Better Living With Robots

40th LAAS Anniversary

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Cambridge, MA

Robots for Everyone

Toyota partner robot

As of January 2008, 2.5M units sold

U.S. Congress mandate to make 1/3 of ground military forces autonomous by 2015

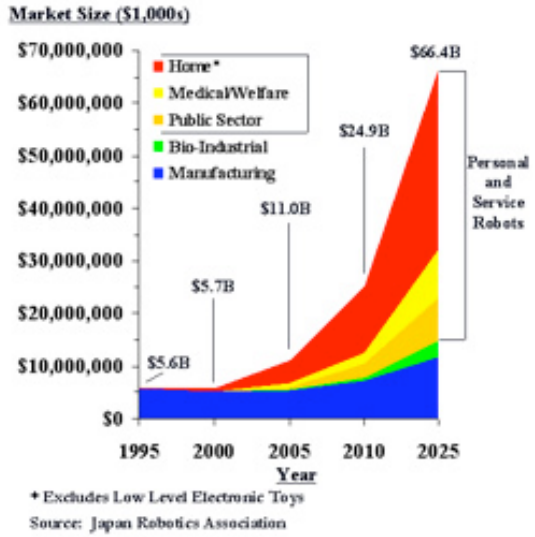


Figure 1: Worldwide Robotics Market Growth

People + Robots

Robots Evoke Strong Socio-Emotional Responses from People

WILL PEOPLE WILL DISCLOSE MORE TO ROBOTS?

"Because if the thing is very highly private and very personal, it might be embarrassing to talk about it to another person, and I might be afraid to be ridiculed for it…And it wouldn't criticize me…"

From: A Nascent Robotics Culture: New Complicities for Companionship

ROBOTS PRESS OUR "DARWINIAN SOCIAL BUTTONS"

"the players who had been Gazing at the cute robot game 30% more to the pot than Those who hadn't"
T. Burnham & B. Hare
Harvard Business School

The Kismet Effect

BETTER EXPERIENCE TO WORK WITH A ROBOT?

"Our findings suggest that, by developing intimacy to the robot, our participants were able to derive increased pleasure from cleaning"
From "*My Roomba is Rambo: Intimate home appliances*"

May 24, 2006 CNET

"We are very vulnerable to technology that knows how to push our buttons in a human way," she says. "We're a cheap date. Something makes eye contact with us and we cave hard. We'd better accept that about ourselves."
Sherry Turkle

TEAM LOYALTY

"recalling an incident when a U.S. soldier begged iRobot to repair his unit's PackBot robot, which they had dubbed Scooby Doo. "Please fix Scooby Doo because he saved my life,"

EMOTIONAL ATTACHMENT

"We did a non-warranty exchange and it was emotionally…it's interesting that 'Spot' was not actually just a robot; it was a… we had some reservation knowing that we are going to send this one back to the company and we are going to get a different one back."

Understanding the Social Side of Robots

Pioneering a new area of inquiry

From robot tools that do things for us…to robot partners that do things *with* us.

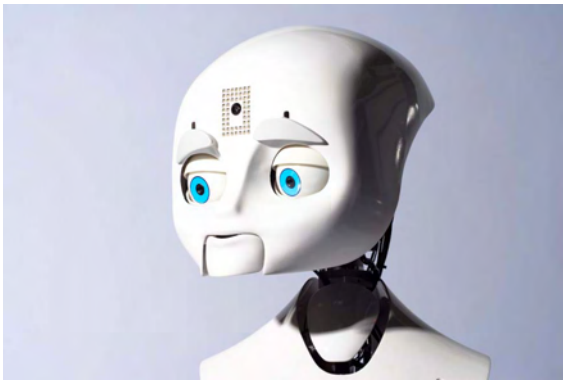
Toward Better Living with Robots

Highlight Four Projects

Long Term HRI

Social Learning

Communication

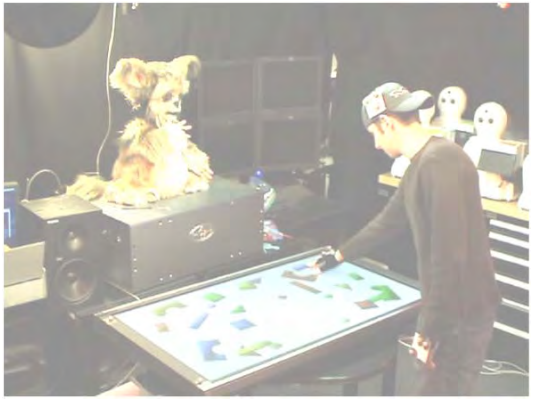


Teamwork

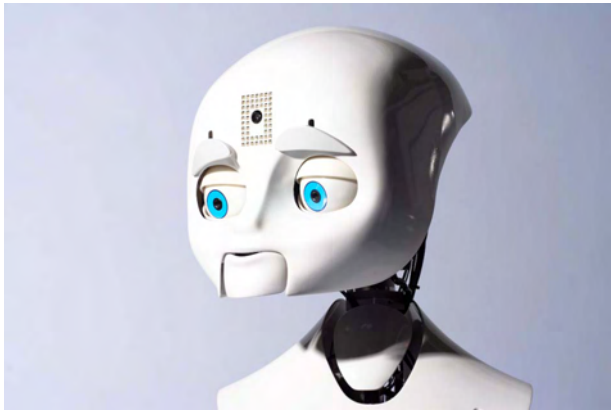
Four Projects

Long Term HRI

Social Learning



Communication



Teamwork

Fluency in Teamwork from Training

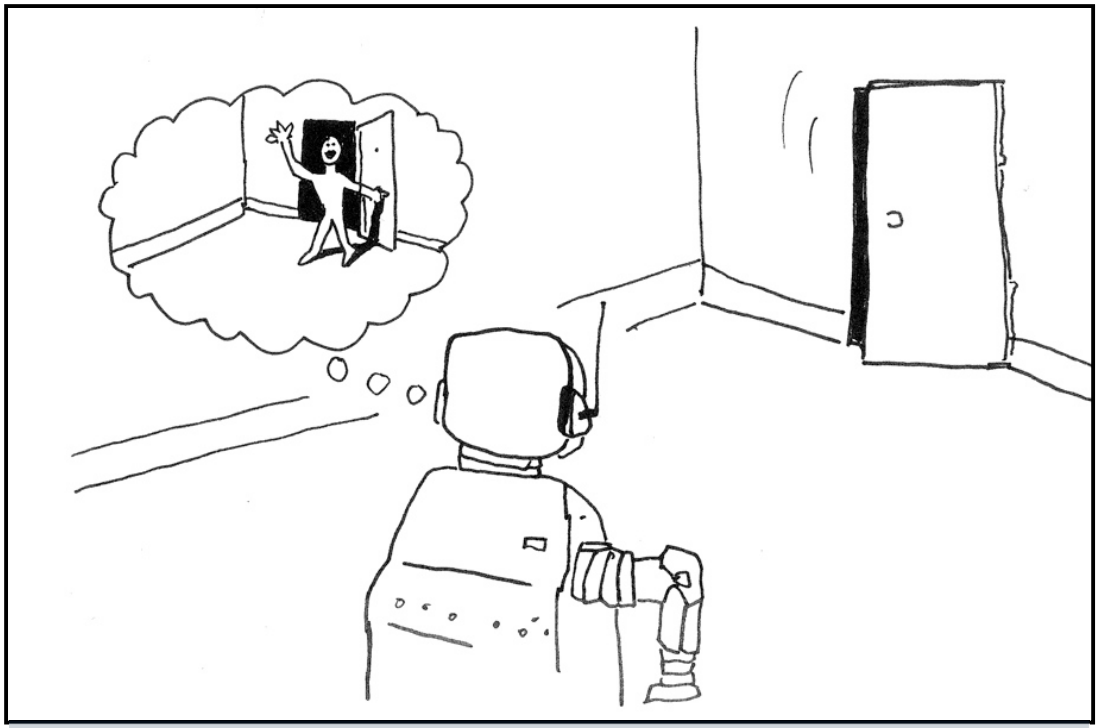
Anticipation and Perceptual Simulation

"Imitative motor activation feeds back into the perceptual processing of conspecifics' behaviors, generating top-down expectations and predictions of the unfolding action"

Wilson & Knoblich, 2005

"The ability to form shared representations of tasks [...] allows individuals to extend the temporal horizon of their action planning, acting in anticipation of others' actions rather than simply responding."

Sebanz, Bekkering & Knoblich, 2006

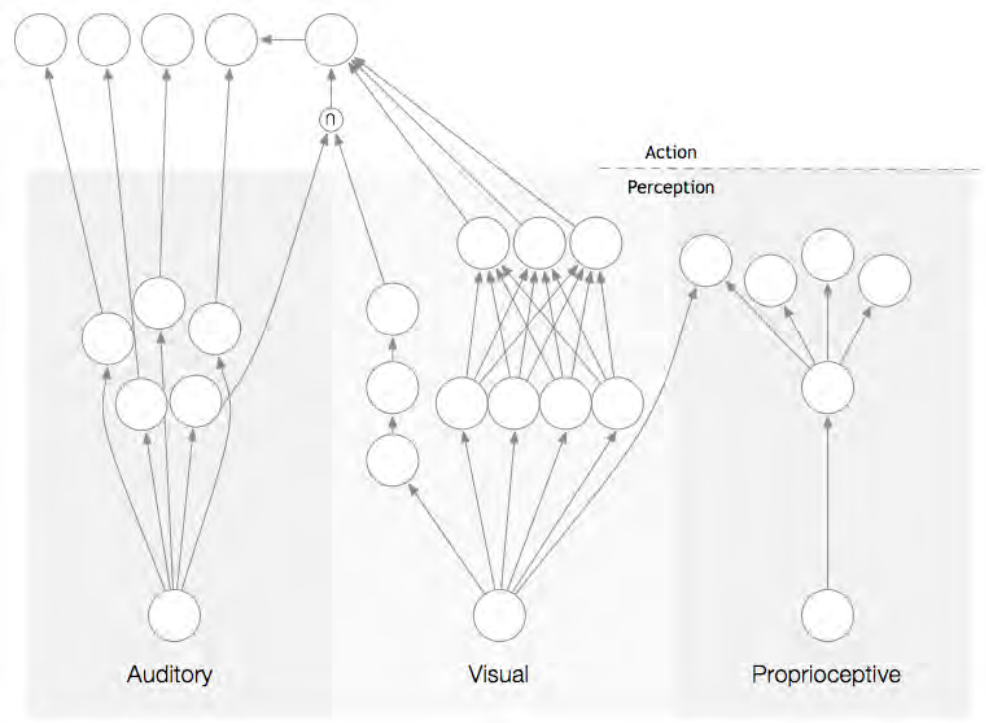


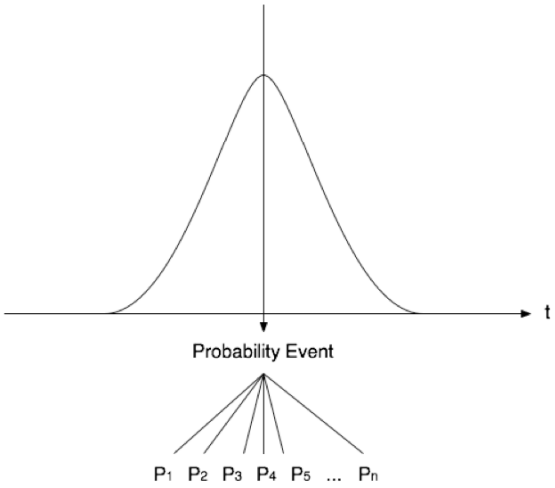
Practice based on two principles: (a) *anticipation* based on a model of repetitive past events, and (b) the modeling of the resulting anticipatory expectation as *perceptual simulation*.

Tri-Modal Experiment Network

Learned Model

(task sequence+timing)



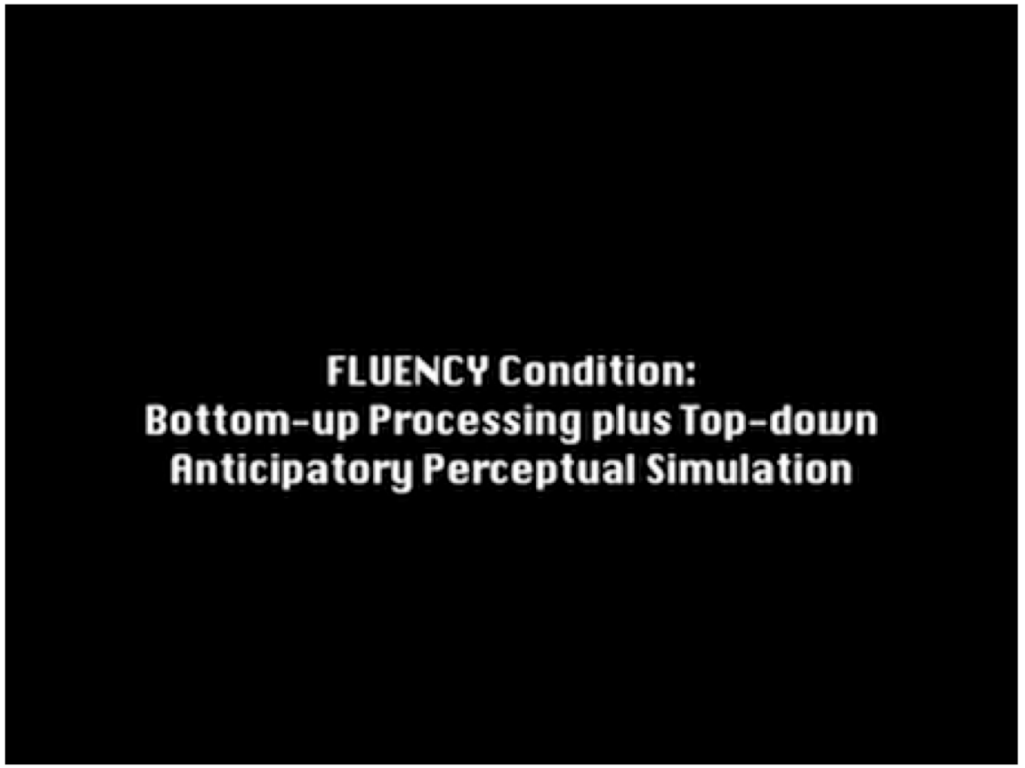


Perceptual Inputs

Tri-modal network
with 5 actions

Improvement from Training

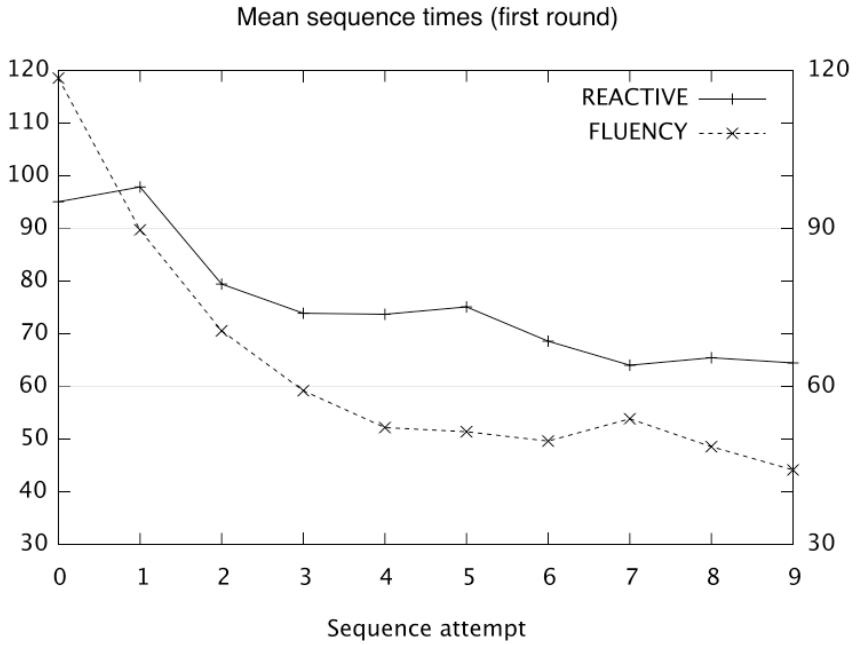
First to explore effects of practice on fluency of H-R interaction

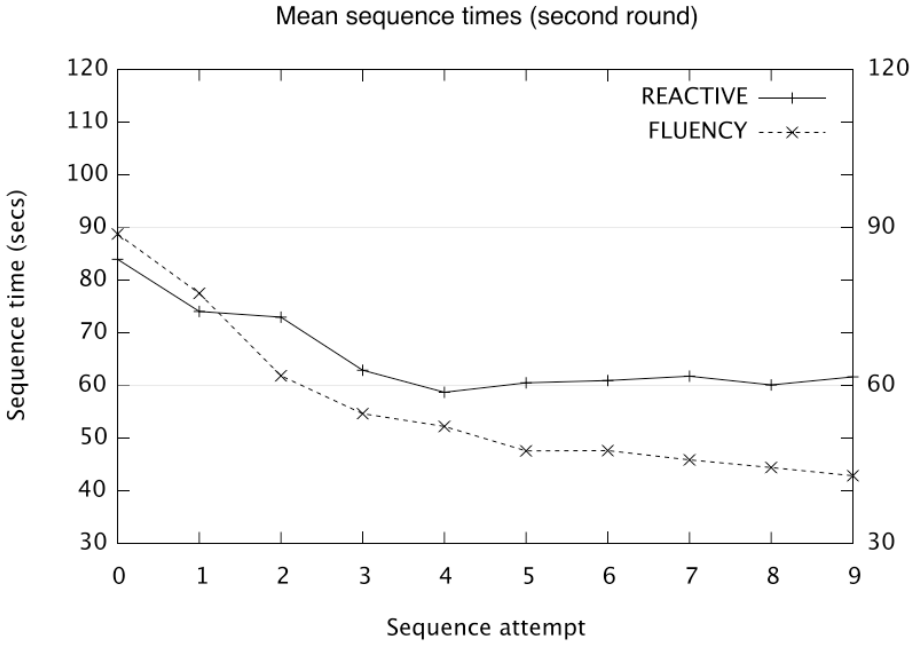


- Two Conditions, 33 participants
  - Reactive (bottom-up only)
  - Adaptive (top-down, bottom-up)

Human Participant Study

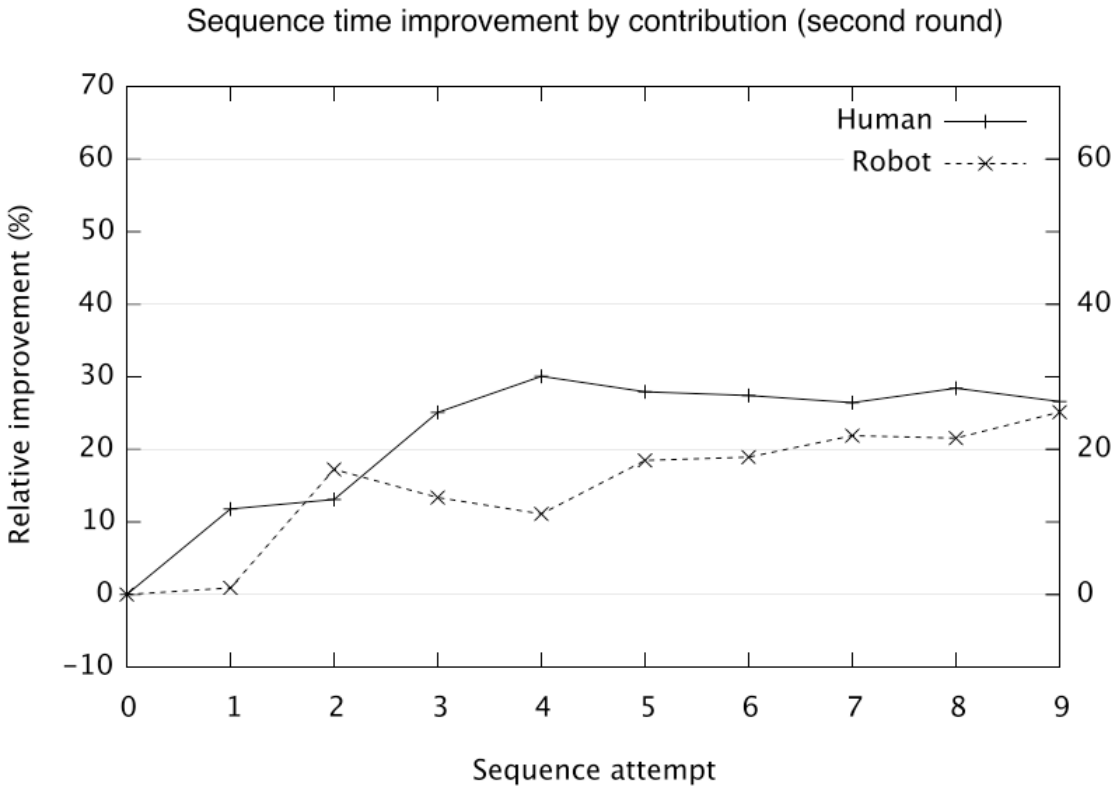
FLUENCY case performs task ~2x faster than REACTIVE case





Co-Learning in Fluency Condition

Similar contribution to team improvement



By the last round, robot contributes to team performance as much as human.

Human Subject Study

Open Section — REACTIVE Condition

"[...] it just felt like a lazy apprentice"

"I felt like I was controlling the robot, rather than it being part of a team."

"It did exactly what it was supposed to."

"The robot performed fairly well, but it did not understand the larger plan of action."

"The robot was more of an assistant than an active team member. But hey, there's always a team leader. That wasn't the robot..."

Human Subject Study

Open Section — FLUENCY Condition

"Highly impressed [...]"

"The robot appeared to learn faster than the human"

"By the end [...], we were good friends and high-fived mentally after the task was done."

"The second sequence would have worked had I not repeatedly picked the wrong colors and one of the stations."
"I am obsolete."

"The robot is better than me."

"The performance could had been better if I didn't make those mistakes."

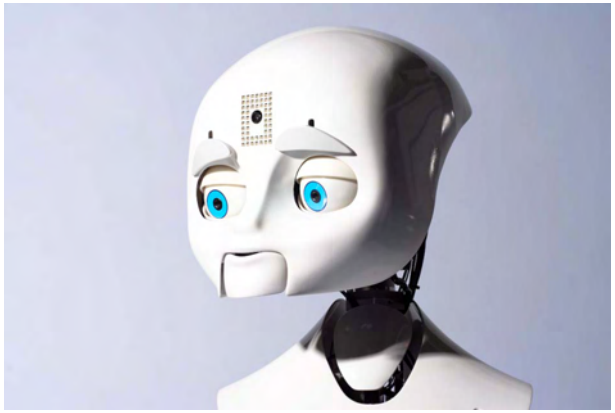
Collaboration in the Face of False Beliefs and Invalid Plans

Four Projects

Long Term HRI

Social Learning

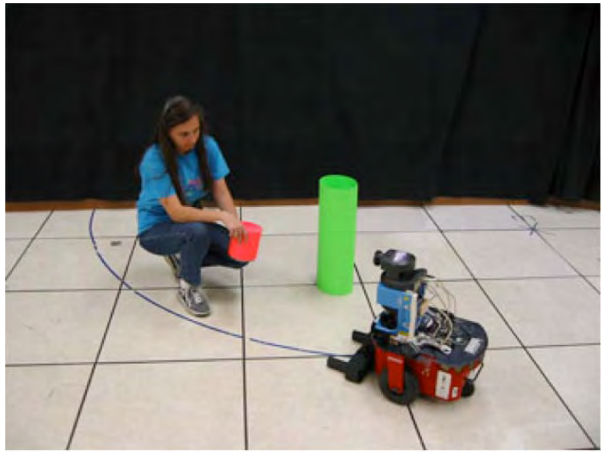
Communication



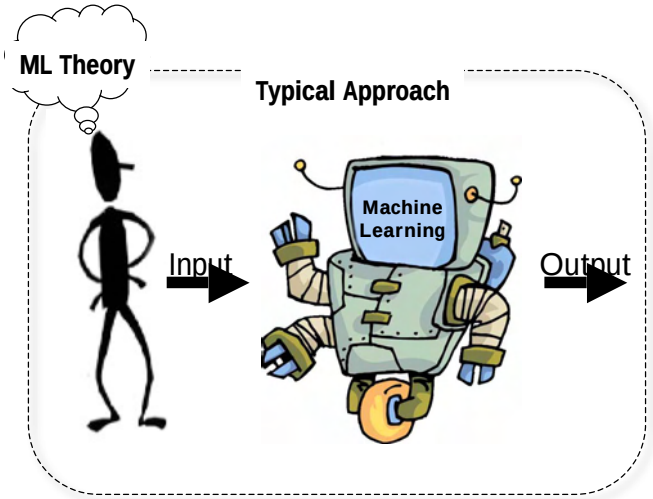
Teamwork

Challenge

How to Build Robots that can Learn from Anyone



From here…

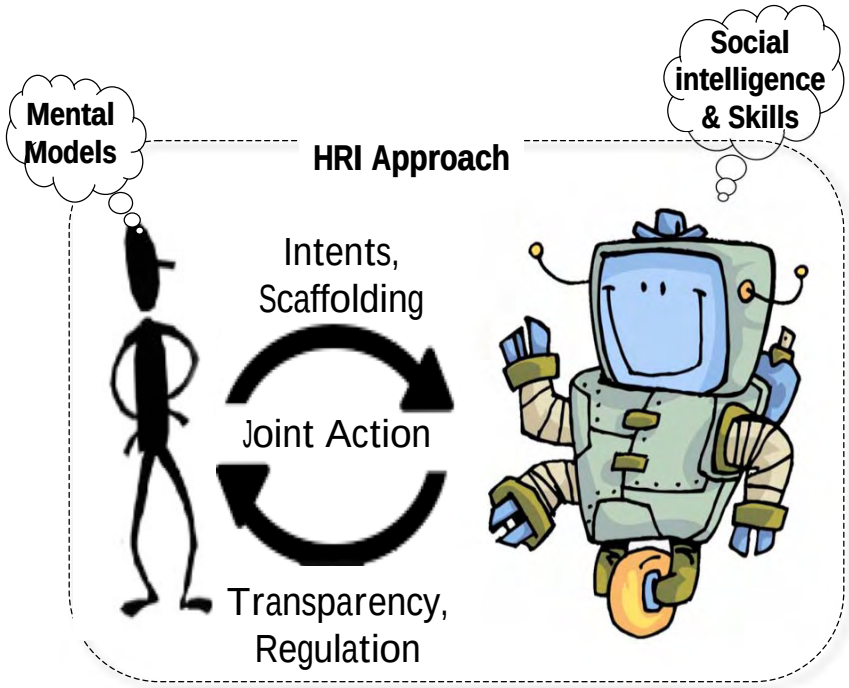


…to here.

People may not know how robots learn, but they bring a lifetime of experience learning/teaching others

Towards a Better Model

Applying a HRI perspective to Teachable Robots



Learning from Environmental Scaffolding

How do people use their bodies and space to structure learning tasks for others?

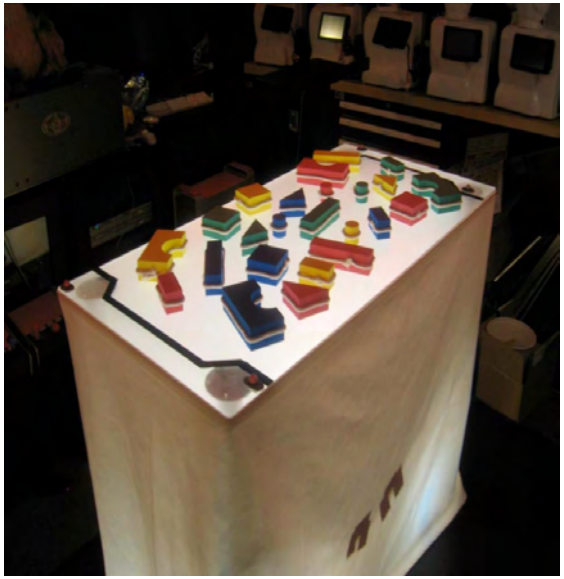
Human-Human

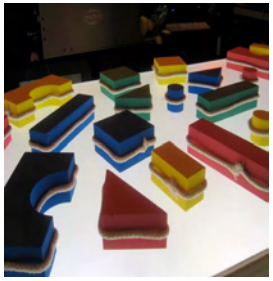
Human-Robot

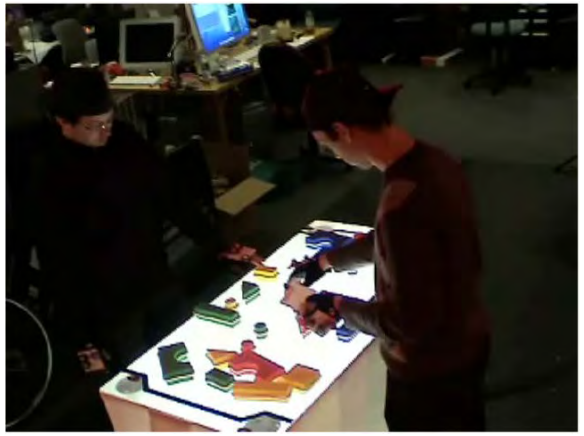
Data-Gathering

VICON

Light Table

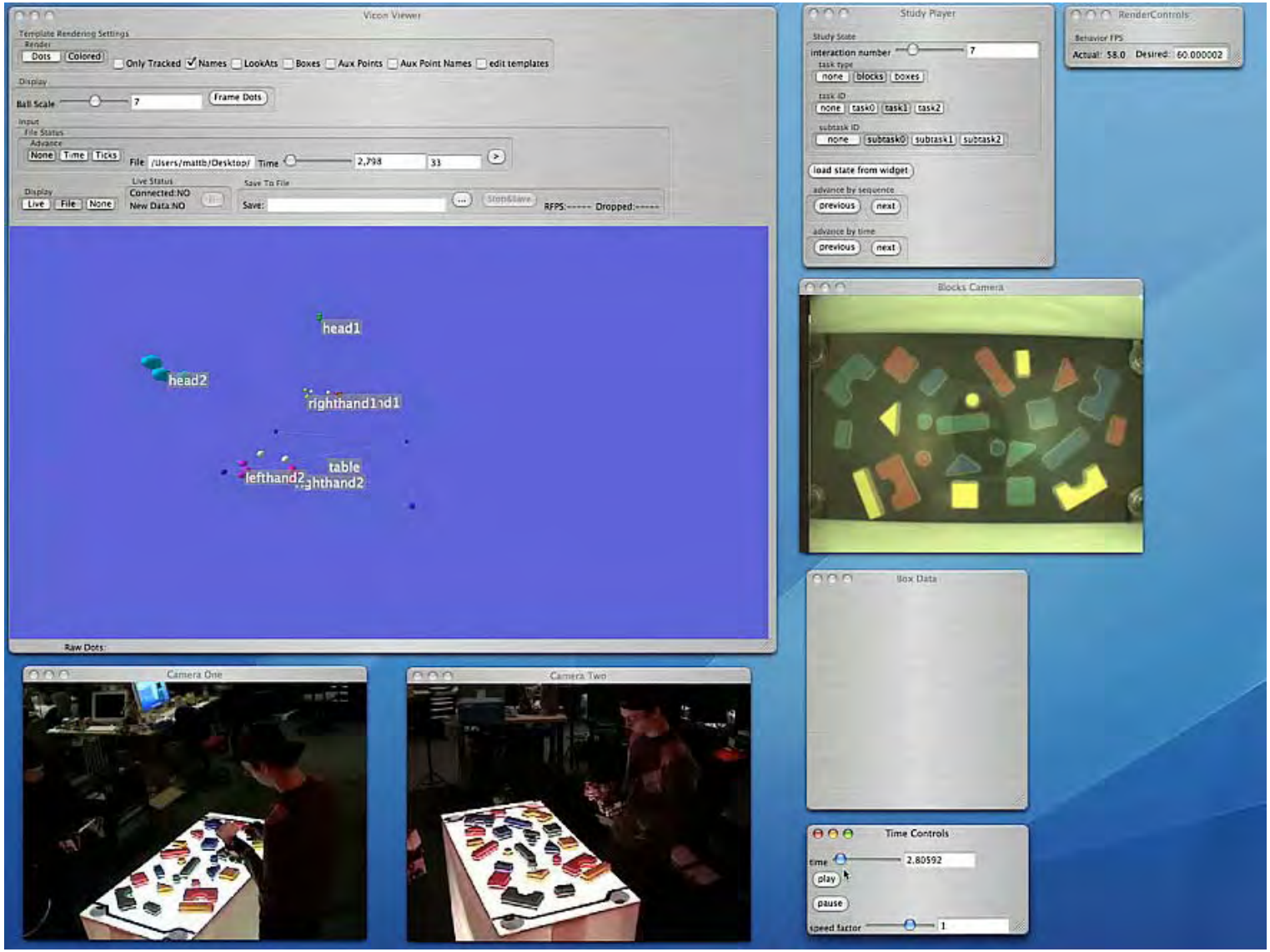






Video

Synchronized Behavior Capture

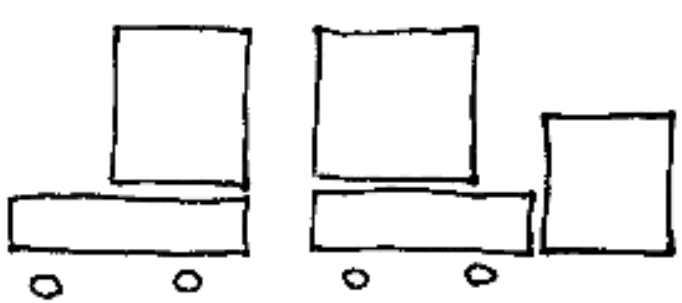


Secret Constraint Tasks

A collaborative task between teacher & learner

Learner Knows

Construct using at least 8 blocks:



Desired Outcome

Teacher Knows

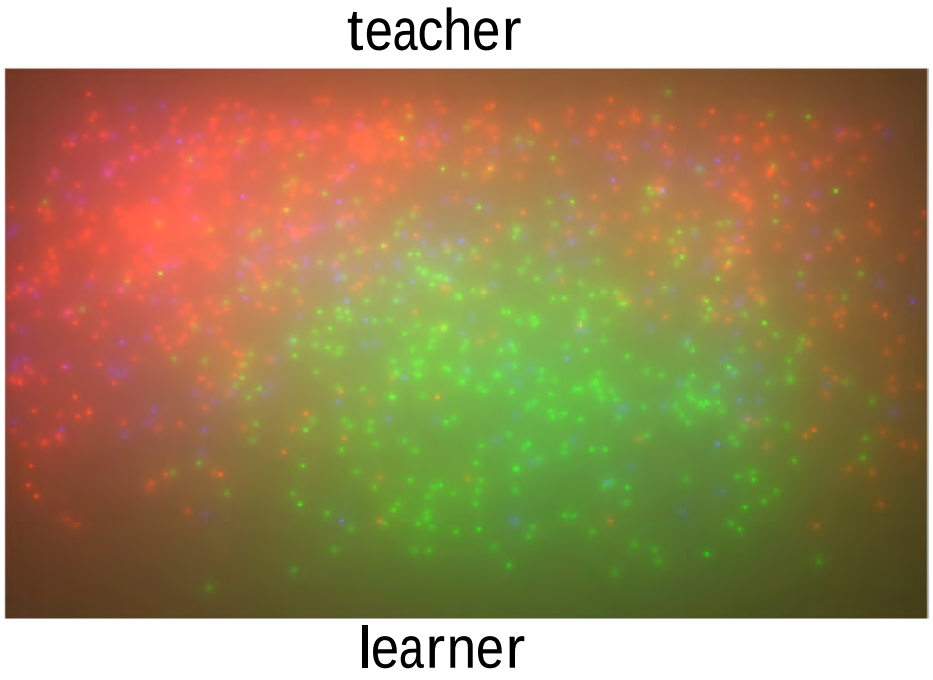
Constraint: the figure must be constructed using all of the **triangular** blocks, and none of the **square** blocks.

What Cues Matter?

Simple Hand and Head Cues
tapping with the index finger
touching with the index finger
pointing
framing with both hands of clustered good blocks
targeting by gaze
Block Movement Cues
block movement towards learner's body or hands
block movement towards center of table
addition of block to figure (often, via replacement of a bad block)
placement of blocks along edge of table closest to learner
clustering with other good blocks
Compound Cues
head nodding accompanying pointing or hand contact with block
head nodding following learner's pointing or hand contact with block
shrugging gesture following learner's block movement - "I don't know/seems OK"
"thumbs up" gesture following pointing or sequence of pointing gestures
pointing back and forth between clustered good blocks and the learner
Emphasis Through Inaction
observation of learner's actions, accompanied by lack of intervention
passing over block in process of providing negative emphasis

Spatial Scaffolding

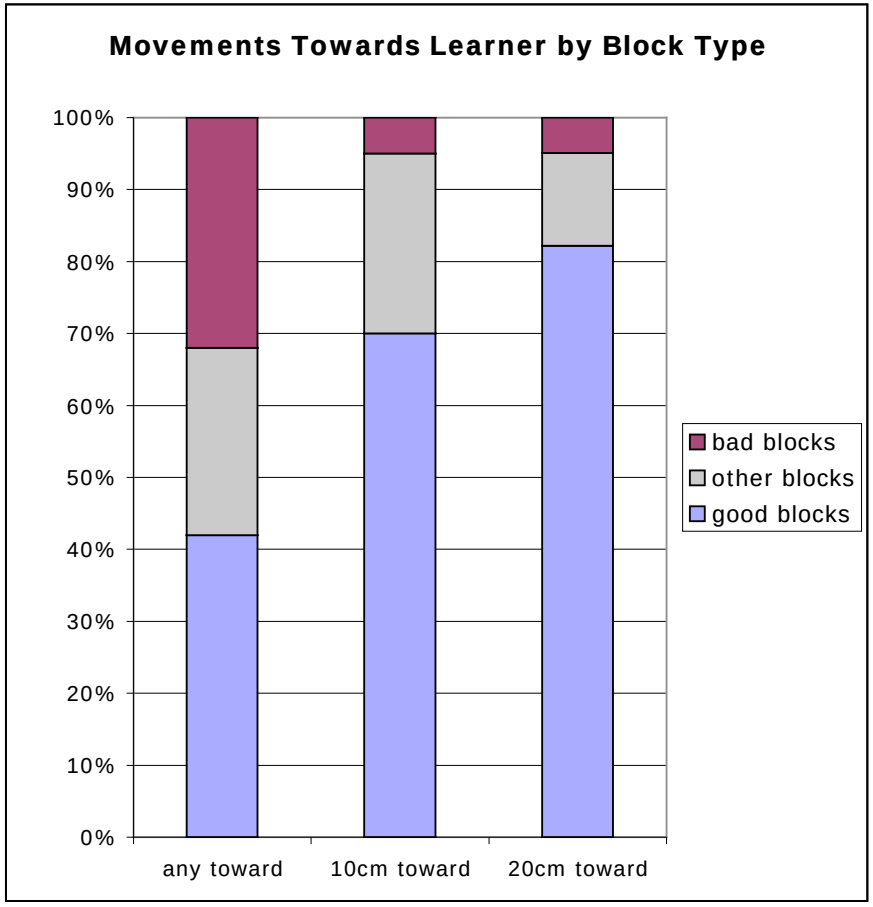
Movement endpoints for good, bad, and other blocks:

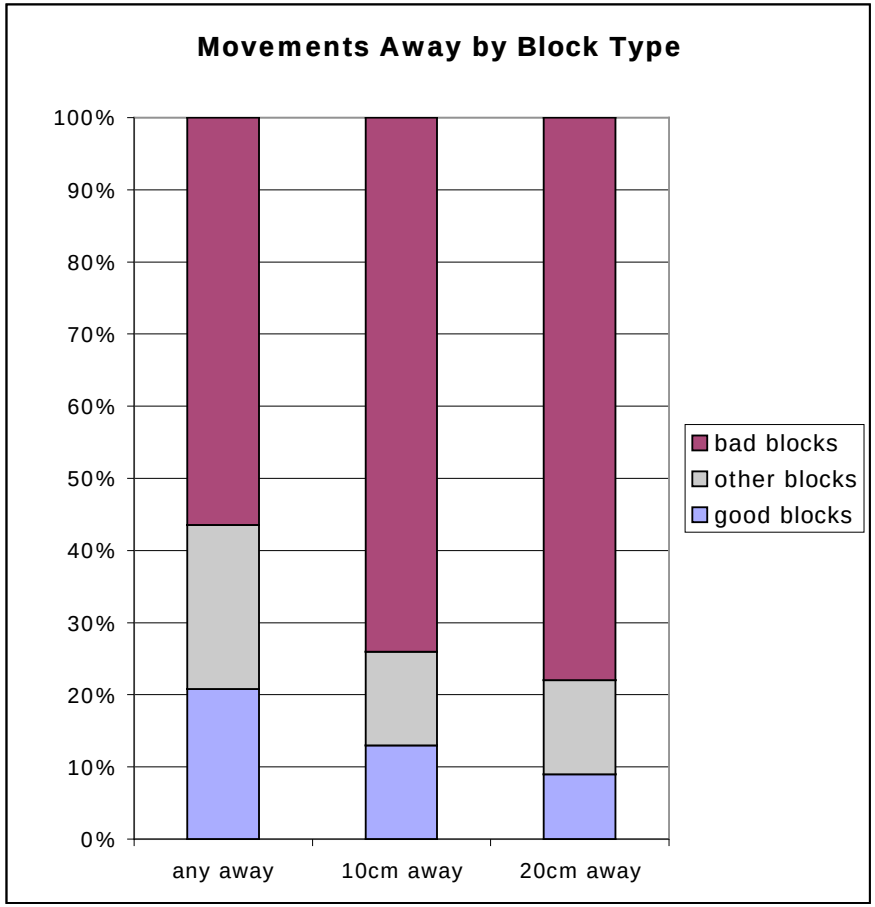


Movements by teachers

Movements by learners

Movements Toward / Away





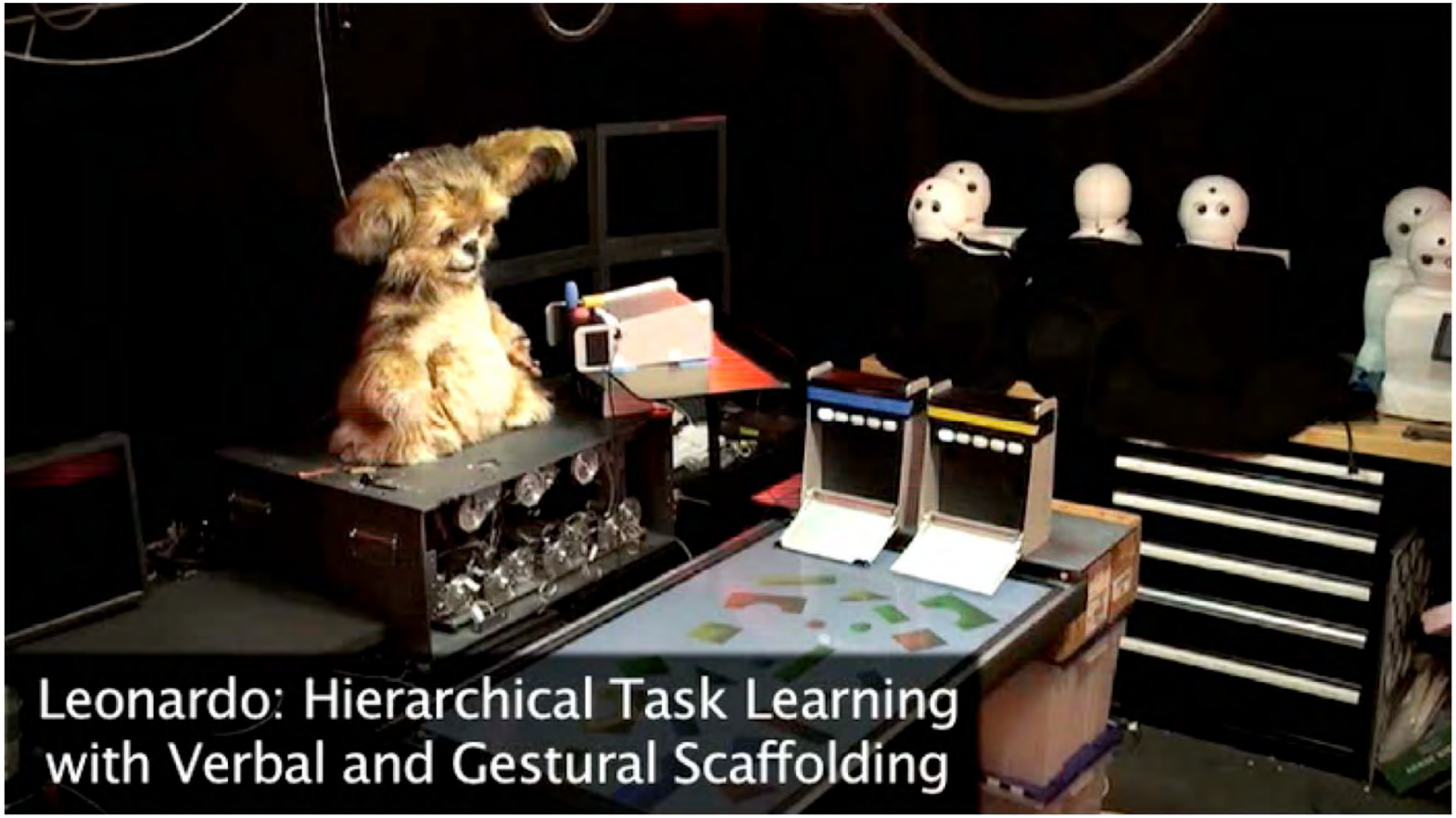
Human-Robot Study

Robot learns successfully from the general public

- Participants NOT told how to teach the robot
- Robot learned secret constraint to complete task successfully in 33 of the 36 interactions (92%)

18 participants, with 2 secret-constraint task interactions each

Putting it Together…



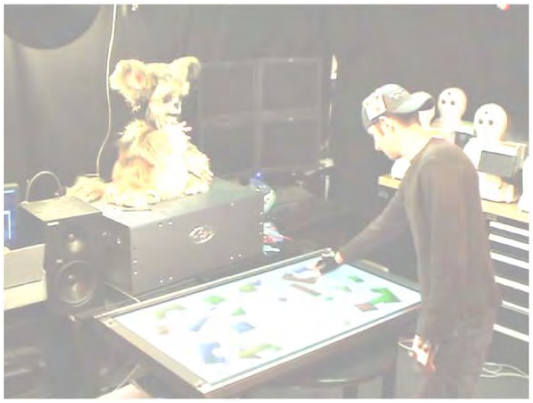
What is Next?

Long-Term Interaction with People in Unstructured Environments

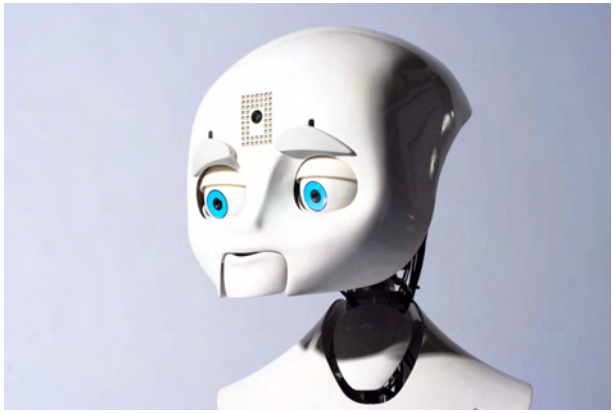
Four Projects

Long Term HRI

Social Learning



Communication



Teamwork

Weight Management

- 65% adults in US are overweight or obese
- Most people who lose weight regain it shortly
- Excess weight leads to chronic health problems
- Diabetes, cardiovascular disease, and stroke. (UN/WHO)

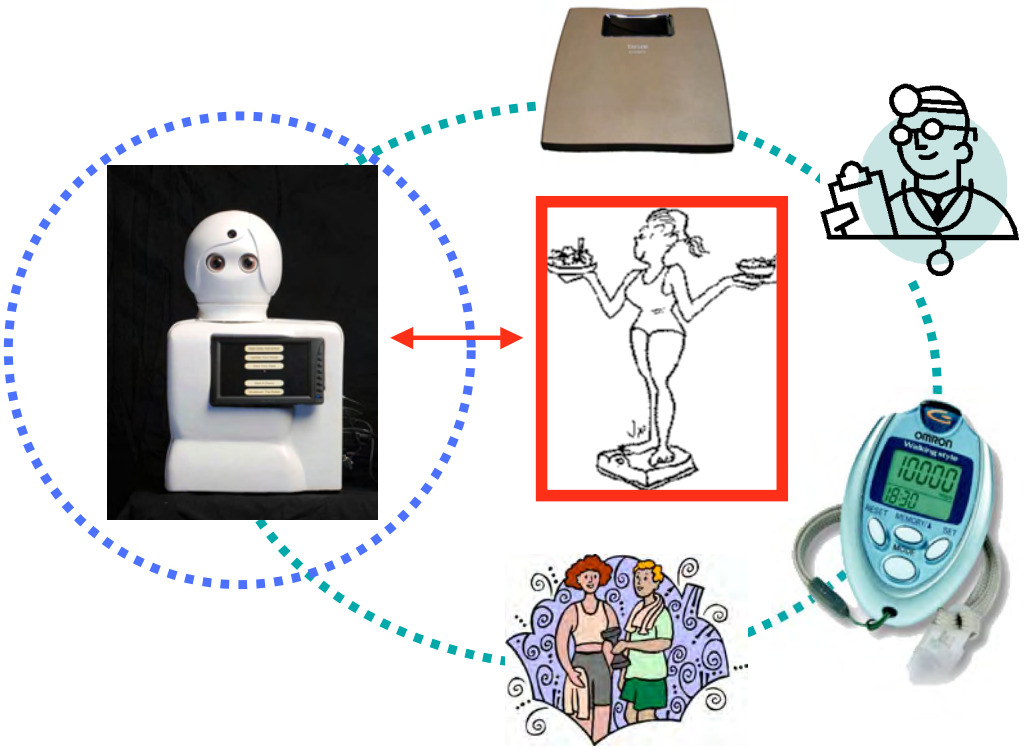
Long-Term Success in Weight Management

- Long-term motivation, must be managed on long-term basis
- Social support
- Accuracy of caloric intake/outake estimates
- **Losing weight is not the problem, it is keeping it off!**

A Robot Diet & Exercise Coach

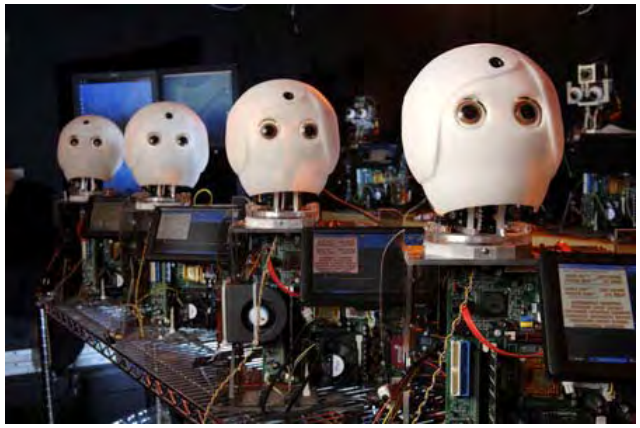
- Long-term motivation & engagement is the most important factor in keeping weight off.
- Social support, building social rapport to work in partnership to goal
- Accuracy of caloric intake & burn-off estimates

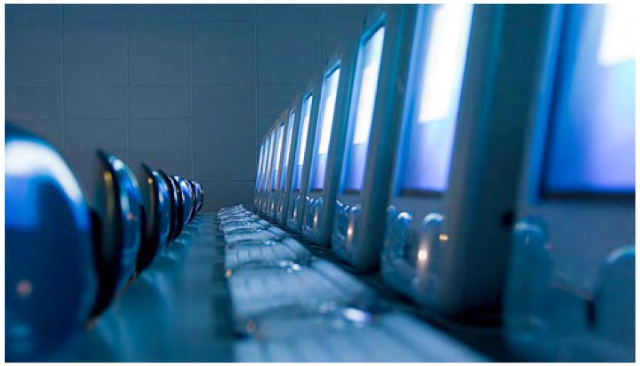
Autom:
A Robot Weight Management Coach



Long-Term HRI Study

- 4+2 week in-home study in Boston Area
- 45 subjects with a weight loss goal
  - 80%F, 18-72 years
- 3 conditions
  - Robot + Relational Model
  - Computer w/touch screen + Relational Model
  - Pen and Paper Log
- Will people be more motivated to work with the robot over the long term and establish a better working alliance?





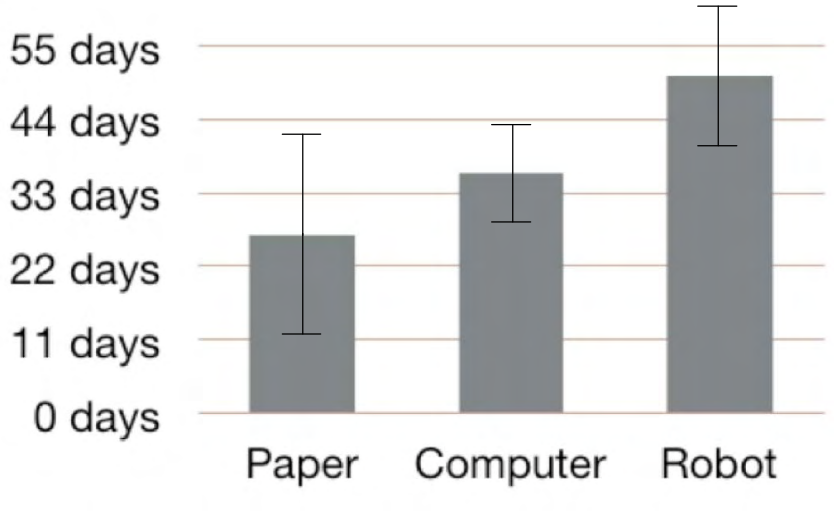
Study results: Duration

Participants used the robot for significantly longer than either of the other systems

Robot: 50.6 days

Computer: 36.2 days

Paper: 26.7 days



One-way ANOVA: $F(2, 30) = 11.51$, $p < 0.001$

Study Results: Working Alliance

Participants felt a closer alliance with the robot than with the computer or the paper log

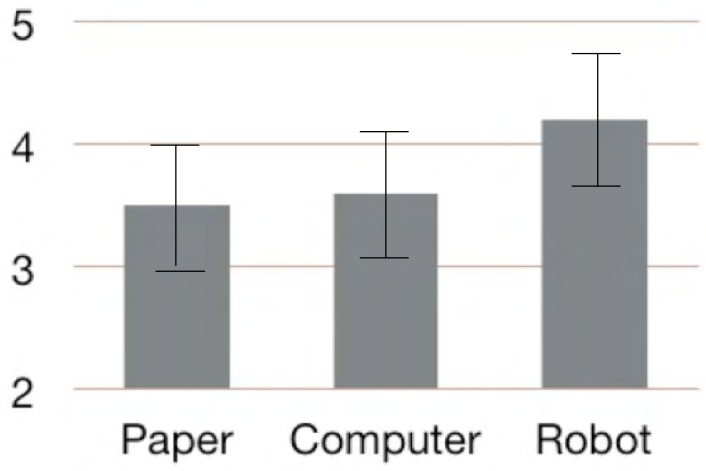
WAI-LF (end of study)

scale: 0..7

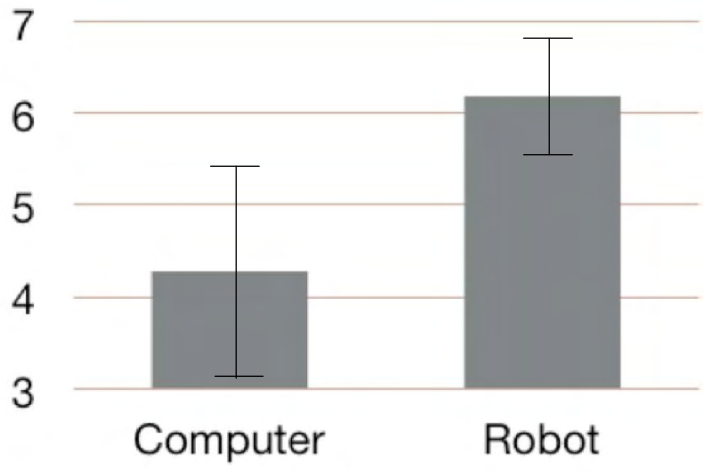
0 = Strongly Disagree

7 = Strongly Agree

WAI-SF (daily)



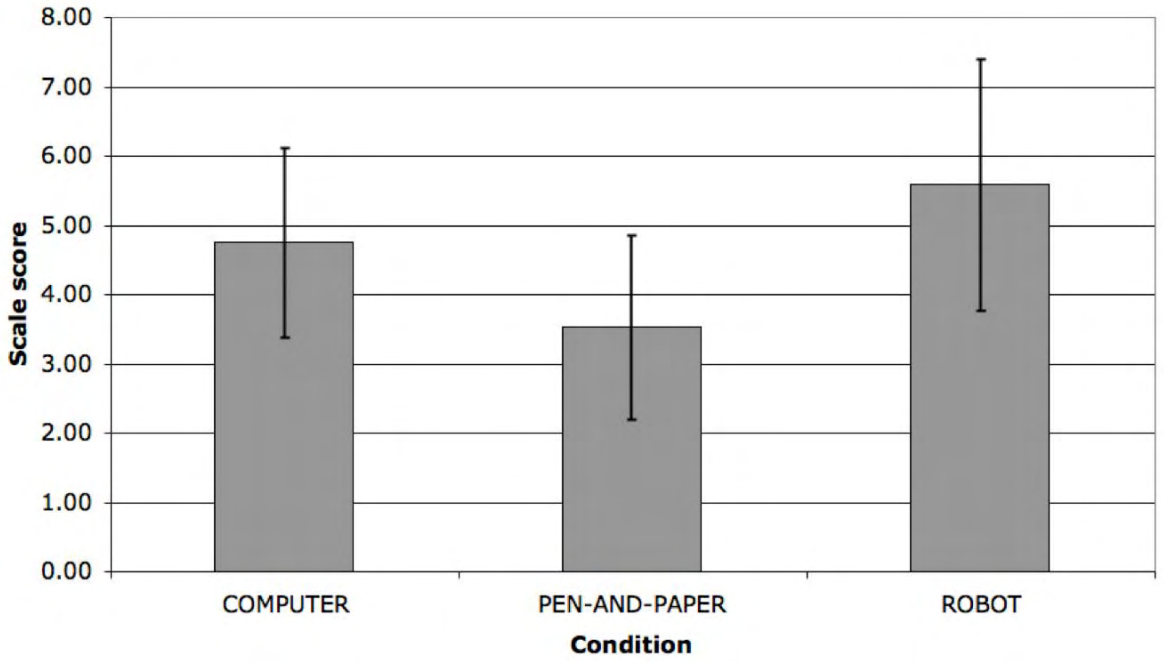
One-way ANOVA: ($F(2, 30) = 5.53$, $p < 0.01$)



Double-sided t test: $t(17) = -5.1$, $p < 0.001$

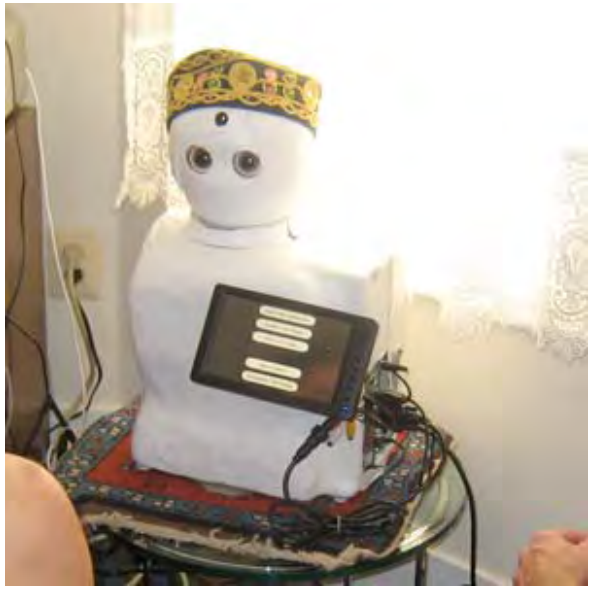
Study results: Trust

Participants trusted the robot more than the computer or the paper log



One-way ANOVA: ($F(2, 30) = 4.98$, $p < 0.05$)

Emotional Relationship

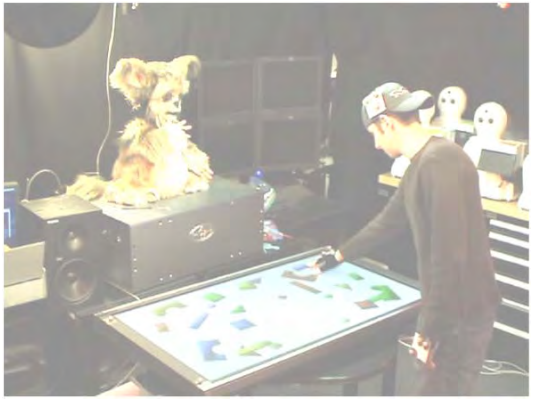


Rosie
Elizabeth
Casper (x2)
My robot
Loquita
Diet Buddy
Robbie
Wendy
Maja
Joselin
Ingrid

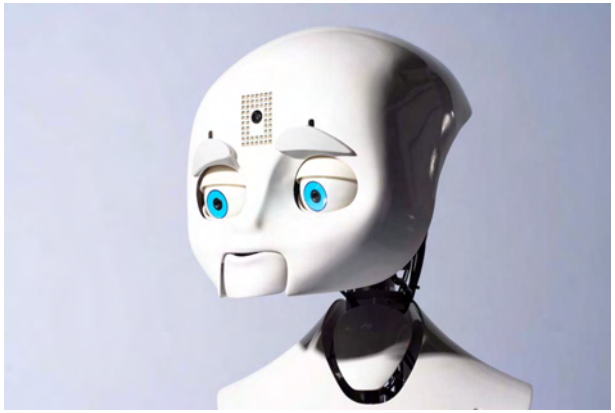
New Projects

Long Term HRI

Social Learning



Communication

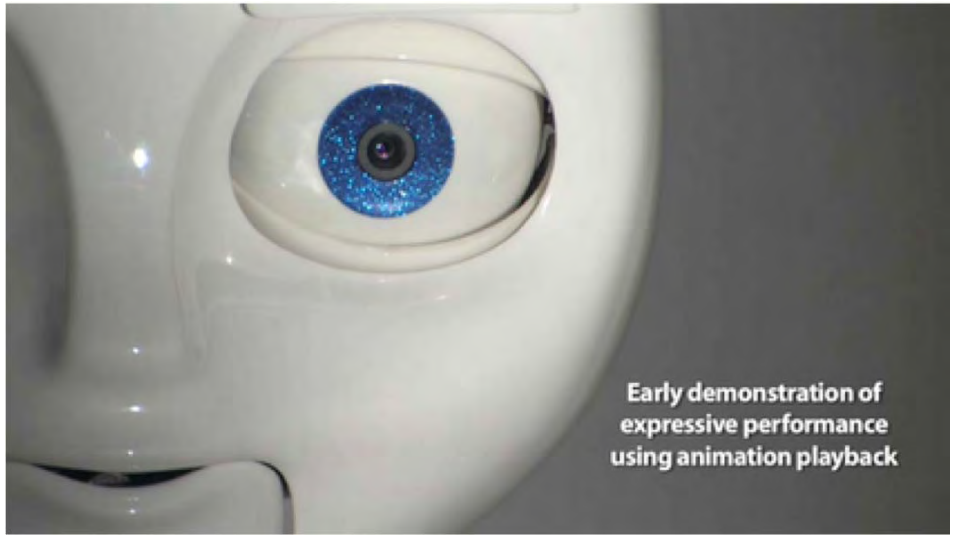


Teamwork

Human Perception of Robots

Ongoing study to understand the role and impact of non-verbal cues

6 week study @
Boston Museum of Science



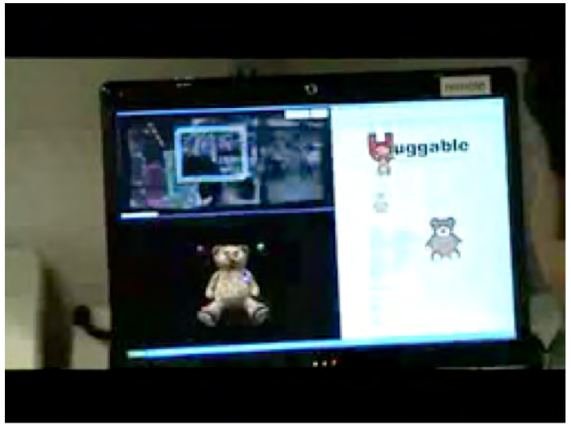
Impact of non-verbal behaviors on people's perception of robot persuasiveness

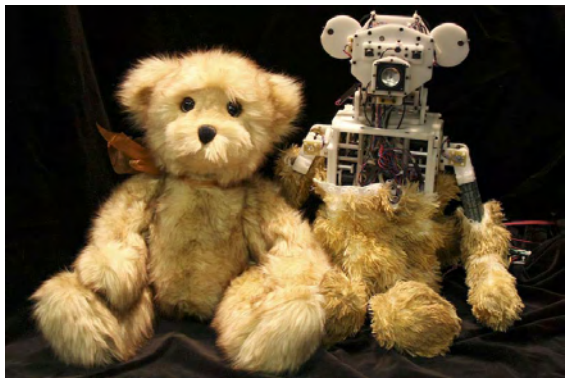
Application to Learning Companions

Distance Learning Technology for early childhood education

6 week study in homes

Robots that provide social support to help you achieve weight management goals





Robot avatars as learning companions for children

6 week study @ Boston Museum of Science

Impact of non-verbal behaviors on people's perception of robot persuasiveness

Our Future with Social Robots

- A coach?
- A new communication medium?
- A learning companion?
- A teammate?
- A teachable helper?
- And more…

What kind of Relationship?

Much remains to understand and ponder…

Fara, age 11
… saying that she could never get timed of the robot because “It’s not like a toy because you can’t teach a toy; it’s like something that’s a part of you, you know, something you love, kind of like another person, like a baby.”

Daire Gaj, age 11

Thank You!


Philipp Robbel
Cynthia Breazeal
Jun Ki Lee
Jeff Lieberman
Cory Kidd
Dan Stiehl
Matt Berlin
Mikey Siegel
Jesse Gray
Siggi Orn
Polly Guggenheim
Guy Hoffman