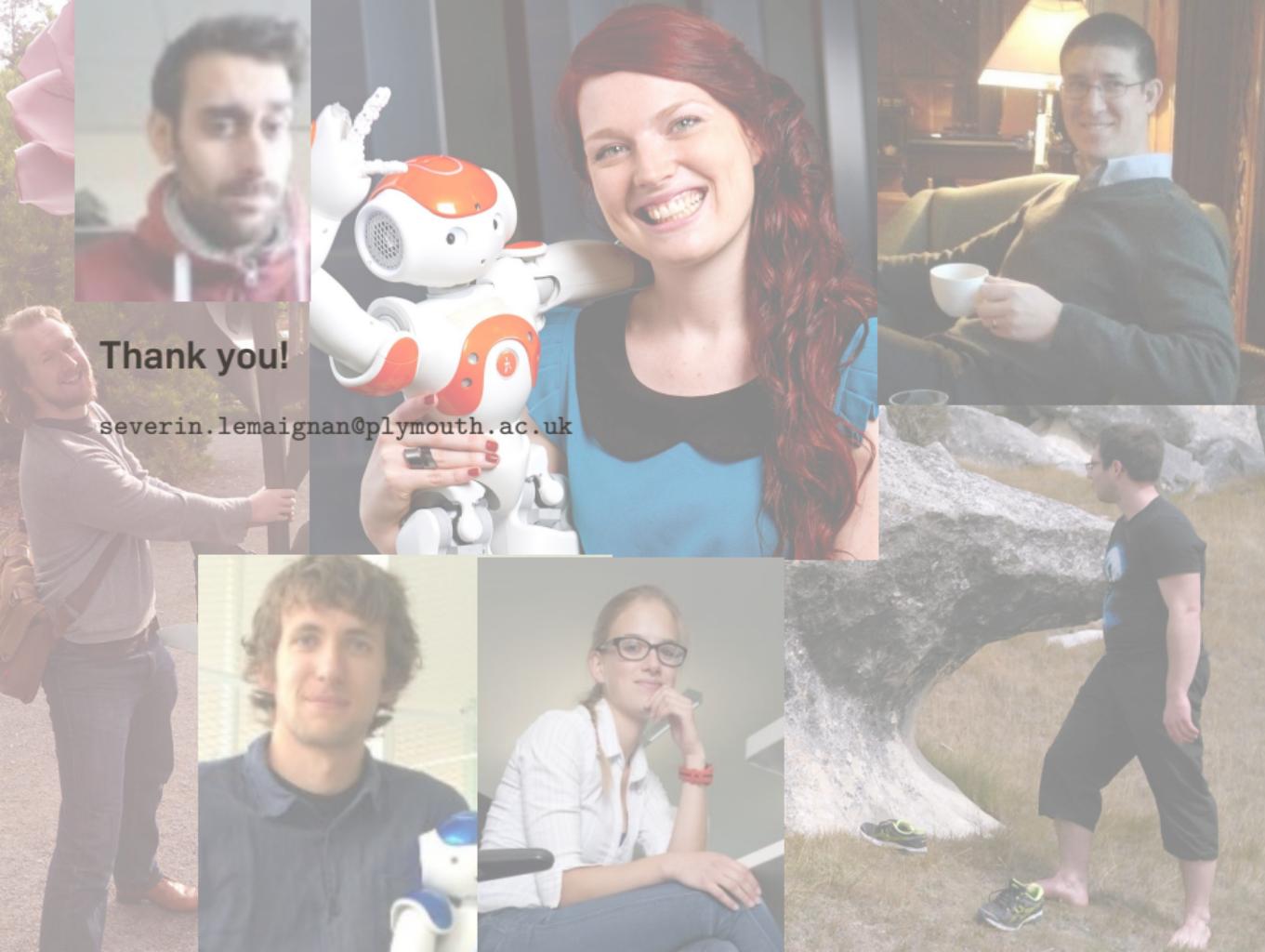
Four main themes: studies, technical developments, theories and methods, design

Deadline: Septembre 5

Most selective conference of the field!

Unconventional research/methodologies: alt.HRI!





Thank you!

severin.lemaignan@plymouth.ac.uk

SUPPLEMENTARY MATERIAL

5. Mutual Modelling and Theory of Mind

6. Role of Unexpected Behaviours

7. More on CoWriter

8. Cognitive Architectures

9. Dialogue Grounding

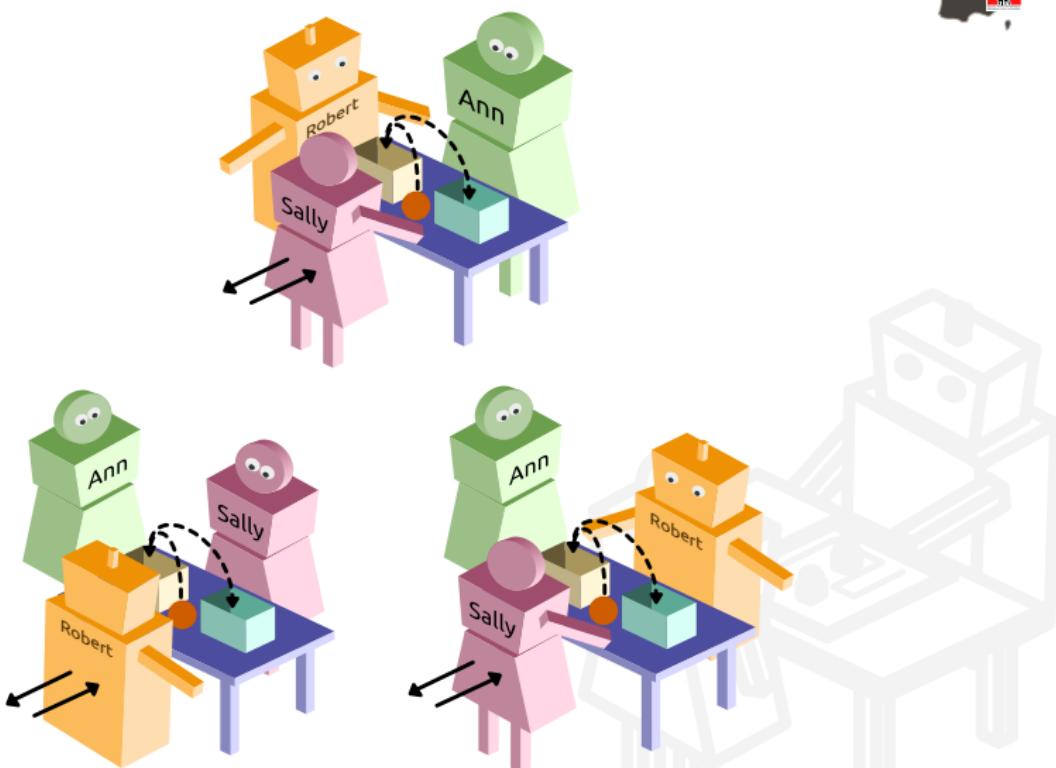
10. Human-aware Planning

11. Performing in Human Environments

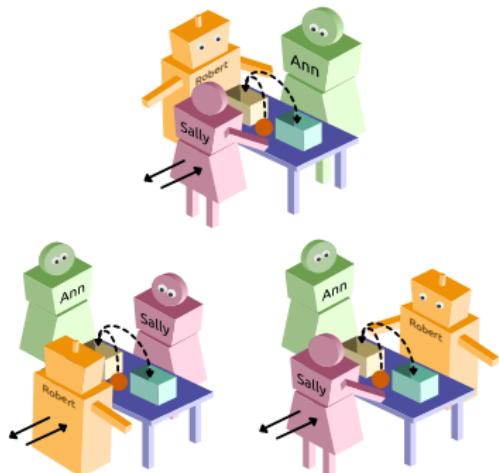


TOM

THE FALSE-BELIEF EXPERIMENT, RELOADED

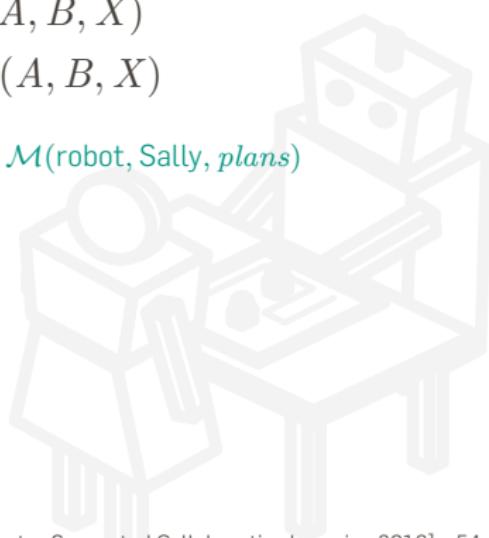


THE FALSE-BELIEF EXPERIMENT, RELOADED



- $\mathcal{M}(A, B, X)$
- $\mathcal{M}^\circ(A, B, X)$

e.g. $\mathcal{M}(\text{robot}, \text{Sally}, \text{plans})$



THE FALSE-BELIEF EXPERIMENT, RELOADED

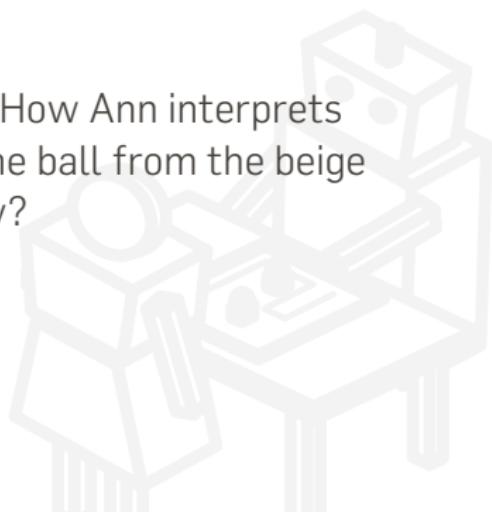


- **Robot is the observer**

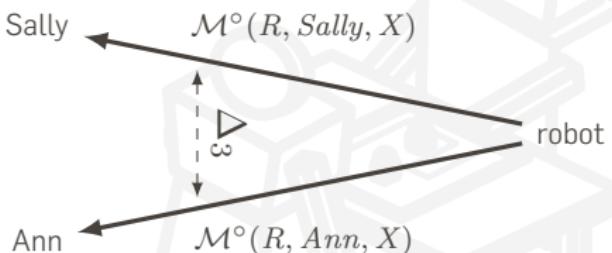
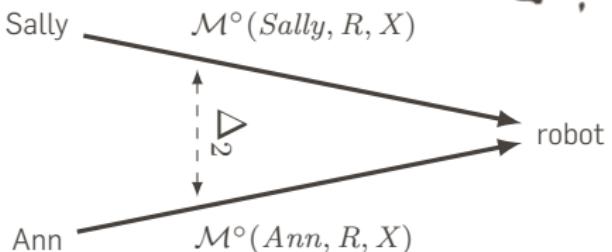
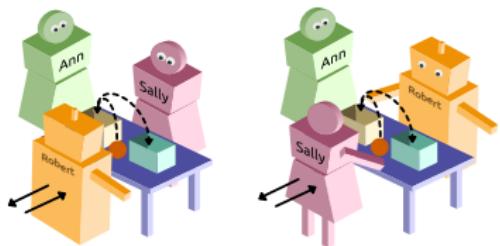
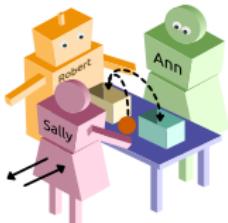
$\mathcal{M}^\circ(R, \text{Sally}|\text{Ann}, \text{plans})$? can the human verbalise it? i.e.
 $\mathcal{M}(H, R, \mathcal{M}(R, H, \text{plans}))$?

- **Robot is an active participant**

$\mathcal{M}(H, R, \text{knowledge}|\text{plans}| \text{goals})$? i.e. How Ann interprets
the behaviour of a robot who moves the ball from the beige
box to the blue box while Sally is away?



THE FALSE-BELIEF EXPERIMENT, RELOADED



THE FALSE-BELIEF EXPERIMENT, RELOADED

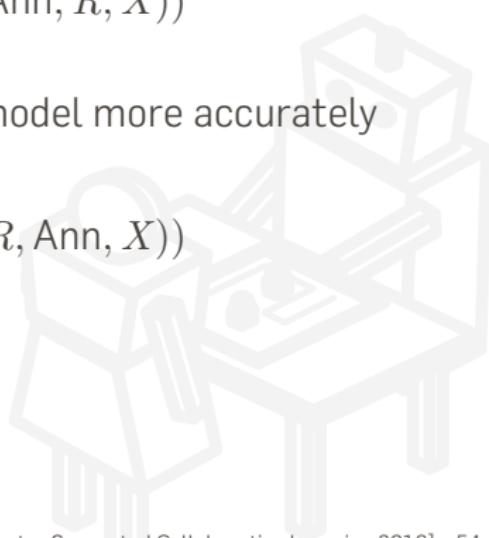


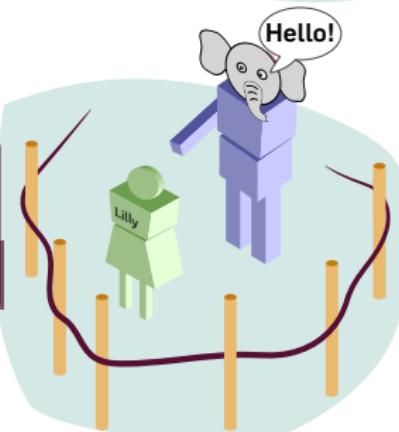
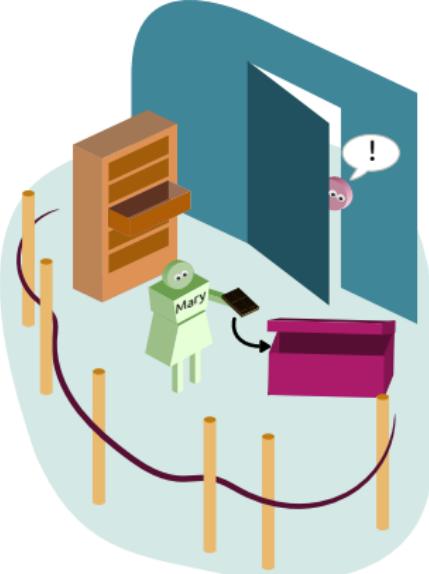
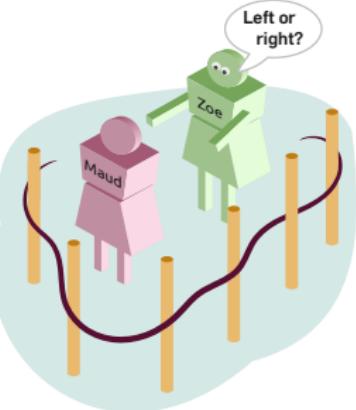
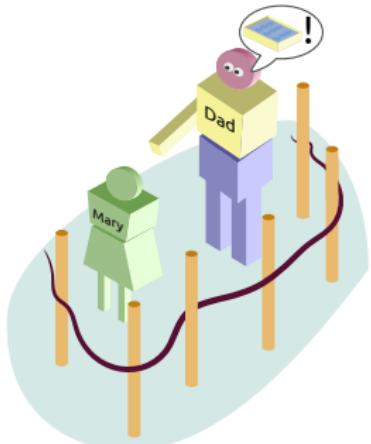
Do Sally and Ann have the same accuracy when modelling the robot?

$$\Delta_2 = \Delta(\mathcal{M}(\text{Sally}, R, X), \mathcal{M}(\text{Ann}, R, X))$$

Conversely, what may lead the robot to model more accurately
Sally or Ann?

$$\Delta_3 = \Delta(\mathcal{M}(R, \text{Sally}, X), \mathcal{M}(R, \text{Ann}, X))$$







SHOPPING LIST FOR HRI?

Already in the HRI fridge

Instrumental gestures

Using person as tool

Talking about desires and emotions

Showing "active" sociability

Elicited structured play

To buy...

Expressive gestures

Using person as receiver of information

Talking about beliefs and ideas

Showing "interactive" sociability

Spontaneous pretend play

AUTISTIC ASSETS AND DEFICITS OBSERVED IN REAL LIFE



Assets	Deficits
Instrumental gestures	Expressive gestures
Using person as tool	Using person as receiver of information
Talking about desires and emotions	Talking about beliefs and ideas
Showing "active" sociability	Showing "interactive" sociability
Elicited structured play	Spontaneous pretend play

UNEXPECTED BEHAVIOURS



UNEXPECTED BEHAVIOURS

	Unplanned by the robot	Planned by the robot
Perceived as non- intentional	A	B
Perceived as intentional	C	D

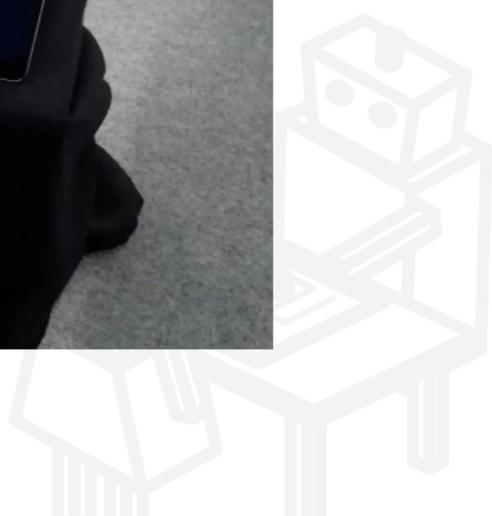


COWRITER



COWRITER DETAILS

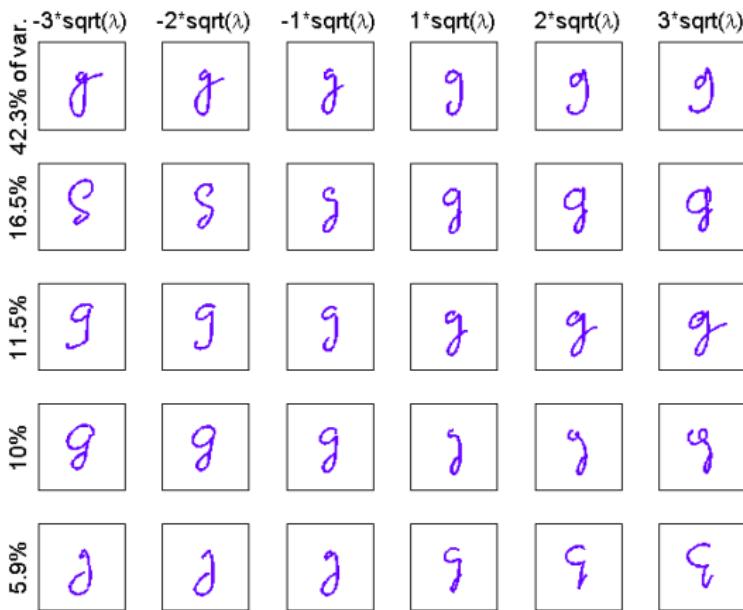
CoWriter: Learning by Teaching





COWRITER DETAILS

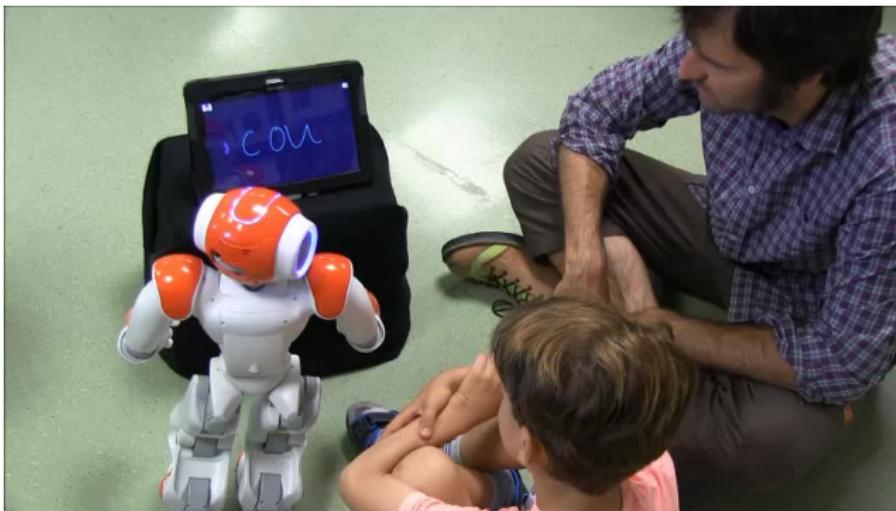
CoWriter: Learning by Teaching

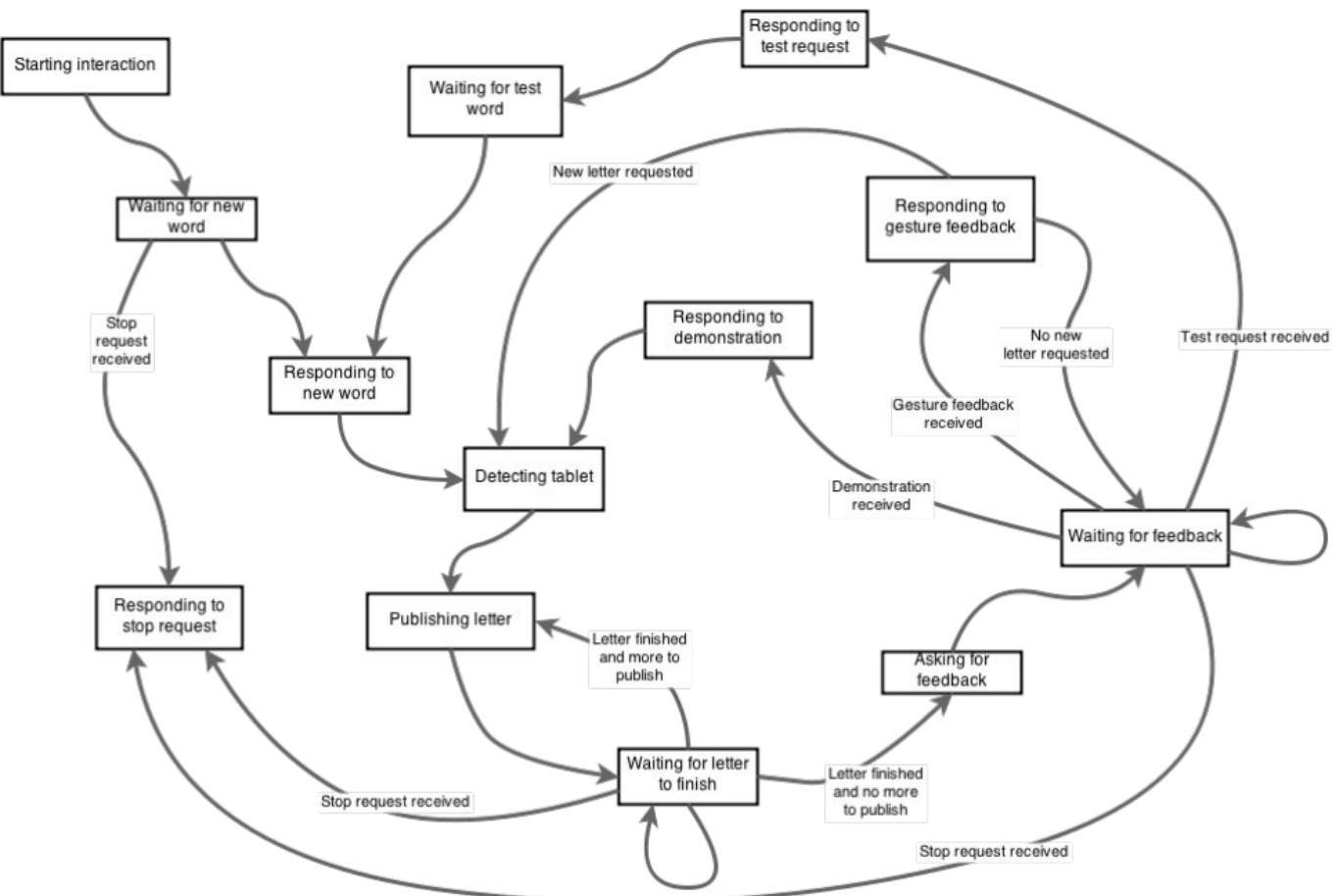


COWRITER DETAILS



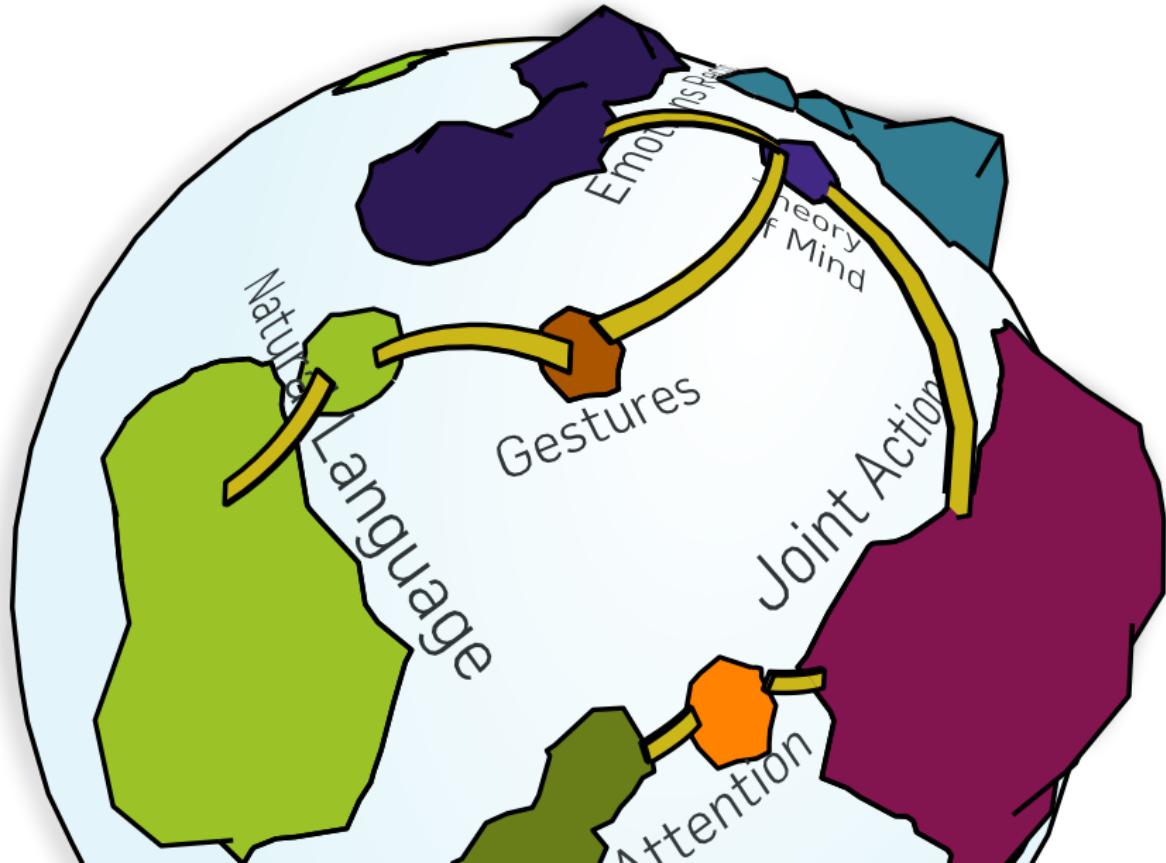
CoWriter: Learning by Teaching

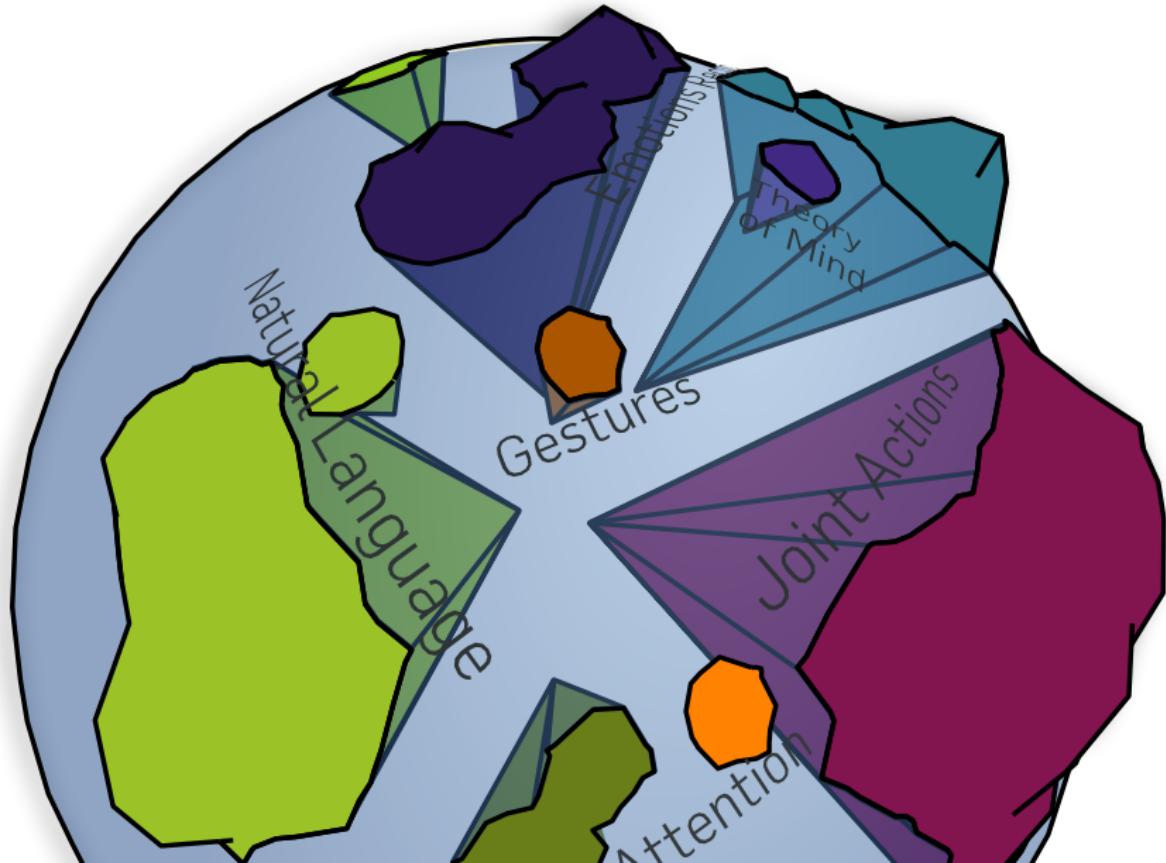


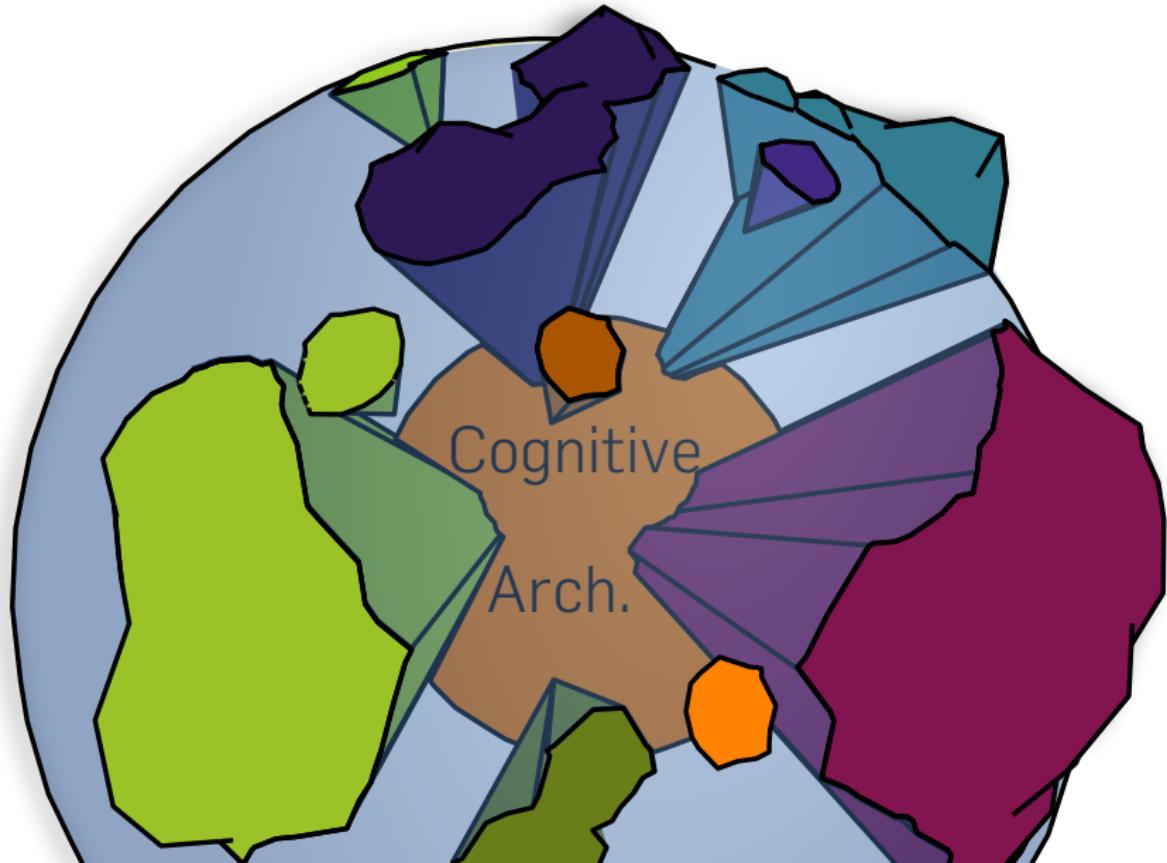


COGARCH





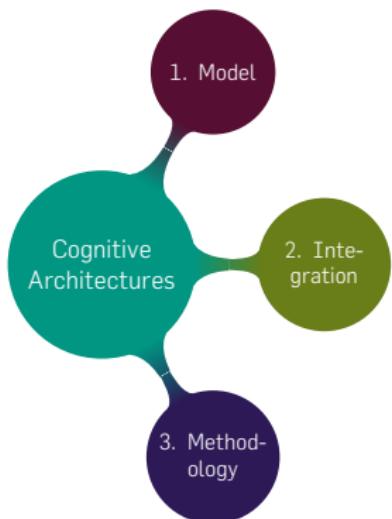




Cognitive

Arch.

COGNITIVE ARCHITECTURES FOR SOCIAL HRI



1. Models of Human Cognition

- Modelling (aspects of) human cognition
- Subsequent application to robots

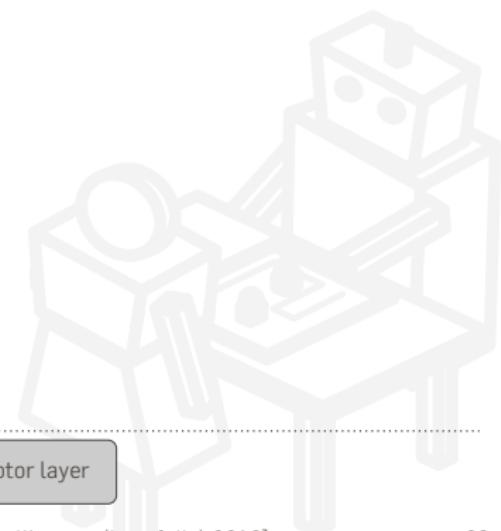
2. Technical Integration

- Define required functionality of robots
- Implement algorithms (etc) necessary

3. A Methodology

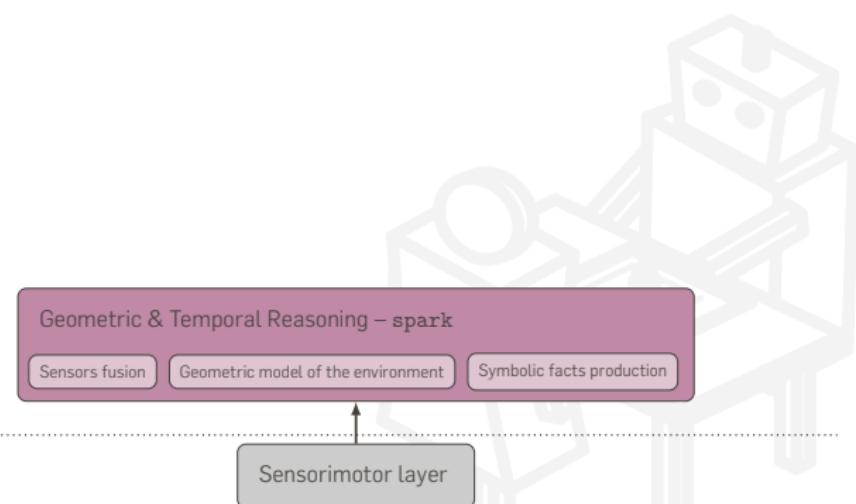
- Formalising assumptions
- Integrating knowledge from multiple disciplines
- Iteratively updating architecture

FROM "TECHNICAL INTEGRATION"...

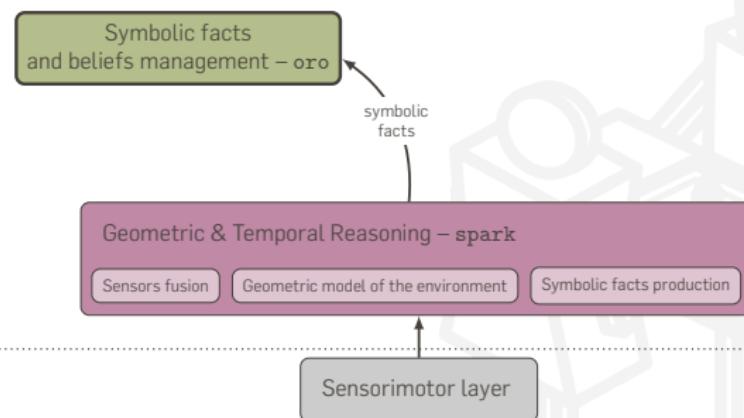
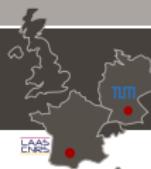




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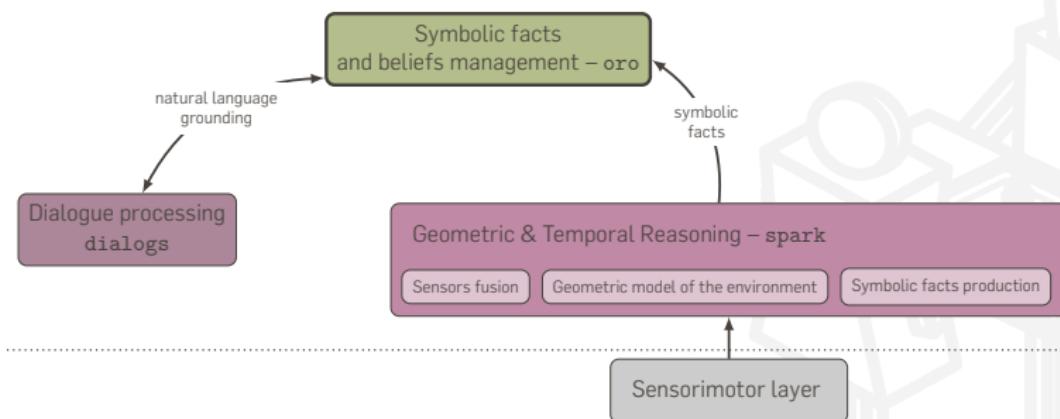


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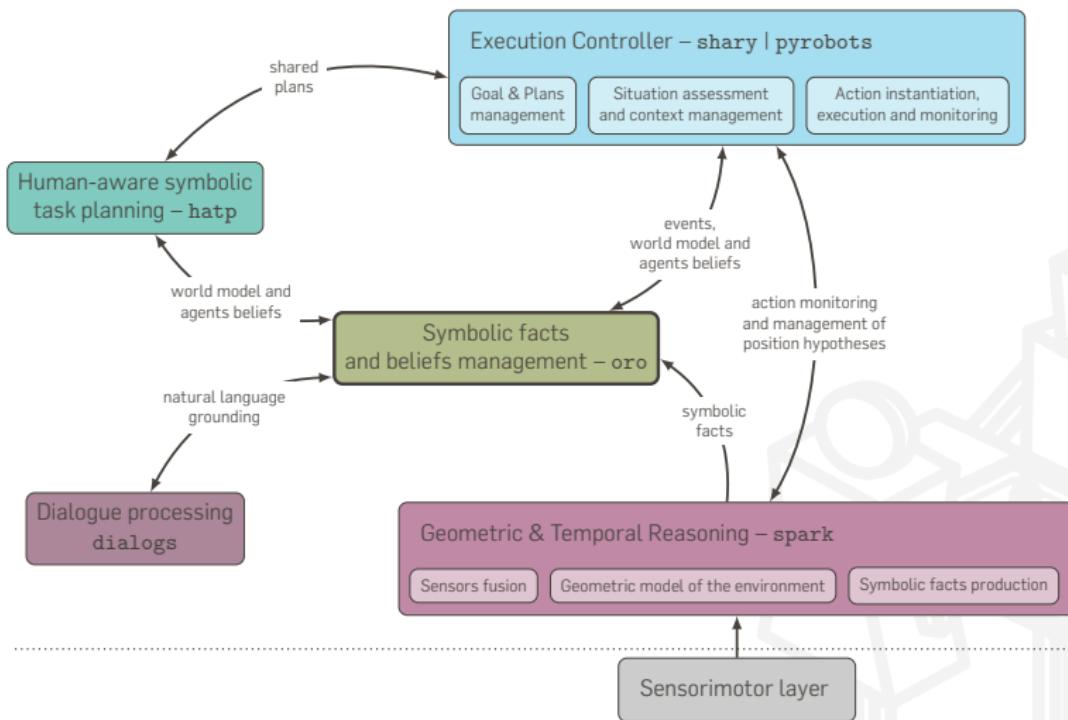


FROM "TECHNICAL INTEGRATION"...



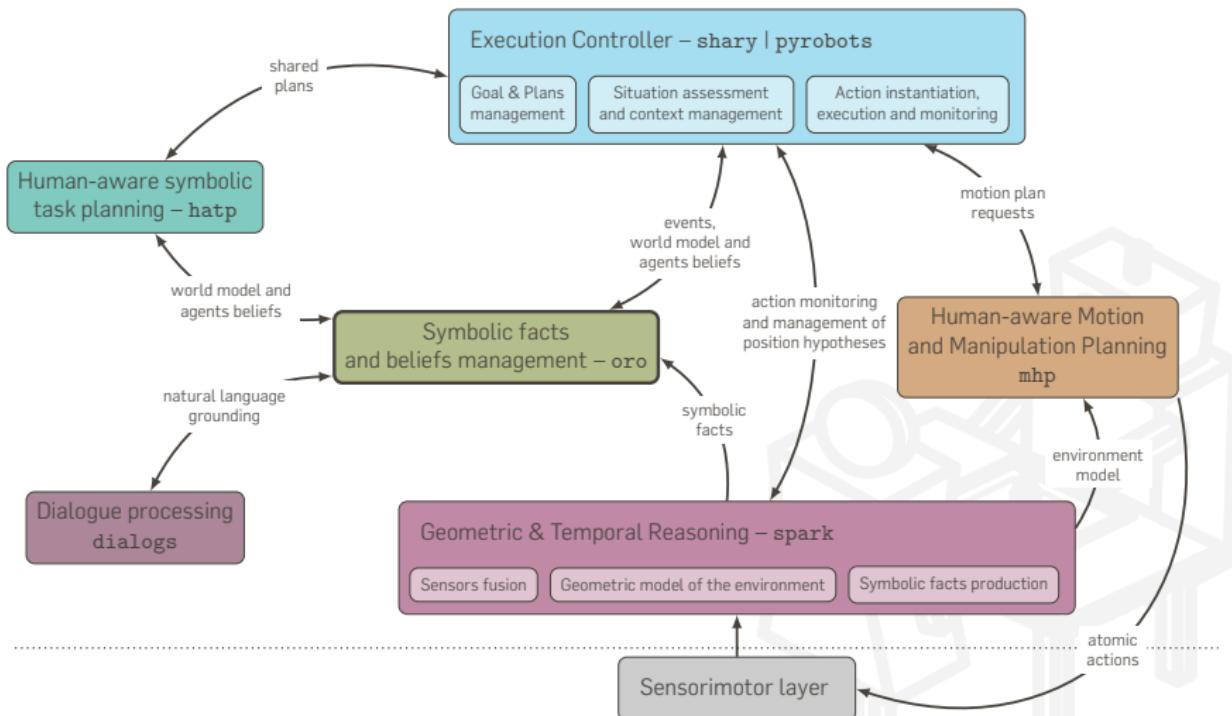


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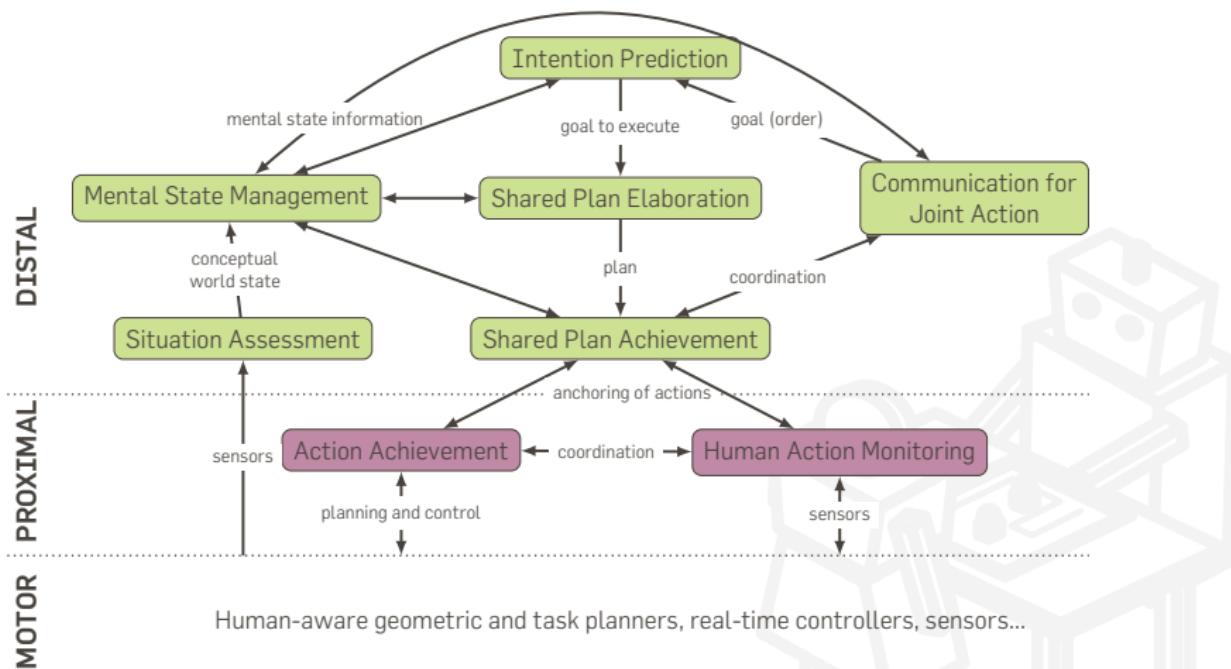




FROM "TECHNICAL INTEGRATION"...



...TO “MODELING OF HUMAN COGNITION”...



DIALOGUE

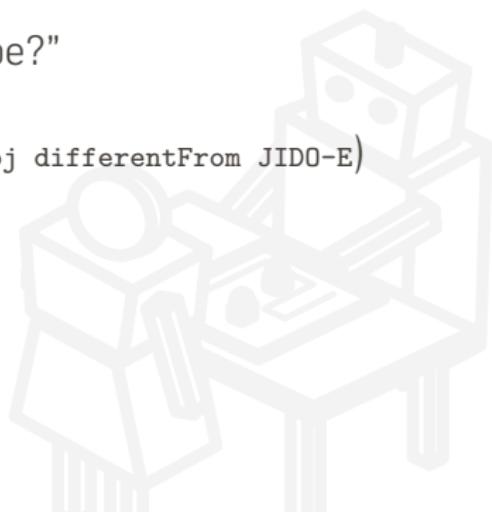


DIALOGUE GROUNDING

"Where is the other tape?"

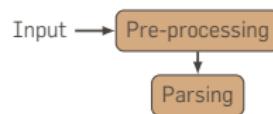


find(?obj isAt ?loc, ?obj type VideoTape, ?obj differentFrom JIDO-E)



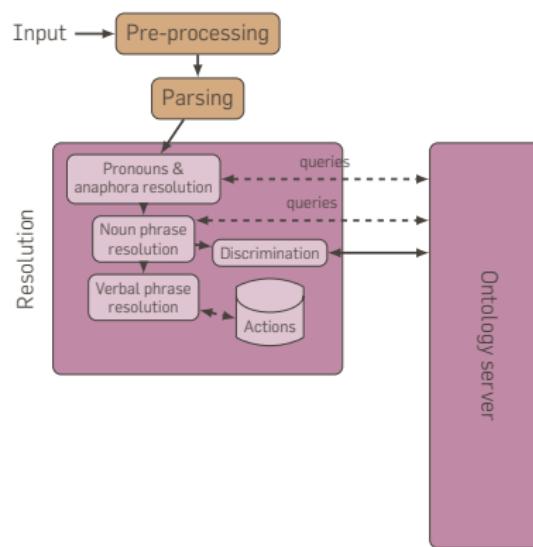


DIALOGUE GROUNDING



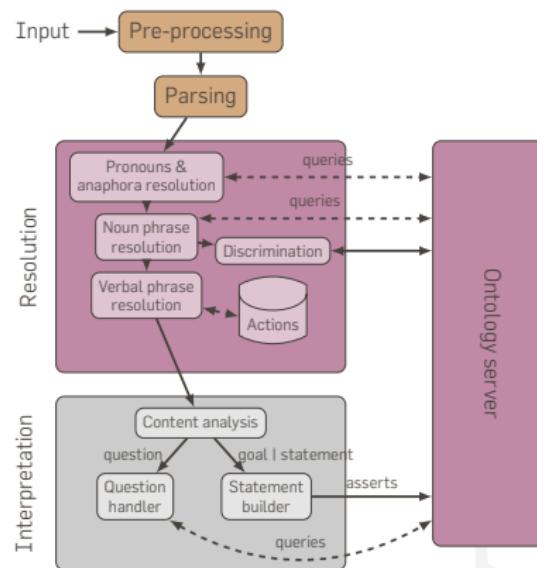


DIALOGUE GROUNDING

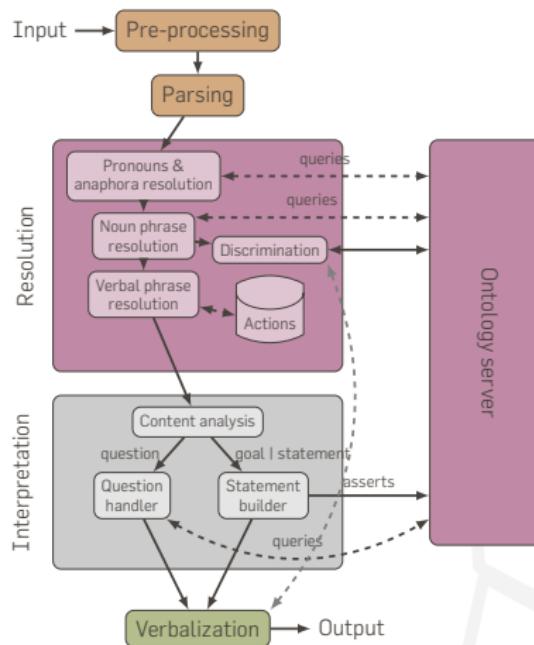




DIALOGUE GROUNDING



DIALOGUE GROUNDING



DIALOGUE GROUNDING



"Give me the book on the table"





DIALOGUE GROUNDING

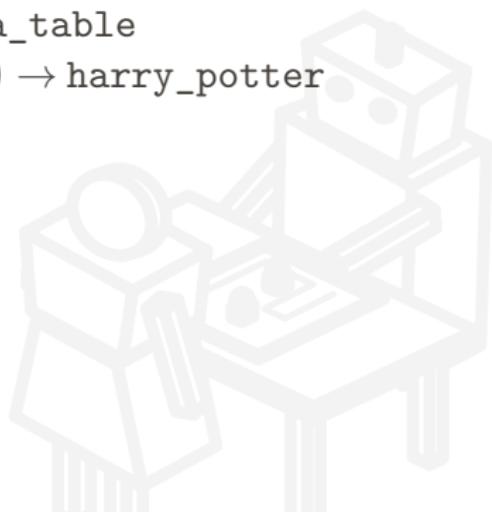
"Give me the book on the table"



`me → baby_1`

`find(?obj type table) → ikea_table`

`find(?obj type book, ?obj isOn ikea_table) → harry_potter`





DIALOGUE GROUNDING

"Give me the book on the table"



`me → baby_1`

`find(?obj type table) → ikea_table`

`find(?obj type book, ?obj isOn ikea_table) → harry_potter`



`baby_1 desires action1,`

`action1 type Give,`

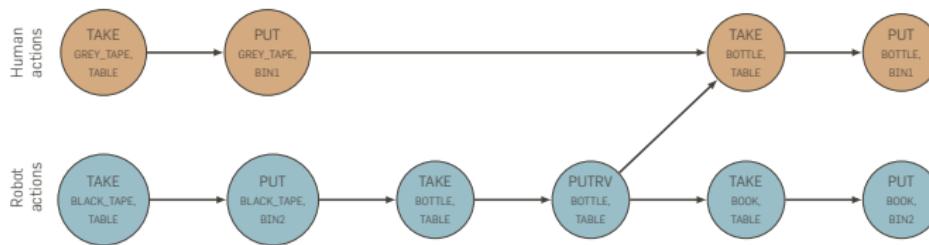
`action1 performedBy myself,`

`action1 actsOnObject harry_potter,`

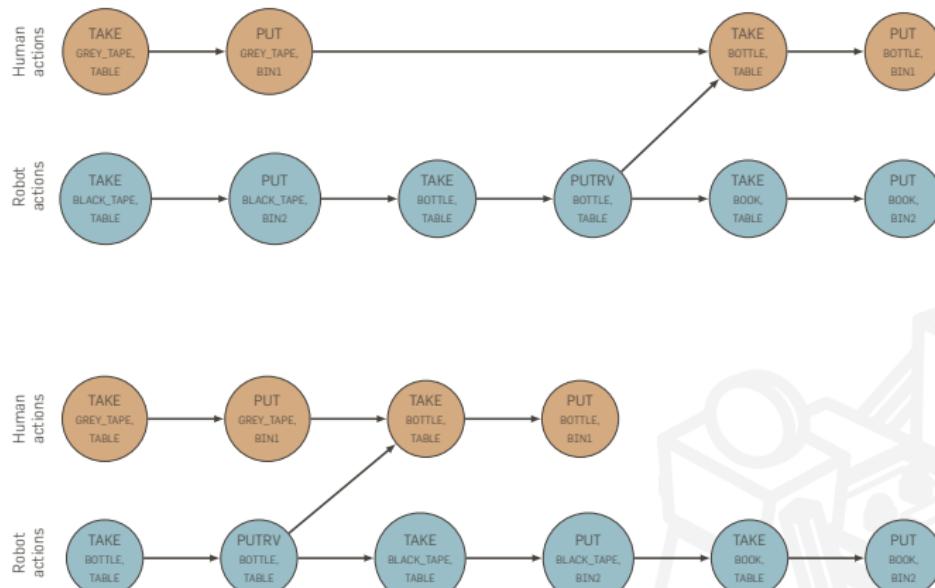
`action1 receivedBy baby_1`

PLANNING

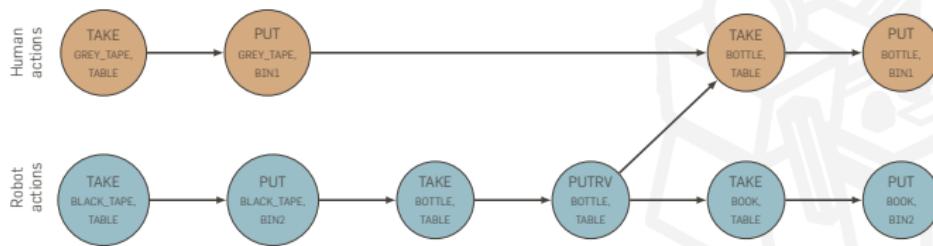
PLANNING FOR THE HUMAN



PLANNING FOR THE HUMAN



PLANNING FOR THE HUMAN





LAAS-CNRS

ACTING

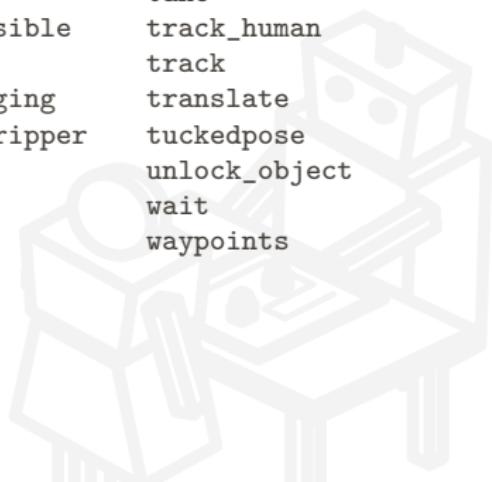


LAAS-CNRS

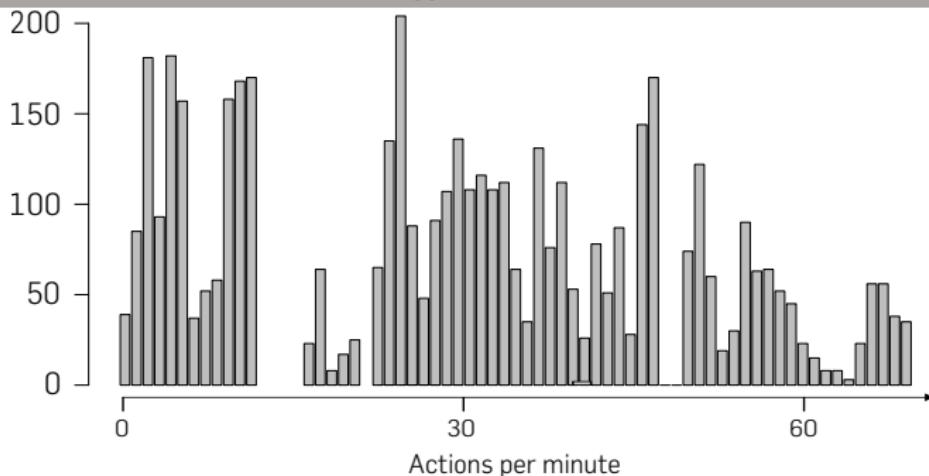
3



amit_give	follow	manipose	setup_scenario
arms_against_torso	glance_to	move_head	show
attachobject	goto	movearm	slow_arms_swinging
basicgive	grab_gripper	moveclose	sorry
basicgrab	grab	open_gripper	speed_arms_swinging
basictake	gym	pick	sweep_look
basket	handover	place_agent	sweep
cancel_follow	handsup_folded	place_object	switch_cameras
cancel_track	handsup_folded2	pointsat	take
cancel	handsup_folded3	put_accessible	track_human
carry	handsup	put	track
close_gripper	hide	rarm_swinging	translate
configure_grippers	idle	release_gripper	tuckedpose
detect_and_grab	init	release	unlock_object
detect	larm_swinging	restpose	wait
disabledevileye	lock_object	rotate	waypoints
display	look_at_ros	satisfied	
dock	look_at_xyz	say	
enabledevileye	look_at	setpose	
extractpose	looksat	settorso	







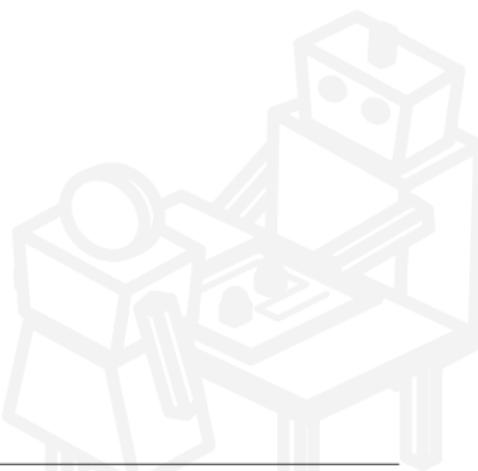
- lightbar
- on_toy_added
- move
- background_blink
- undock
- pulse_row
- blink
- on_lolette
- placeeyes

- on_bumped
- up_down_row
- wakeup
- look_at_caresses
- on_toy_removed
- sneak_in
- on_lolette_removed
- fall_asleep
- look_at_lolette

- active_wait
- closeeyes
- lightpattern
- turn
- idle
- playsound
- blush

PYROBOTS

```
1  from robots import GenericRobot
2  from robots.concurrency import action, ActionCancelled
3  from robots.resources import Resource, lock
4
5  class MyRobot(GenericRobot):
6      # ... state + lowlevel action
7
8  WHEELS = Resource("wheels")
9
10 @clock(WHEELS)
11 @action
12 def move_forward(robot):
13     target = [1.0, 0., 0., "base_link"]
14
15     try:
16         robot.goto(target)
17
18         while(robot.dist_to(target) > 0.1):
19             robot.sleep(0.5)
20
21     except ActionCancelled:
22         robot.stop()
```



```
1 with MyRobot() as robot:
2
3     robot.whenever("my_bumper", True).do(move_forward)
4
5     try:
6         while True:
7             time.sleep(0.5)
8     except KeyboardInterrupt:
9         pass
```

