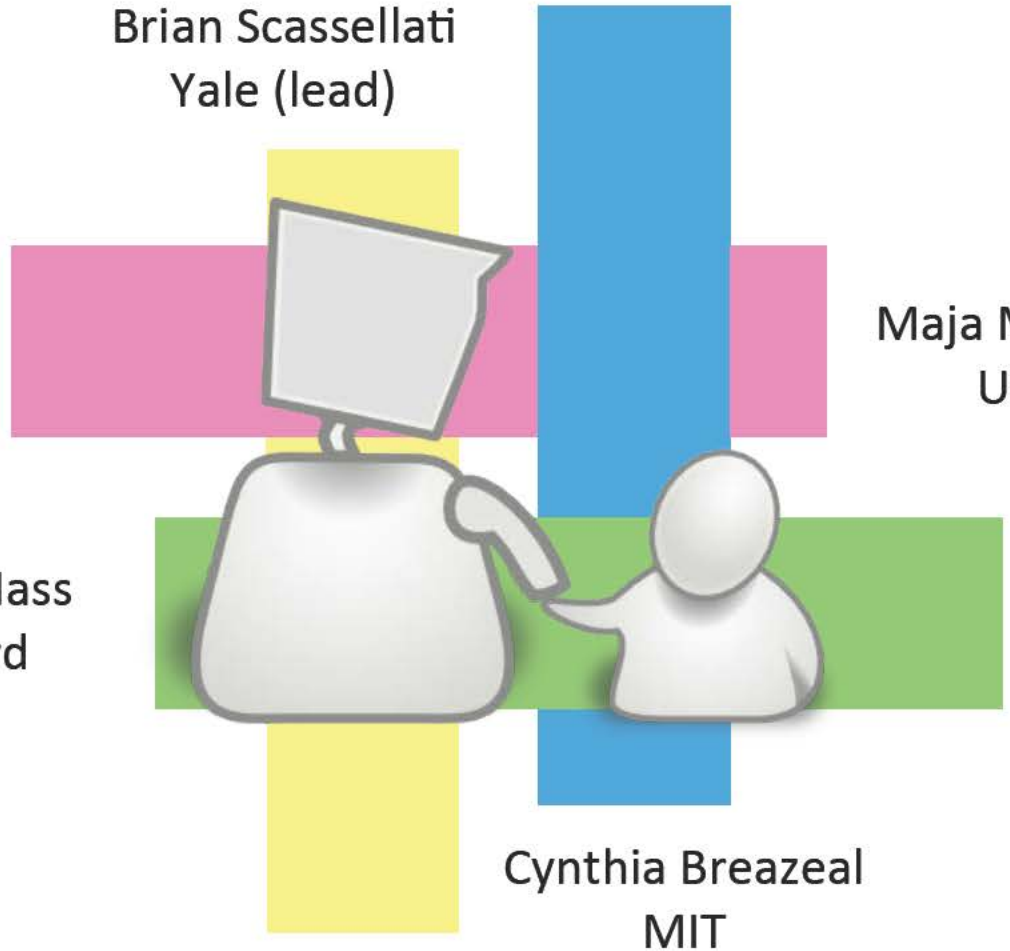
Socially Assistive Robots

NSF Expedition in Computing PI meeting



Vision

- To create socially assistive robots that supplement the efforts of educators, therapists, parents and clinicians to teach social, emotional, and cognitive skills to children, including those with social or cognitive deficits.

Supporting Cognitive and Social Disabilities

- Social and cognitive deficits in children have quadrupled in the US in the last decade alone

- Flexible interactions need to adapt to the changing context
- Heterogeneous presentations; robot must be personalized to the child's strengths and deficits
- Engagements must progress as the child become more adept, over a period of months to years

Pleo engaging children with developmental disabilities @ Yale

English Language Learning

- 20% of US school children are raised in homes where English is not the primary language

- Language learning is socially gated; personal interaction is essential
- Needs to adapt to individual vocabulary and concepts
- Requires long-term exposure and engagement over years for fluency

Dragonbot for language learning @ MIT

Health Maintenance

- 17% (or 12.5 million) of children and adolescents in the US aged 2-19 years are obese

- Must shape the interaction to make it engaging, motivating, and effective
- Motivation techniques must be tailored to the individual child
- Social support is critical for long-term behavior change and adherence

Bandit providing exercise routines @ USC

Expedition Vision

Imagine a robot that can …

… guide the child toward long-term behavioral goals;

… be customized to the particular needs of the child;

… develop and change as the child does;

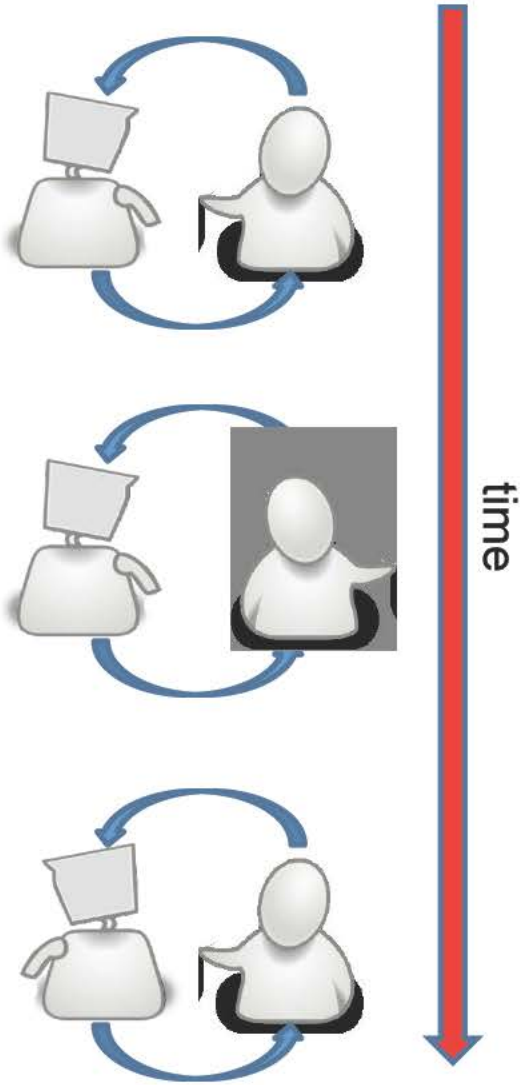
… engage the child as a peer, not as a parent, teacher, toy, or pet.

Research Thrusts

- To achieve this vision, we need transformative computational discoveries
  - Models of the dynamics of social interaction
  - Algorithms for personalized assistive interactions
  - Framework for long-term guidance and support

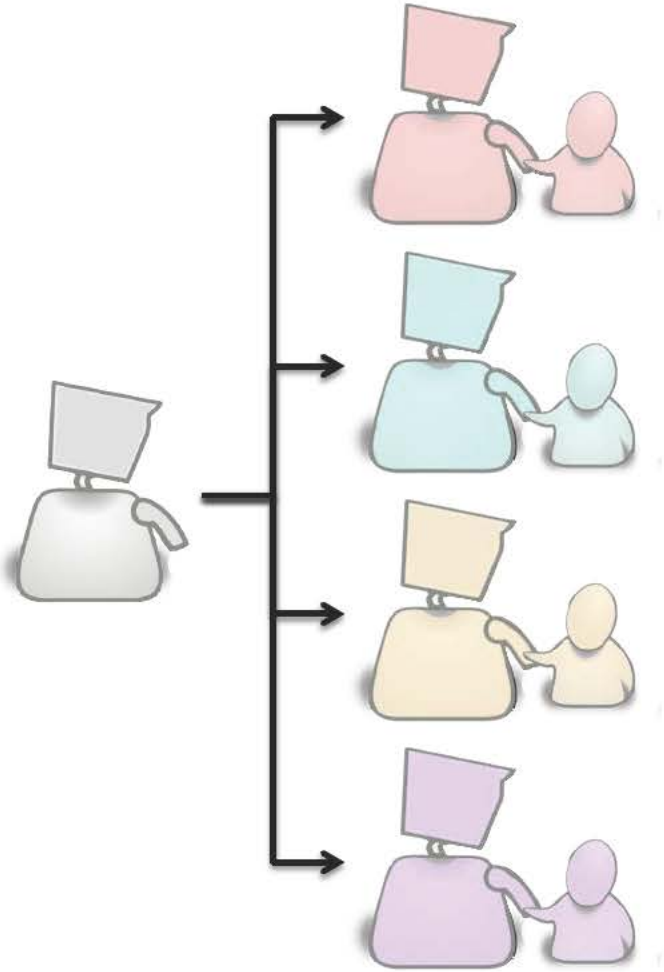
Models of the Dynamics of Social Interaction

- State-of-the-art
  - In-the-moment social cue recognition
  - Brittle behavior selection
- New capabilities
  - Engage in dynamic interplay
  - Steer toward a behavioral goal
  - Leverage social information on trust, credibility, engagement from within the social dynamics



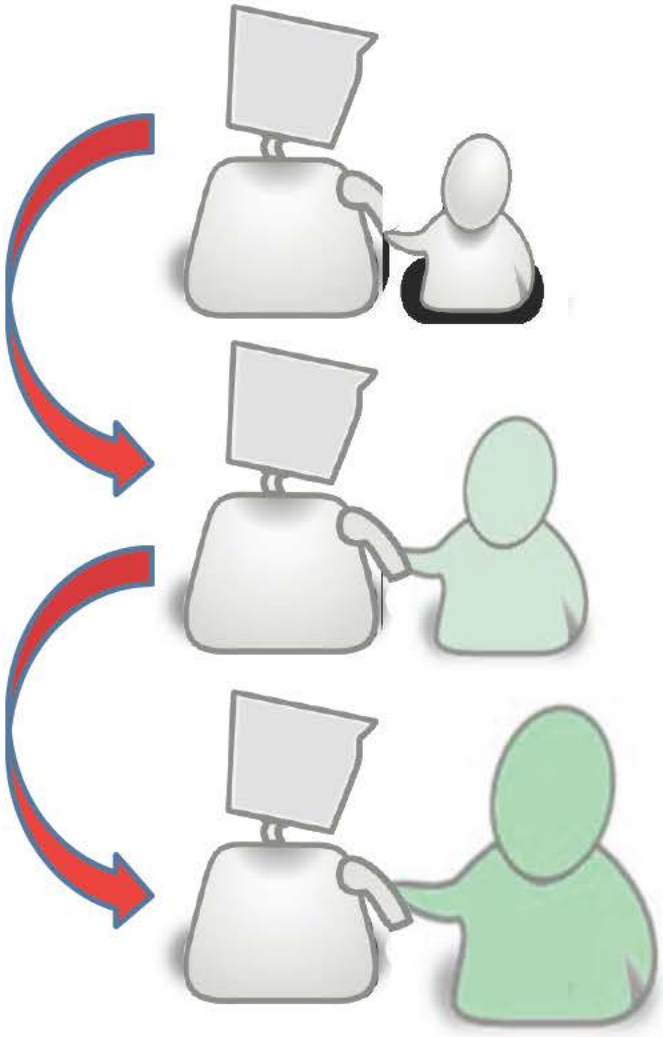
Algorithms for Personalized Assistive Interactions

- State-of-the-art
  - User-choice or survey-driven personalization
  - Stationary and homogeneous training and testing
  - Recommender systems
- New capabilities
  - Continuous adaptation to individual differences
  - Goal-driven adaptation
  - Unique corpus of interaction data across a large population



Framework for Long-Term Guidance and Support

- State-of-the-art
  - Few long-term social interactions
  - Template-driven responses
- New capabilities
  - System grows with the child (scaffolding)
  - Sustained motivation and engagement
  - Characterize of the evolution of interaction over time across a population



SAR Core Research Team

Robot Development Partners


Scassellati


Matarić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Technology Partners


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Outreach Partners


Resnick


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Evaluation Partners


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Application Partners


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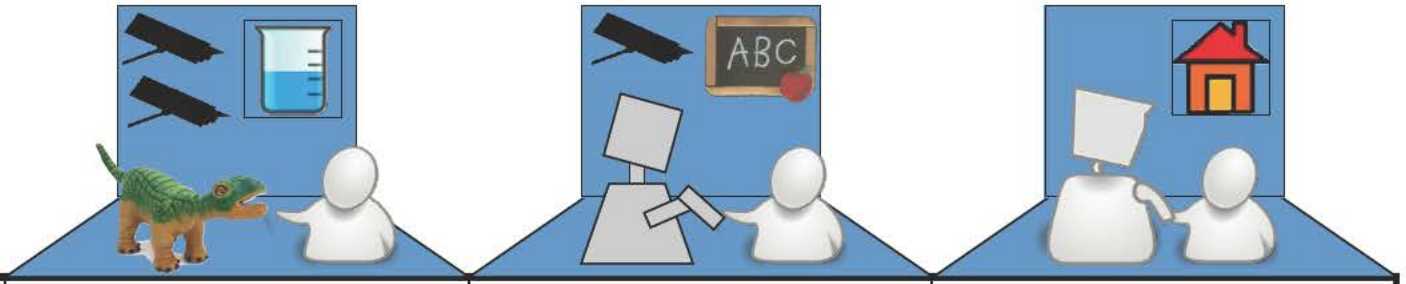
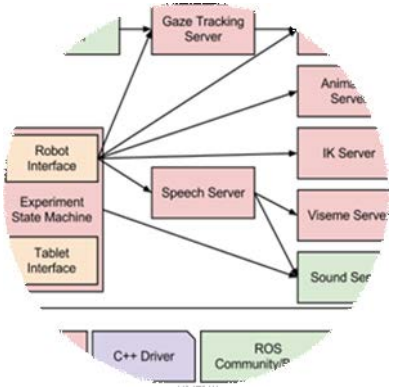
Wolf

Research Plan



	Year 1	Year 3	Year 5
Deployment location	Laboratory	Preschool classroom	Home
Application domain	Health maintenance	English language learning	Children with social deficits
Type of robot	Off-the-shelf	Research prototype	Replicated design
Sensing & computation	Instrumented in room	Portable external sensing package	Self-contained within robot
Behavioral scope	Monitor one particular skill	Engage multiple target skills	Adapt as child's changing skill level
Interaction length	1 week	2 months	1 year
Evaluation criteria	Pleasant and engaging interaction	+ Adherence to an educational goal	+ Generalization to other interactions

Year 1 Research Highlights



Child-Robot behavior as a Catalyst for Child-Adult behavior

- Pre-encounter interview
- Robot encounter
  - "afraid of water"
  - Child prompted to provide appropriate prosodic intonation
- Post-encounter interview

23 ASD + 12 TD controls (age 8-12 yrs),
high-functioning (full scale IQ >70) , verbal, ASD diagnosis (ADOS, ADI-R)

Child-Robot behavior as a Catalyst for Child-Adult behavior

Child-Robot behavior as a Catalyst for Child-Adult behavior

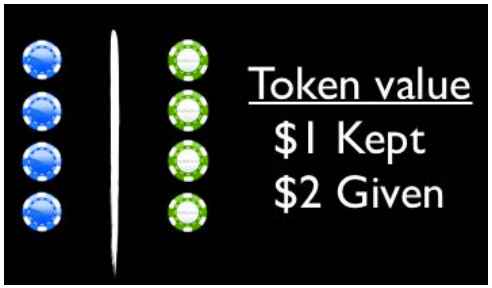
more *face-to-face orientation* to the interviewer
(paired one-sided t-test, p = .03)
more *relevant statements* to an interviewer's personal story
(paired t-test, p=0.004)

Computational Models of Trust

Task:

1) 5-minute conversation

2) Give-Some-Game

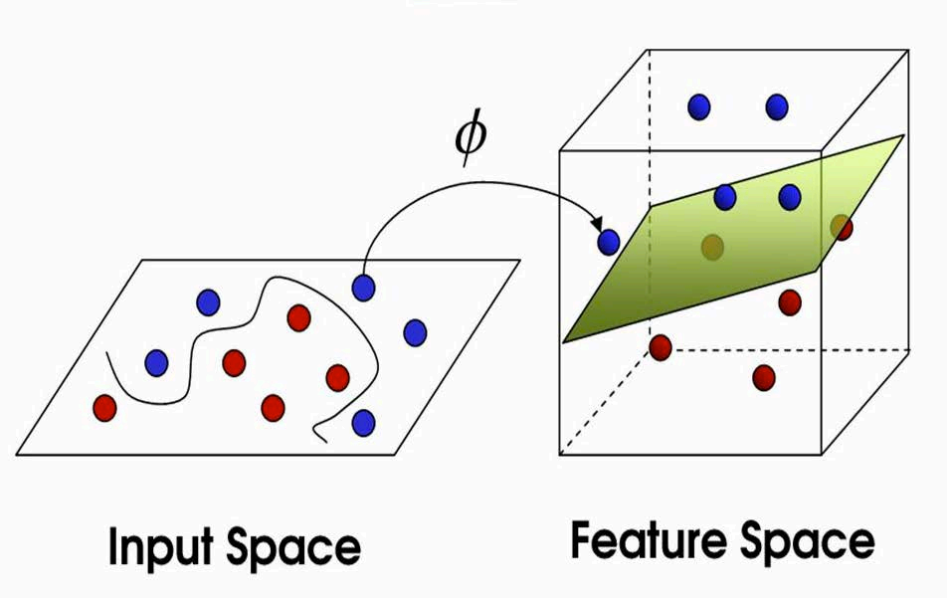


Data:

- Video data
- Nonverbal coding
- Trust measurements

- 56 dyadic interactions or 112 individuals
- Undergraduates at Northeastern University
- 31% male and 69% female.

Computational Models of Trust



Support Vector Machines
- high dimensional properties
- success in prior works
- off-the-shelf classifier

Feature Extraction

I. Counts, durations, means of the 4 trust-related gestural cues
- cross arms, touch hand, touch face, lean away

II. Temporal features by encoding templates looking for certain patterns of emitted gestures

III. Features derived for both participant and their partner along with their differences

Computational Models of Trust

Classification Results

model	description	Mean prediction error	t-test
svm	rbf kernel nested LOOCV	0.73	---
random	randomly guesses 0,1,2,3,4 tokens	1.24	$p <$ **0.000**0003*
human	human judgement	1.00	$p <$ **0.000**4025*
a priori	always guesses 2 tokens	0.83	$p <$ **0.014**4585*

SVM model significantly outperforms all baselines

*Wilcoxon's Signed Rank test with a Bonferroni correction of $p < .0166$ for significant difference

Year 1 Demonstration

- Nutrition training interaction
- 1st grade students
- Integrates:
  - Hardware from MIT
  - Software from Yale
  - Experimental design from USC
  - Evaluation mechanisms from Stanford
- Autonomous interaction flow, but with tele-operated perception and dialog selection

Year 1 Demonstration

- 4-week long, twice-weekly intervention
- Each week focuses on a different education goal
  - Choosing whole grains and non-sugary drinks for lunch
  - Choosing healthy after-school snacks
  - Choosing healthy cereals and a balanced breakfast
  - Choosing colorful vegetables as sides at dinner
- 1st day with robot as expert, 2nd day for collaborative problem solving

Year 1 Demonstration

Outreach

- Year 1:
  - Get kids into our labs
  - Get researchers into schools
  - Large-scale and hands-on events at multiple sites
- Years 2-5:
  - Social robot toolkit
  - Curricular materials
  - Evaluation program

Outreach

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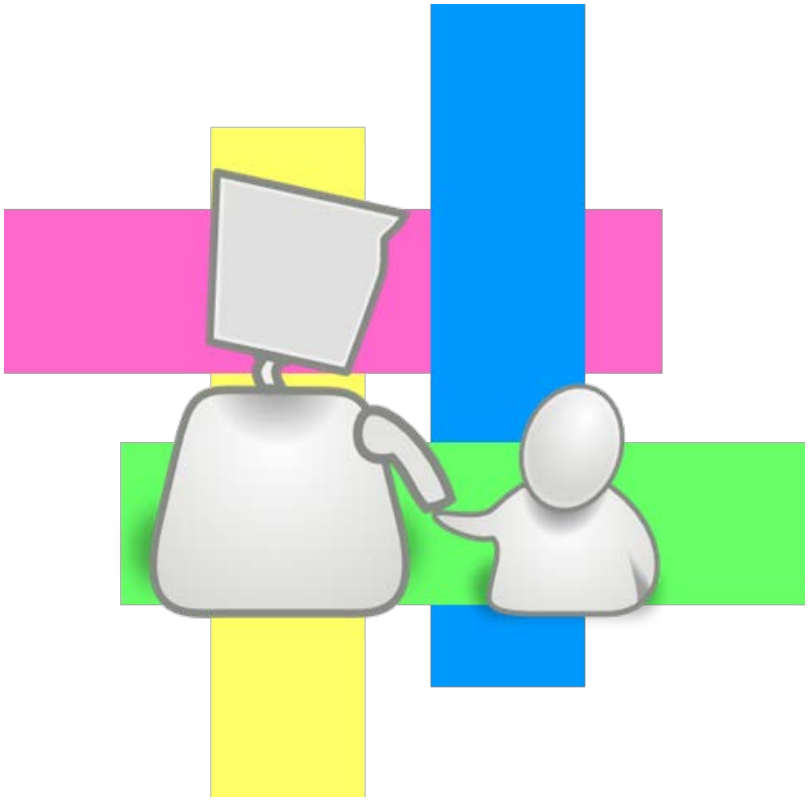
An NSF Expedition in Computing



- Present for PI meeting:
  - Brian Scassellati (Yale, PI)
  - Maja Matarić (USC, co-PI)
  - Cynthia Breazeal (MIT, co-PI)
  - David Feil-Seifer (Yale, NSF CI Fellow)
  - Henny Admoni (Yale, graduate student)

www.RobotsHelpingKids.org