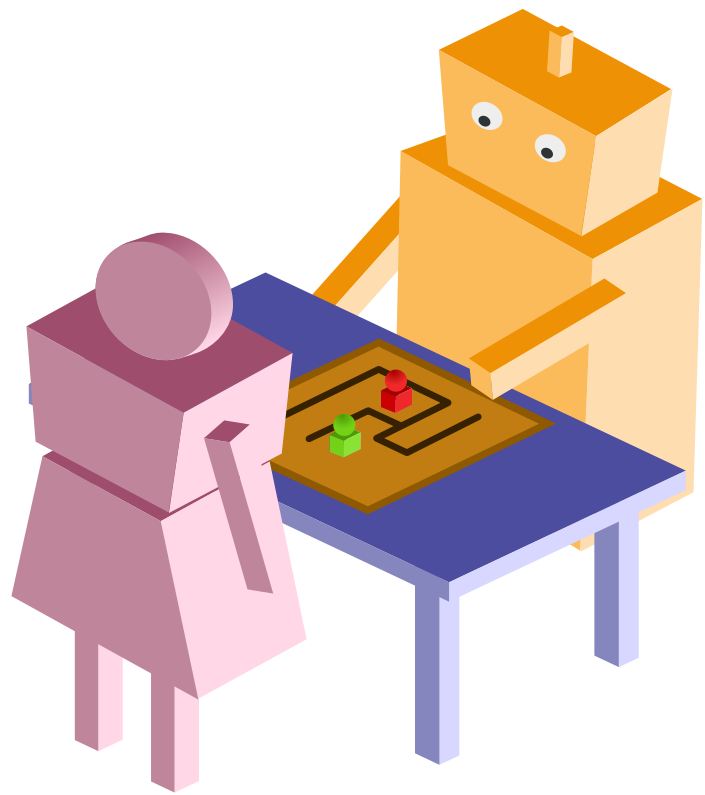
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

More Cognition into my Interaction!

@Centre for Robotics and Neural Systems, Plymouth

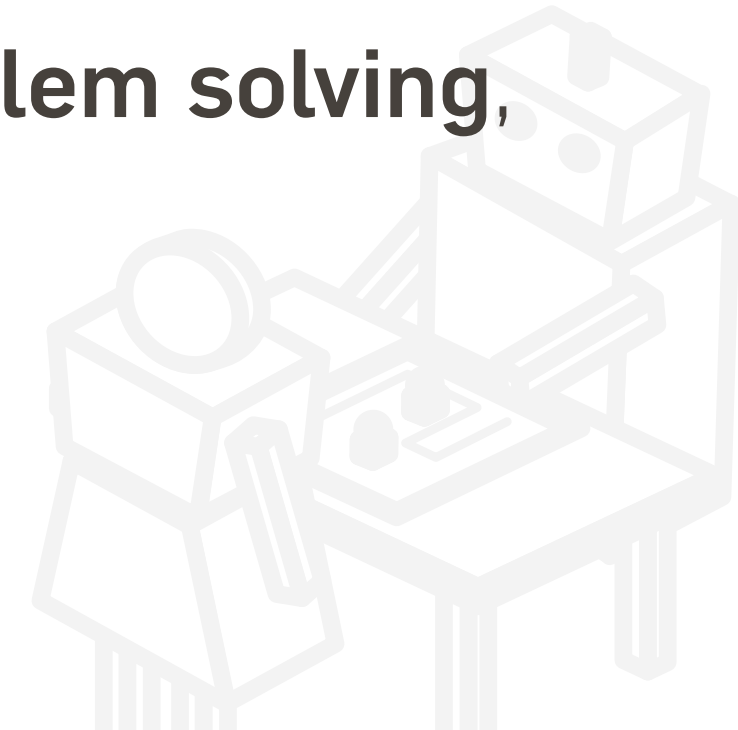
July 4, 2014

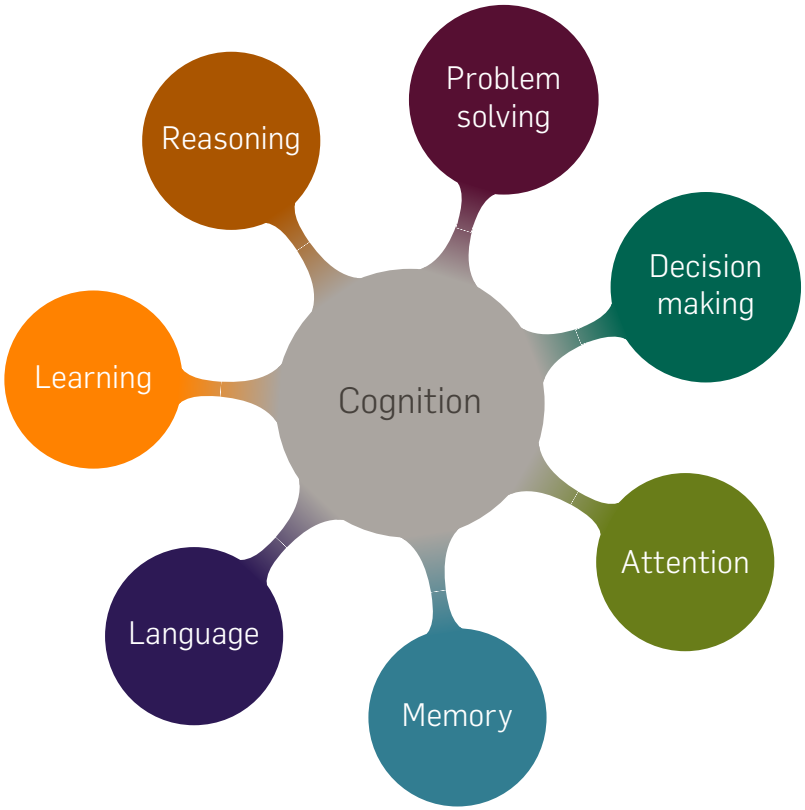


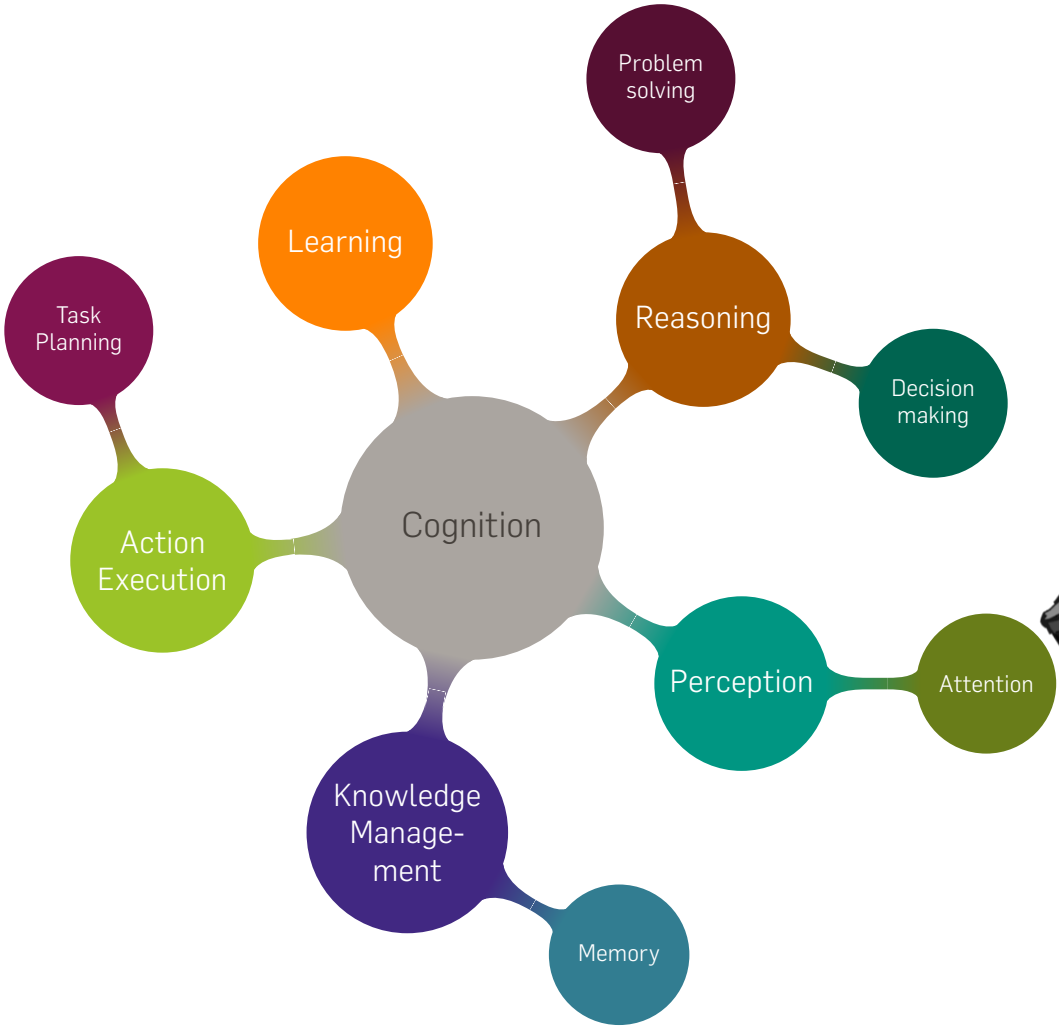
Séverin Lemaignan

Computer-Human Interaction
for Learning and Instruction **EPFL**

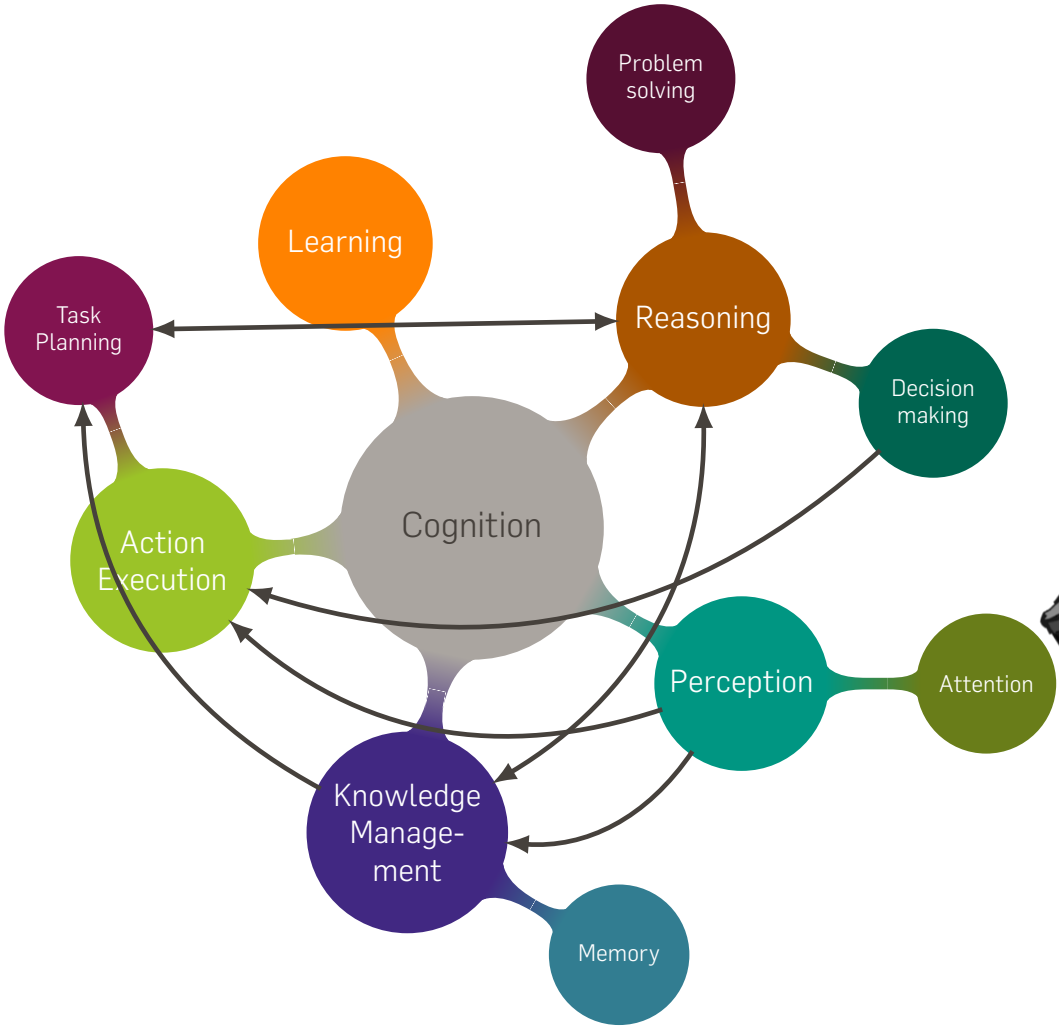
"Cognition is a group of mental processes that includes **attention**, **memory**, producing and understanding **language**, **learning**, **reasoning**, **problem solving**, and **decision making**."




Problem solving
Reasoning
Decision making
Learning
Cognition
Attention
Language
Memory


Problem solving
Learning
Task Planning
Reasoning
Decision making
Action Execution
Cognition
Perception
Attention
Knowledge Manage-ment
Memory


PR2


Problem solving
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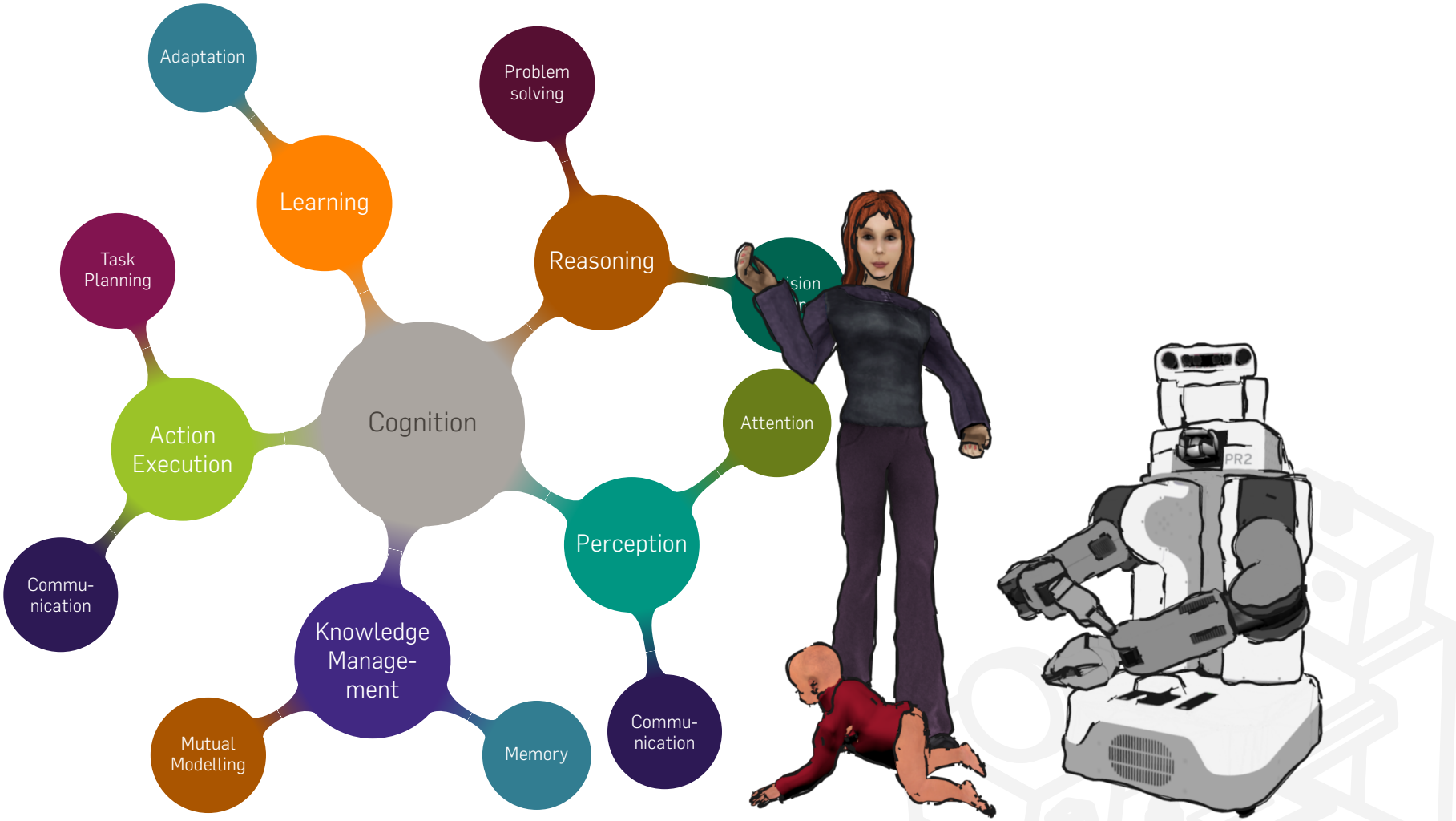
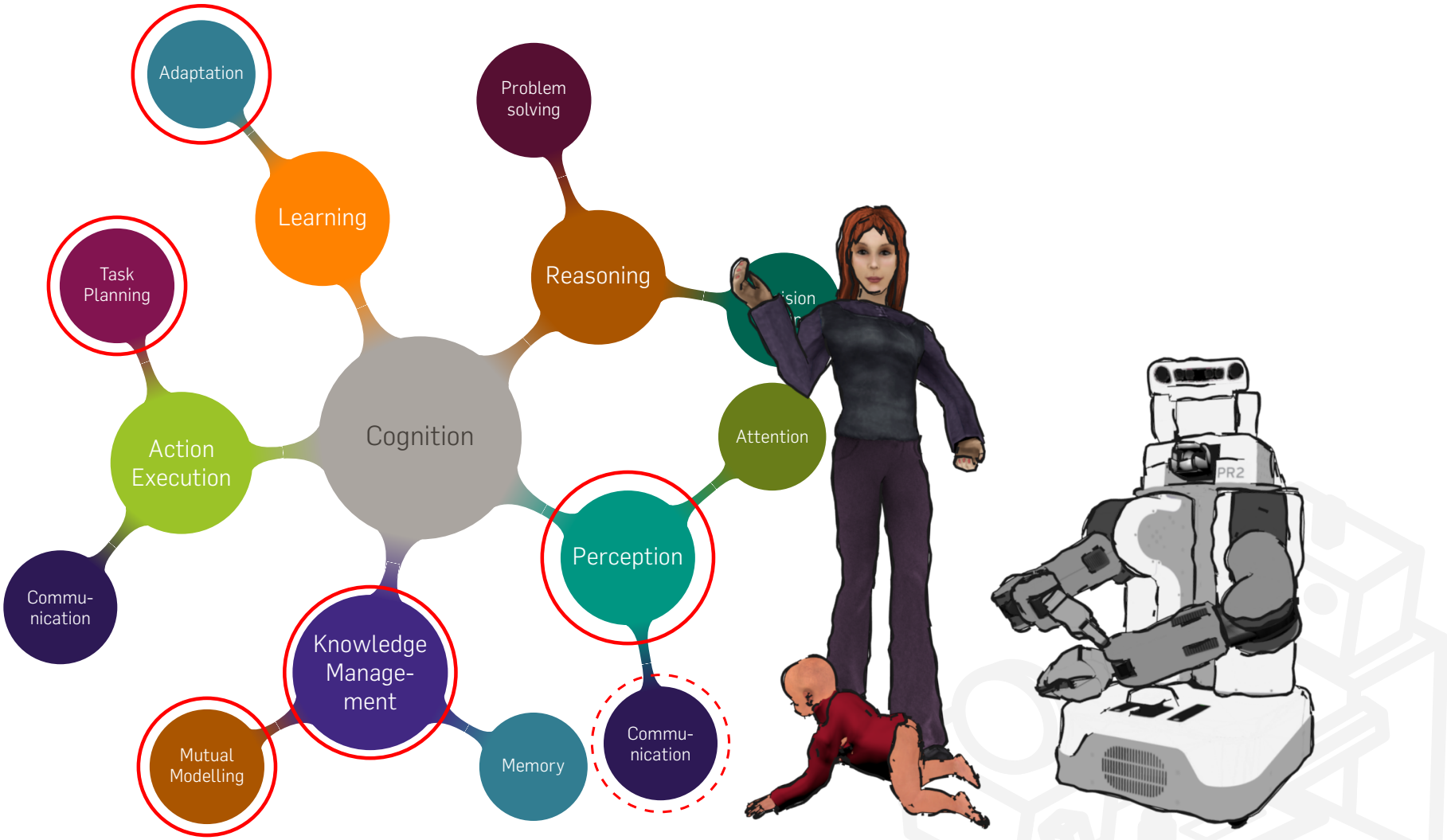
Memory


PR2


Adaptation
Learning
Problem solving
Reasoning
Task Planning
Action Execution
Cognition
Attention
Perception
Commu-nication
Knowledge Manage-ment
Mutual Modelling
Memory
Commu-nication
PR2


Adaptation
Learning
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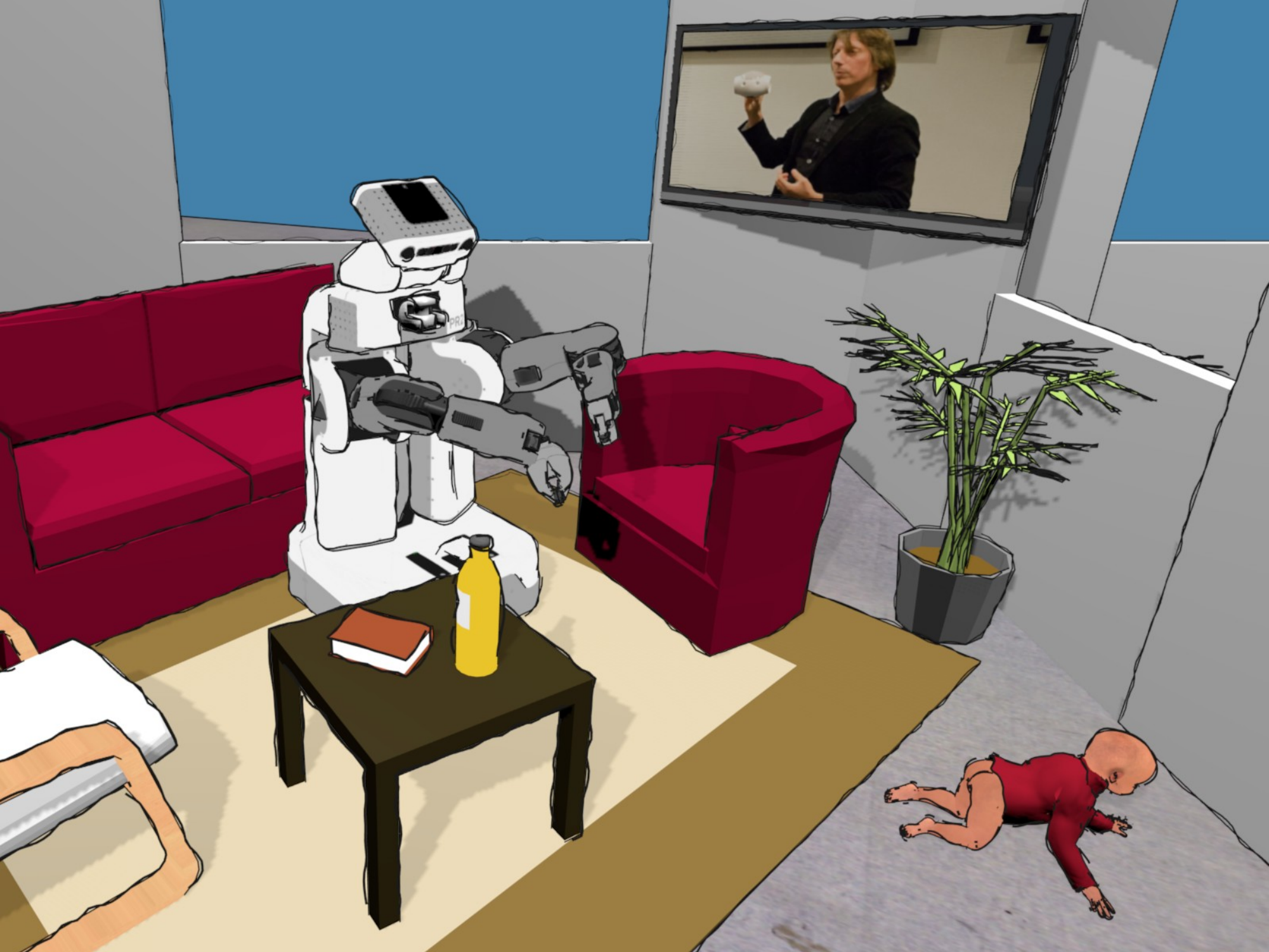
Commu-nication
PR2

OVERVIEW

1. Represent
2. Act
3. Adapt
4. What next?

REPRESENT



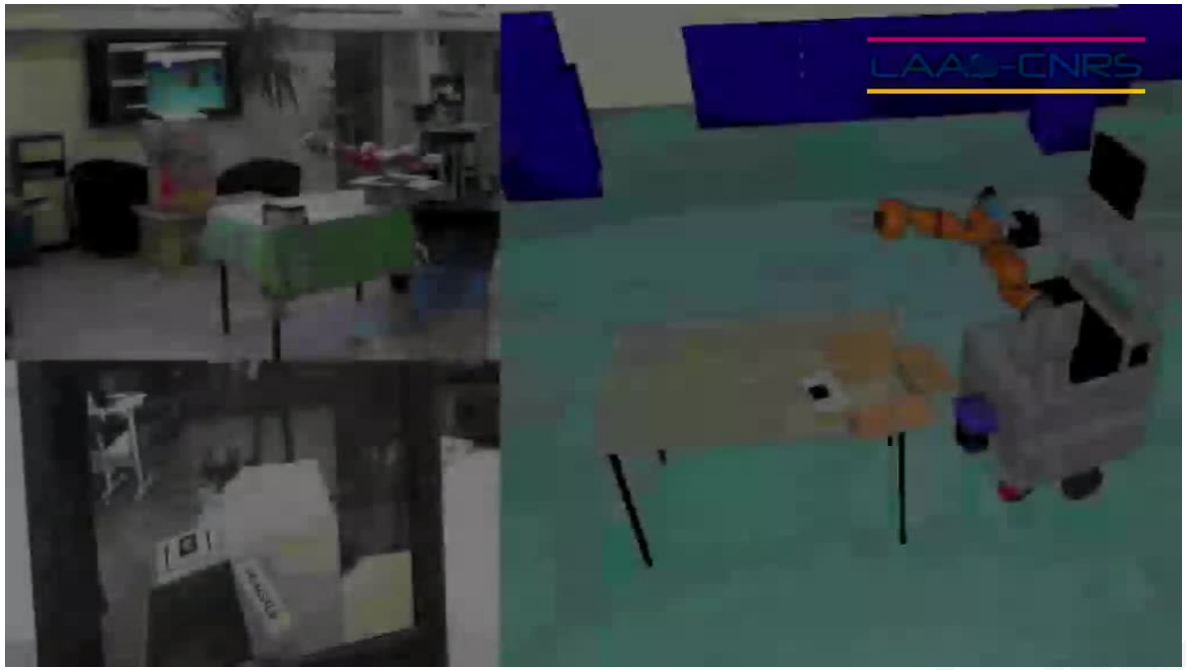

Mix of geometry, time, semantics
High geometric/temporal granularity (e.g. nodding)
Lots of common-sense knowledge, cultural background
Account for uncertainties
Remember the past, imagine the future

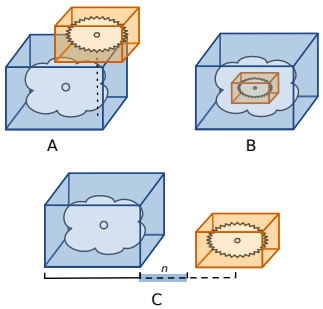
REPRESENTATION

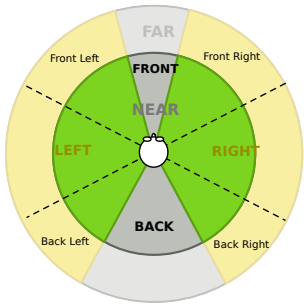
Building robotic qualia: “what it is like for the robot to experience…”

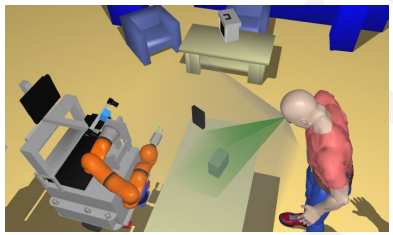
1. From situation assessment…
2. …to symbolic models…
3. …to perspective taking…
4. …to(wards) mutual modelling

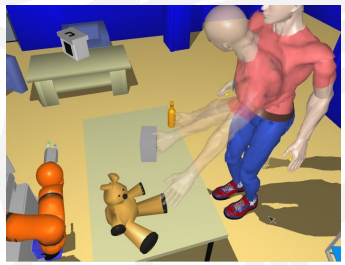
SITUATION ASSESSMENT





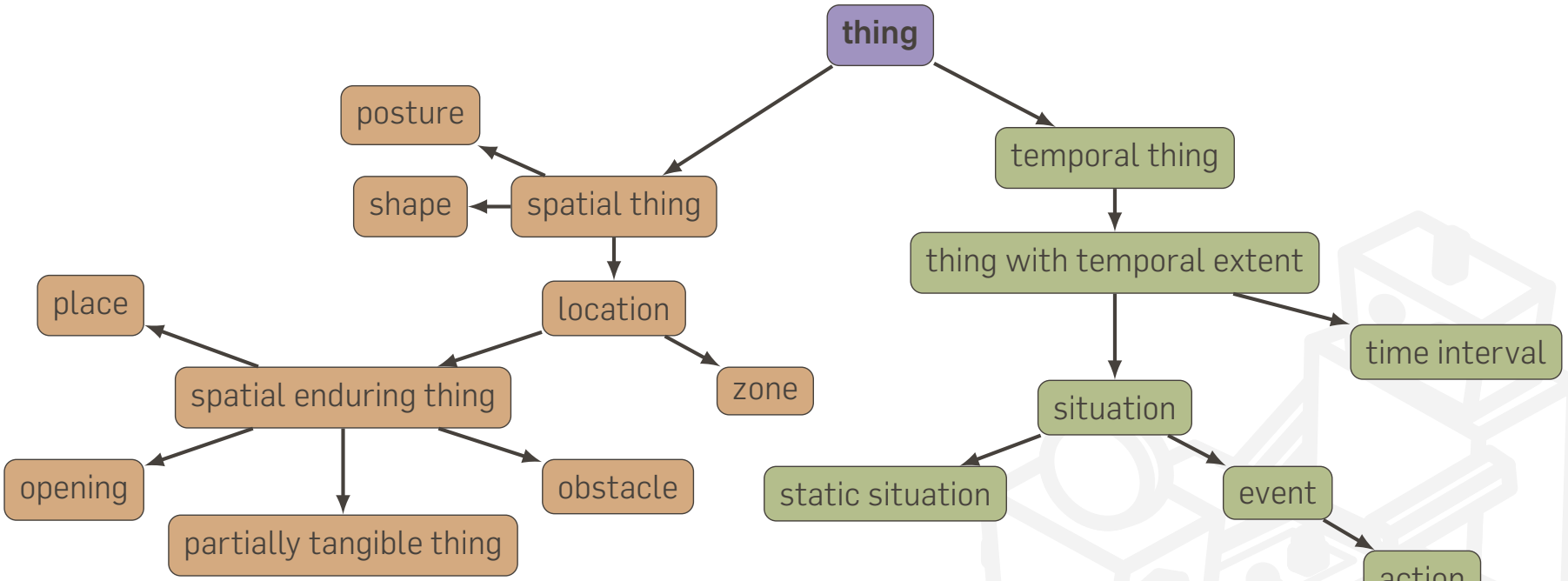




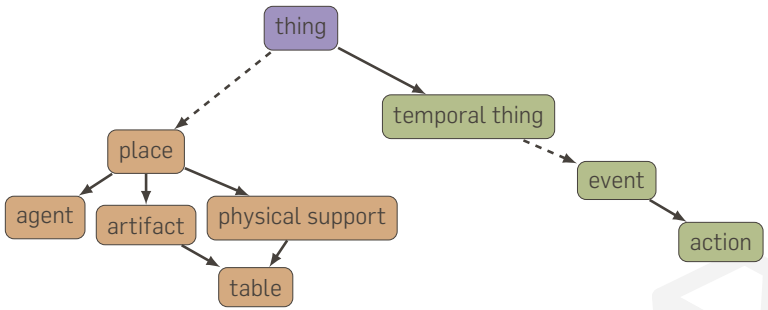


Subject	Predicate	Object
Location	isAt ≡ cyc:objectFoundInLocation	Location
	→ isOn ≡ cyc:above_Touching	
	→ isIn	
	→ isNextTo	
Location	isAbove ≡ cyc:above-Generally	Location
Location	isBelow	Location
Location	hasRelativePosition	Location
	→ behind ≡ cyc:behind-Generally	
	→ inFrontOf ≡ cyc:inFrontOf-Generally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

FROM SPATIAL MODEL TO SYMBOLIC MODEL

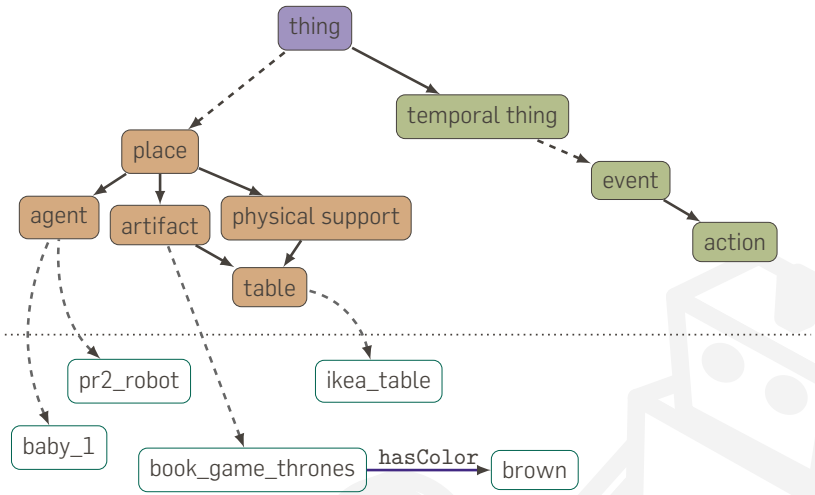


ONLINE INSTANTIATION



[Lemaignan, Alami, **Explicit Knowledge and the Deliberative Layer: Lessons Learned**, IROS 2013]

ONLINE INSTANTIATION



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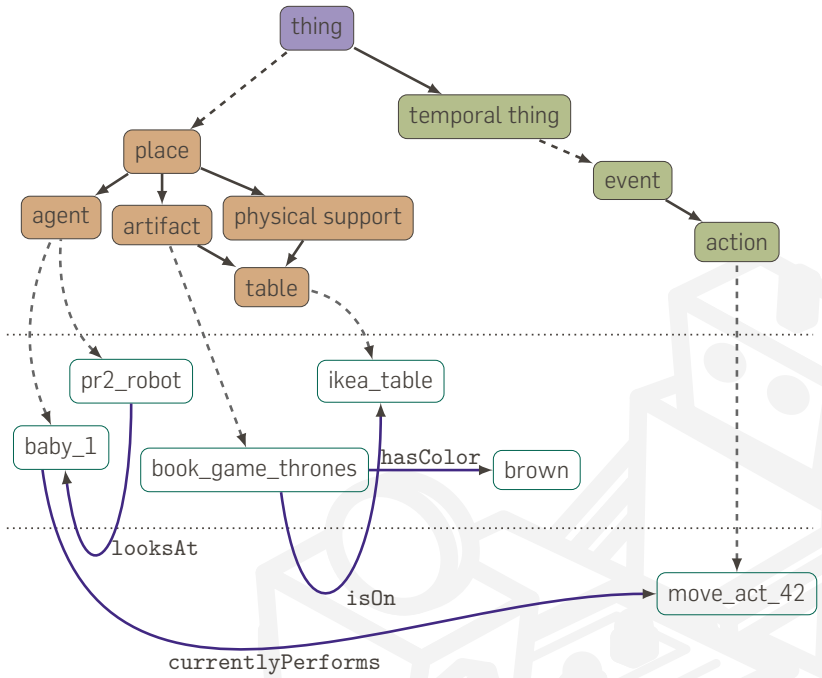


[Lemaignan, Alami, **Explicit Knowledge and the Deliberative Layer: Lessons Learned**, IROS 2013]

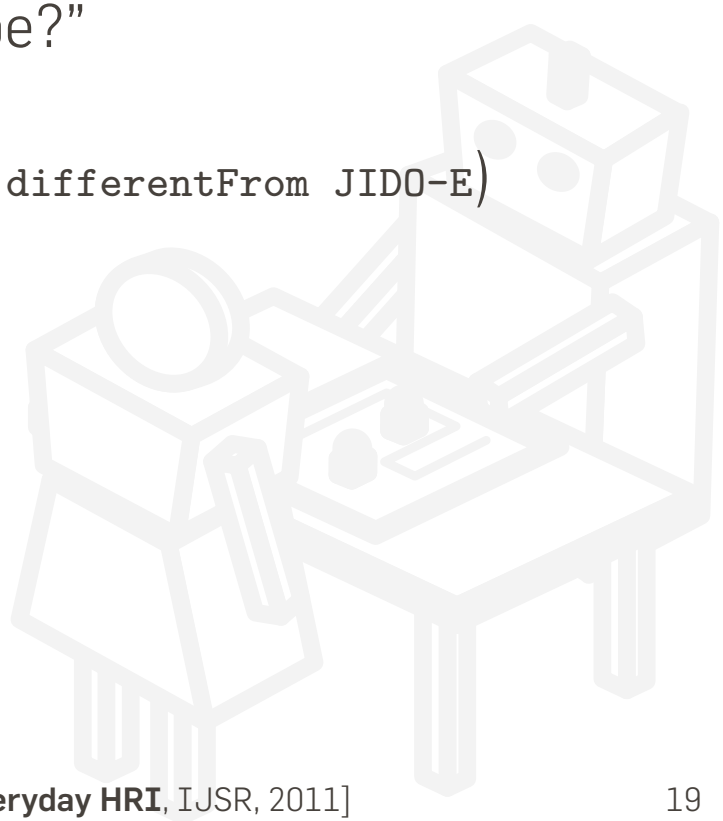

LAAS-CNRS

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

"Where is the other tape?"

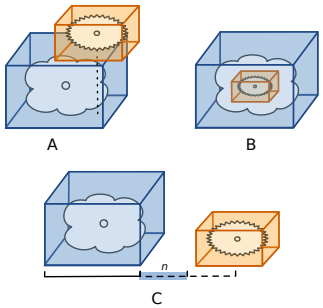
↓

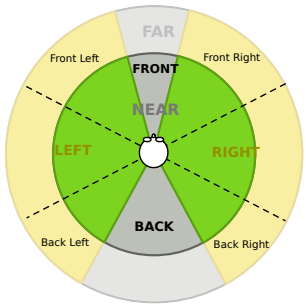
find(`?obj isAt ?loc, ?obj type VideoTape, ?obj differentFrom JIDO-E`)

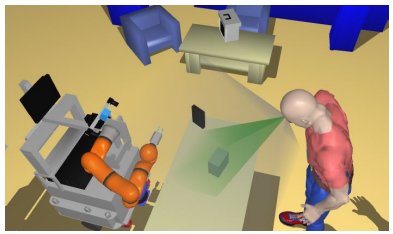


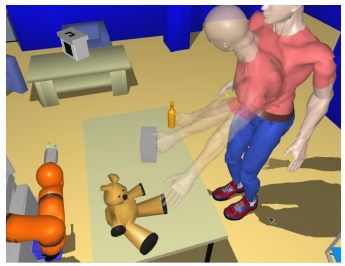
[Lemaignan et al., **Grounding the Interaction: Anchoring Situated Discourse in Everyday HRI**, IJSR, 2011]

PERSPECTIVE TAKING

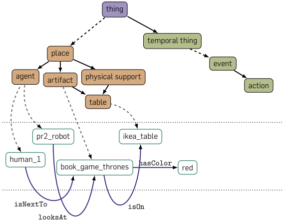


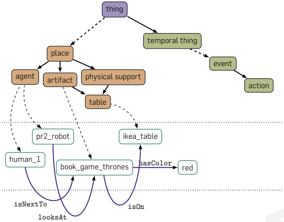


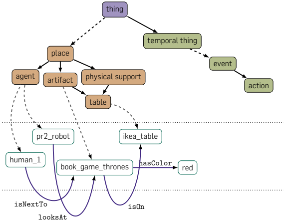




MULTIPLE SYMBOLIC MODELS







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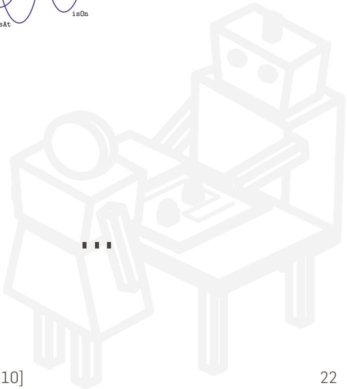
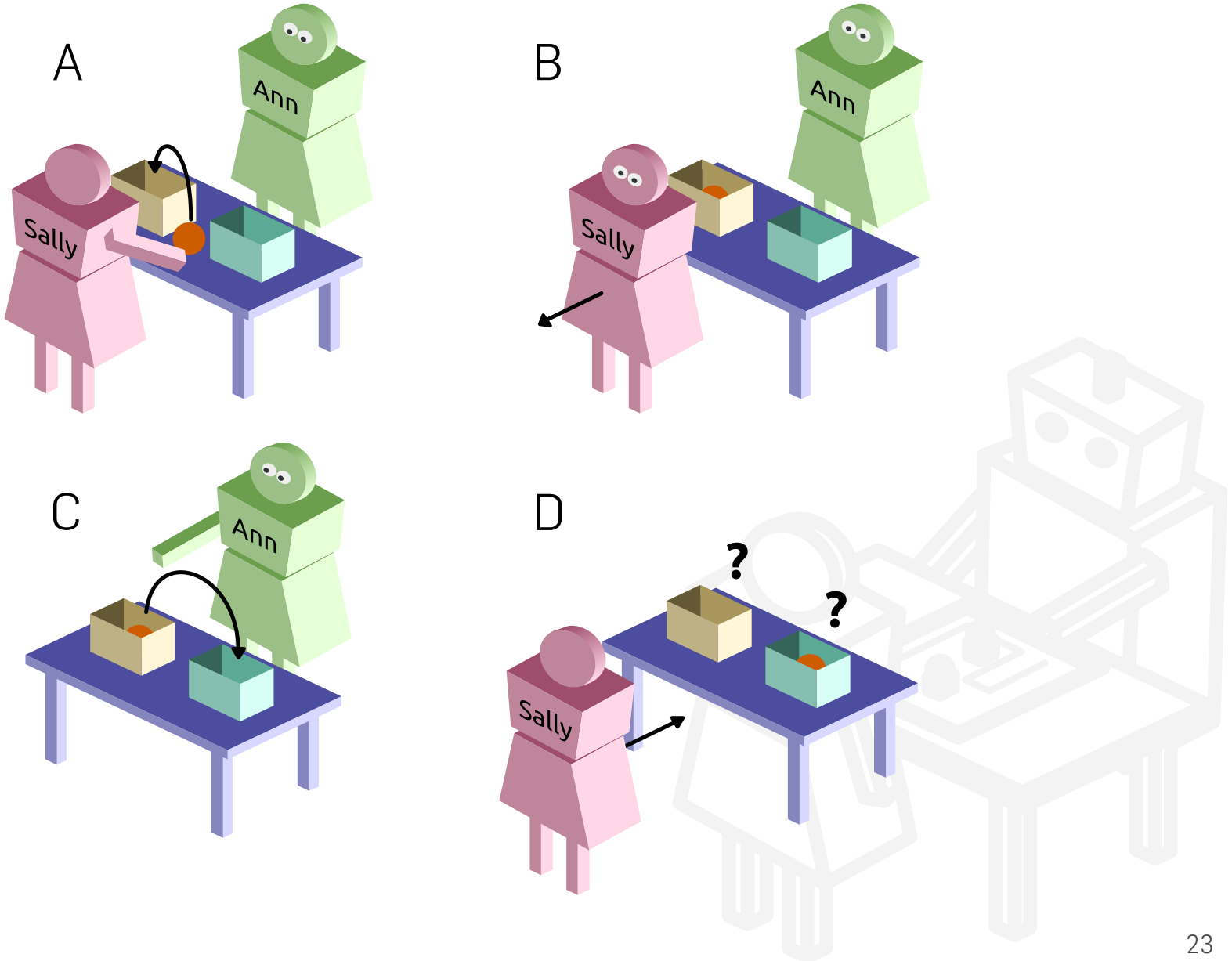


[Ros et al., **Which One? Grounding the Referent Based on Efficient HRI**, ROMAN 2010]

THE FALSE-BELIEF EXPERIMENT



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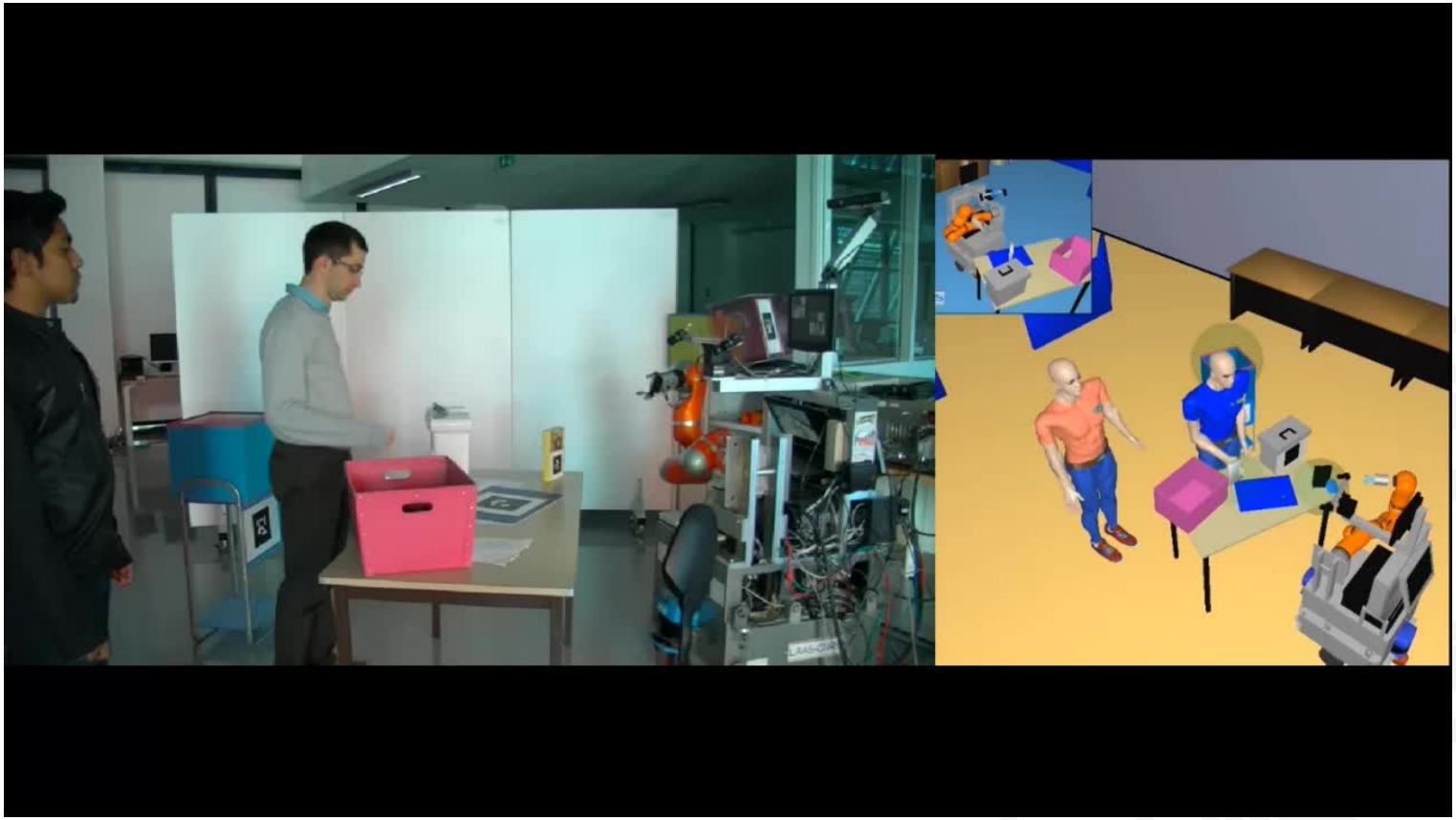
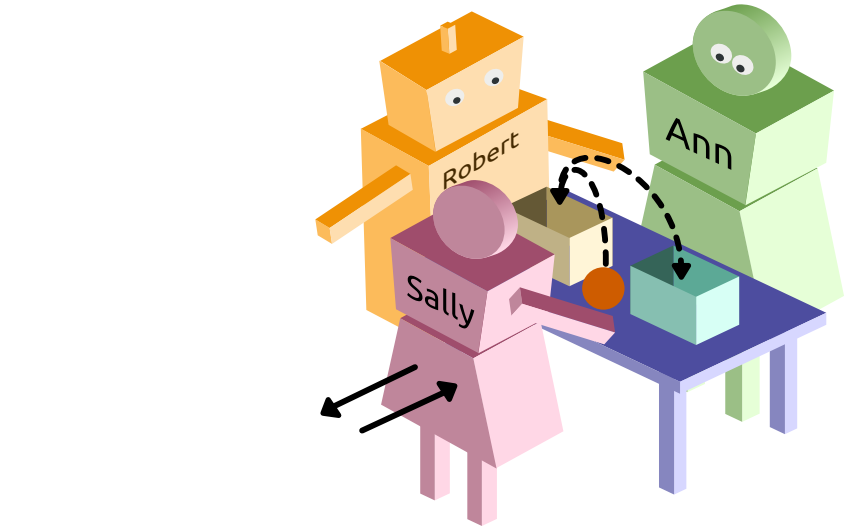
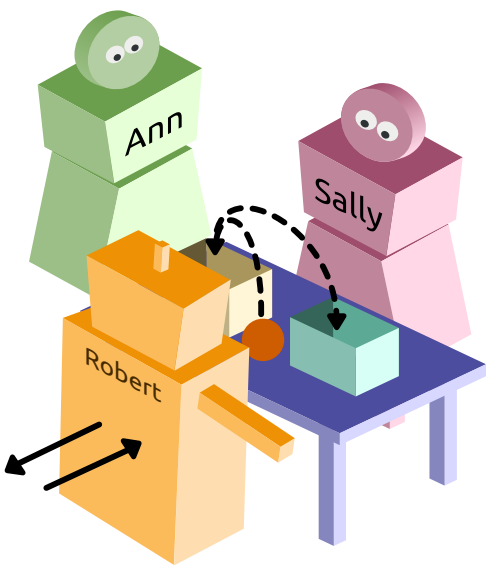
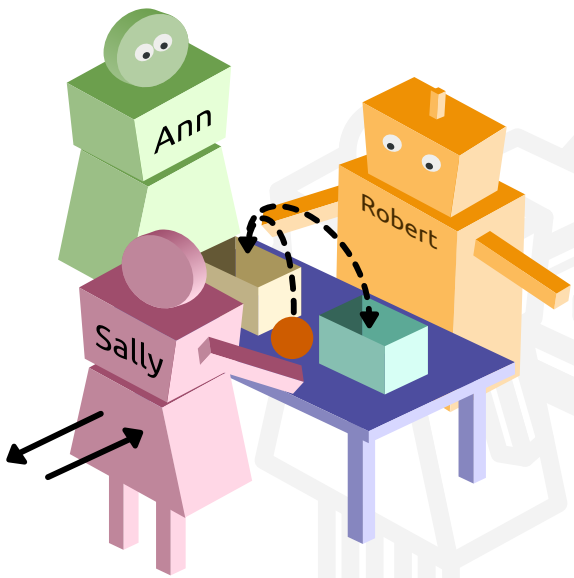


[Warnier et al., **When the Robot Puts Itself in Your Shoes**, ROMAN 2012]

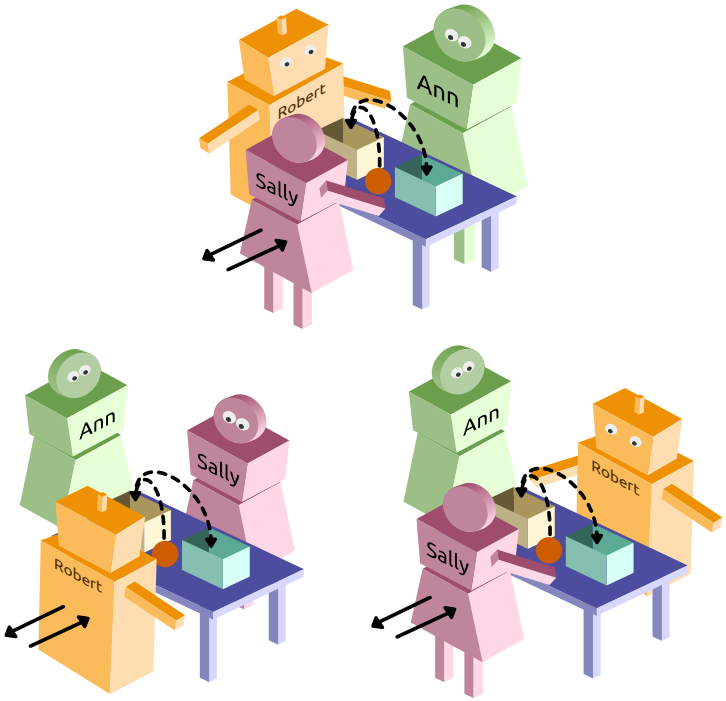
THE FALSE-BELIEF EXPERIMENT, RELOADED







THE FALSE-BELIEF EXPERIMENT, RELOADED



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

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

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

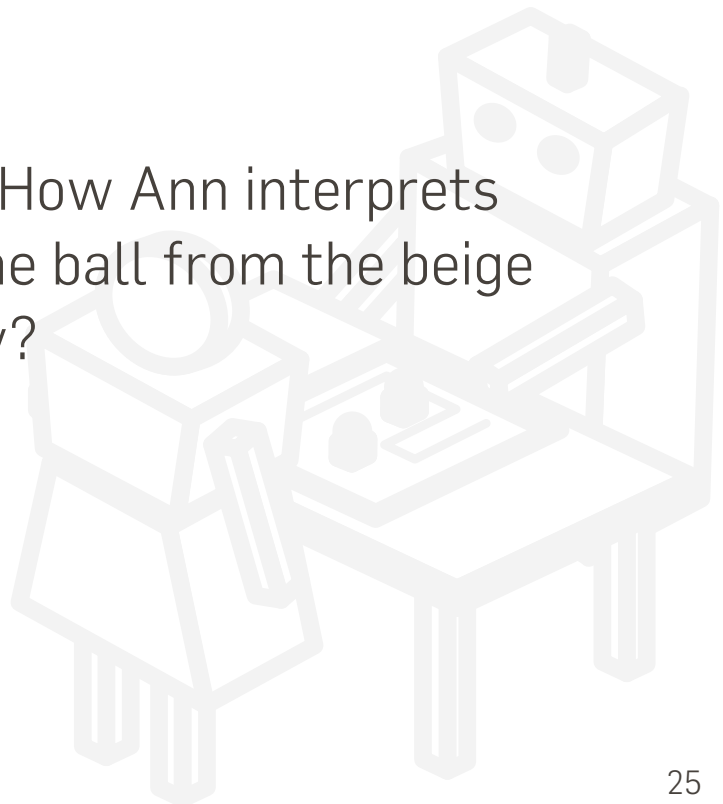
THE FALSE-BELIEF EXPERIMENT, RELOADED

Robot is the observer

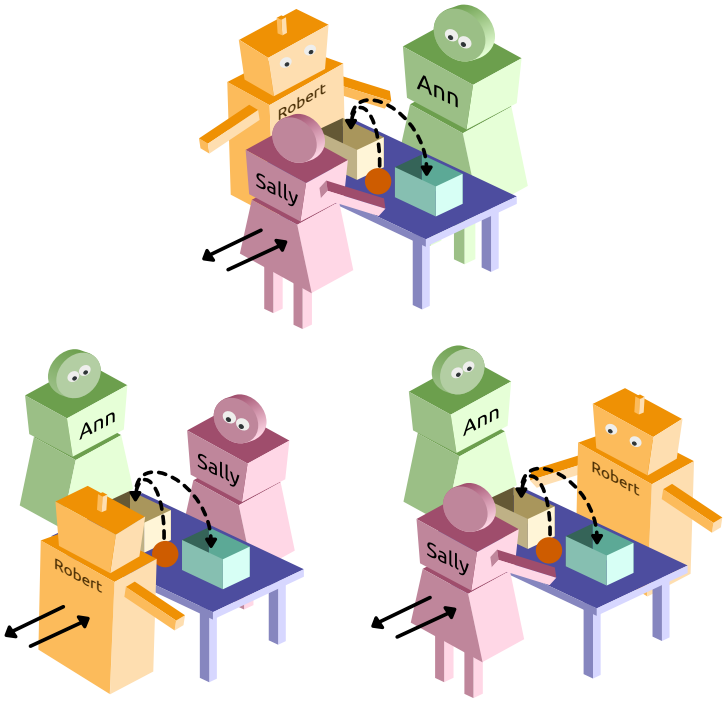
$\mathcal{M}^{\circ}(R, \text{Sally}|\text{Ann}, plans)$? can the human verbalise it? i.e. $\mathcal{M}(H, R, \mathcal{M}(R, H, plans))$?

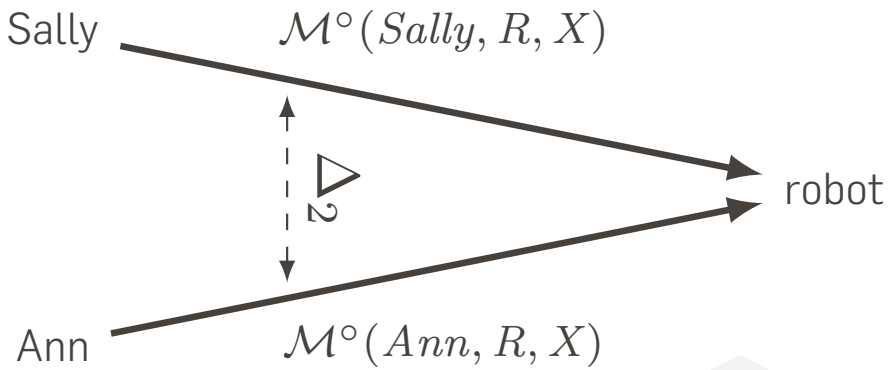
Robot is an active participant

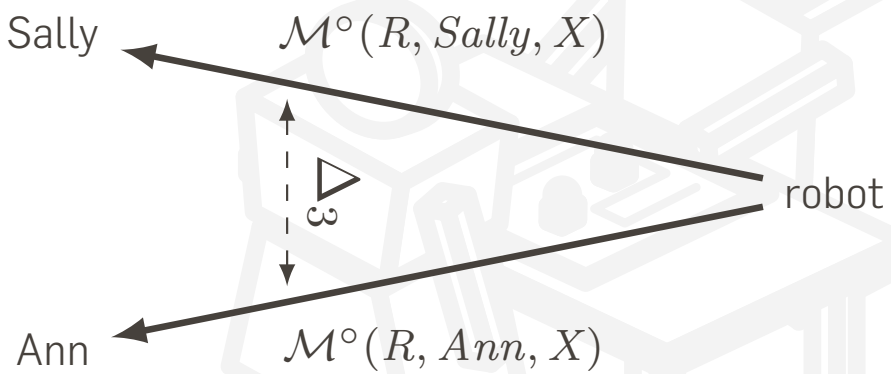
$\mathcal{M}(H, R, knowledge|plans|goals)$? i.e. How Ann interprets the behaviour of a robot who moves the ball from the beige box to the blue box while Sally is away?



THE FALSE-BELIEF EXPERIMENT, RELOADED







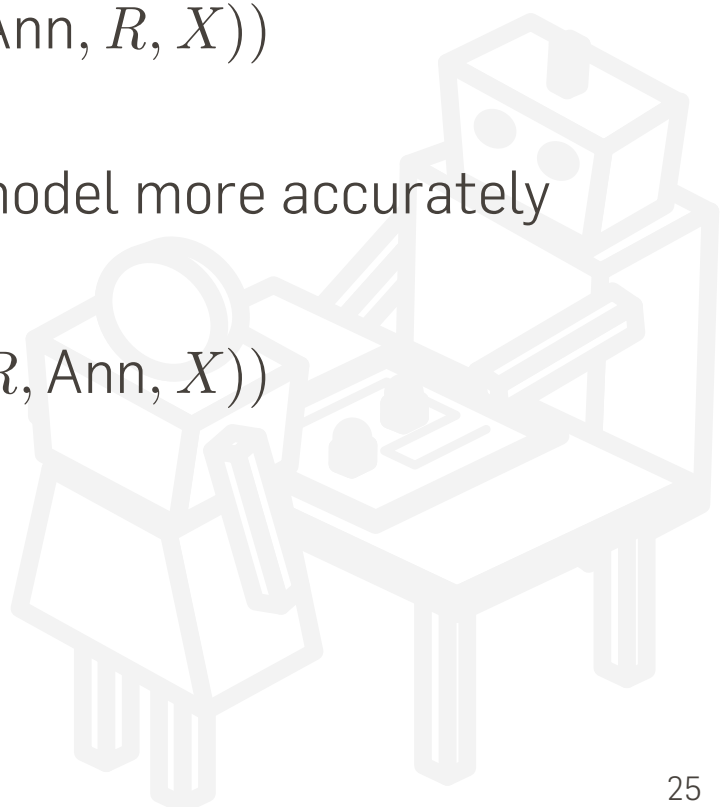
THE FALSE-BELIEF EXPERIMENT, RELOADED

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

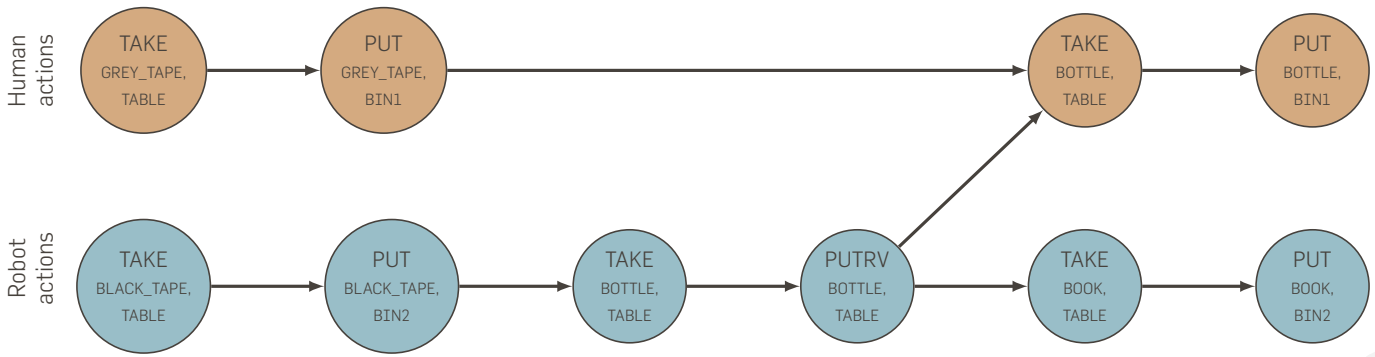
$$\Delta_2 = \Delta(\mathcal{M}(\text{Sally}, R, X), \mathcal{M}(\text{Ann}, R, X))$$

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

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



PLANNING FOR THE HUMAN



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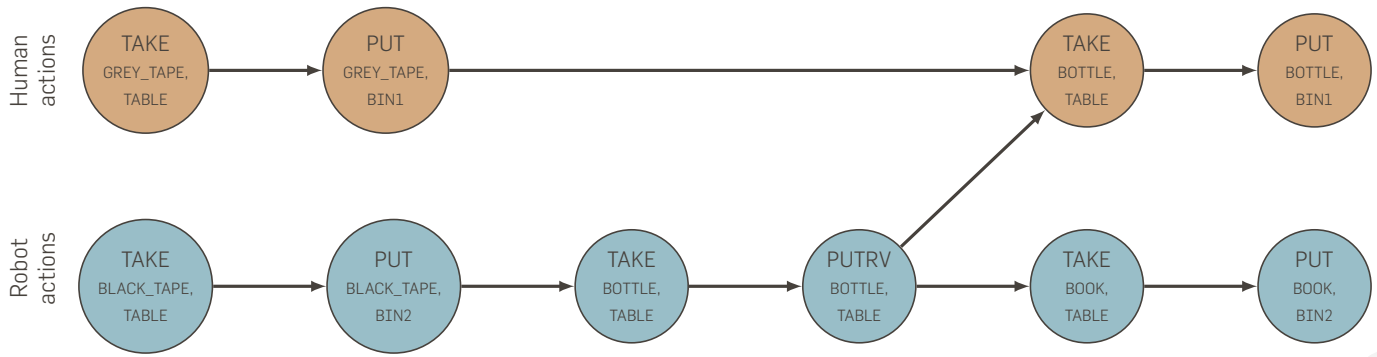
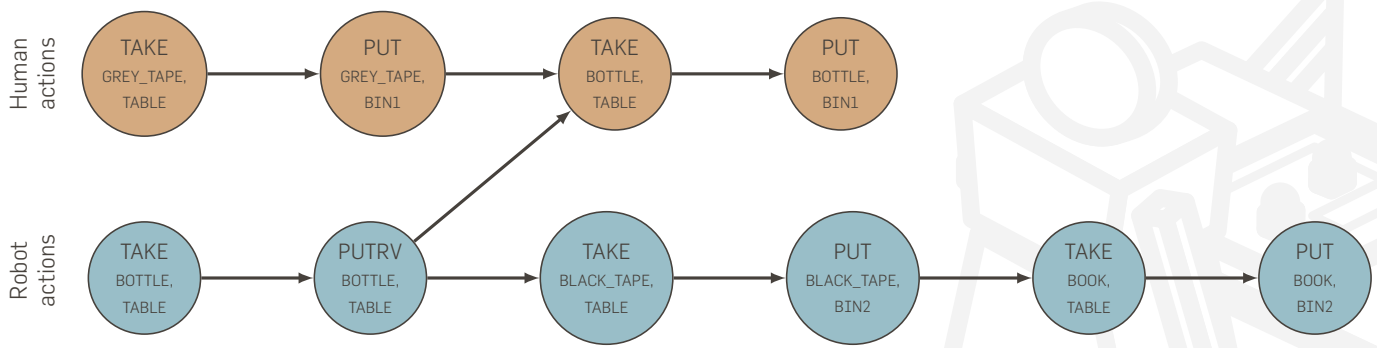
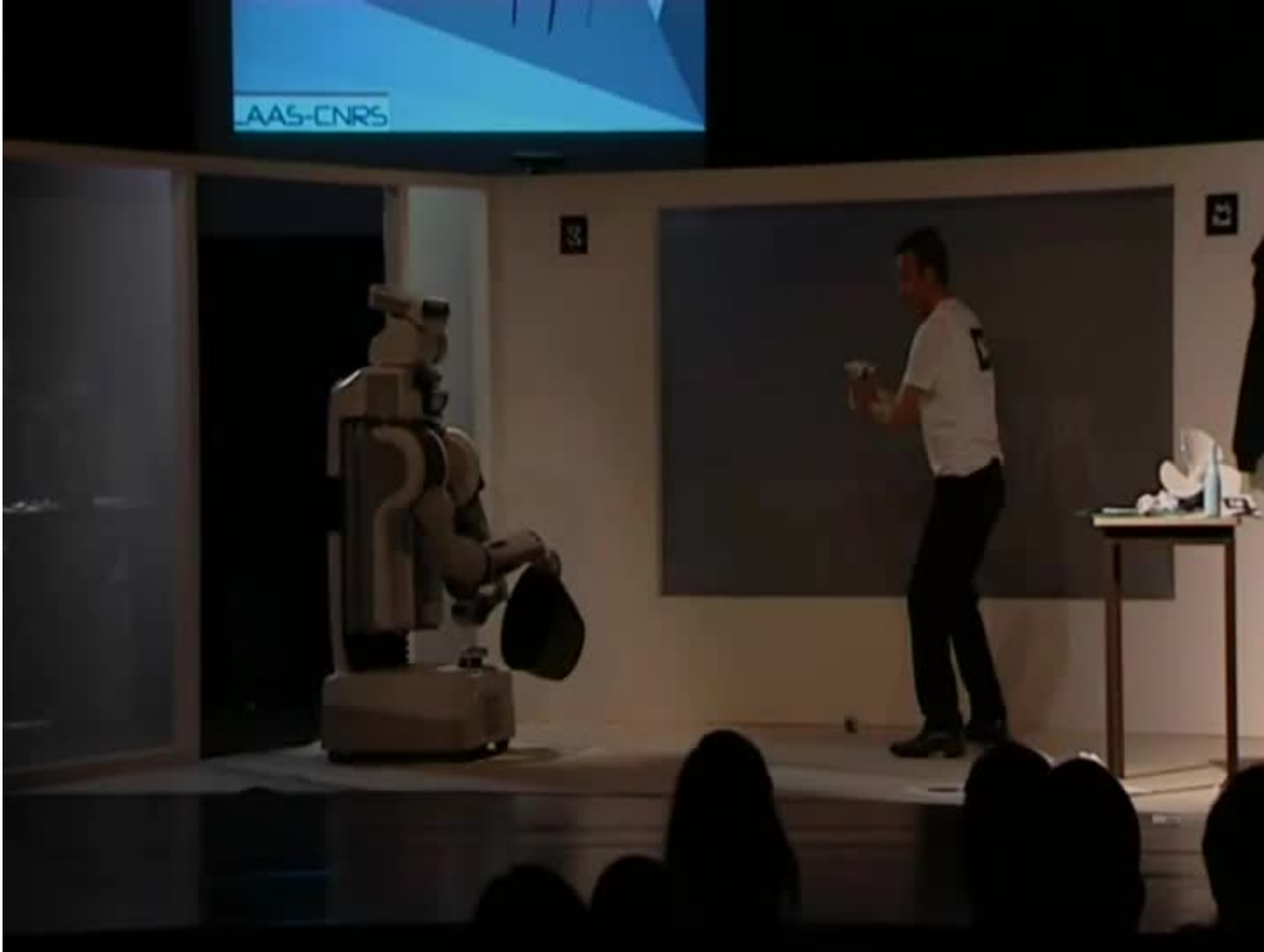


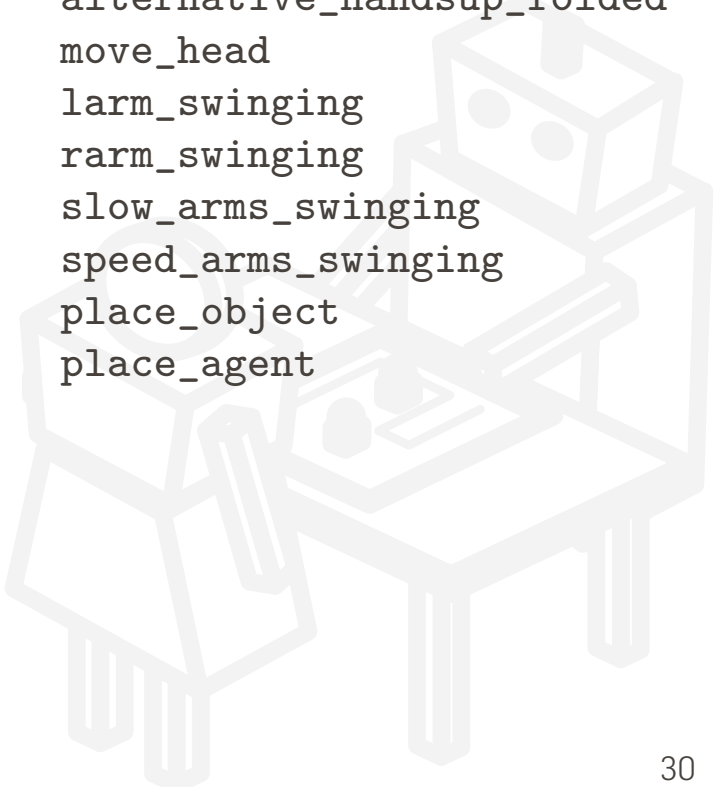


ACT

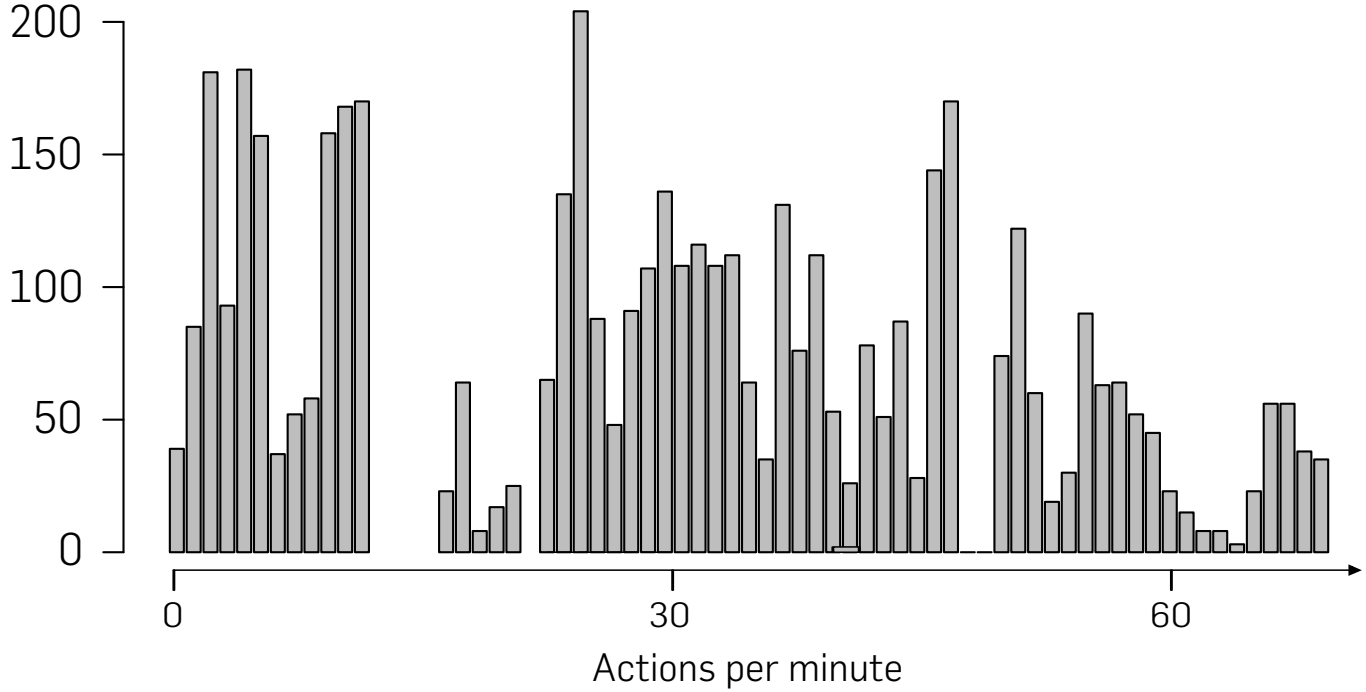

PR2
PR2


LAAS-CNRS

```
grab
release
detect
detect_and_grab
release_gripper
grab_gripper
open_gripper
close_gripper
pick
basicgive
basicgrab
amit_give
goto
cancel
carry
enabledevileye
disabledevileye
setpose
manipose
restpose
tuckedpose
idle
look_at
look_at_xyz
track
track_human
cancel_track
look_at_ros
glance_to
sweep_look
setup_scenario
lock_object
unlock_object
wait
basket
gym
handsup
arms_against_torso
handsup_folded
alternative_handsup_folded
move_head
larm_swinging
rarm_swinging
slow_arms_swinging
speed_arms_swinging
place_object
place_agent
```

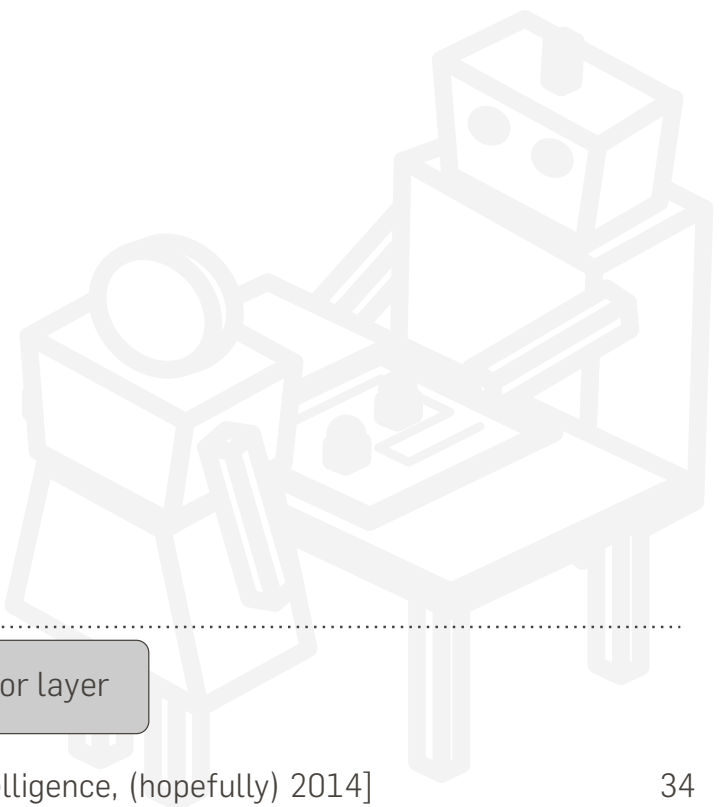


grab	basicgive	setpose	unlock_object
release	handover	manipose	wait
detect	amit_give	extractpose	display
detect_and_grab	put_accessible	restpose	init
say	show	settorso	basket
satisfied	hide	tuckedpose	gym
sorry	goto	idle	handsup
release_gripper	moveclose	movearm	arms_against_torso
grab_gripper	carry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



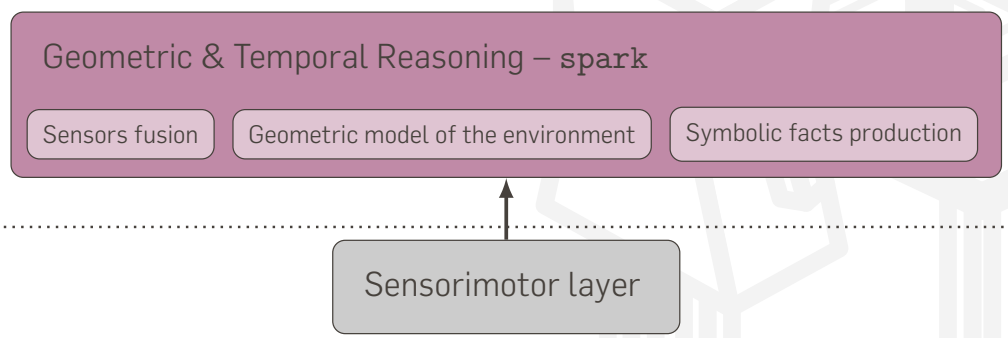
lightbar	on_bumped	active_wait
on_toy_added	up_down_row	closeeyes
move	wakeup	lightpattern
background_blink	look_at_caresses	turn
undock	on_toy_removed	idle
pulse_row	sneak_in	playsound
blink	on_lolette_removed	blush
on_lolette	fall_asleep	
placeeyes	look_at_lolette	

ONE ARCHITECTURE INSTANTIATION



Sensorimotor layer

ONE ARCHITECTURE INSTANTIATION



[Lemaignan et al., **Human-Robot Interaction: Tackling AI challenges**, Artifical Intelligence, (hopefully) 2014]

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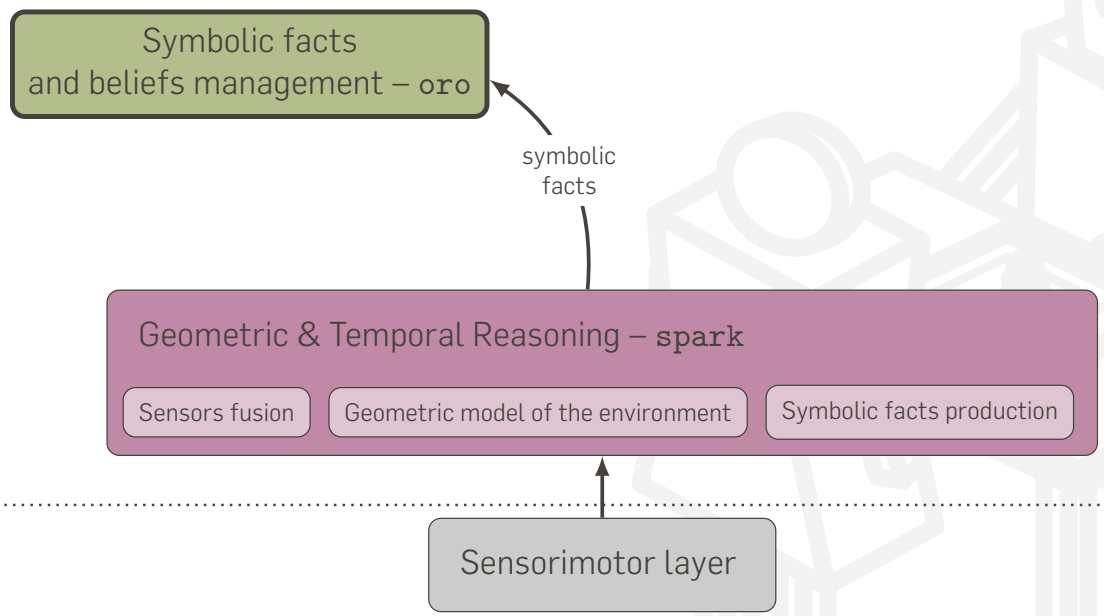
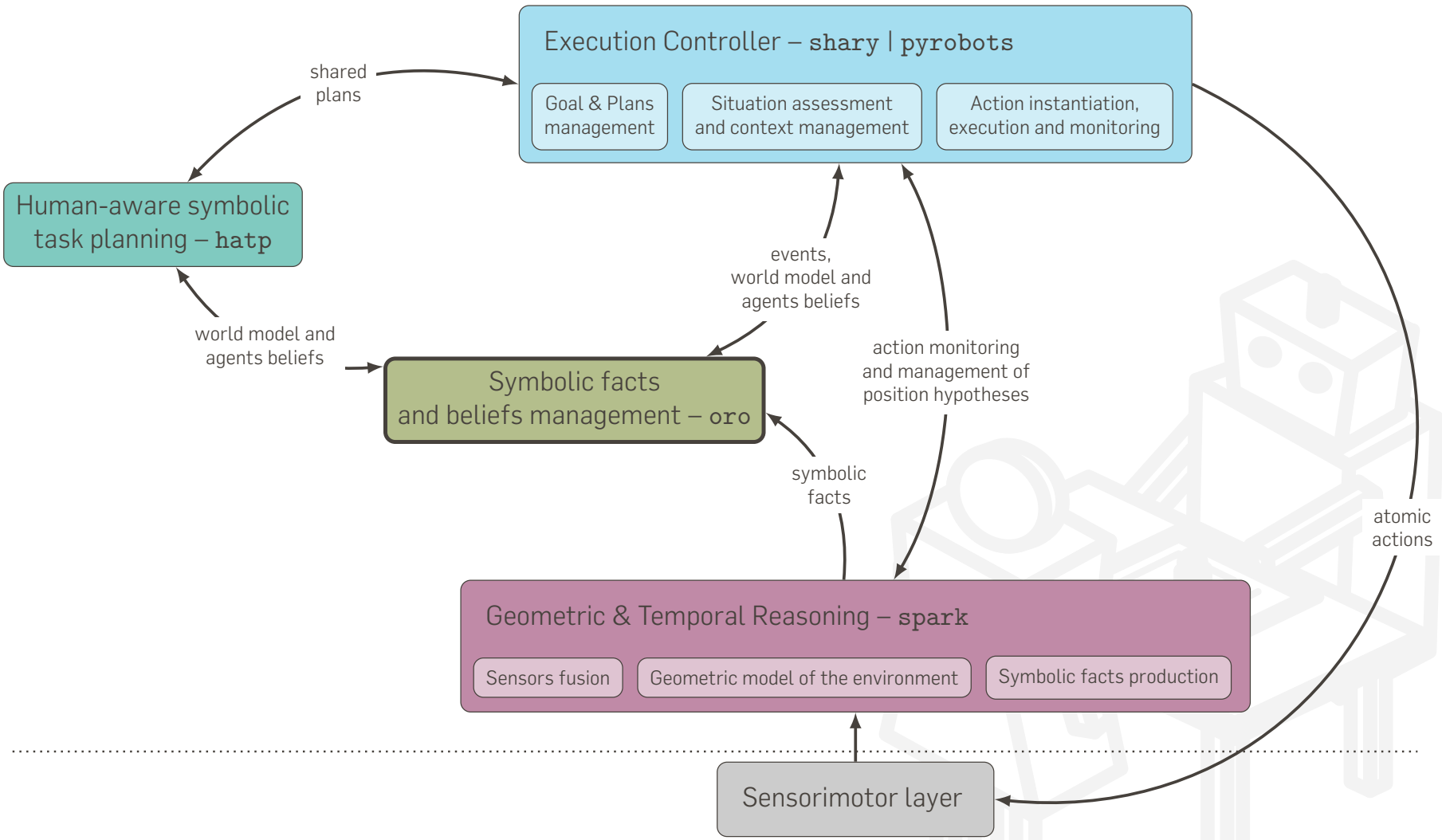


[Lemaignan et al., **Human-Robot Interaction: Tackling AI challenges**, Artifical Intelligence, (hopefully) 2014]

ONE ARCHITECTURE INSTANTIATION



[Lemaignan et al., **Human-Robot Interaction: Tackling AI challenges**, Artifical Intelligence, (hopefully) 2014]

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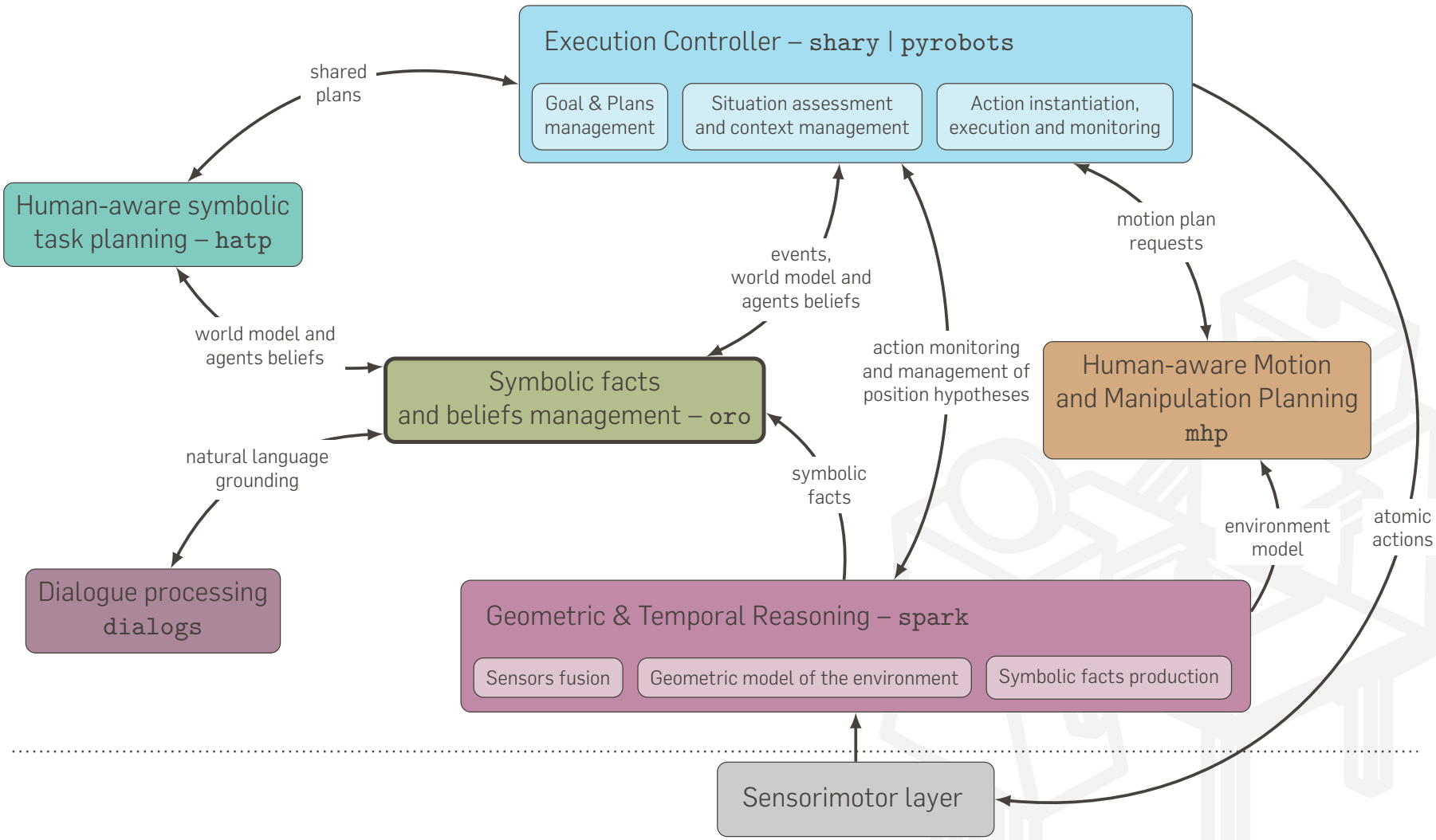
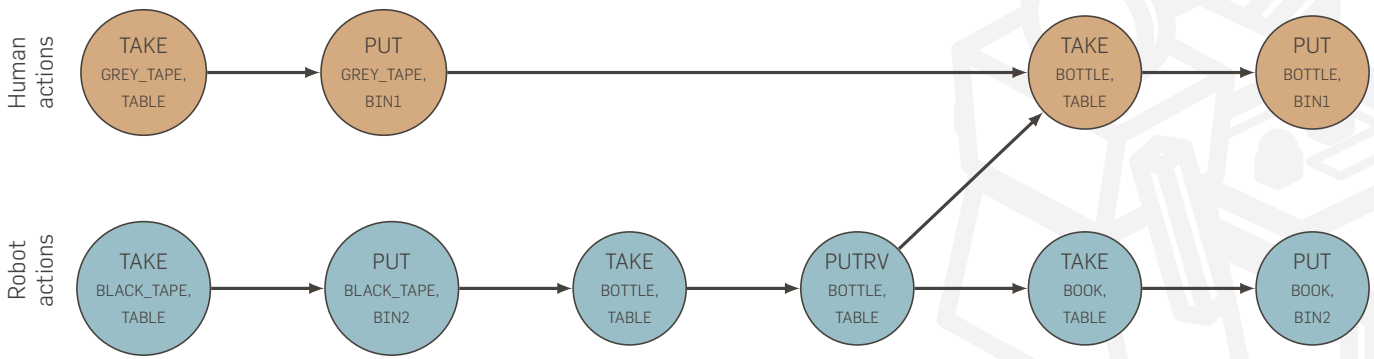


[Lemaignan et al., **Human-Robot Interaction: Tackling AI challenges**, Artifical Intelligence, (hopefully) 2014]

PLANNING FOR THE HUMAN

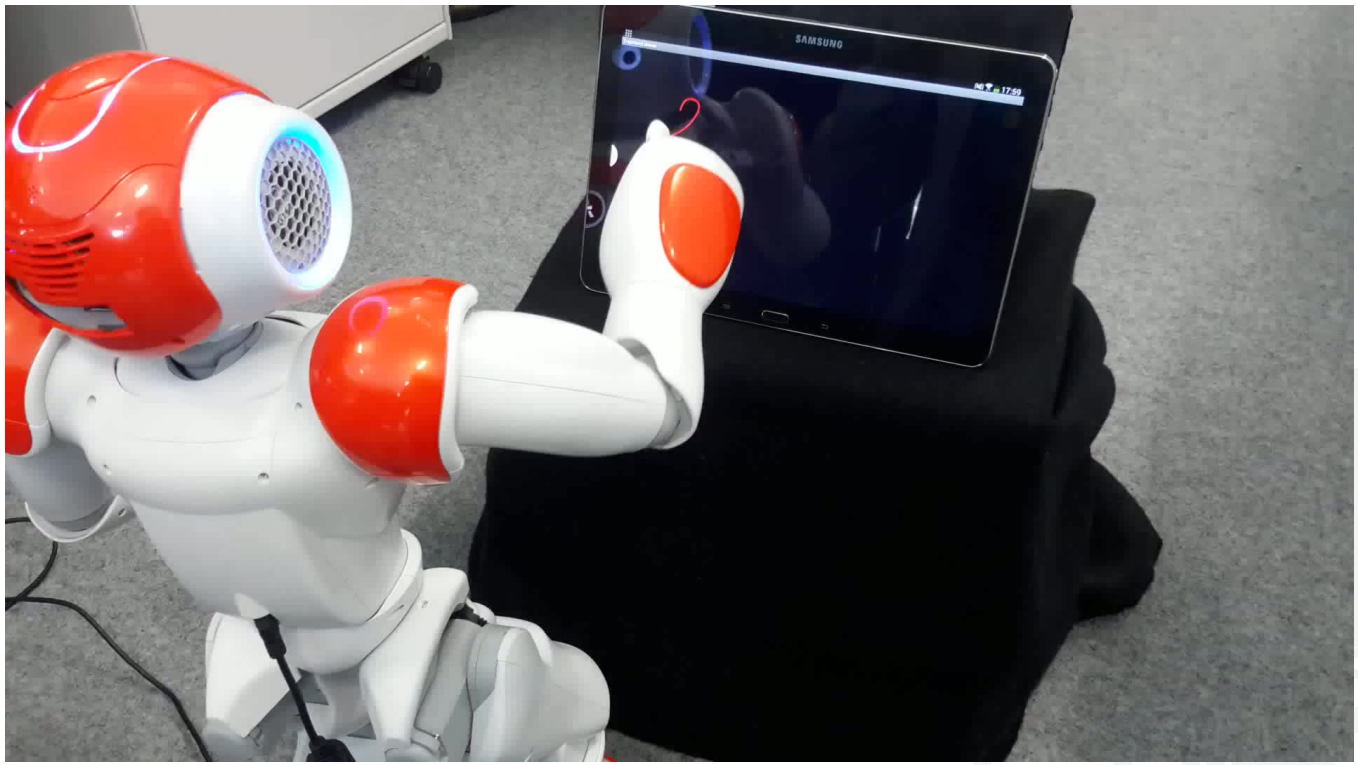



LAAS-CNRS

ADAPT

LIFE-LONG ADAPTATION?

CoWriter: Learning by Teaching



LIFE-LONG ADAPTATION?

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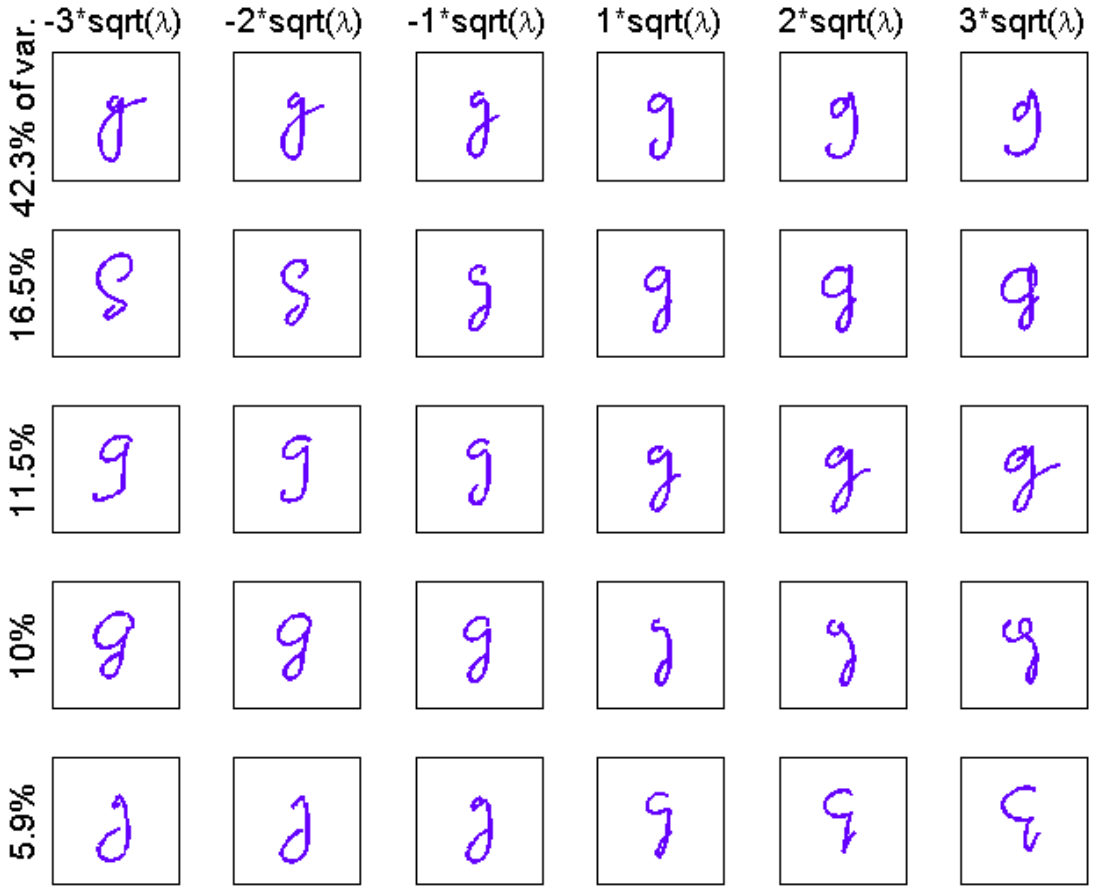
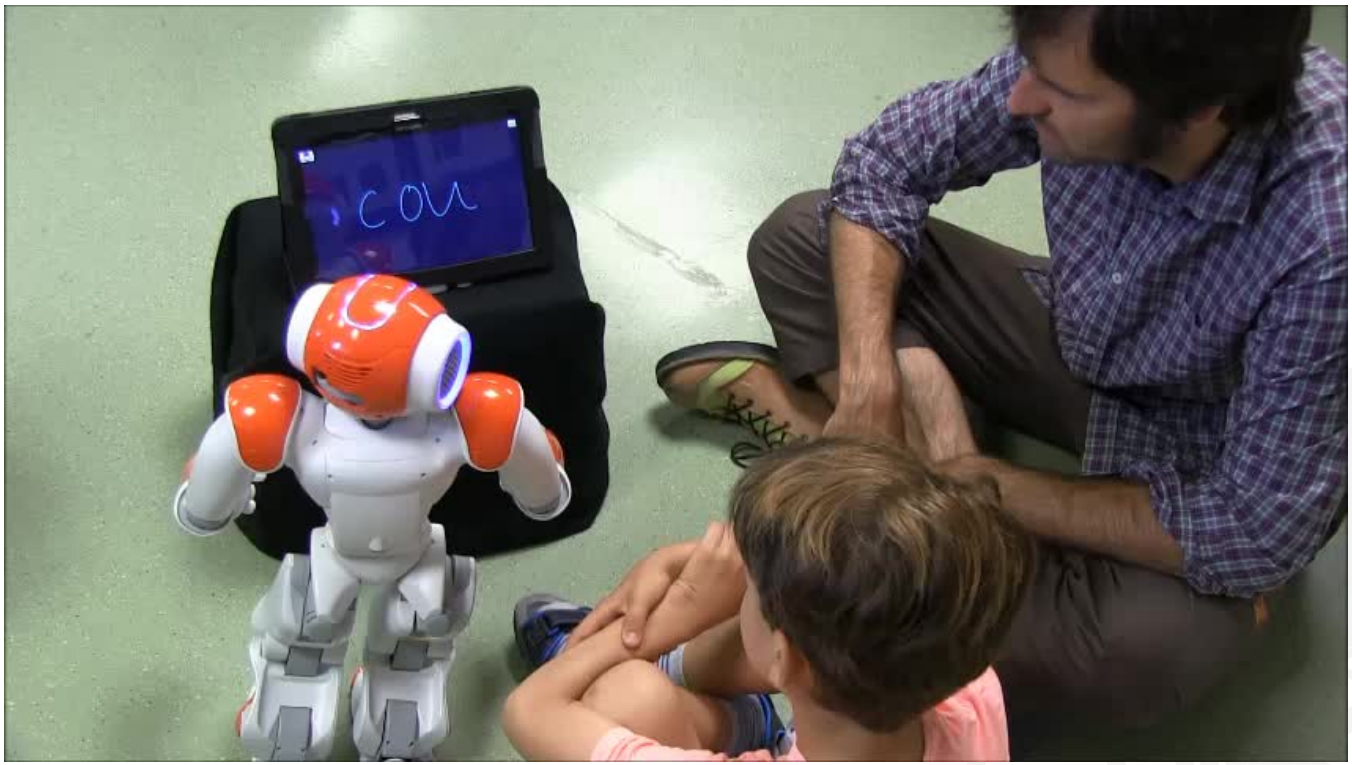
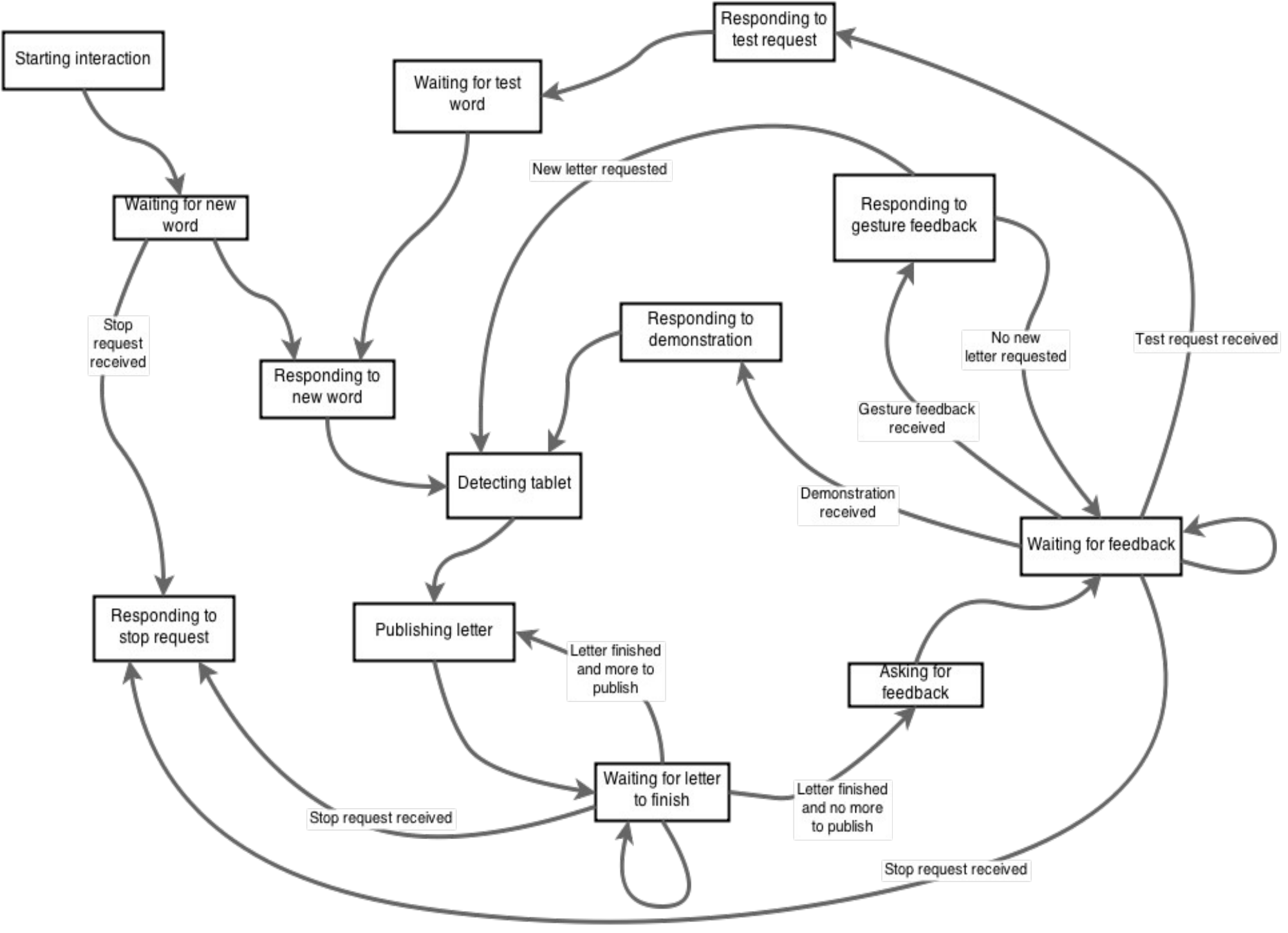


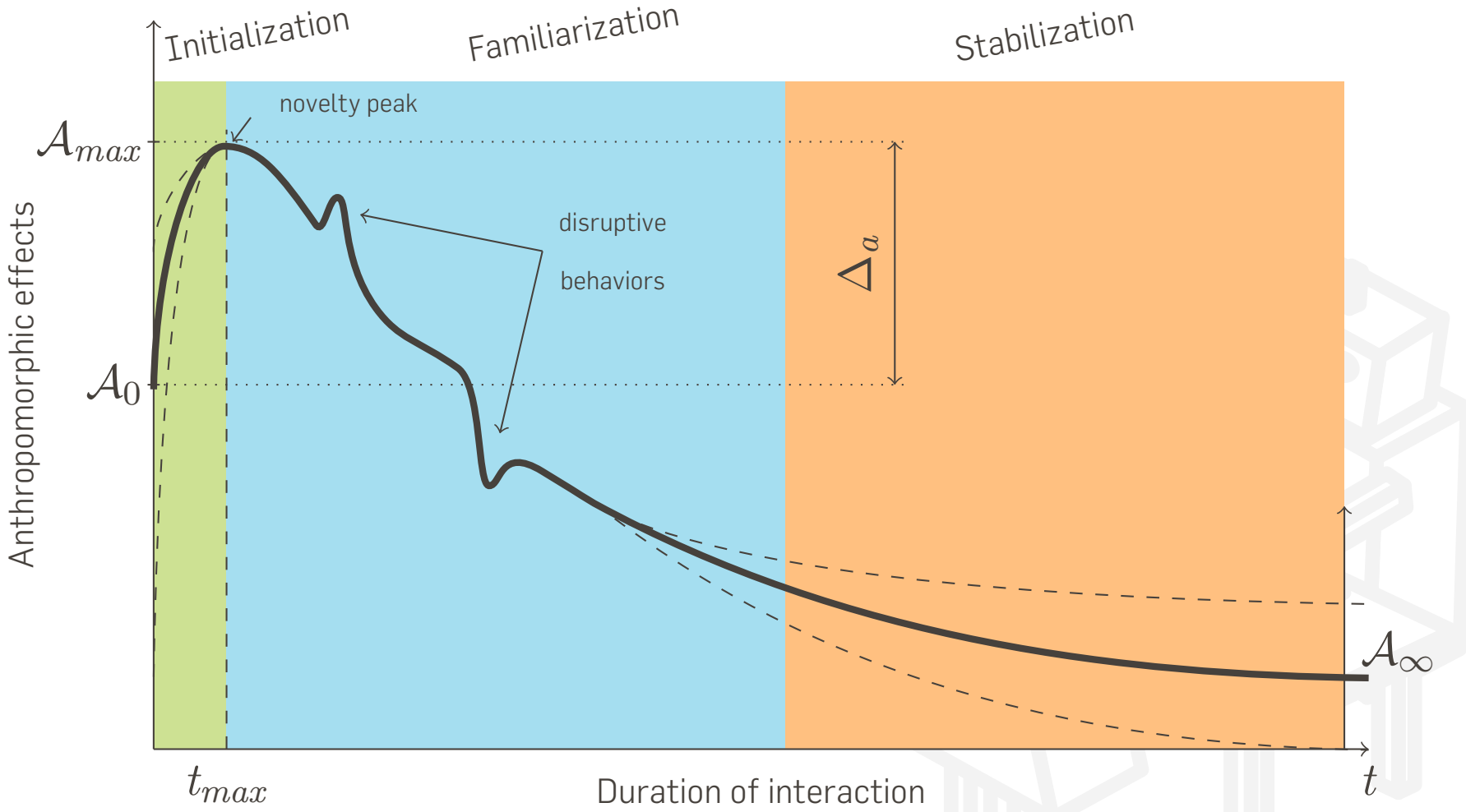
LIFE-LONG ADAPTATION?

CoWriter: Learning by Teaching



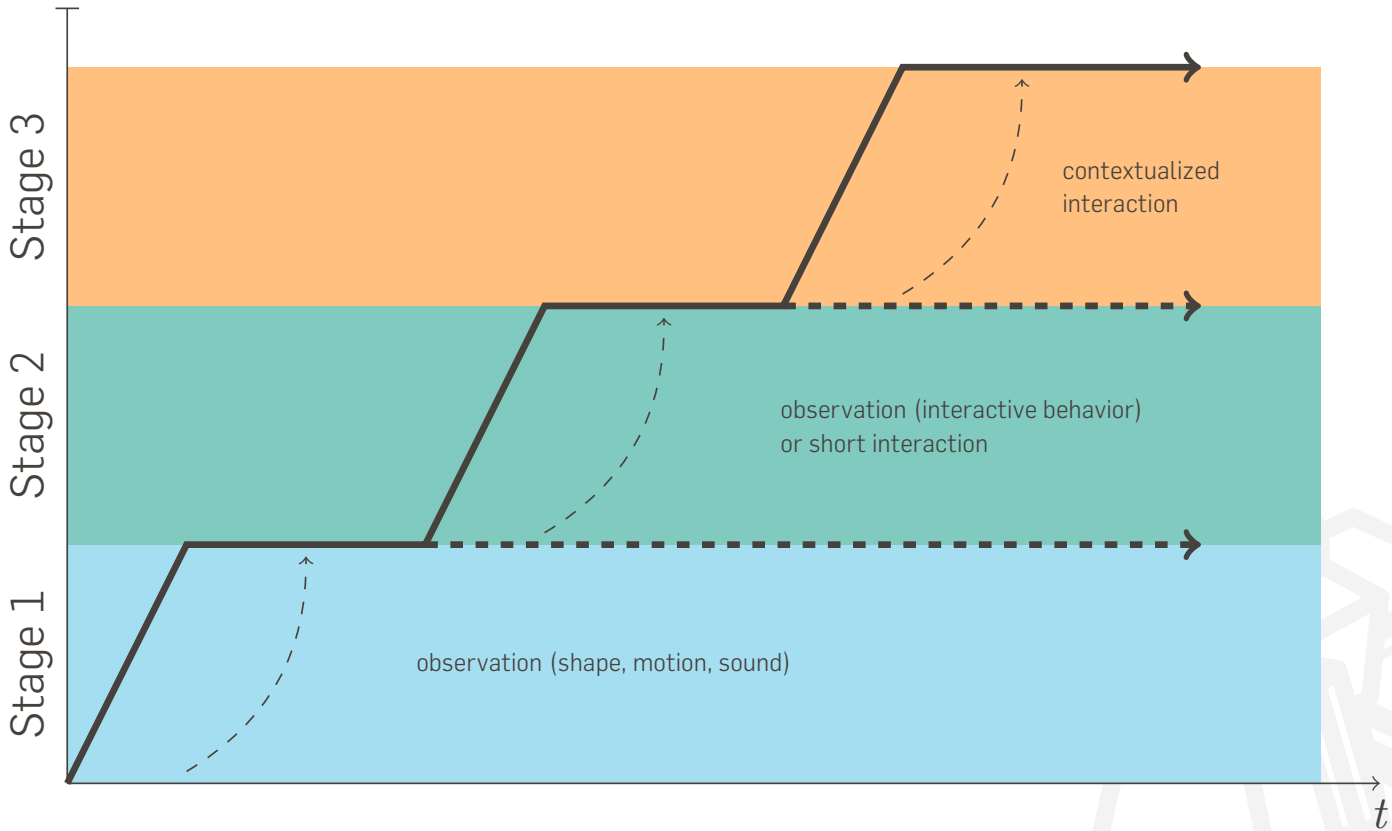

Starting interaction
Responding to test request
Waiting for test word
Waiting for new word
New letter requested
Responding to gesture feedback
Stop request received
Responding to new word
Responding to demonstration
No new letter requested
Test request received
Gesture feedback received
Detecting tablet
Demonstration received
Waiting for feedback
Responding to stop request
Publishing letter
Letter finished and more to publish
Asking for feedback
Waiting for letter to finish
Letter finished and no more to publish
Stop request received
Stop request received

HOW DO WE PERCEIVE ROBOT OVER TIME?



[Fink, Lemaignan, Dillenbourg, **Dynamics of Anthropomorphism in HRI**, Frontiers in Cognitive Sciences, submitted]

COGNITIVE INTERPRETATION?



adapted mental model
$\longrightarrow$ adapted interaction
(anthropomorphic or not)

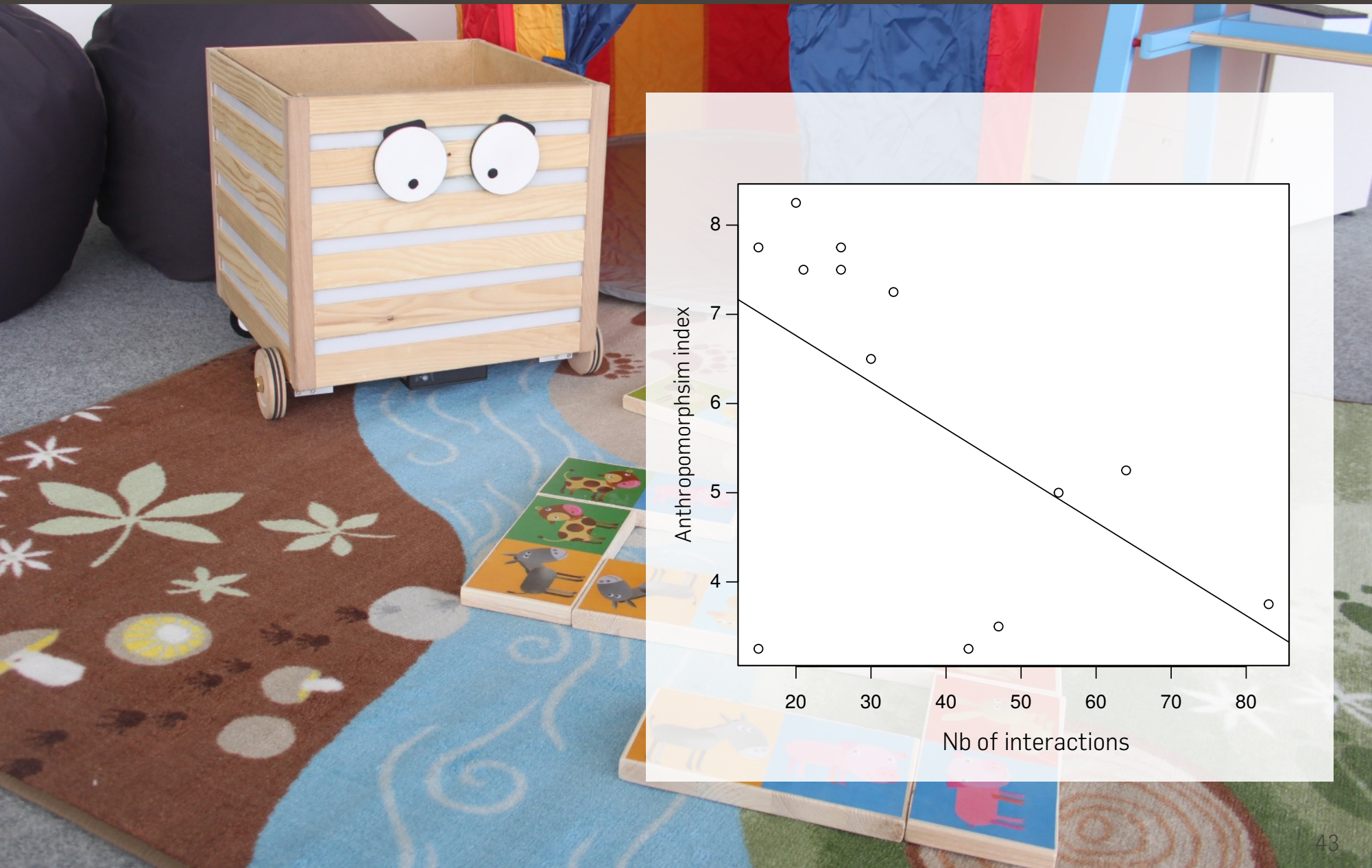
projection of existing mental models (familiarity)

pre-cognitive anthropomorphism

UNEXPECTED BEHAVIOURS

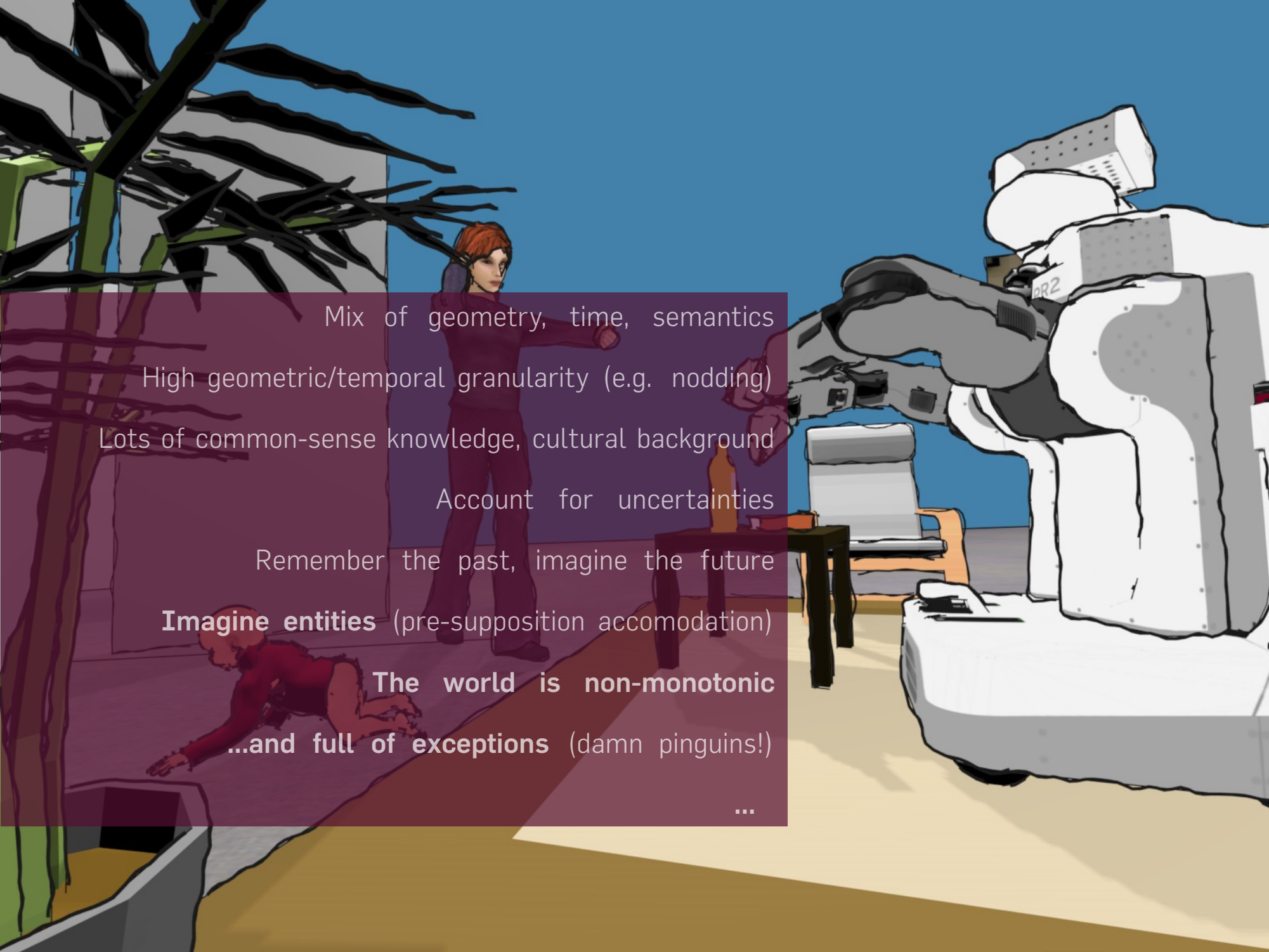
	Unplanned by the robot	Planned by the robot
Perceived as non-intentional	A	B
Perceived as intentional	C	D

ANTHROPOMORPHISM != ENGAGEMENT

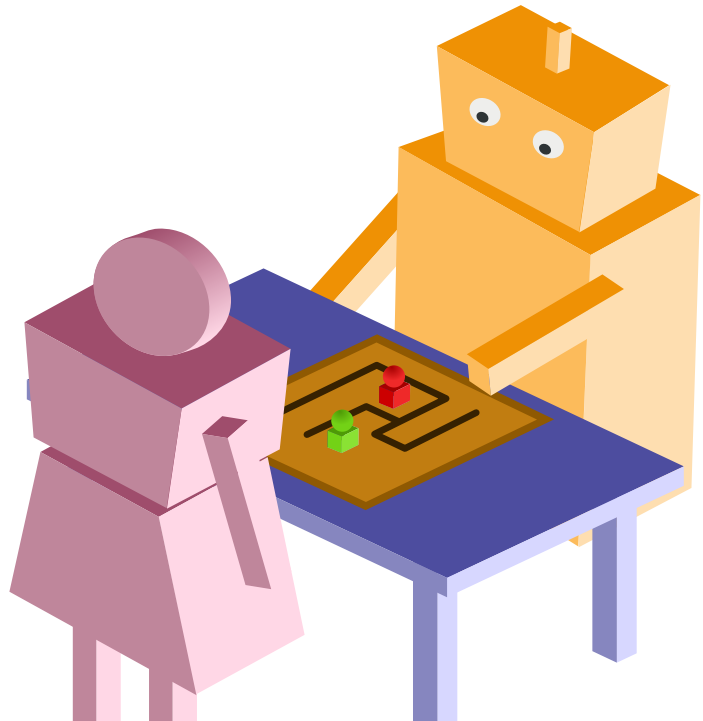


WHAT NEXT?


Mix of geometry, time, semantics
High geometric/temporal granularity (e.g. nodding)
Lots of common-sense knowledge, cultural background
Account for uncertainties
Remember the past, imagine the future


Mix of geometry, time, semantics
High geometric/temporal granularity (e.g. nodding)
Lots of common-sense knowledge, cultural background
Account for uncertainties
Remember the past, imagine the future
Imagine entities (pre-supposition accomodation)
The world is non-monotonic
...and full of exceptions (damn pinguins!)
...

Mutual Modelling: from visual perspective taking to...



Thank you!

severin.lemaignan@epfl.ch