

Mental model alignment in human-robot communication

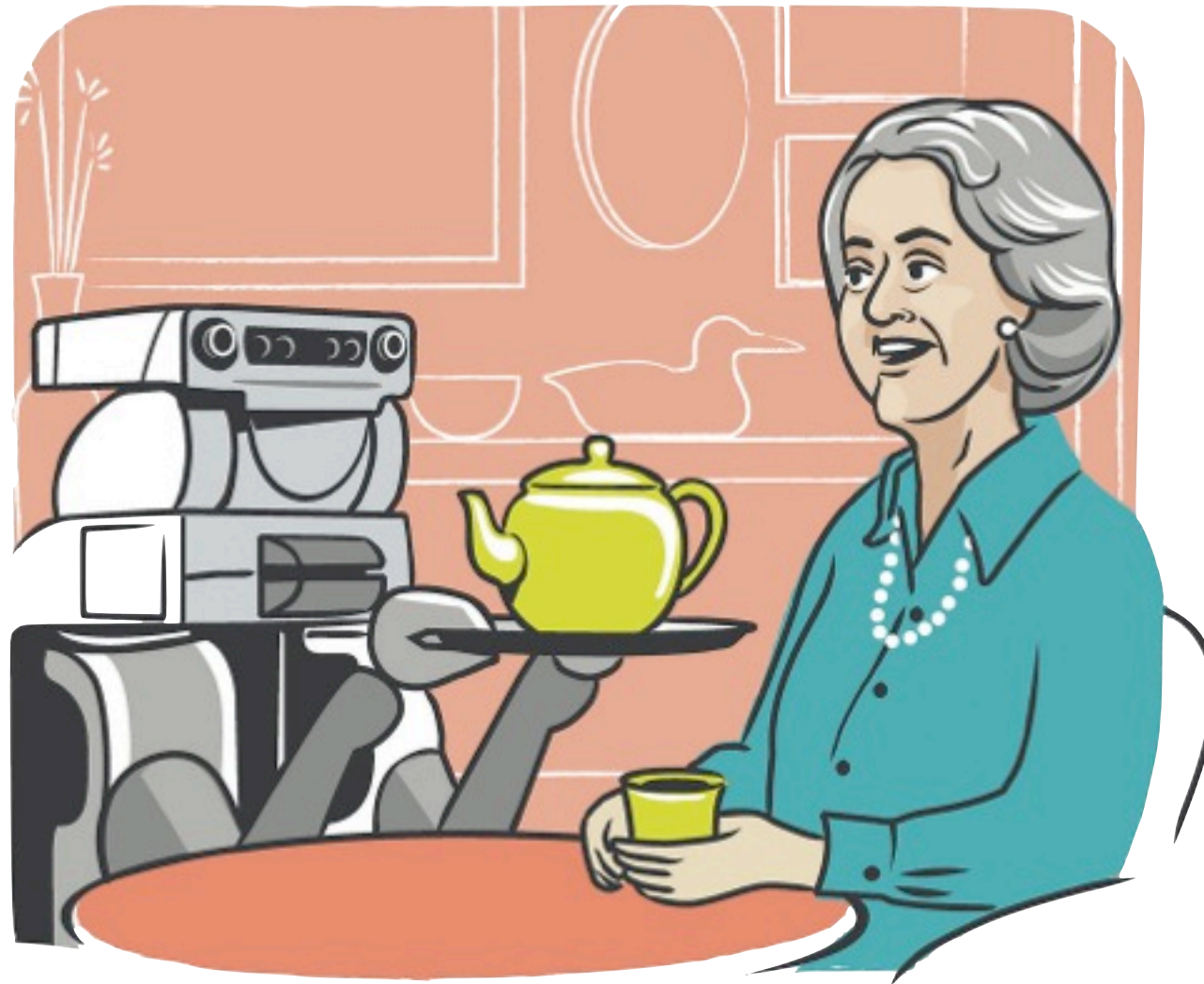
MAYA CAKMAK

July 23th, 2013

UW-MSR Summer Institute on Understanding Situated Language in Everyday Life

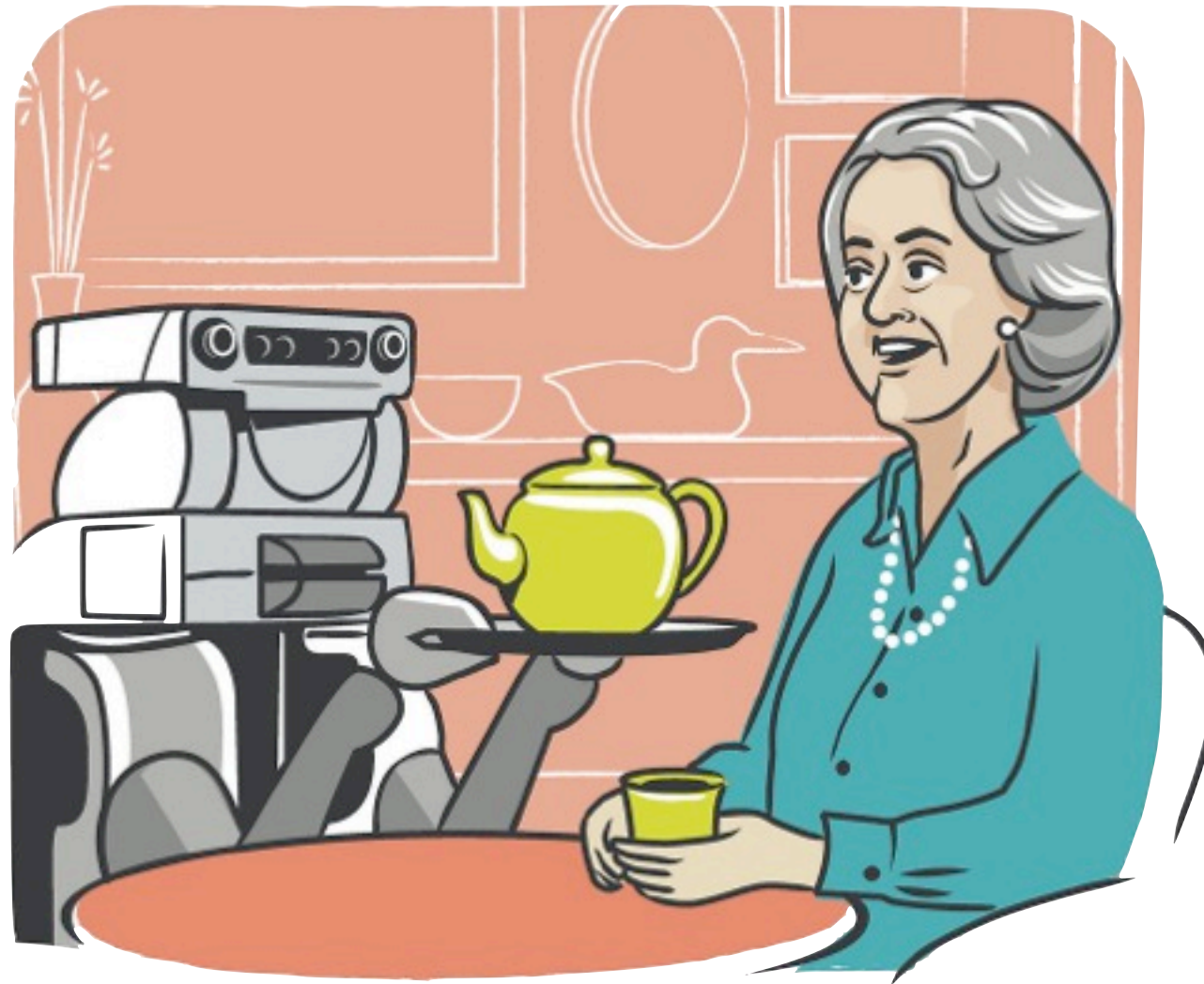


HUMAN-ROBOT COMMUNICATION



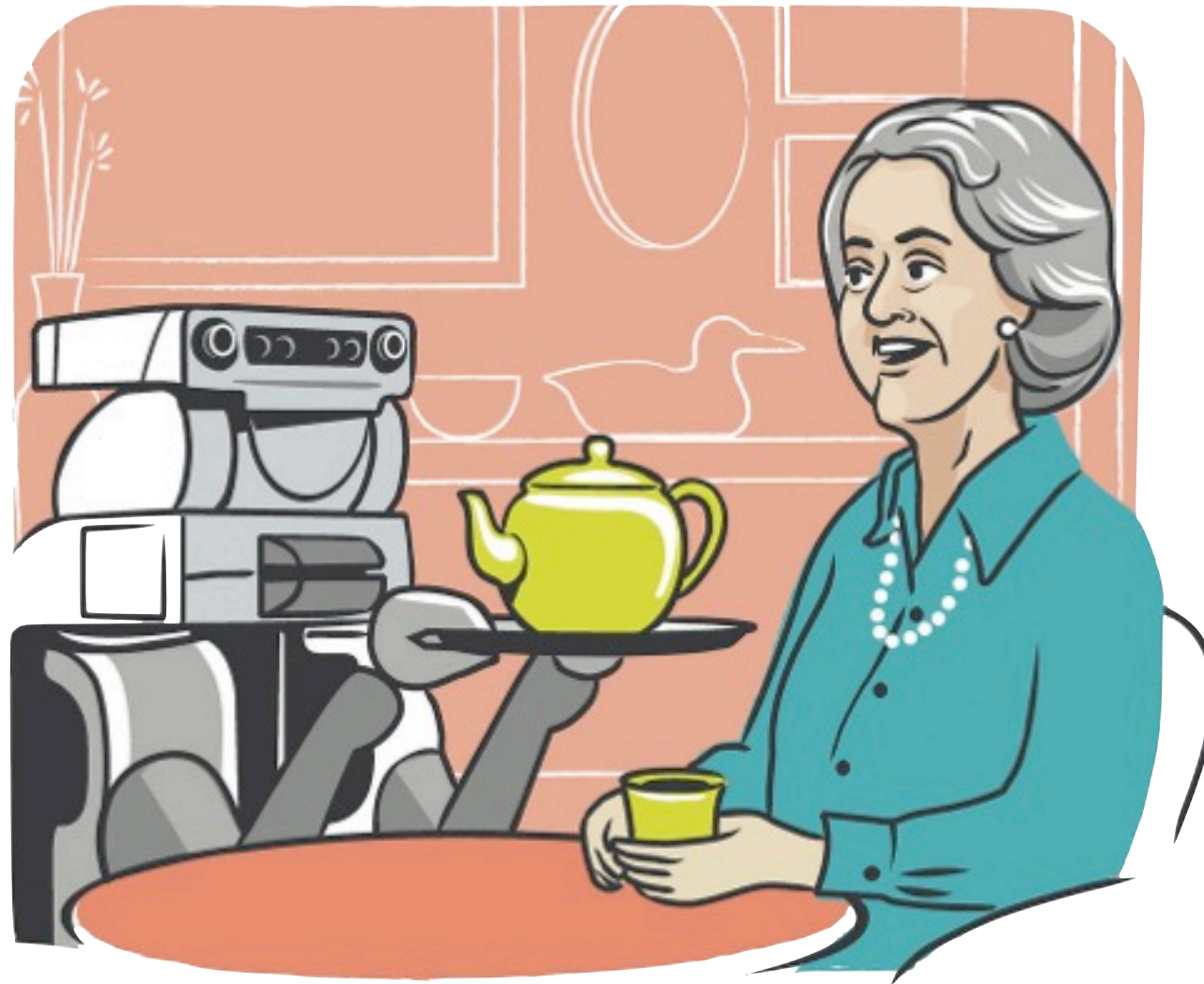
Teach robots how to understand/speak English

HUMAN-ROBOT COMMUNICATION



~~Teach robots how to understand/speak English~~
Teach humans how to understand/speak Robotese

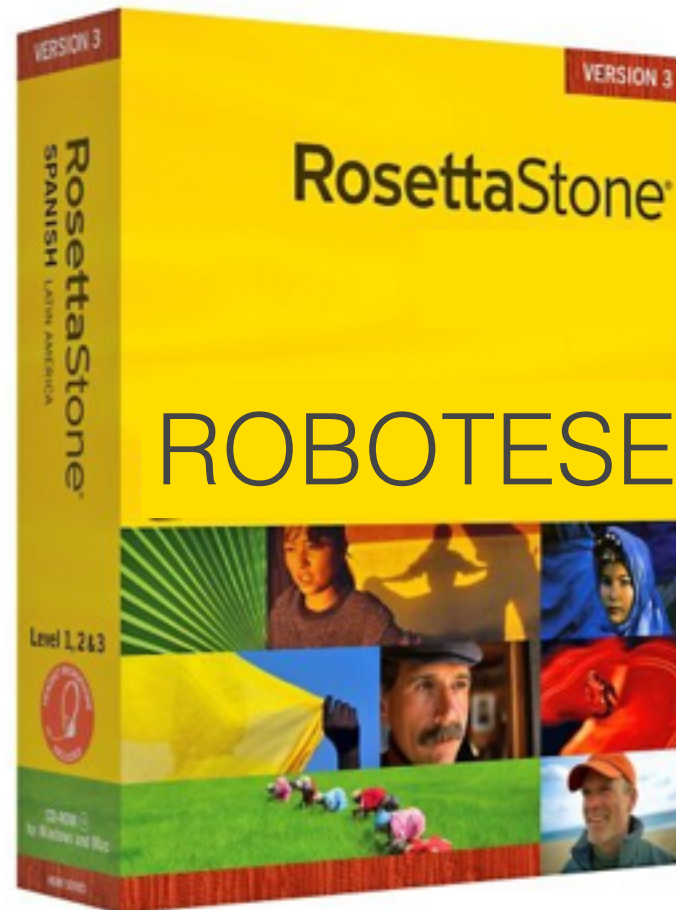
HUMAN-ROBOT COMMUNICATION

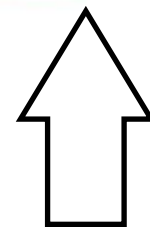
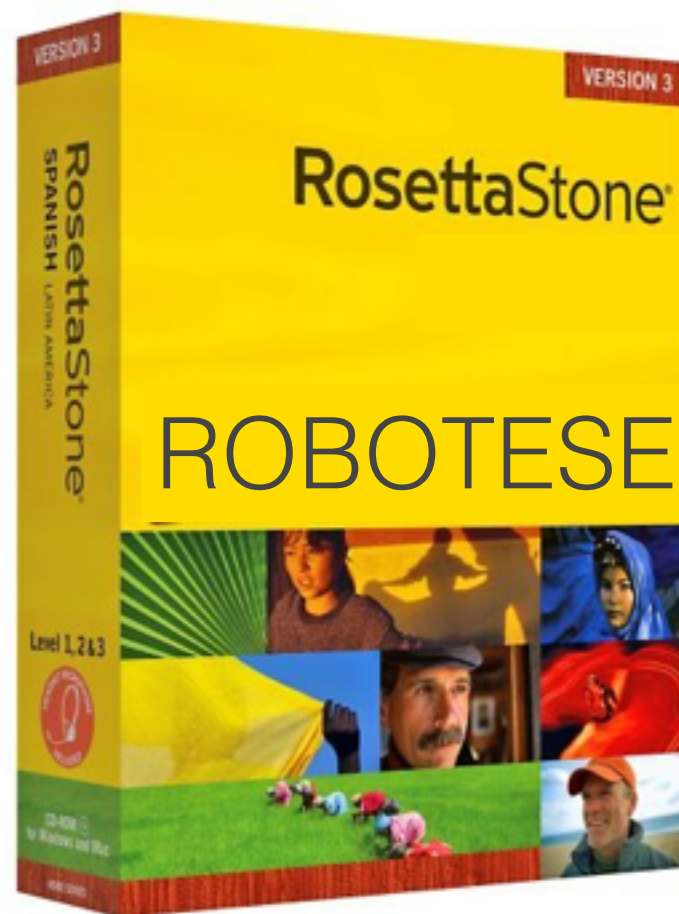


Assumptions

Humans are smarter/more flexible than **robots**

Robotese is much simpler/more structured than **English**

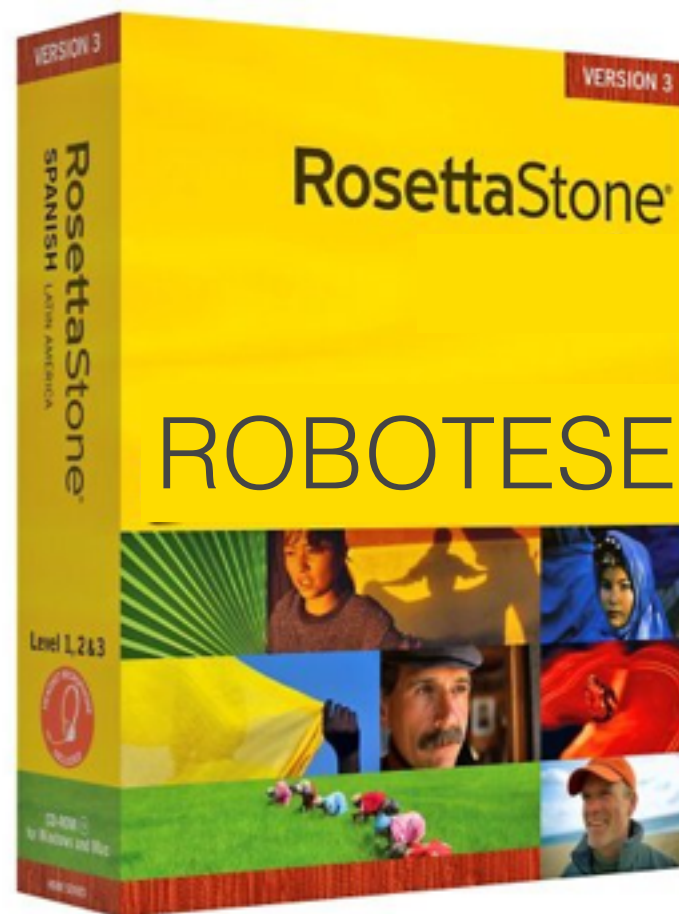




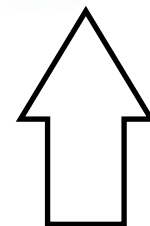
Tasks

grammar, vocabulary

Spoken language
Gestures
Actions
Physical interaction



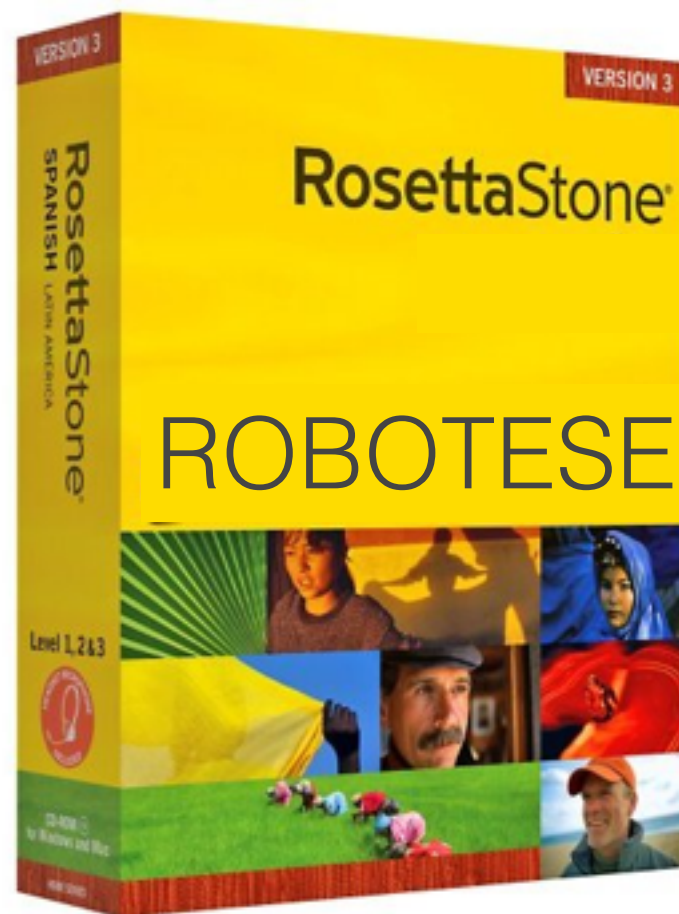
Spoken language
Sounds
LEDs
Expressions
Gestures
Actions



Tasks

grammar, vocabulary

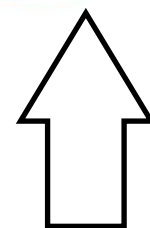
Spoken language
Gestures
Actions
Physical interaction



Spoken language
Sounds
LEDs
Expressions
Gestures
Actions

More explicit

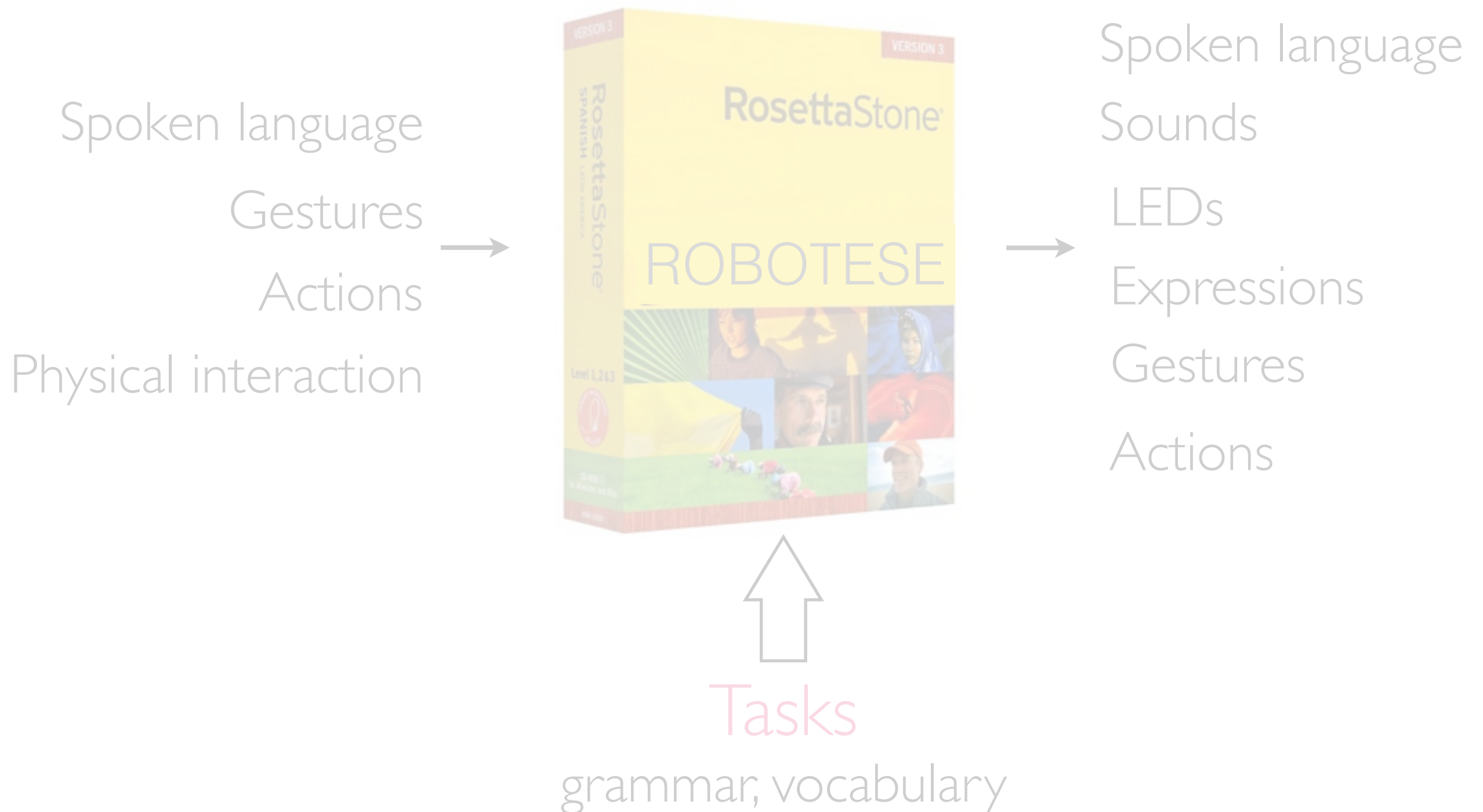
Unfamiliar channels



Tasks

grammar, vocabulary

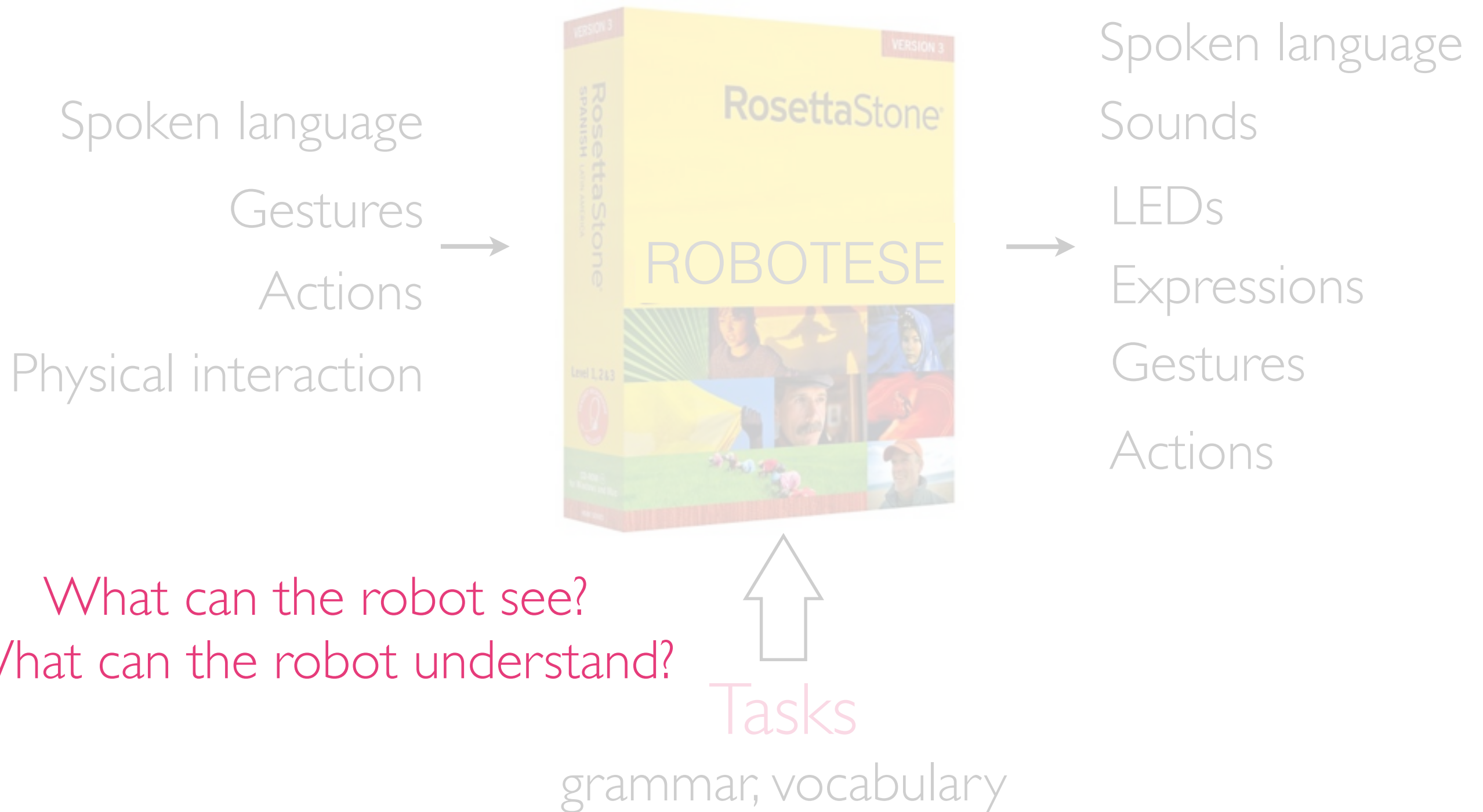
MENTAL MODEL ALIGNMENT



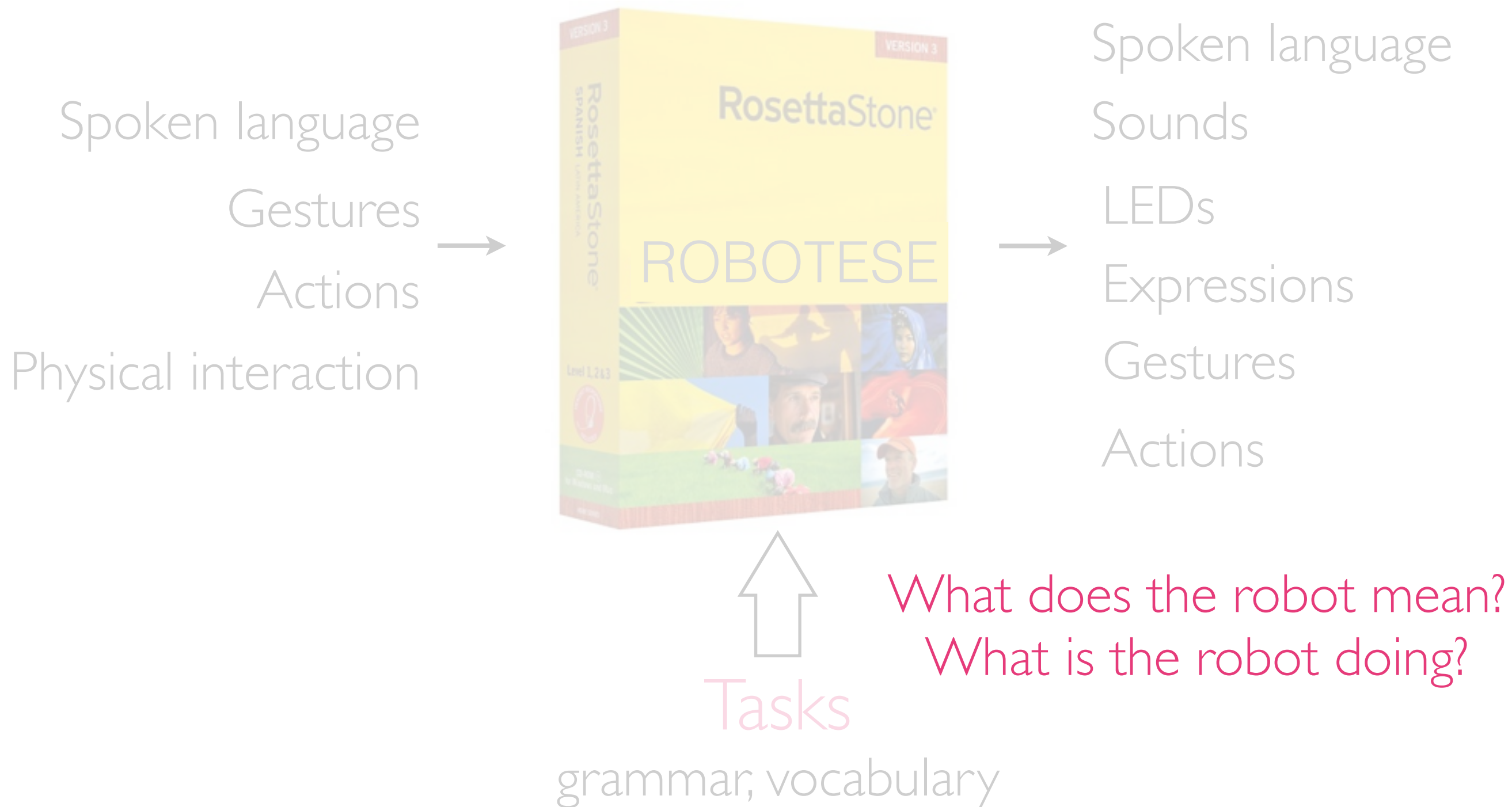
What does the robot know?

What can the robot represent/learn?

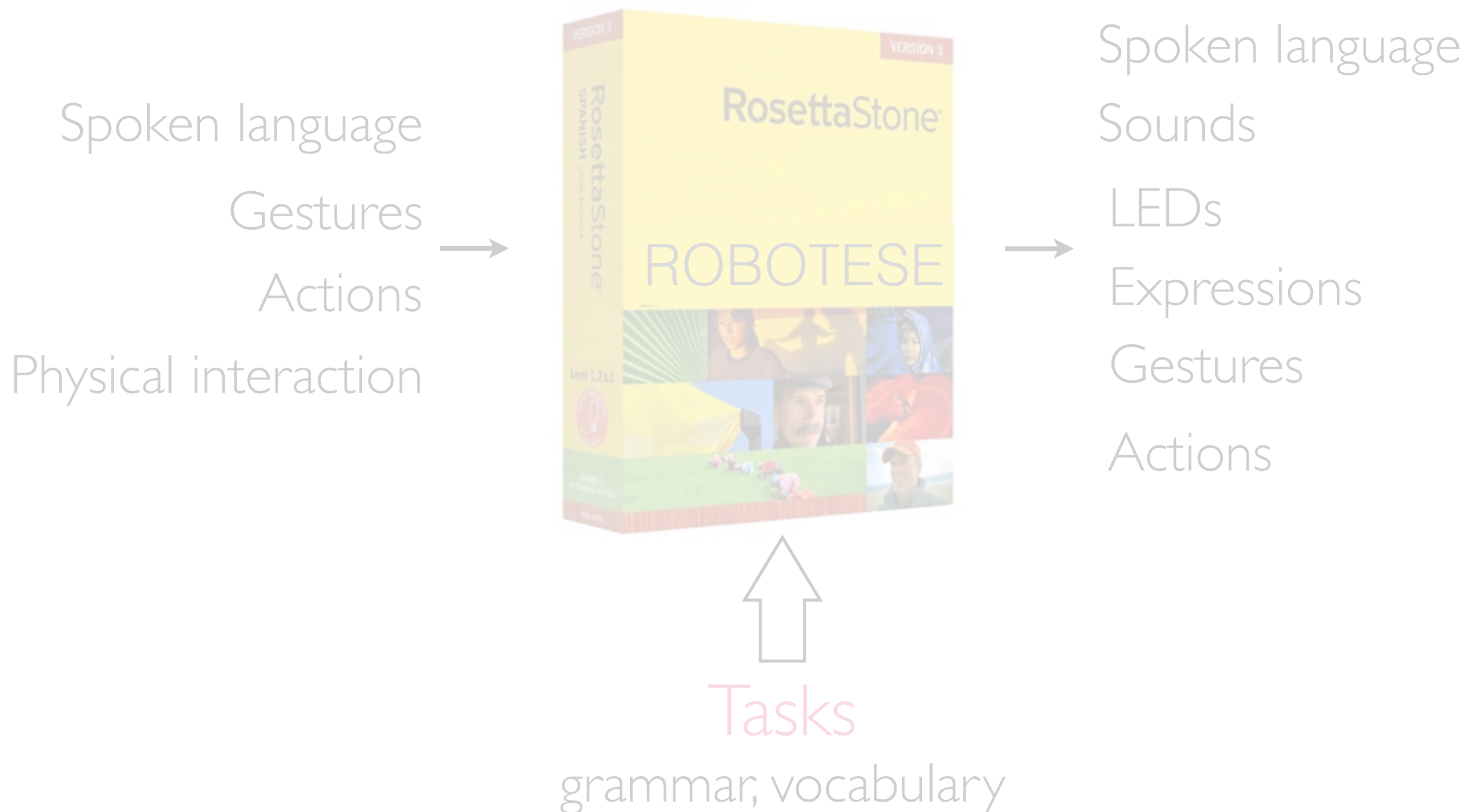
MENTAL MODEL ALIGNMENT



MENTAL MODEL ALIGNMENT



MENTAL MODEL ALIGNMENT



How can I get the robot to do X (something useful)?

MENTAL MODEL ALIGNMENT

What can we do?

Interaction design

Explicit instruction

MENTAL MODEL ALIGNMENT

Previous work

Teaching people how to teach robots

Making robots ask questions

Crazy ideas

Robot-world goggles

Robot driving license

MENTAL MODEL ALIGNMENT

Previous work

- * Teaching people how to teach robots

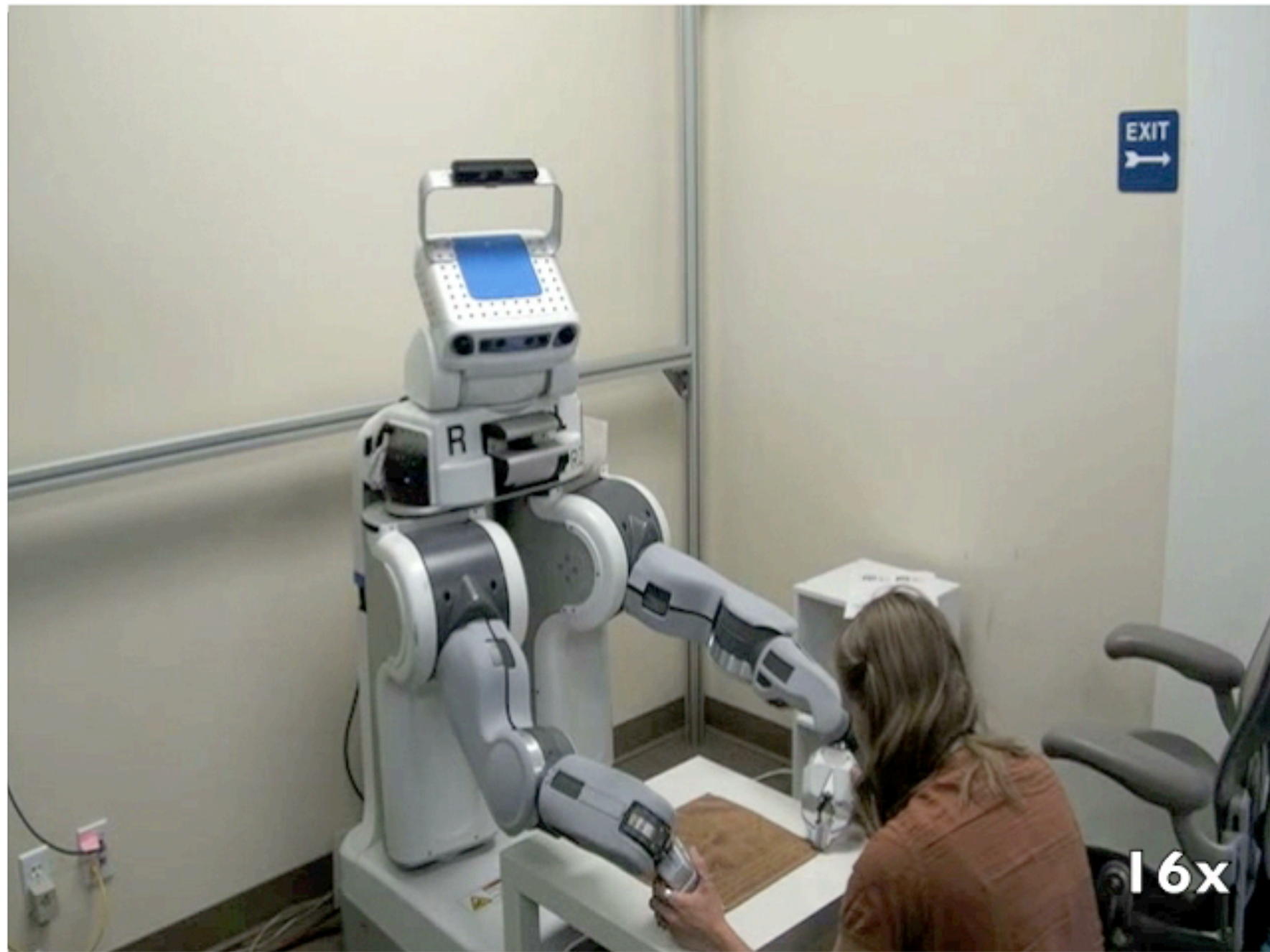
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END-USER ROBOT PROGRAMMING



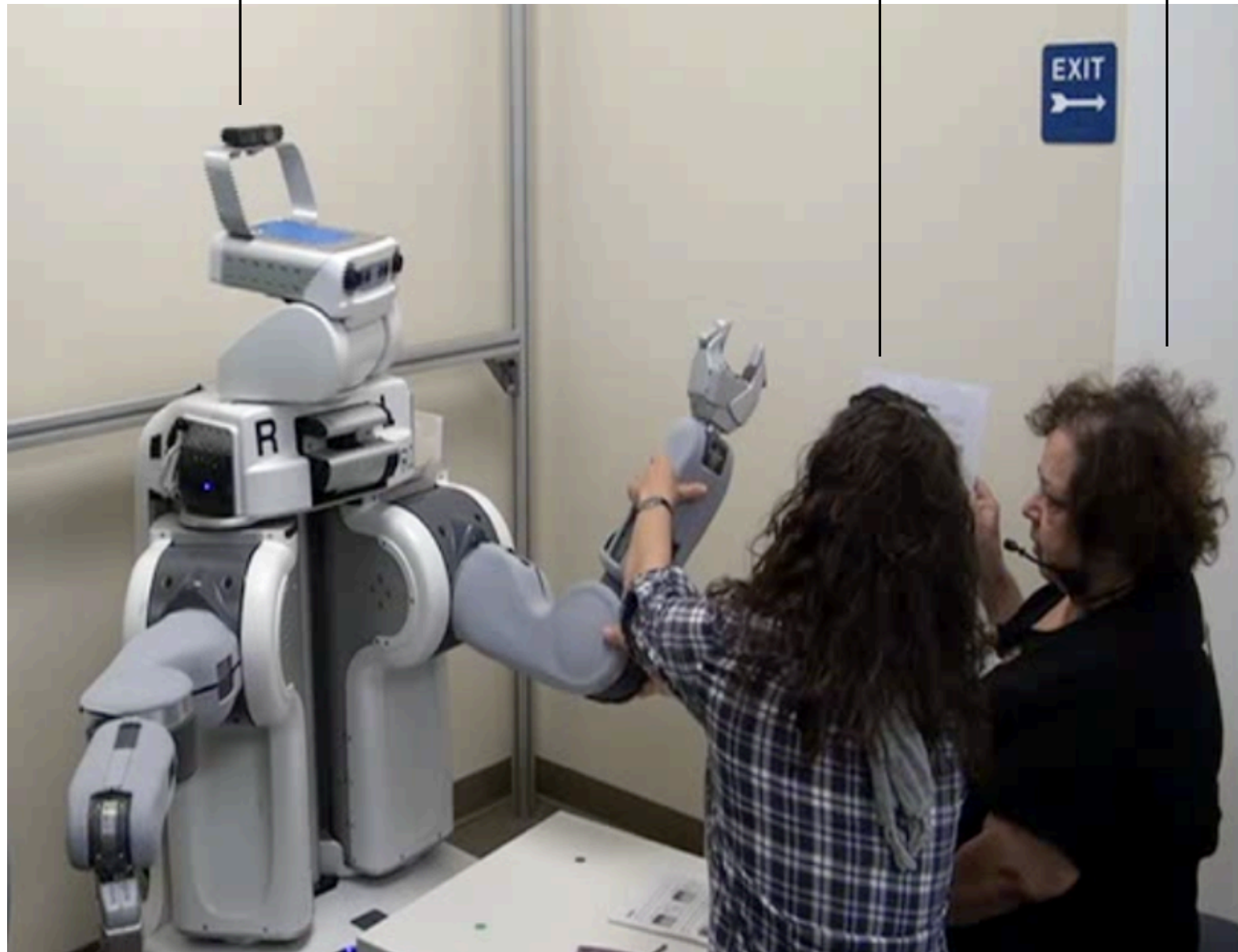
[VIDEO]

MOTIVATION

ROBOT

EXPERIMENTER

USER

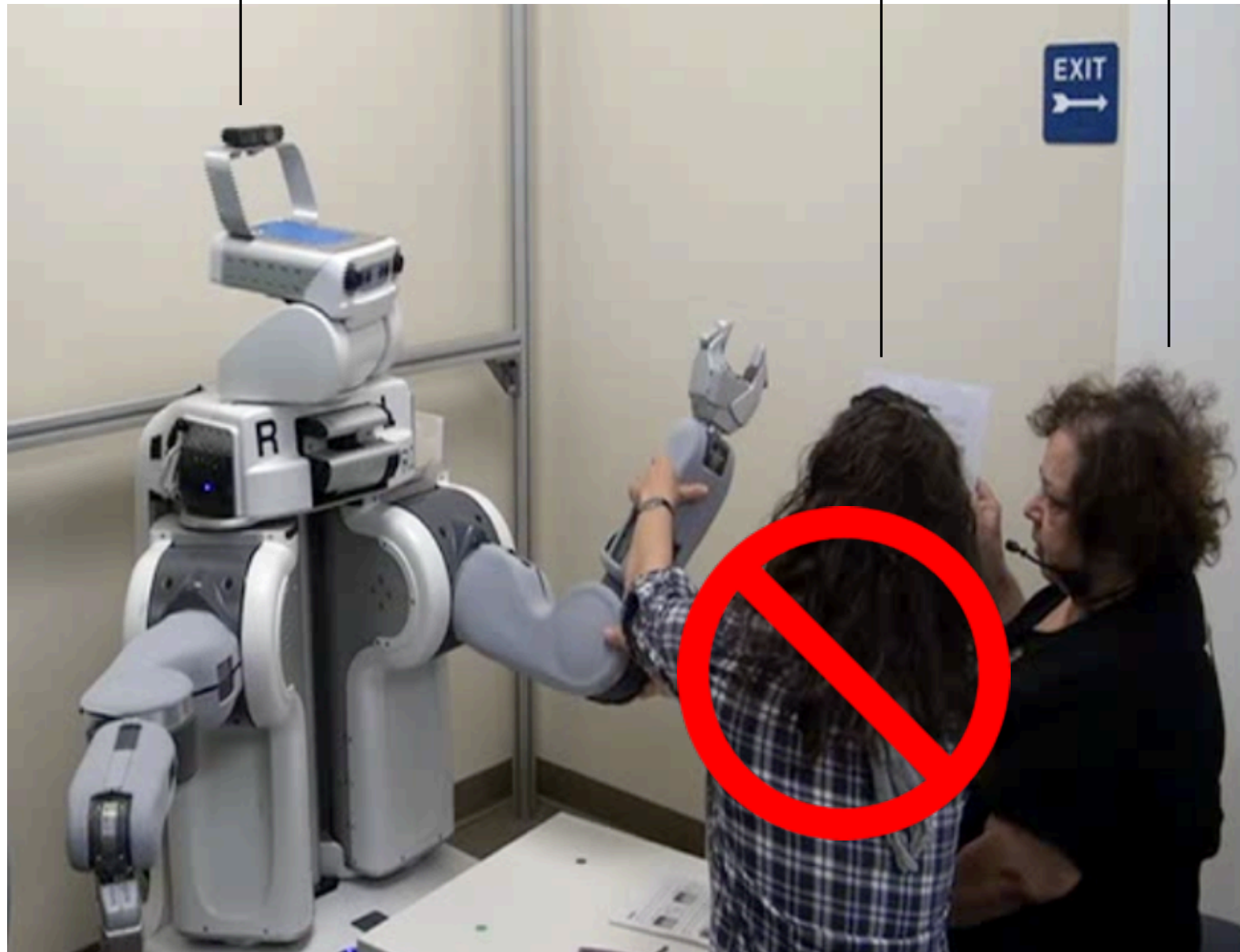


MOTIVATION

ROBOT

EXPERIMENTER

USER



INSTRUCTIONAL MATERIAL

User Manual

Programming PR2 by Demonstration

You can program PR2 to do what you want by creating a new skill and saving a sequence of arm poses and hand actions (open/close) into that skill. When you execute the skill, PR2 will go through these poses and actions in the order you saved them. You can keep adding poses to the skill after executing it, or clear the skill to start over.

The speech commands described below will allow you to interact with PR2 to program new skills. PR2 will verbally respond to all your commands. If you do not hear a response, try repeating the command.

COMMAND	DESCRIPTION
TEST MICROPHONE	Use this command to test if the microphone is working.
RELEASE RIGHT ARM HOLD LEFT	Use these commands to release the robots arms so you can move them around, or to make them hold a certain pose.
OPEN RIGHT HAND CLOSE LEFT	Use these commands to open and close the robot's hands.
CREATE SKILL	Use this command to create a new skill. PR2 indicate the name of the skill (for example "skill-1") in its response.
SAVE POSE	Use this command to save PR2's current arm pose into the skill. Make sure to hold the arm in place while using this command. To make the robot open or close its hand at the saved pose as part of the skill, first use the hand action command, and then use this command, while holding the arm in place.
EXECUTE SKILL	Use this command to execute the current skill. PR2 will go through the poses and hand actions saved into the skill so far.
CLEAR SKILL	Use this command to delete all the poses and hand actions that have been saved into the skill so far.
NEXT SKILL PREVIOUS	Use these commands to switch to the next or previous skill. These commands will let you navigate through skills in the order they were programmed.
UNDO LAST COMMAND	Use this command after using one of the commands above, in order to undo its effect (excluding TEST MICROPHONE and EXECUTE SKILL).

User manual

Tutorial

Programming PR2 by Demonstration

Step 1: GETTING STARTED

To make sure PR2 hears your commands say **TEST MICROPHONE** and wait for PR2's response.

Step 2: MOVING THE ARMS

- Say **RELEASE RIGHT ARM**.
- Grab PR2's right arm and move it around. Try to get a sense of its range of motion.
- Move the arm to a neutral pose and say **HOLD RIGHT ARM** while still holding the arm in place. Now let the arm go. Slightly push the arm to observe that the arm is stable.
- Repeat the same with the left arm using the commands **RELEASE/HOLD LEFT ARM**

Step 3: USING HAND ACTIONS

- Say **OPEN RIGHT HAND** and observe how the right hand moves. When the hand stops moving say **CLOSE RIGHT HAND**.
- Repeat (a) with the left hand, but this time hold an object inside the hand before saying **CLOSE LEFT HAND**.

Step 4: PROGRAMMING A SKILL: WAVING

- Say **CREATE SKILL** and listen to PR2's response.
- Release PR2's right arm and move it to a waving pose. Say **SAVE POSE** while holding the arm in place.
- Move the arm to a different pose slightly to the right of the first pose. Say **SAVE POSE** while holding the arm in place.
- Save a third pose slightly to the left of the first pose.
- Let PR2's arm go and say **EXECUTE SKILL**. Observe the skill playing out.

Step 5: ADDING A HAND ACTION TO THE SKILL

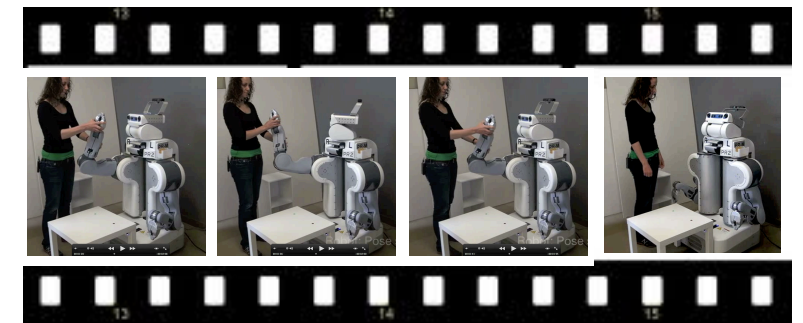
- Release the right arm and move it to a neutral pose. Say **OPEN RIGHT HAND** and then **SAVE POSE**. Make sure to hold the arm still while saying both commands.
- Execute the skill to observe the added hand action at the end of the waving skill.

Step 6: DELETING A POSE AND CLEARING A SKILL

- Add a dummy pose to the skill. Then say **UNDO LAST COMMAND**, listen to PR2's response.
- Say **CLEAR SKILL**, listen to PR2's response, and then try to execute the skill.
- Add new poses into the skill to make PR2 wave with the left arm, and execute the skill.

Step 7: NAVIGATING SKILLS

- Say **CREATE SKILL** and listen to PR2's response.
- Say **PREVIOUS SKILL** and listen to PR2's response.
- Say **NEXT SKILL** and listen to PR2's response. Say **NEXT SKILL** again and listen to PR2's response.



Tutorial

Video

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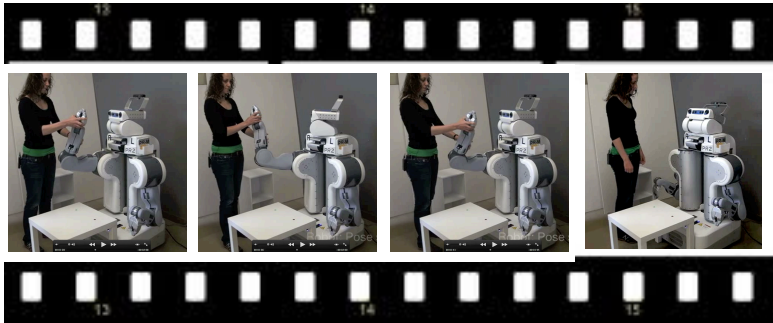
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User manual

Tutorial

Video



HOW WE FAILED

Superstition/inefficiency

[VIDEO]

Functional ignorance

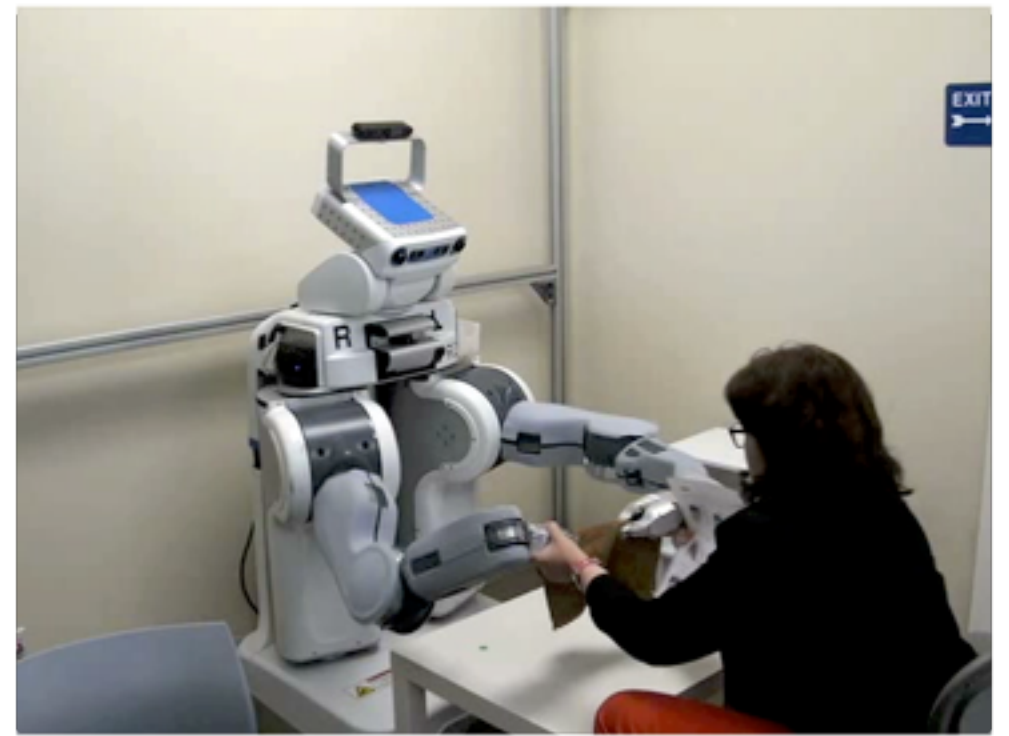
[VIDEO]

HOW WE FAILED



Superstition/inefficiency

[VIDEO]



Functional ignorance

[VIDEO]

HOW WE FAILED



Superstition/inefficiency

[VIDEO]



Functional ignorance

[VIDEO]

MENTAL MODEL ALIGNMENT

Previous work

Teaching people how to teach robots

✱ Making robots ask questions

Crazy ideas

Robot-world goggles

Robot driving license

MOTIVATION

Existing tools assume **good teachers...**

MOTIVATION

Existing tools assume good teachers...

- ▶ large number of demos
- ▶ variance in demos
- ▶ smooth/consistent demos

MOTIVATION

Existing tools assume good teachers...

- ▶ large number of demos
- ▶ variance in demos
- ▶ smooth/consistent demos

... everyday users are not!

- ▶ inaccurate mental model
- ▶ limited time, patience, attention, memory

MOTIVATION

Existing tools assume good teachers...

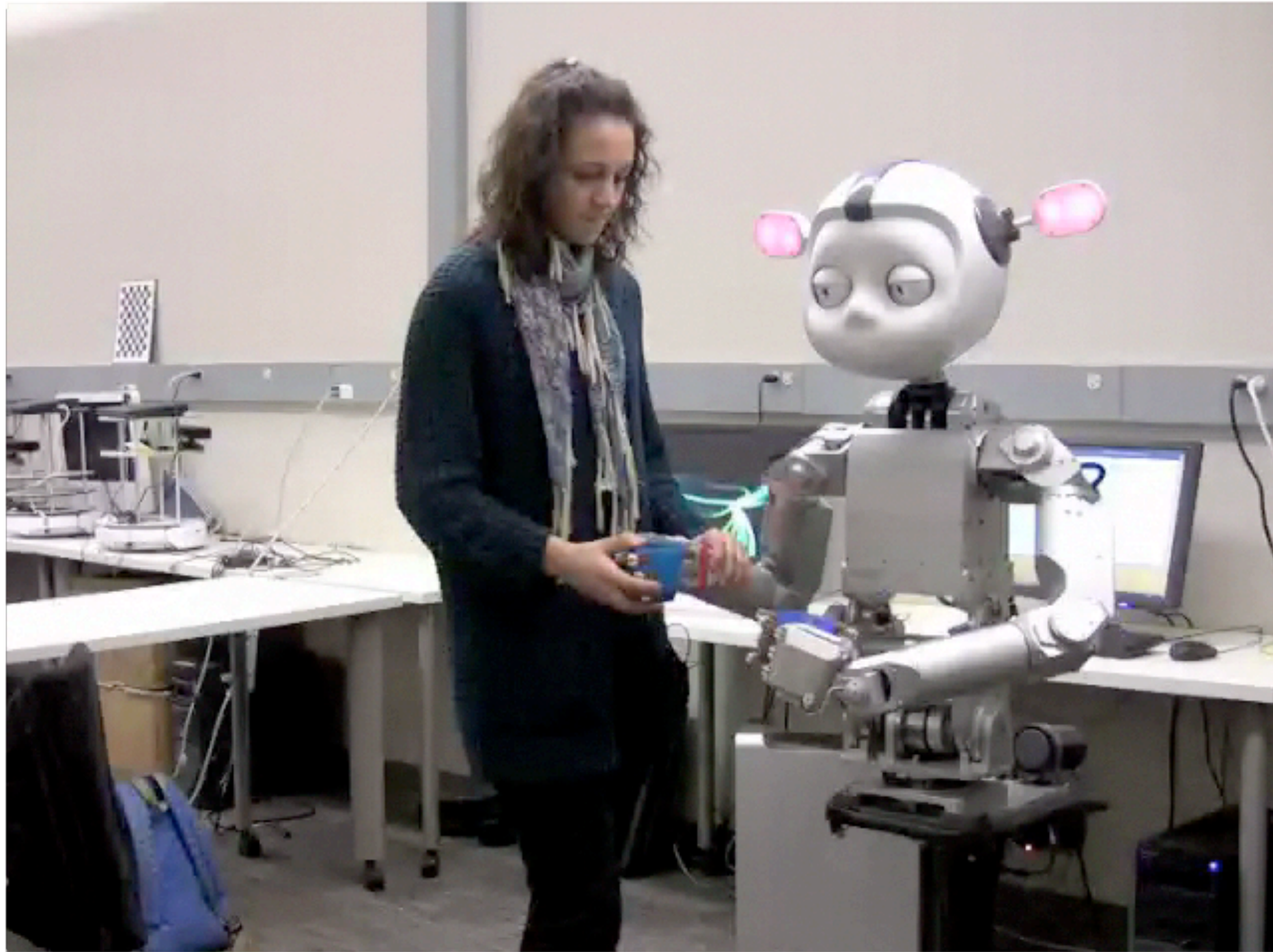
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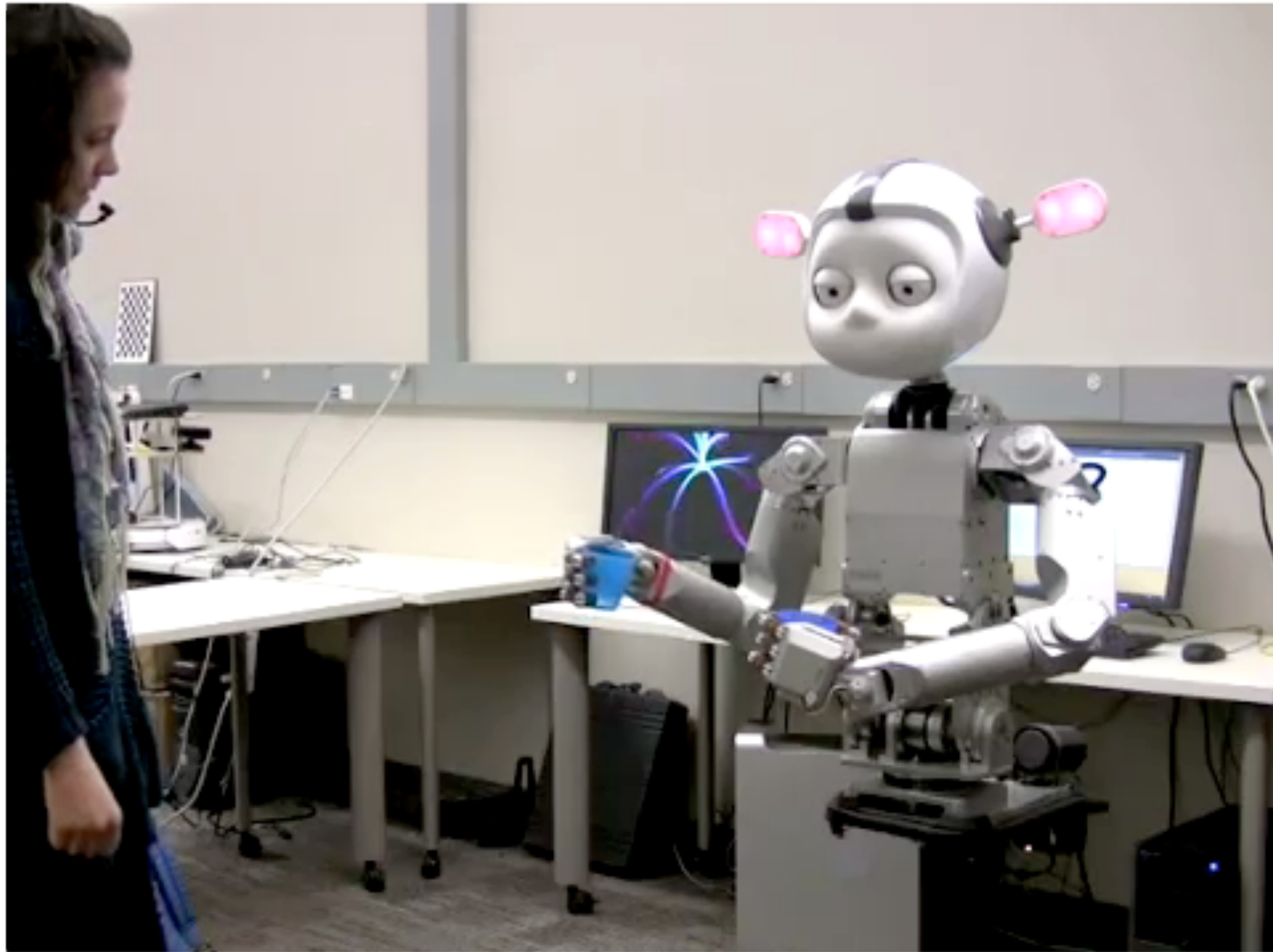
CHALLENGE: BETTER DEMONSTRATIONS, FASTER!

SIMPLE QUESTIONS



[VIDEO]

COMPLEX QUESTIONS

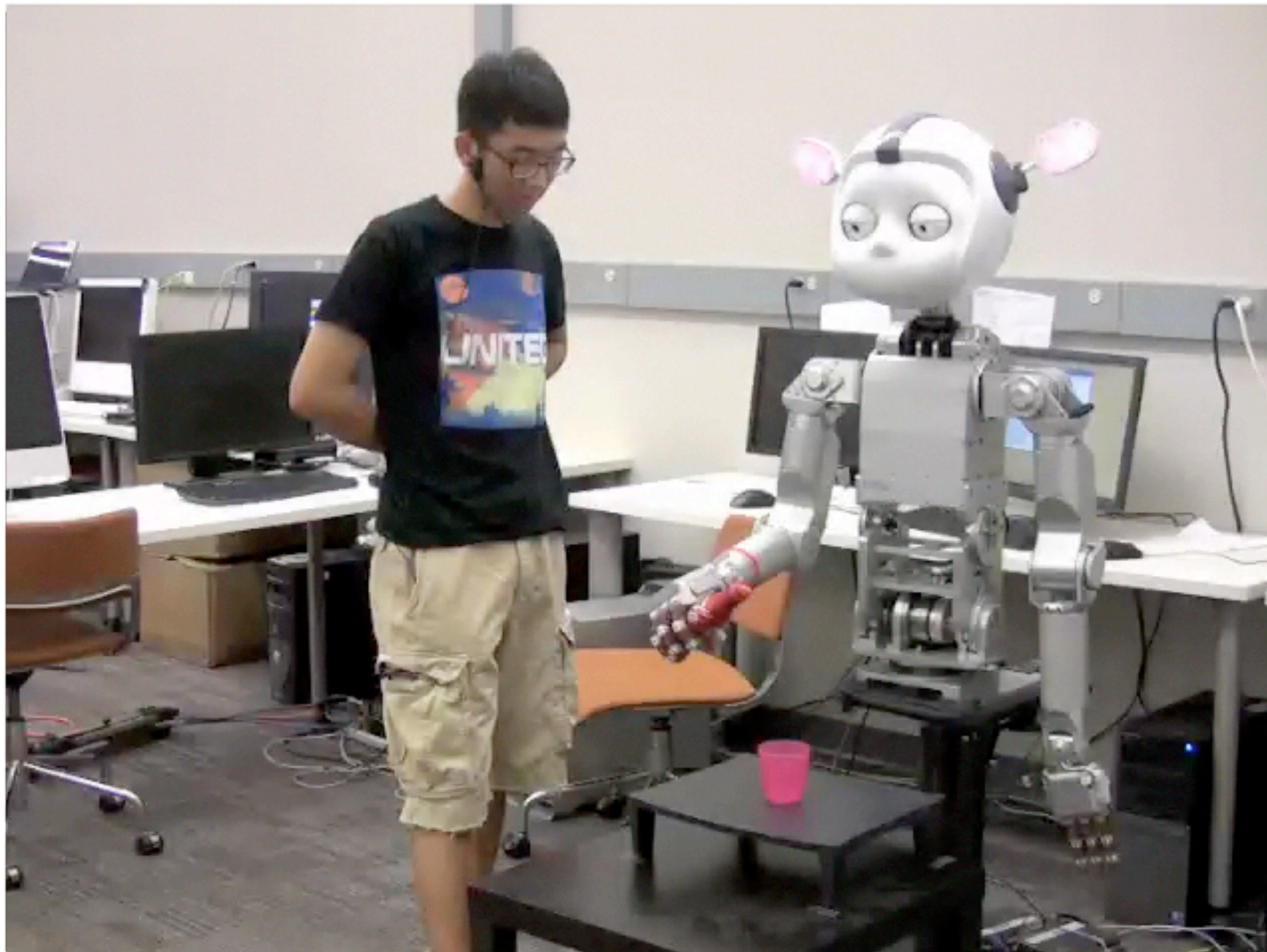


[VIDEO]

BEGINNER IN ROBOTESE

[VIDEO]

BEGINNER IN ROBOTESE



[VIDEO]

MENTAL MODEL ALIGNMENT

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Robot driving license

SEEING WHAT THE ROBOT SEES



[VIDEO]

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HOW MUCH DO WE NEED TO TEACH?



Buy and start using



Pass a test before being
allowed to use

HOW MUCH DO WE NEED TO TEACH?



Buy and start using



?



Pass a test before being
allowed to use

HOW MUCH DO WE NEED TO TEACH?



Buy and start using



?



Pass a test before being
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MENTAL MODEL ALIGNMENT

Teach humans how to understand/speak Robotese

What can we do?

Interaction design

Explicit instruction

Questions?

