

Developing Innovative Technology to Enhance Research and Practice  
in Individuals on the Autism Spectrum:  
A Computational Behavioral Science Approach

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## Telemetrics

Technology-enabled (video, audio, physiological) behavioral assessment that is unobtrusive, longitudinal, and carried out in naturalistic settings can:

- reduce reactive arrangements/increase compliance
- increase ecological validity
- model maturational change over time
- enable multi-modal data analysis & visualization
- provide just-in-time feedback
- evaluate response to intervention



# Telemetric Assessment of Stereotypical Motor Movements

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Goodwin, Haghghi, Tang, Akcakaya, Erdogmus, & Intille, S (2014). *2014 Pervasive and Ubiquitous Computing*

Albinali, Goodwin, Intille (2012) *Pervasive and Mobile Computing*

Goodwin, Intille, Albinali, Velicer (2010) *Journal of Autism and Developmental Disorders*

Albinali, Goodwin, Intille (2009) *Ubicomp*. Best Paper Award.



Playback Remote

Pause Stop < > << >>

11:30AM

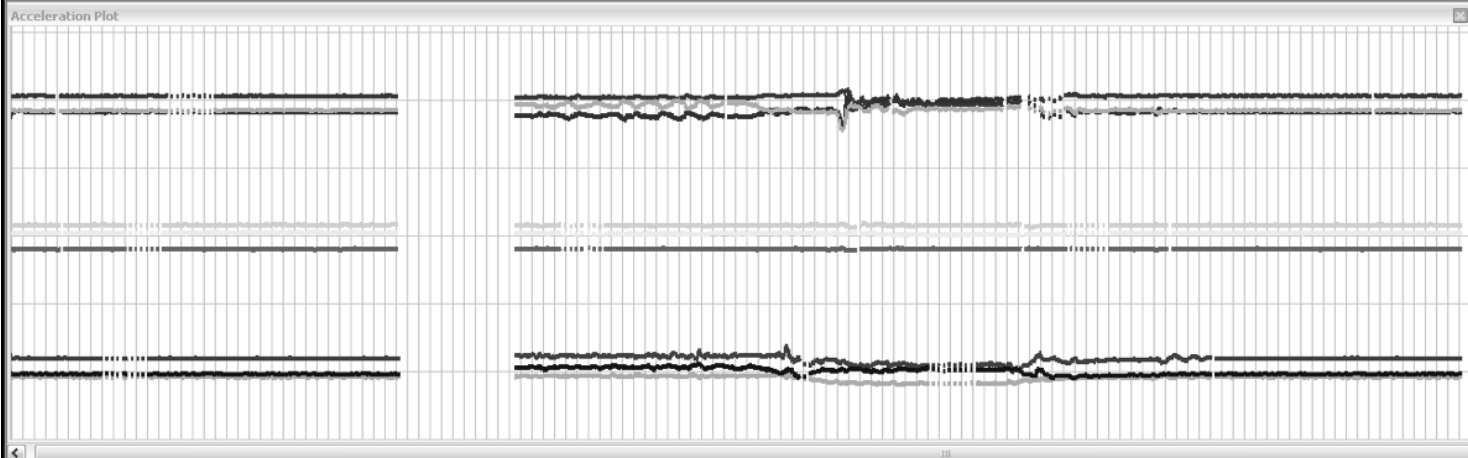
01/17/2008 11:30:01.693

Playing

Show Quick Summary

Quick Labels

Time	Status	Data
01/17/2008 11:24:48.458	stop	A- Flapping
01/17/2008 11:24:49.109	start	A- Flapping
01/17/2008 11:25:01.573	stop	A- Flapping
01/17/2008 11:30:19.857	start	A- Flapping
01/17/2008 11:30:35.035	stop	A- Flapping
01/17/2008 11:30:38.479	start	A- Flapping
01/17/2008 11:30:43.808	stop	A- Flapping
01/17/2008 11:30:49.654	start	A- Flapping
01/17/2008 11:30:53.618	stop	A- Flapping
01/17/2008 11:30:59.290	start	A- Rocking
01/17/2008 11:31:02.536	stop	A- Rocking
01/17/2008 11:31:03.598	start	A- Rocking
01/17/2008 11:31:14.384	stop	A- Rocking
01/17/2008 11:31:19.846	start	A- Flapping
01/17/2008 11:31:21.644	stop	A- Flapping
01/17/2008 11:31:21.970	start	A- Rocking
01/17/2008 11:31:28.666	stop	A- Rocking
01/17/2008 11:31:28.902	start	A- Flapping
01/17/2008 11:31:33.408	stop	A- Flapping
01/17/2008 11:31:39.032	start	A- Flapping
01/17/2008 11:31:43.620	stop	A- Flapping
01/17/2008 11:31:50.356	start	A- Flapping
01/17/2008 11:31:53.956	start	A- Rocking
01/17/2008 11:32:00.937	stop	A- Rocking
01/17/2008 11:32:01.437	start	A- Flapping
01/17/2008 11:32:04.287	stop	A- Flapping
01/17/2008 11:32:05.263	start	A- Rocking





# Video Coding vs. Real-Time Coding vs. Pattern Recognition

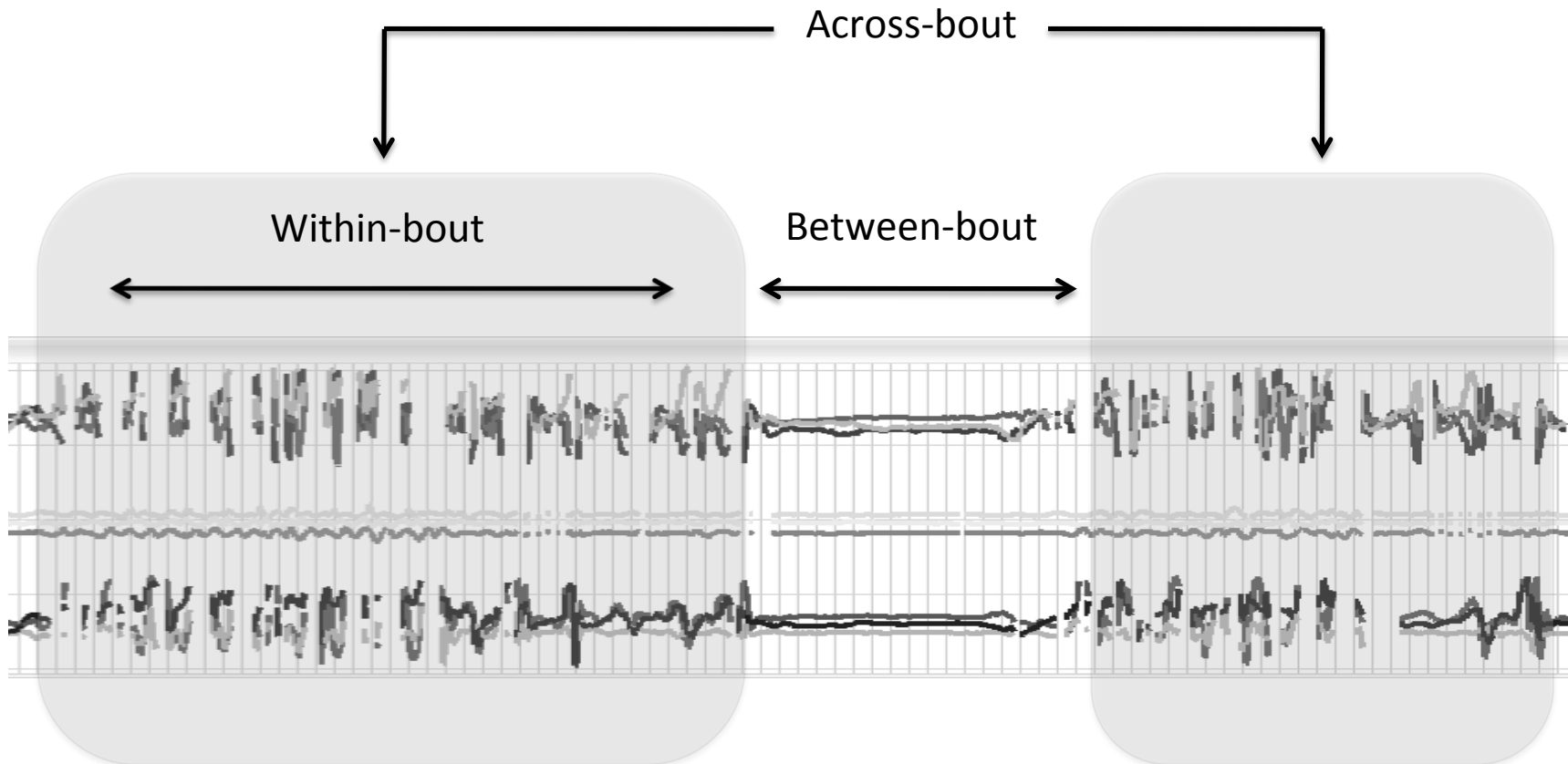
	LAB			CLASS		
	Offline IRR Avg % Agree	Real-Time Avg % Agree	Pattern Recognition Avg Accuracy	Offline IRR Avg % Agree	Real-time Avg % Agree	Pattern Recognition Avg Accuracy
JK	.83   .66	.68   .36	.84   .68	.95   .90	.57   .14	.86   .56
EH	.97   .94	.35   -.30	.95   .63	.99   .98	.46   -.08	.84   .55
CF	.97   .93	.49   -.02	.97   .67	.94   .88	.61   .21	.95   .63
TM	.97   .93	.74   .48	.93   .83	.98   .97	.77   .55	.86   .72
CS	.92   .85	.67   .35	.85   .68	.94   .87	.65   .30	.87   .70
DB	.89   .78	.77   .54	.97   .91	.97   .94	.70   .40	.87   .74
OVERALL	.92   .84	.60   .20	.90   .87	.96   .92	.63   .25	.90   .84

# Quantify Kinematics

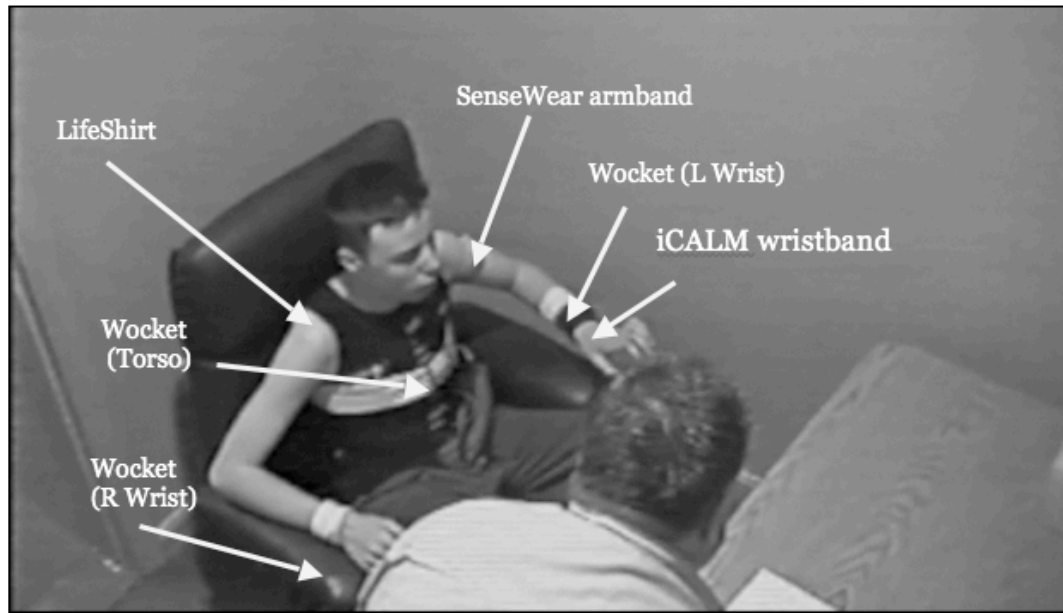
Variance vs invariance over time > indicate biological vs operant mechanisms

Response topography & dynamics across settings/activities > indicate function

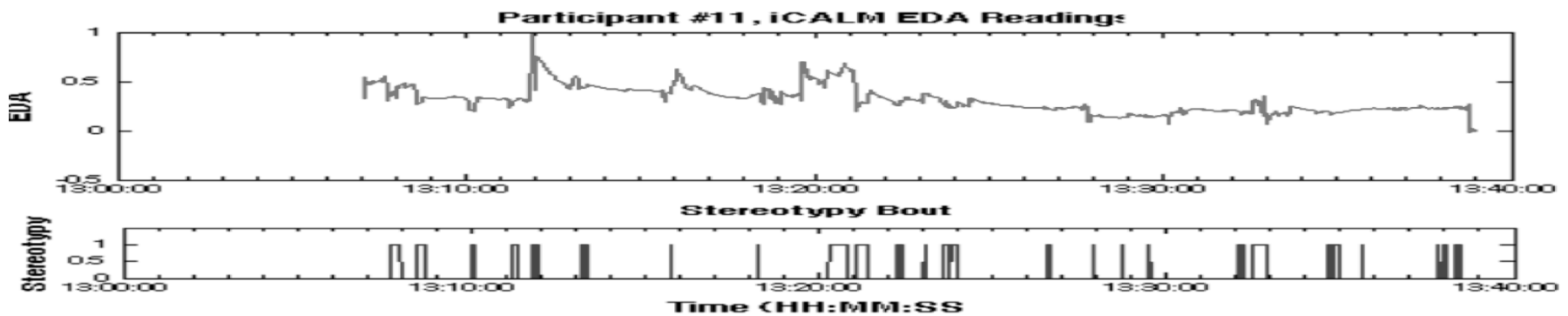
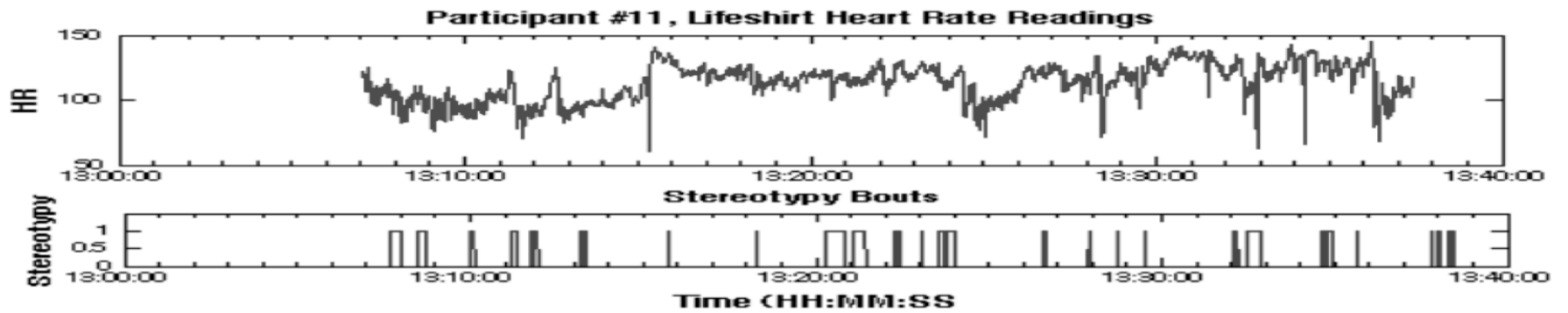
Response frequency & intensity > indicate response to intervention



# Concomitant ANS Monitoring



HR/HRV  
Respiration  
EDA  
Temperature



# Telemetric Assessment of the Autonomic Nervous System

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Goodwin et al. (2006) *Focus on Autism and Other Developmental Disabilities*

Groden, Goodwin et al. (2005) *Focus on Autism and Other Developmental Disabilities*

Fletcher, Dobson, Goodwin et al. (2010) *IEEE Trans. on Info. Tech. in Biomed.*



Poh, Swenson, Picard (2010) *IEEE Trans. Bio. Eng*

- Event marker
- Length: 56.6mm (2.15")
- Width: 38.1mm (1.5")
- Height: 14.7mm (0.60")
- Weight: 22.7g (0.8oz)



- EDA sensors
- Temp sensors
- Motion detector
- USB port

**Package includes everything you need to successfully measure and visualize data**

- Sensors
- Electrodes
- Wristband
- Software to compare, review, label and share data

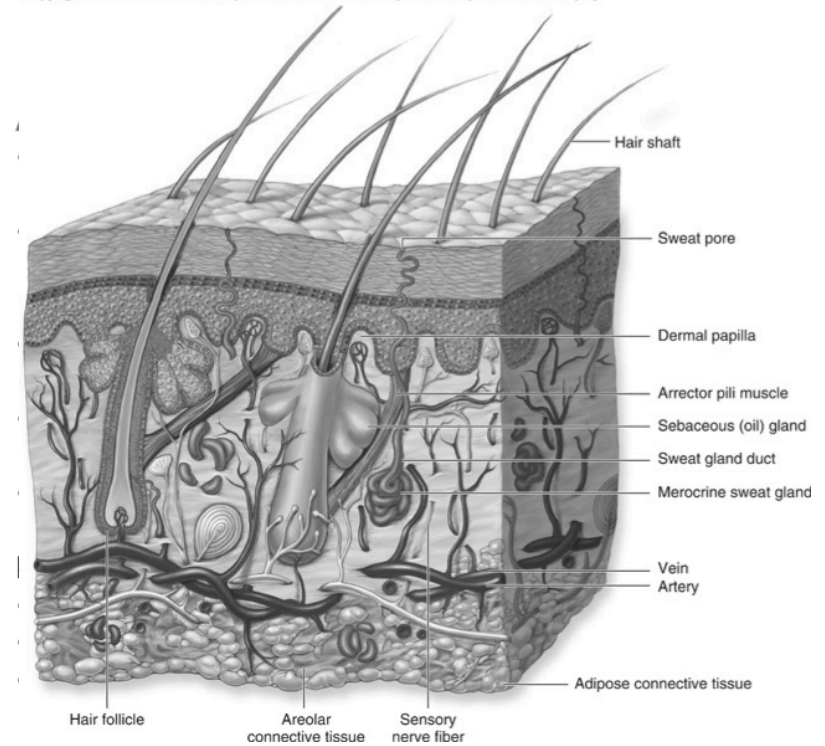
### Sensors

- Electrodermal activity (EDA) in microsiemens
- Electrode temperature in Celsius or Fahrenheit
- 3-Axis accelerometer in G's
- Sampling rates at 2,4,8,16,32 Hz

### Sensor Accuracy

- Validated with cognitive, affective and physical tasks\*
- Highly correlated with FDA-approved sensor\*
- Test published in top scientific peer review journal\*
- Every sensor tested for quality control
- For additional validation, please visit [www.affectiva.com/resources/](http://www.affectiva.com/resources/)

\* Note: refers to core Q Sensor technology from MIT



CNS circuits involved in control of EDA: amygdala, premotor cortex, pre-frontal cortex, hypothalamus, reticular activating system, and hippocampus.

# Telemetric Assessment of Challenging Behaviors

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Cohen, IL, Yoo, HY, Goodwin, MS, Moskowitz (2011). *International Handbook of Autism and Pervasive Developmental Disorders*.

Ciptadi, Goodwin, & Rehg (2014). *European Conference on Computer Vision*.

# CENTER FOR DISCOVERY – LAB SCHOOL

10 cameras  
(8 streampix, 2  
axis)

2 microphones

Wireless HR/V

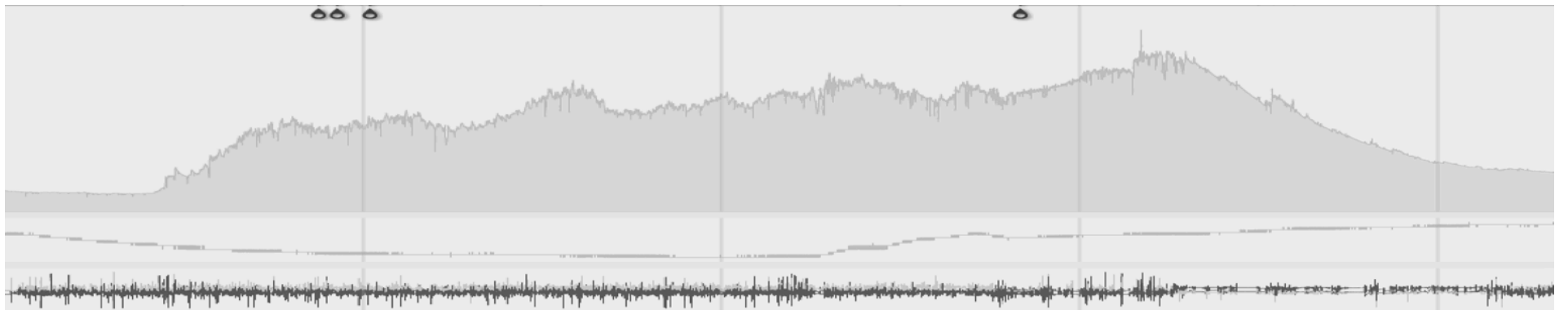
Wireless EDA,  
AccM, Temp

Center for Discovery  
Lab School



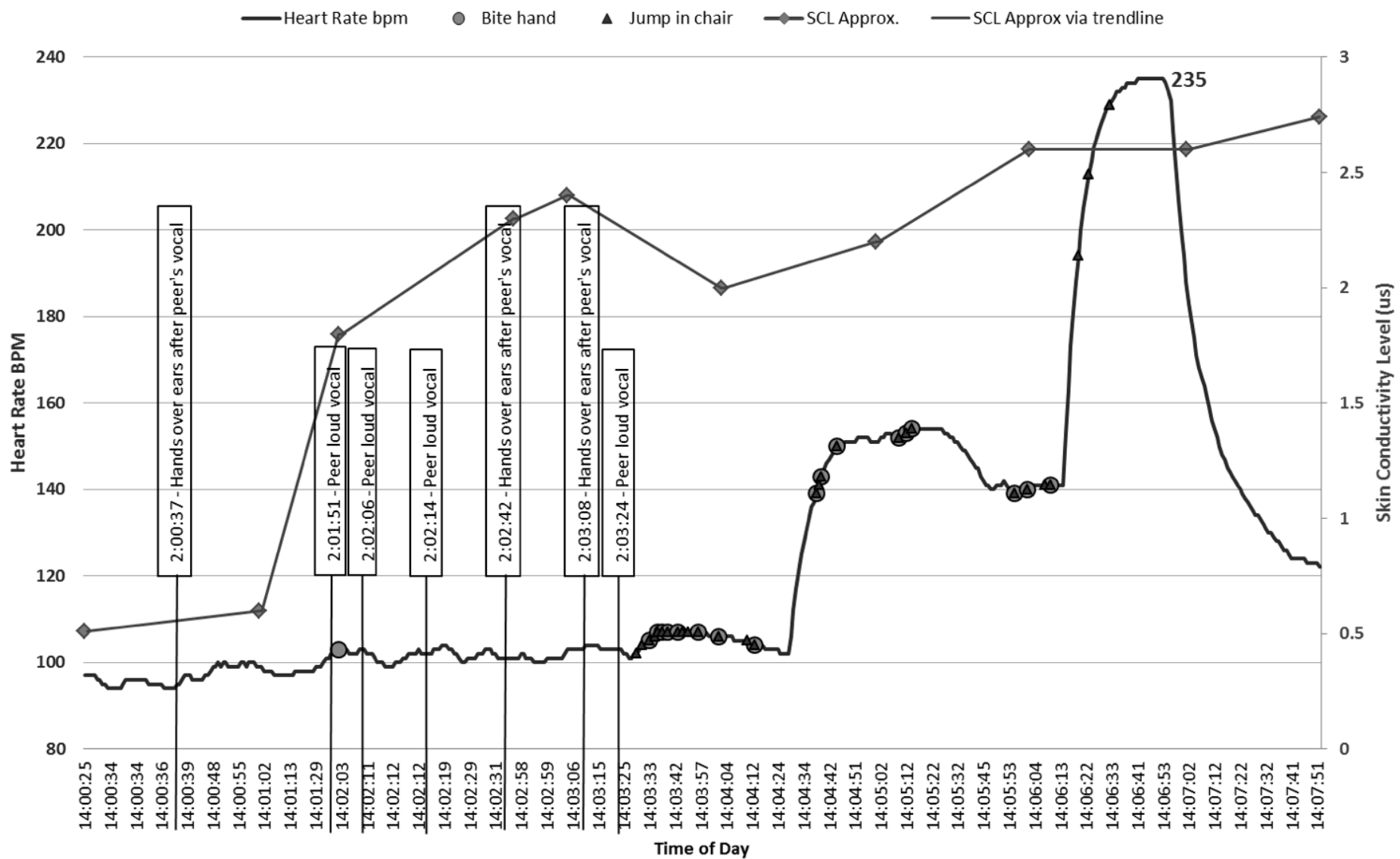




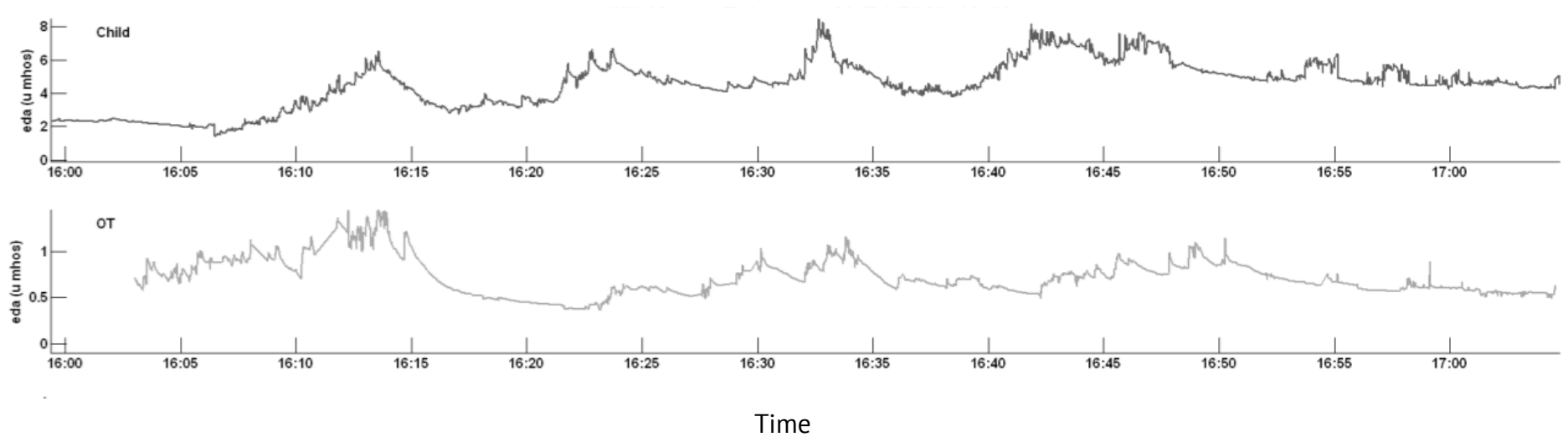




# Tantrum 4/02/2012



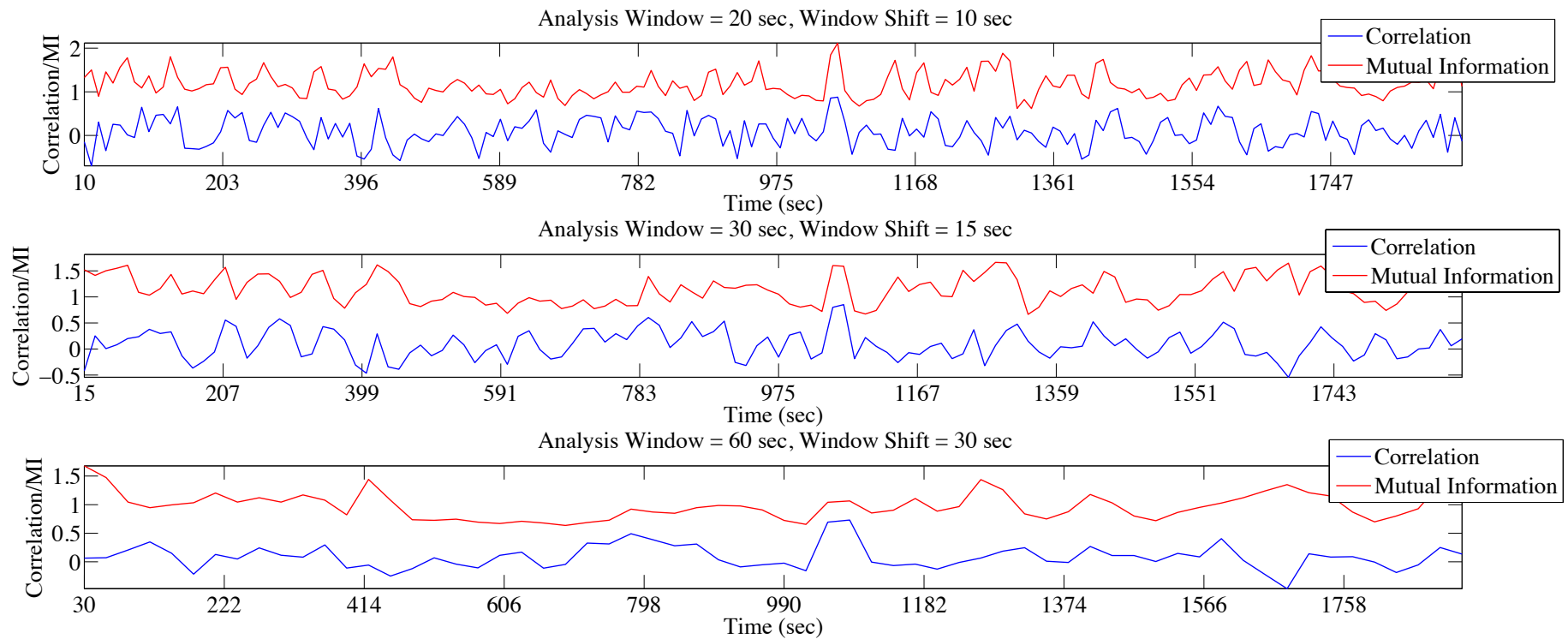
# Interpersonal Physiology/Child-Therapist Co-Regulation



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Chaspari, Goodwin, Wilder-Smith, Gulsrud, Mucchetti, Kasari, & Narayanan, S. (2014)  
*39th International Conference on Acoustics, Speech and Signal Processing.*

# Phasic SC Synchrony Measures Sliding Window Plots



- Different time scales exhibit different levels of detail.
- Small time-scales show local synchrony measures.
- Large time-scales indicate the general trend of synchrony measures.
- Modeling synchrony measures with time-series analysis/Poisson Process.

# In-Situ, Ultradense Audio & Video Recording



## Speechome Recorder

- installs in minutes
- no holes or wiring
- safe
- secure
- holds 3-5 months of data
- remote 'diary note' control
- telepresence function
- precise 3D tracking
- dyadic interaction dynamics
- social and speech interaction filters



(265.0, 286.0)

(763.0, 431.064)  
9:12:01:300





Caregiver

Child

# BBCS

## Bio-Behavior Capture System

### Northeastern

Matthew S. Goodwin, PhD

Oliver Wilder-Smith

### Georgia Tech

Jim Rehg, PhD

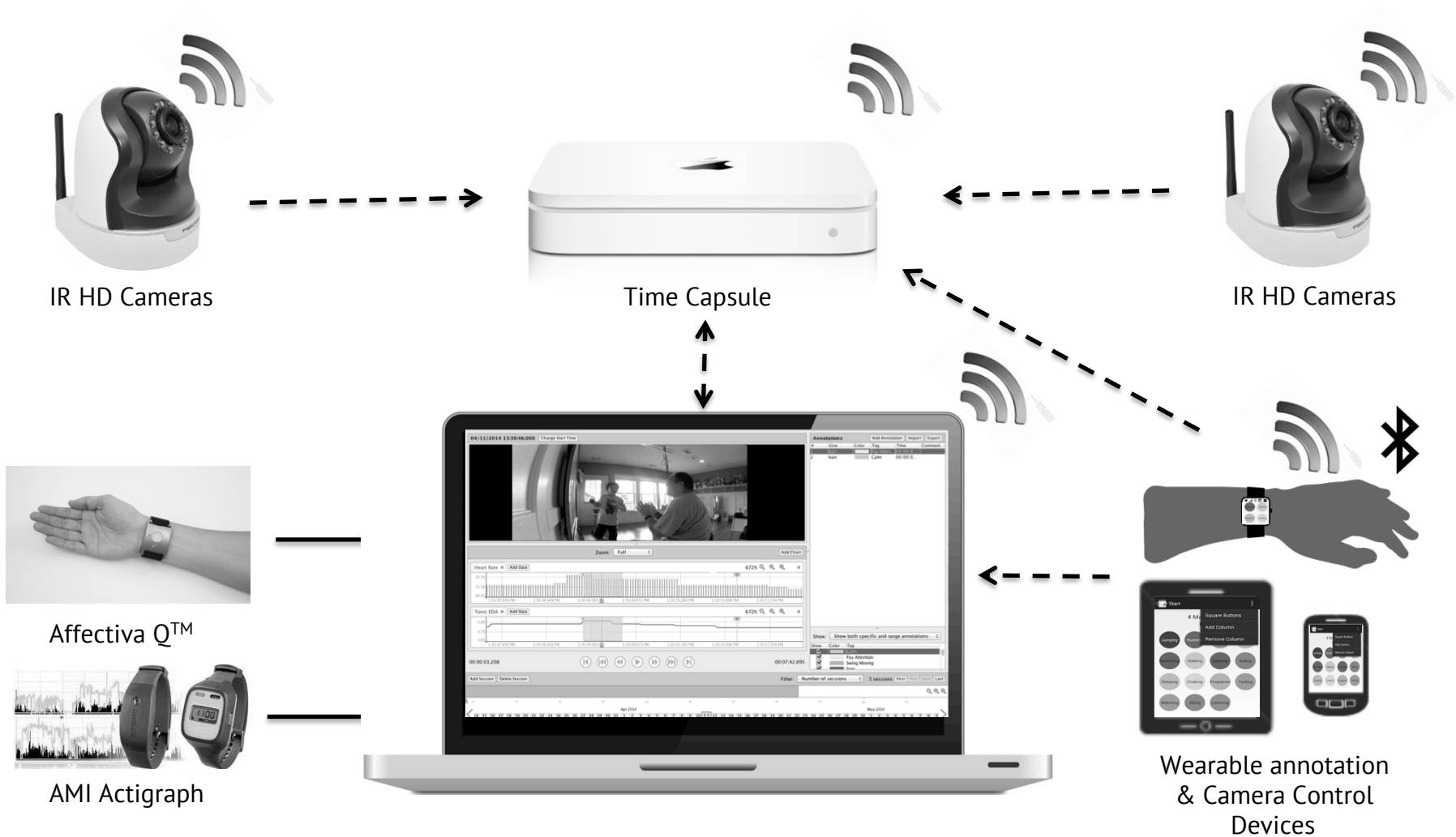
Gregory Abowd, D. Phil

Ivan Riobo

Chan Ho Kim

Akshay Gupta

# System Architecture



Computationally Analyzing Validated, Standardized,  
Clinician-Child Assessments of Autism Spectrum Disorders in Laboratory Settings

Northeastern

Matthew S. Goodwin, PhD

Oliver Wilder-Smith

Georgia Tech

Jim Rehg, PhD

Boston University

Stan Sclaroff, PhD

Umass Boston

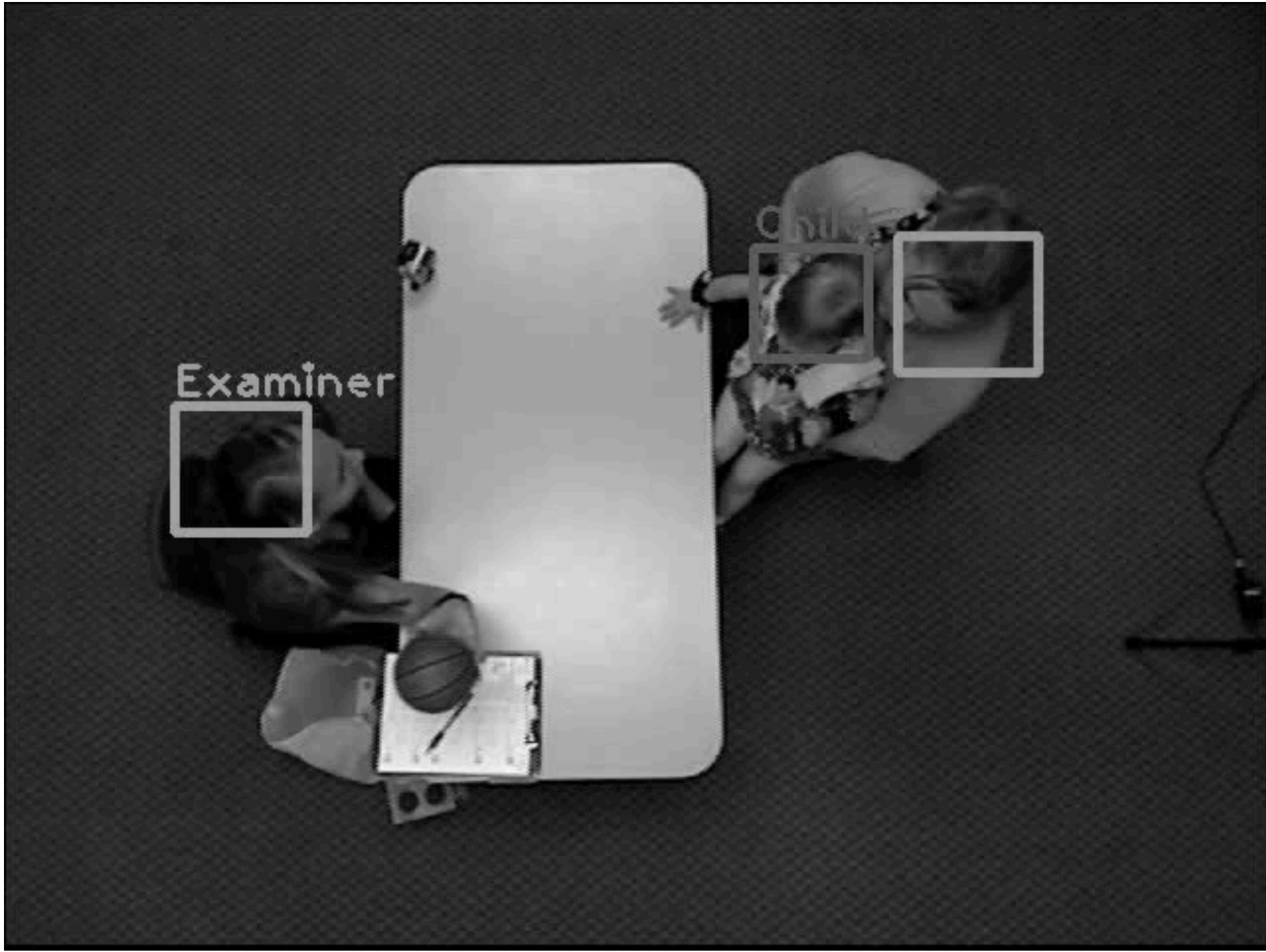
Alice Carter, PhD

Nancy Snidman, PhD

Examiner

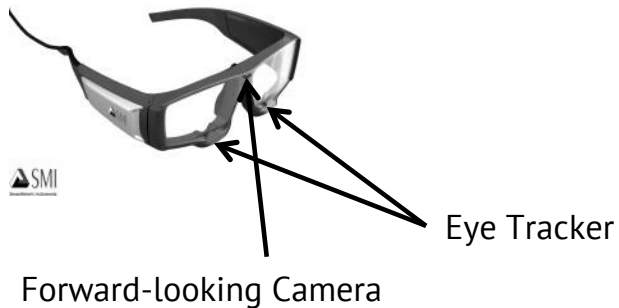


Child



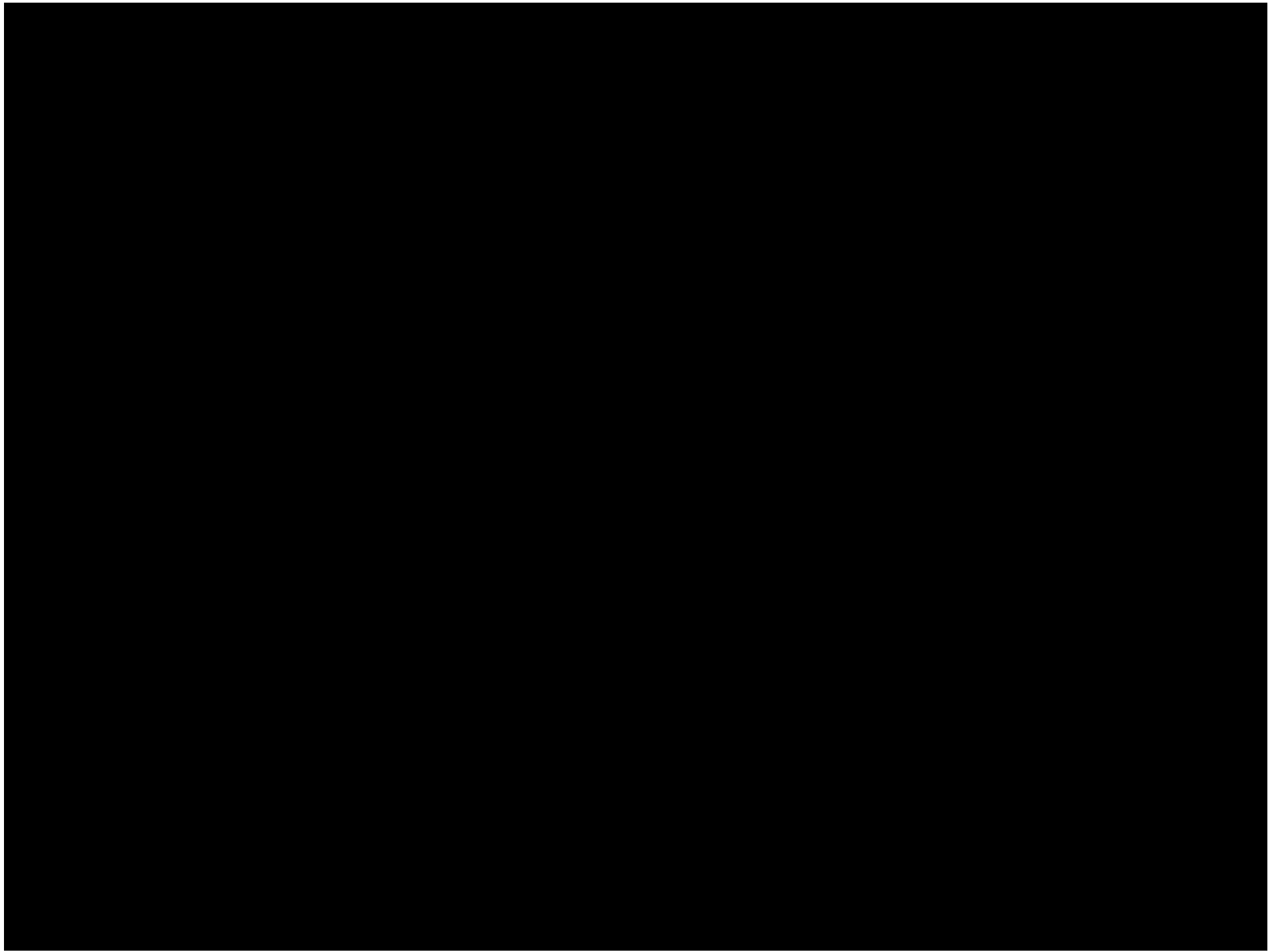
# Noninvasive Detection of Eye Contact

## Egocentric view with face analysis



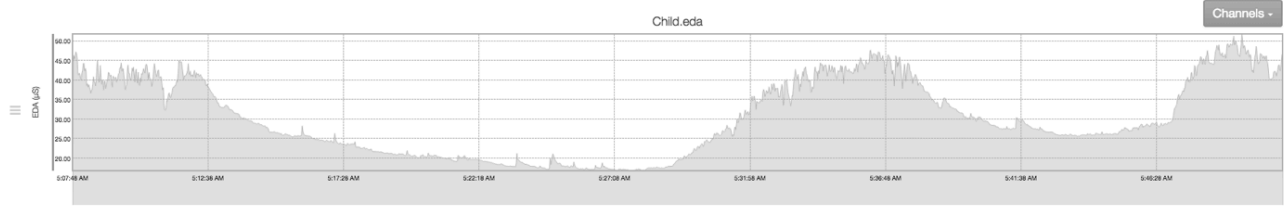
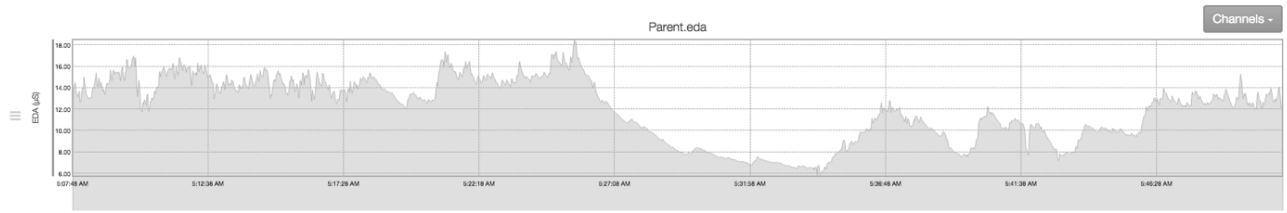
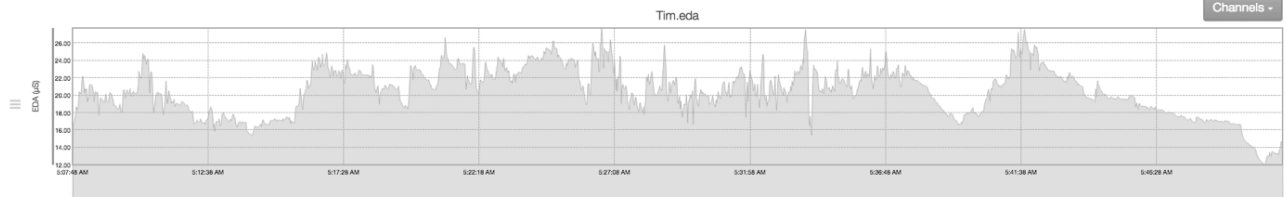
Eye contact is defined as:

- Detected face with gaze towards glasses
- Examiner gaze point inside detected face









# NSF Expeditions in Computing

“Computational Behavioral Science:  
Modeling, Analysis, and Visualization of Social and Communicative Behavior”

Co-PI & Associate Project Director

David Forsyth  
CS  
UIUC



James Halle  
Education  
UIUC



Karrie Karahalios  
CS  
UIUC



Mark Clements  
ECE  
GT



Jim Rehg  
CS  
GT



Gregory Abowd  
CS  
GT



Matthew Goodwin  
Northeastern



Roz Picard  
Media Lab  
MIT



Rana el Kaliouby  
Media Lab  
MIT

Takeo Kanade  
CS  
CMU



Stan Sclaroff  
CS  
BU



Anind Dey  
CS  
CMU



Jeffery Cohn  
Psychology  
Pitt



Opal Ousley  
Psychology  
Emory



Nate Call  
Marcus Inst



Rosa Arriaga  
CS  
GT



Mario Romero  
CS  
GT



Agata Rozga  
CS  
GT



Sungbok Lee  
EE  
USC



Shri Narayanan  
EE & Psych  
USC

www.interpersonalphysiology.org

The screenshot shows a web browser window with the URL <http://www.interpersonalphysiology.org>. The page title is "Interpersonal Physiology". A dark navigation bar contains a "Home" link and a search icon. The main content area is divided into two columns. The left column features a "Home" section with a welcome message and a "What is Interpersonal Physiology?" section with a detailed paragraph. The right column contains a "Subscribe to our mailing list" form with fields for Email, First Name, and Last Name, and a "Subscribe" button. Below the main content is a "Leave a Reply" section with a disclaimer and input fields for Name, Email, Website, and Comment.

Interpersonal Physiology

Home

**Home**

Welcome to the home page of the Interpersonal Physiology Research Group. This page is a collaboration between scientists and students using physiological measures to study interpersonal interactions. We hope this forum will foster greater inter-lab collaborations, increase awareness of relevant methods, and help people to maintain up-to-date references related to work in this area. This page is being launched in connection with a systematic review of the research, expected out in 2015. New content will be added shortly following publication of the review. Please feel free to sign up with our mailing list to receive notifications when new content is added. We invite relevant comments, recommendations, and contacts for additional information.

**What is Interpersonal Physiology?**

Interpersonal physiology is the study of relationships between people's physiological activities (e.g., heart rate, breathing rate) during social interactions. Converging evidence shows that a person's autonomic system changes in relationship to the autonomic systems of the people around them. This leads to a range of phenomenon, including physiological synchrony (e.g., synchronized heart rates), discordance, when one person's arousal level increases while their partner's decreases, and coregulation, when one person's physiology is leading the activities of their partners'. Measures of physiology have been used to show that a couple is locked into a heated argument, a therapist is empathizing with her patient, and that one individual is leading the behaviors of his teammates. Whether it is family dynamics or group behaviors, psychotherapy or team leadership, a better understanding of physiologies influence on social relationships can lead to important new insights. Though interpersonal physiological interactions are currently underexplored, the field is undergoing a rapid expansion, and nearly all research to date indicates that these are critical processes underlying all social interactions.

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Murat Akcakaya, PhD  
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Miriam Zisook, BA

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