Socially Assistive Robotics for Supporting Child Assessment and Development

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Socially Assistive Robotics

Robots that help people help themselves

They provide a key combination of features:

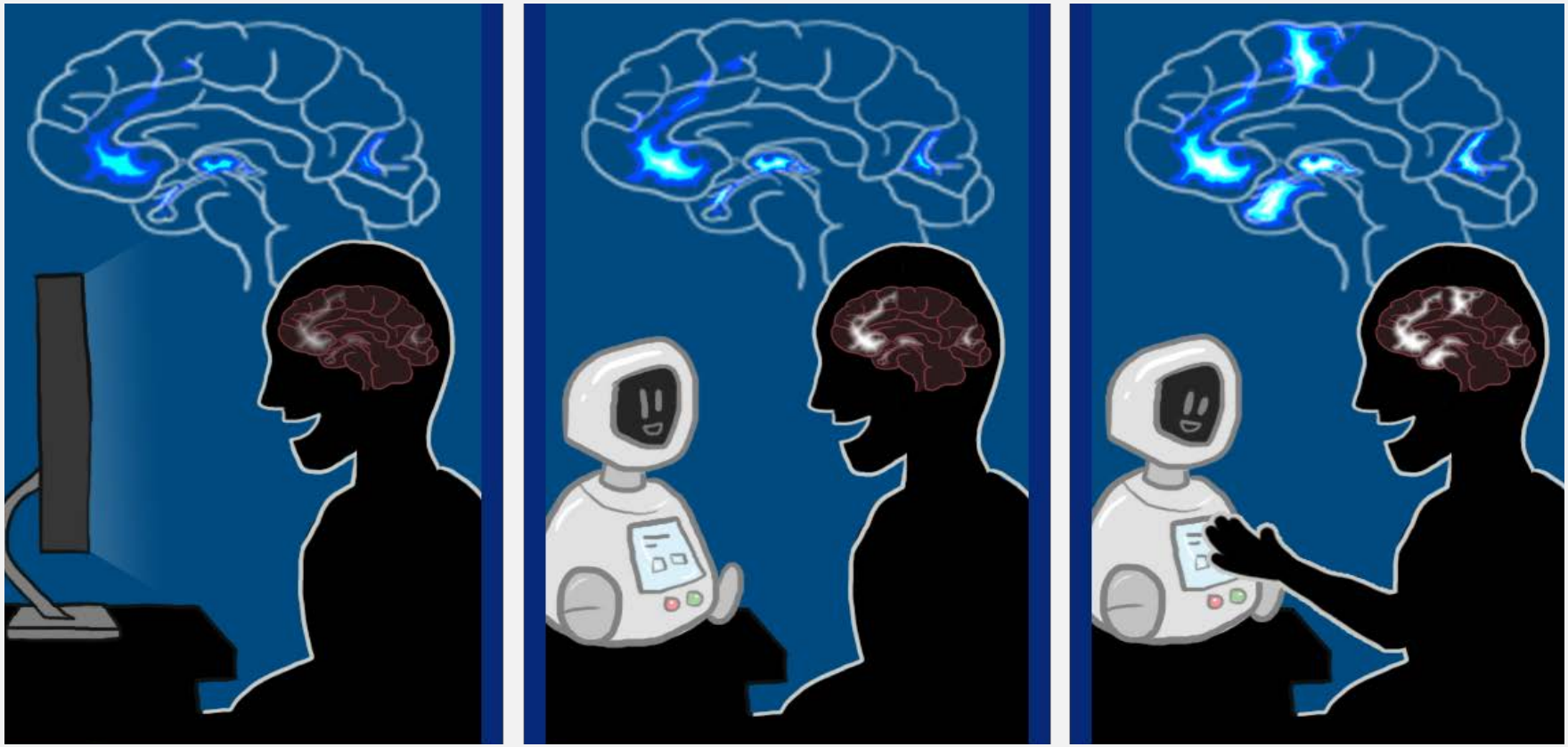
- Monitoring ("the quantified self")
- Assessment
- Coaching

Most importantly:

CONTINUOUS and PERSONALIZED
EMBODIED SOCIAL SUPPORT:
MOTIVATION + COMPANIONSHIP

New Yorker Magazine, Nov 2009
article by Jerry Groopman

Embodiment is Fundamental for Interaction & Learning



The Role of the Robot

A robot is not just a toy, pet, camera, or reinforcement tool

It is a supportive & knowledgeable peer, buddy, or coach:

- **has agency, behaves contingently**
- **is inherently motivating and rewarding**
- **has a character/personality (some predictability and some surprise)**

SAR for ASD

- A rapidly growing field; over 10,000 peer-reviewed articles
- Committed interdisciplinary researchers
- World-wide interest
- Numerous studies & insights

Almost 20 Years of SAR for ASD

Goal:

- Safe, continual assessment with emotional and social support
- Creates opportunities for shaping and practicing social, cognitive, and emotion regulation skills
- Serves as a social catalyst to bringing the child closer to peers and others

Current state:

- Numerous one-of small-scale studies
- Insufficient federal funding and robot platforms to scale up research
- A few startups
- Rapid progress in ML-supported real-time perception, dialog

Our ~20 Years of SAR for ASD

Single-session studies:

- The role of robot contingency, agency, and embodiment

Multi-session studies:

- Learning by imitation

Long-term studies:

- Motor learning
- Infant-mother dyads
- In-home cognitive and social skill learning

Contingent Robot Behavior

Robots are agents, but are they perceived as such and does it matter?

Contingency implies agency and distinguishes robots from toys

Findings:

- **Children with ASD engage in more and richer social behaviors with a contingently behaving robot than with a randomly behavior robot**

Embodiment & Agency

How do robot morphology (embodiment) and agency relate?

Findings:

- **Perceived agency is determined by developmental stage, not by the robot's embodiment**
- **Users fall into one of two groups: robot is agent or object**
- **Agent group attends to speech and to human-like features**
- **Object group attends to buttons and less at human-like features**

→ Robot morphology and behavior should match the user's development stage and interaction needs and goals

Robot-Guided Learning by Imitation

Imitation is complex and important for motor and social learning

Robots learn by imitation, can they teach, too?

The robot provides:

- **Personalized level of challenge**
- **Shaped feedback via graded cueing**

Results:

- **Improved learner autonomy**
- **Decreased learner frustration**

Robot-Guided Social Learning by Example

Bullying is ubiquitous, is it learned? Can a proper response be taught?

The robot provides:

- **Recognition and labeling of undesirable behavior**
- **Examples of how to respond calmly**

Movement Practice Through Infant-Robot Interaction

Infant motor development is critical; at-risk infants are hard to diagnose and to engage in movement practice

Can robots get infants to move in a directed fashion?

- **Infant-sized humanoid robot to engage mirror neurons and motivate targeted/prescribed movement practice**

Associated benefit: quantitative assessment of infant development

Movement Practice Through Infant-Robot Interaction

Approach: adaptive feedback & reward, and personalized challenge

Findings:

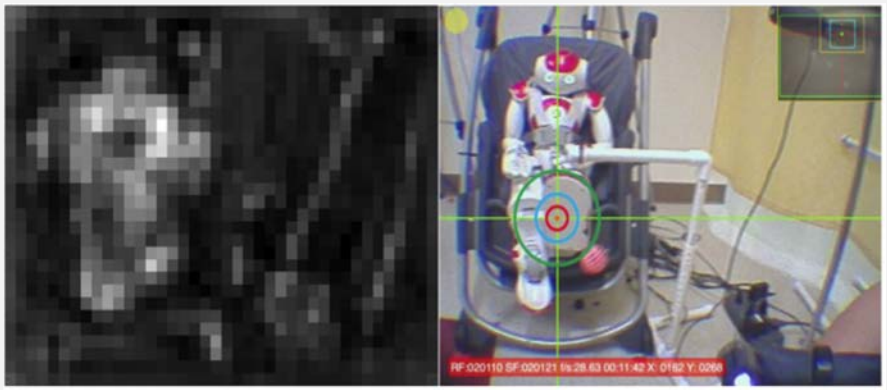
- **Infants attend to the robot, move less while watching, more after**
- **Appear to imitate and follow the challenge**

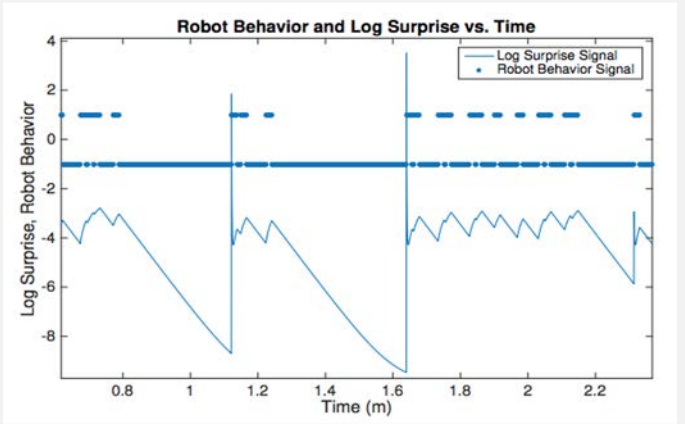
Modeling Infant Surprise

Can we drive the infant's visual attention?

Findings:

- **Bayesian model of surprise (Itti & Baldi '06) works for infants as well as adults**
- **We can drive infant visual attention, resulting in directed imitation**

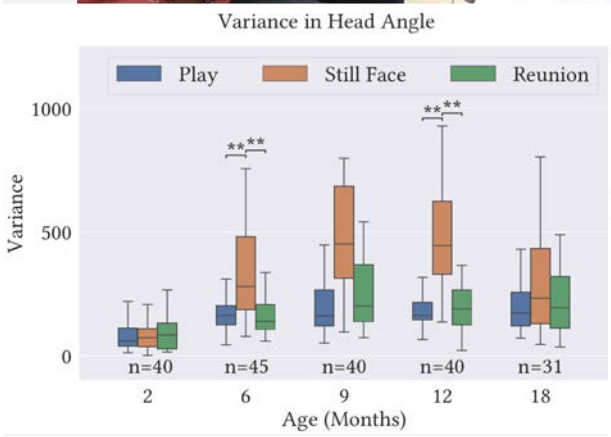


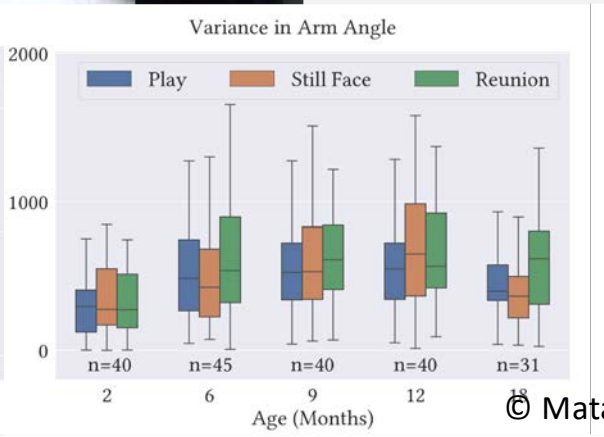


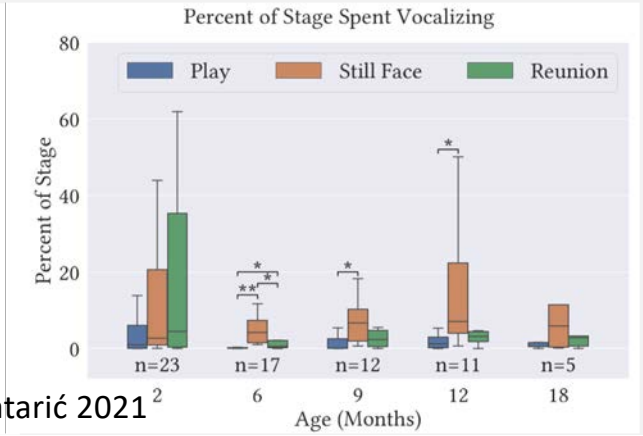
Modeling and Coaching Dyadic Interactions

Caregiver stress and distractions measurably impact early infant development

- **Approach: monitor, model, and coach dyadic interactions to personalize to caregiver-child needs**







Personalizing In-Home Learning

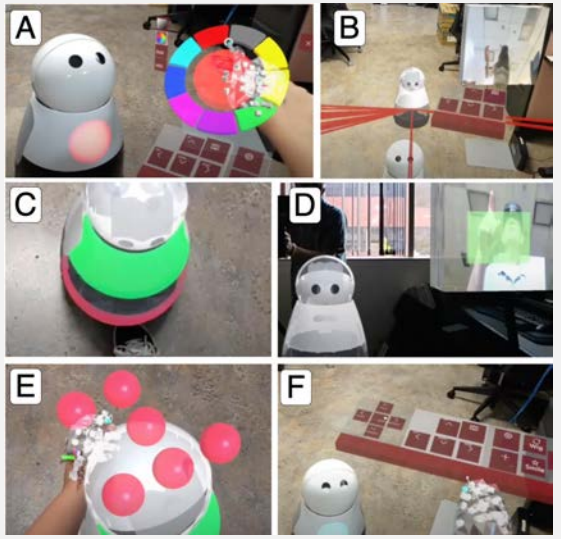
- 40 homes (20 in LA, 20 in New Haven); month+ in the home, supporting math and social skill learning
- **Strong results supporting both math and social skill gains and retention (1+ month post)**
- Unique dataset

Sharing an Augmented World for Learning

Augmented reality (AR, e.g., Pokemon GO) is becoming affordable and easy to use. Can it help children to understand others better and learn more easily?

AR for Theory-of-Mind, kinesthetic learning:

- **"Look inside" the robot via AR to "see" the robot's intents, goals, mechanisms**
- **The robot is a less opaque social partner for interaction practice**
- **Interaction can include movement and virtual objects & visualizations**



A Treasure Trove of Insights About ML

- **Vast variance between and within users/study participants**
- Most popular deep learning methods are less effective than tree-based ones
- Novel transfer learning challenges: do data from other children help to model and predict a new child user?

SAR State-of-the-Art Summary

- Users smile, pet, hug, engage, and play with and learn from socially assistive robots, adhere with therapies, form bonds
- User stress is reduced, socialization increased, outcomes sustained
- Interactions elicit communication, turn taking, initiating play, adherence and practice, even the first social smile

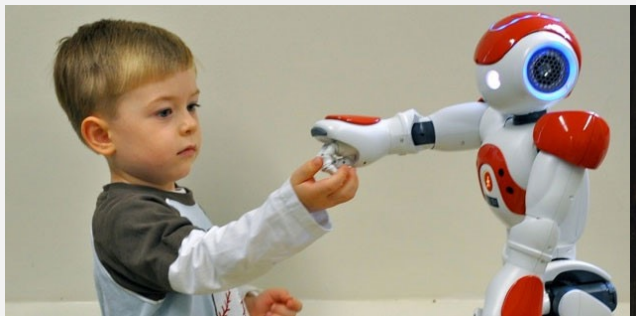
Some Consumer Products

Specialized products:



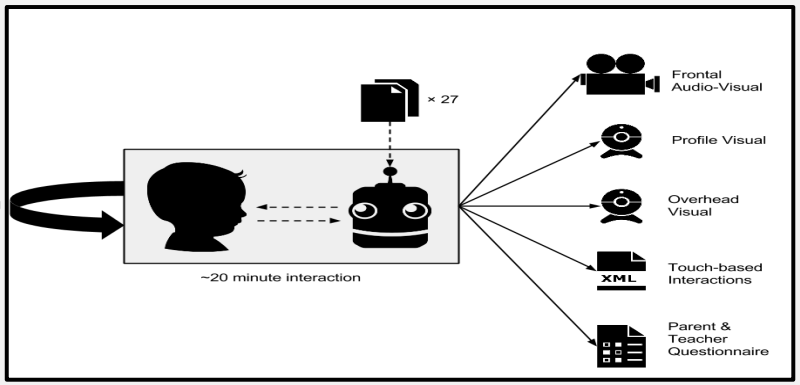
Milo (Robokind, >$6500), Moxie (Embodied, $1000), HomePal (MOVIA, >$2800)

General robot platforms with specialized software/services: NAO, Buddy, QT



Real-World Studies and Datasets are Too Rare

Most computing research uses convenient datasets, convenience populations, unimodal data (video only), unrealistic scenarios



Often this is not by researcher choice

There is a paucity of useful data from:

- **Real-world contexts (e.g., homes)**
- **Realistic, complex interactions**

Everyone is Unique

- Every user is different and every user changes over time
- Human-machine interaction is a mutually-shaped social dynamic
- Machines must observe, learn from, and interact using multi-modal data
- Big data and deep learning are not enough; personalization is critical for adoption and efficacy
- **We need more interdisciplinary collaborations, open minds, and funding for large studies**

Human-Robot Interaction That Empowers

- Personalized machines can be a key aid in development
- They enhance, not replace human experts and interventions
- They allow for continuous assessment and personalized support
- When human support is not available, they can change lives



A BIG THANK YOU to MY STUDENTS and OUR COLLABORORS & SUPPORTERS

QUESTIONS ?