

Socially Assistive Robotics for Infant and Early Child Development

Maja J Matarić

Computer Science, Neuroscience & Pediatrics

University of Southern California

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Socially Assistive Robotics

Robots that help people help themselves

Apps can give us:

- Monitoring (“the quantified self”)
- Assessment
- Coaching

But what we need is:

**CONTINUOUS and PERSONALIZED
EMBODIED SOCIAL SUPPORT:
MOTIVATION + COMPANIONSHIP**

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New Yorker Magazine, Nov 2009
article by Jerry Groopman

The Role of the Robot

The robot is not just a toy

It is a motivation and reinforcement tool

AND

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)



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Motor 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

Motor Practice Through Infant-Robot Interaction

See infant interaction video here:
<http://robotics.usc.edu/interaction/sponsors/babies>

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

Can We Drive Infant Visual Attention So It Will Drive Movement?

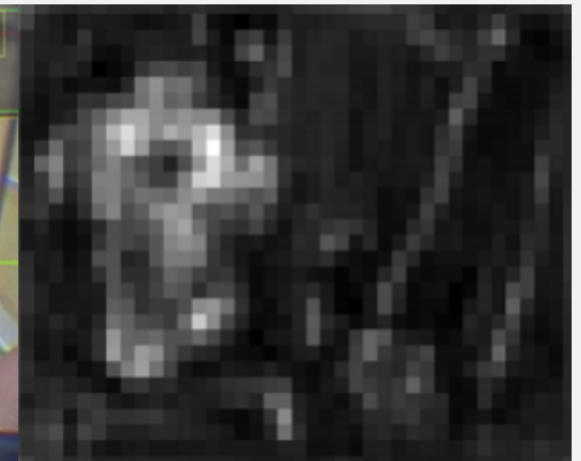
Infant visual attention is drawn to areas with temporal and spatial saliency

Findings:

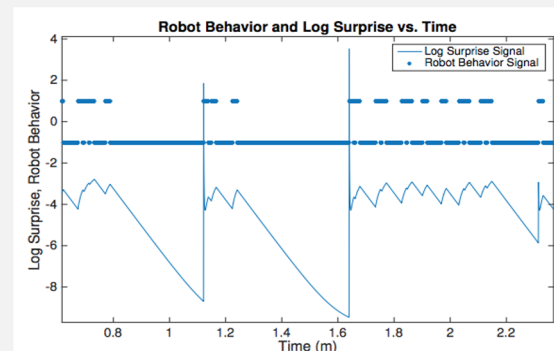
- Bayesian model of surprise (Itti & Baldi '06) works for infants as well as adults
- We can drive visual attention toward directed imitation



View from head-mounted camera



“Bayesian Surprise” of camera view



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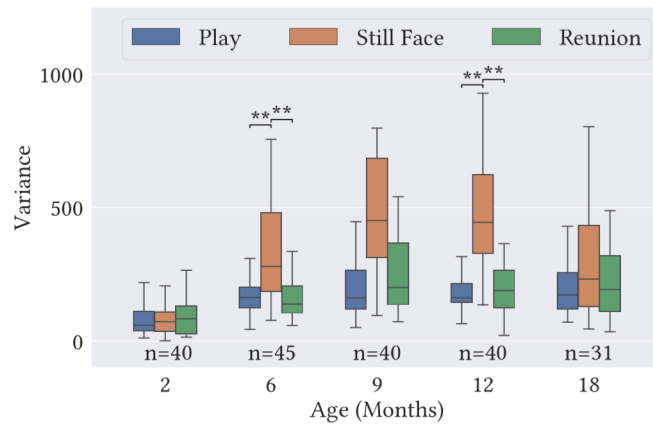
Understanding Dyadic Interactions



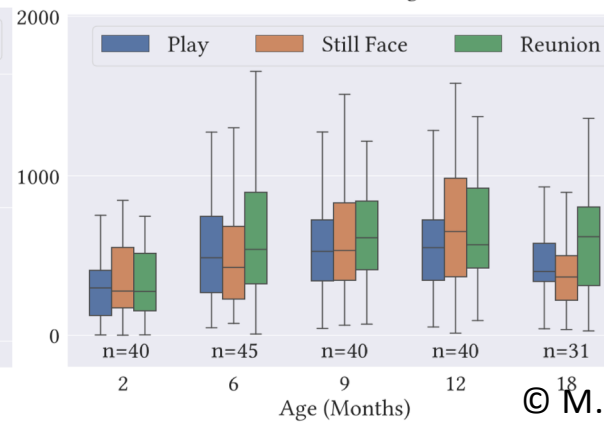
Caregiver stress and distractions measurably impact early infant development

Infants respond to social stress with different modalities at different developmental stages

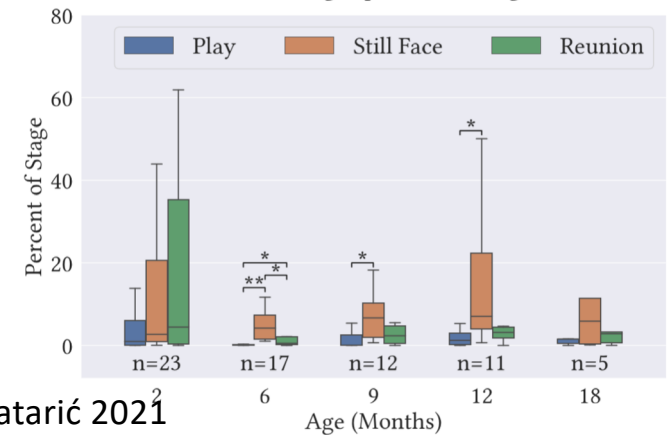
Variance in Head Angle



Variance in Arm Angle



Percent of Stage Spent Vocalizing



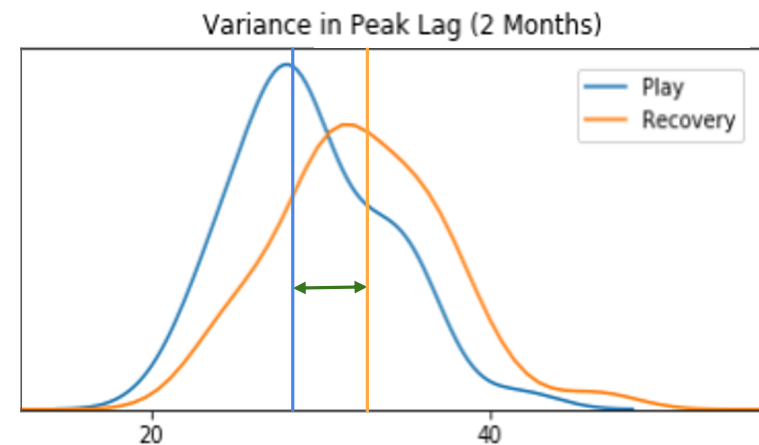
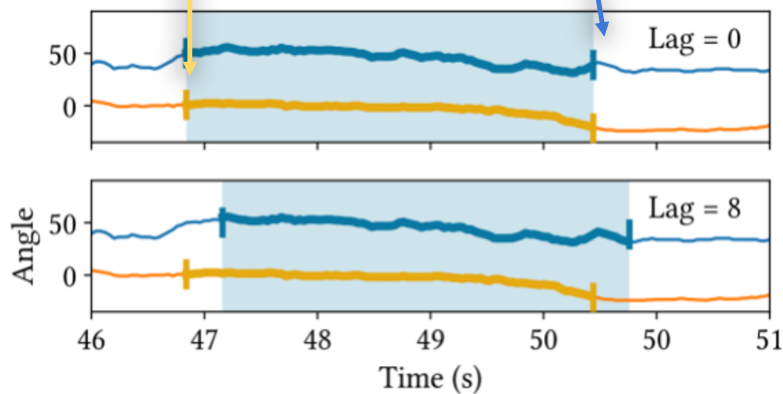
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Shaping Dyadic Interactions



Infants and mothers coordinate behaviors across modalities

We can teach mothers/caregivers to shape infant behavior in an engaging interactive activity



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Socially Assistive Robotics for Autism Spectrum Disorders

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



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15+ Years of SAR for ASD

Goal:

- Safe, always available, steady 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 brave startups
- Rapid progress in AI-supported real-time perception, dialog

Our 15+ Years of SAR for ASD

Single-session studies:

- The role of robot contingency, agency, and embodiment

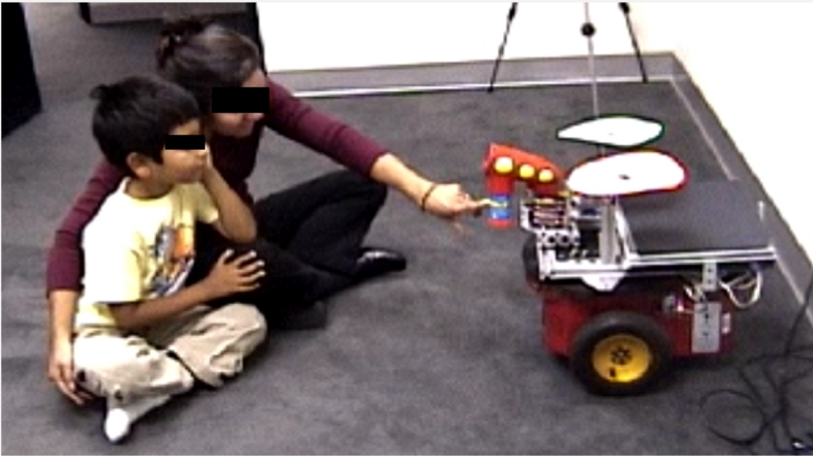
Multi-session studies:

- 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

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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 vs. object
- Agent group attends to speech and to humanoid features
- Object group attends to buttons and less at humanoid features

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

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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

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Results:

- Improved learner autonomy
- Decreased learner frustration

Personalizing In-Home Learning

see NSF Science Nation video:

https://www.youtube.com/watch?v=NbTDF3_djI8&ab_channel=NationalScienceFoundation



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- 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

A Treasure Trove of Insights About AI in the Real World

- One size does not fit anybody: vast variance between and within children
- Fancy machine learning not adapted to this use yet: most popular AI methods less effective than “older” tree-based ones
- New challenges: novel transfer learning / generalization challenges



Real-World Studies and Datasets are Too Rare

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

Often this is not by researcher choice →



There is a paucity of useful data from:

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

SAR State-of-the-Art Summary

- Children 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



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Every Child is Unique

- Every child is different and every child 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 part of health care
- They enhance, not replace human experts and support
- They can help caregivers to provide complex care regimens
- They allow for continuous assessment and personalized support

