

SMIL

Connecting the Brain to the Body
from Molecules to Complex Social Behaviors



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Lecture 1 – Part I

The Study of Social Behaviors

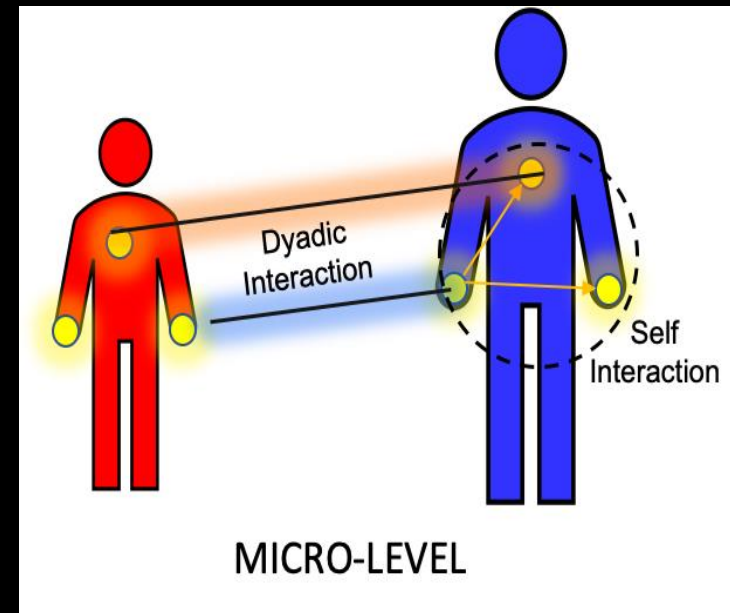
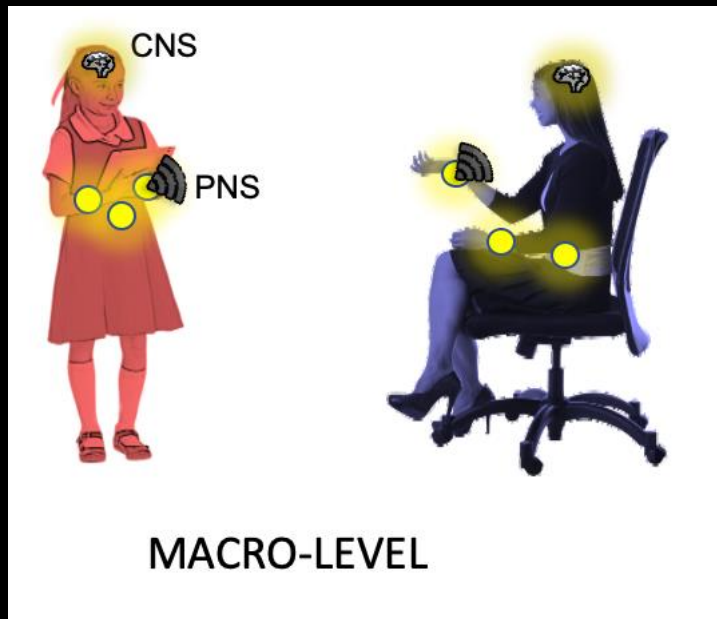
A Clinical Example

Class Objectives

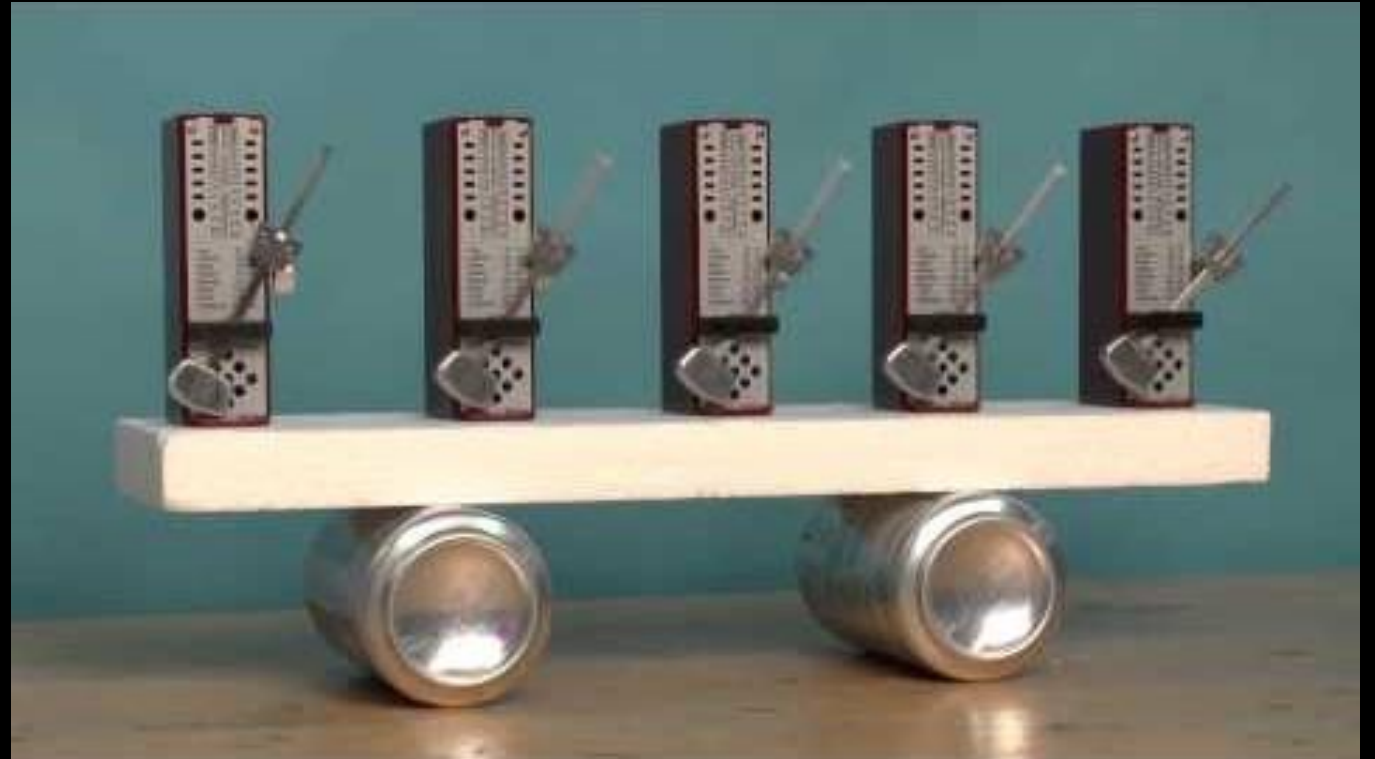
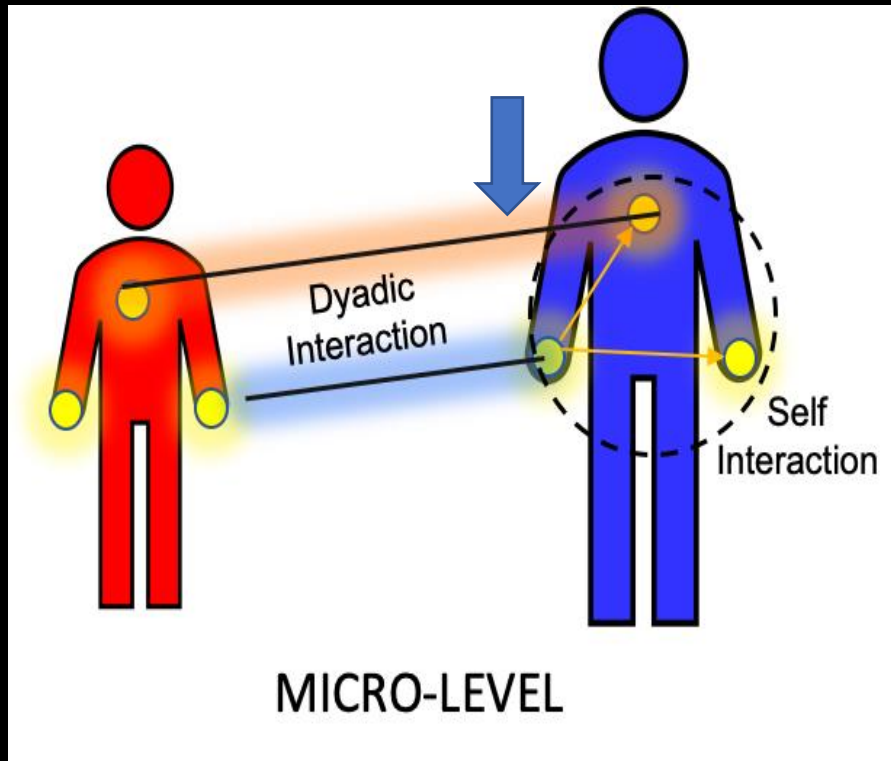
- Learn about natural behaviors from a biorhythmic perspective
- Learn about levels of behavioral description and their applications
- Translate existing methods in brain science to behavioral science
- Learn about biosensors
 1. What types of wearable biosensors are out there at our reach
 2. What are some caveats
 3. How to scale their use from lab basic science to e.g. 10K+ users

Digital ADOS-2: An example of the use of wearables in research

Social Behaviors as Complex Dynamical Systems: Augmenting Observation (Macro-) with Sensors (Micro-) Levels



Cohesiveness -- Shared Biorhythms Hidden to the Naked Eye

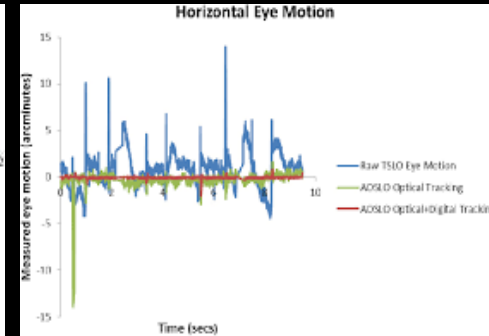
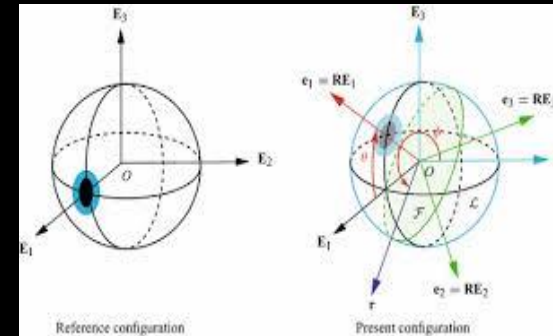
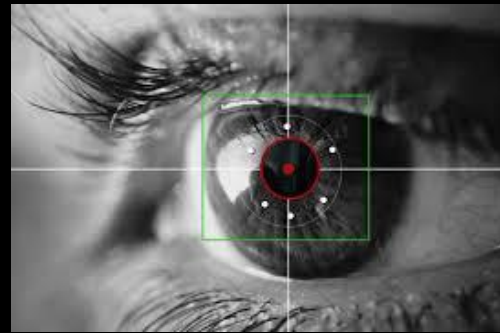


What biorhythms can we use to study social interactions?

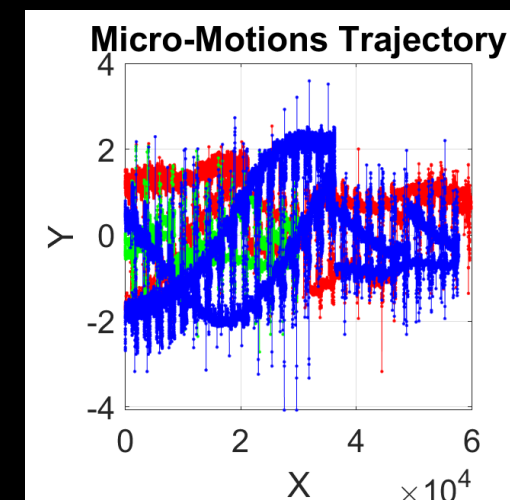
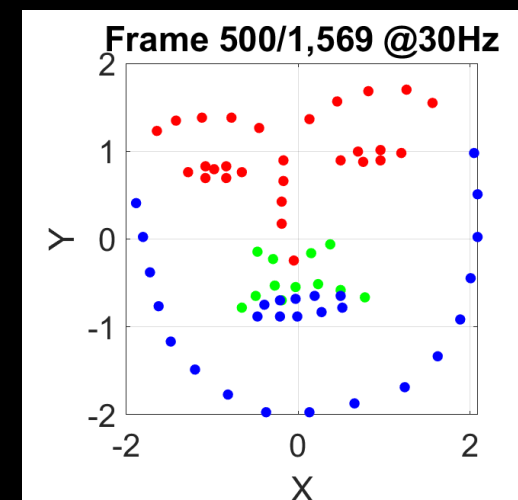
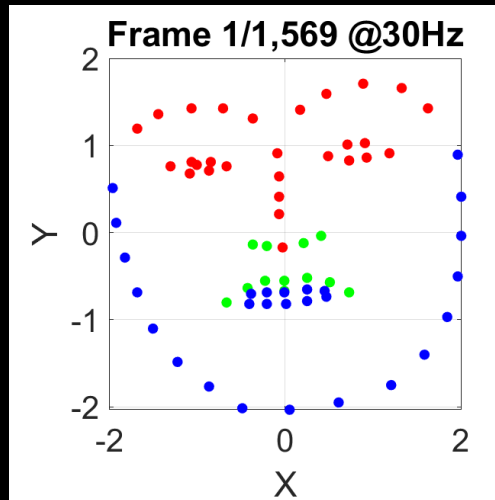


Other Biorhythms
Pupil dilation
Cortisol in saliva
Skin electrodermal activity
Respiration (Heart R peaks)

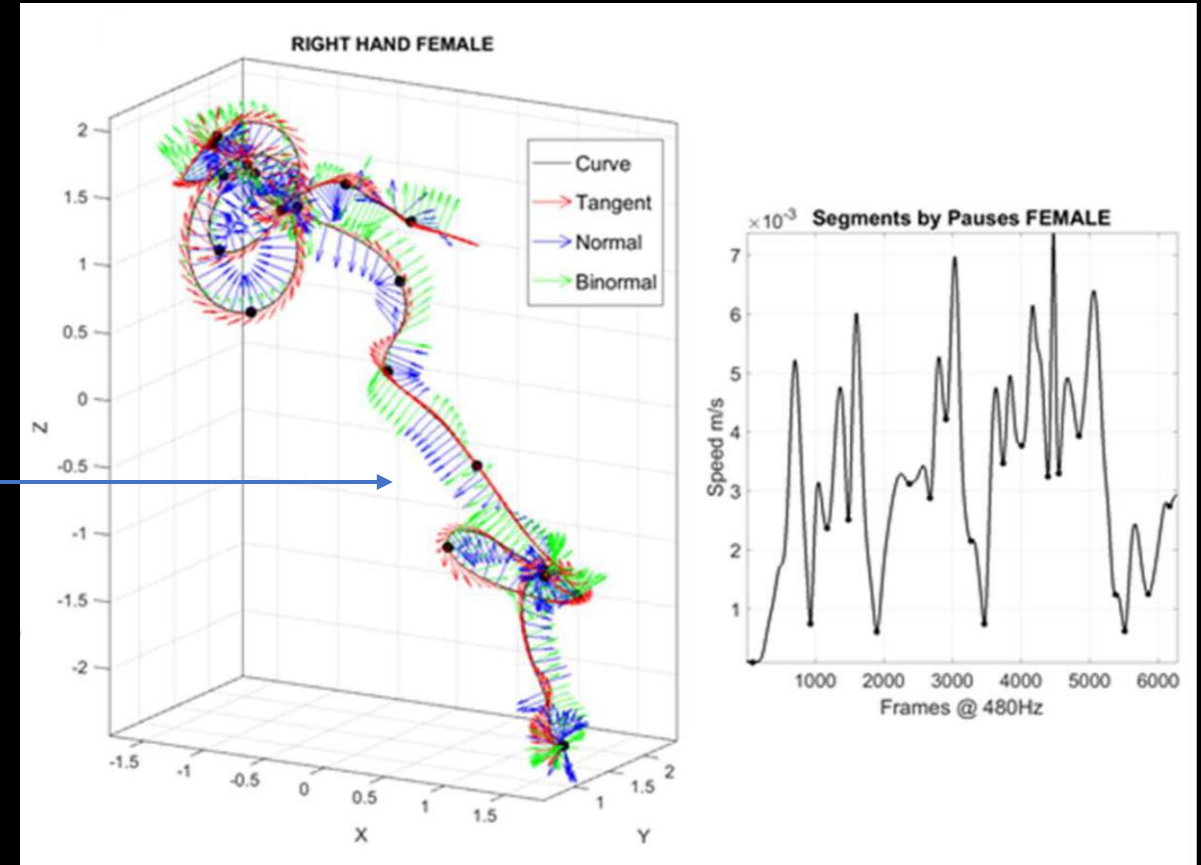
Eye Movements



Facial Micro-expressions



What other biorhythms can we use to study social interactions?



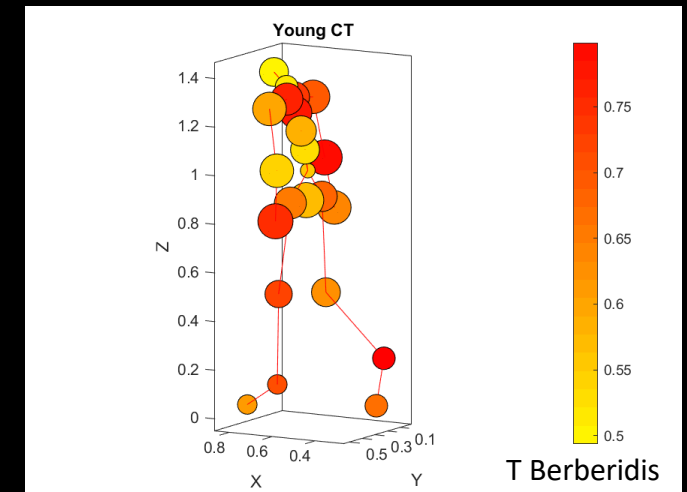
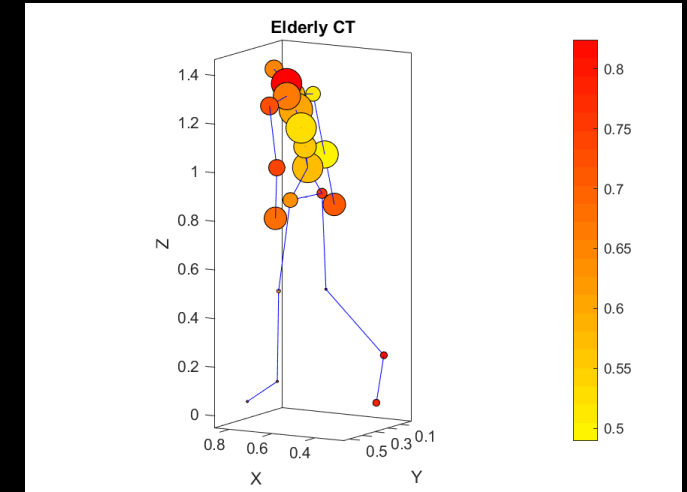
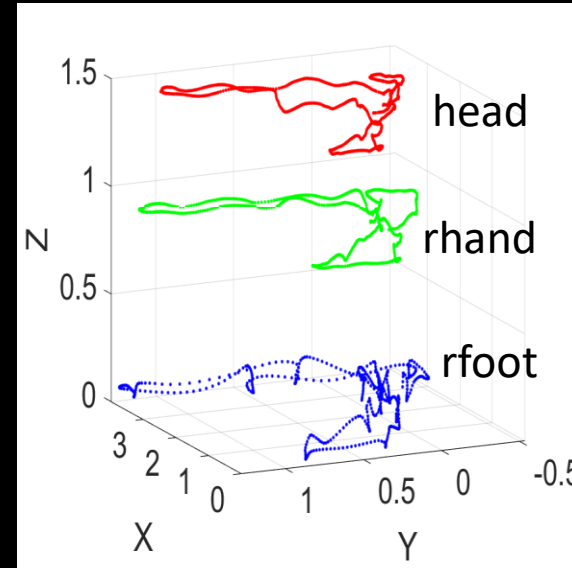
➔ Other Biorhythms
Bodily Kinematics
Heart Activity
Electrodermal Activity
Anything that fluctuates over time

[PhaseSpace Active Infrared Cameras 960Hz](#)

What other biorhythms can we use to study social interactions?



➔ Other Biorhythms
Bodily Kinematics
Heart Activity
Electrodermal Activity
Anything that fluctuates over time



What do they all have in common?

- Involuntary – largely beneath awareness
- Time series data (dynamically changing)
- Highly variable
(peaks and valleys shifting amplitude and timing)
- Become periodic at different frequencies
- Form synergies
- Can be harnessed with off-the-shelf technology
- Can measure behavior continuously during natural activities



Physical Sensors



Proxy Sensors

How are they different?

- Camera based systems have a layer of inference that depends on external factors (occlusion, light sources, stability of body parts, etc.)
- Physical sensors read out the output of the biorhythmic motions that are self-generated by the nervous systems
- Motion artifacts (introduced by physical motions, e.g. EEG, MEG, etc.) vs external artifacts (fMRI, image-based pose estimation, etc.)
- Different physical units (e.g. mV, cm, deg, etc.) vs pixels, light intensity, etc.



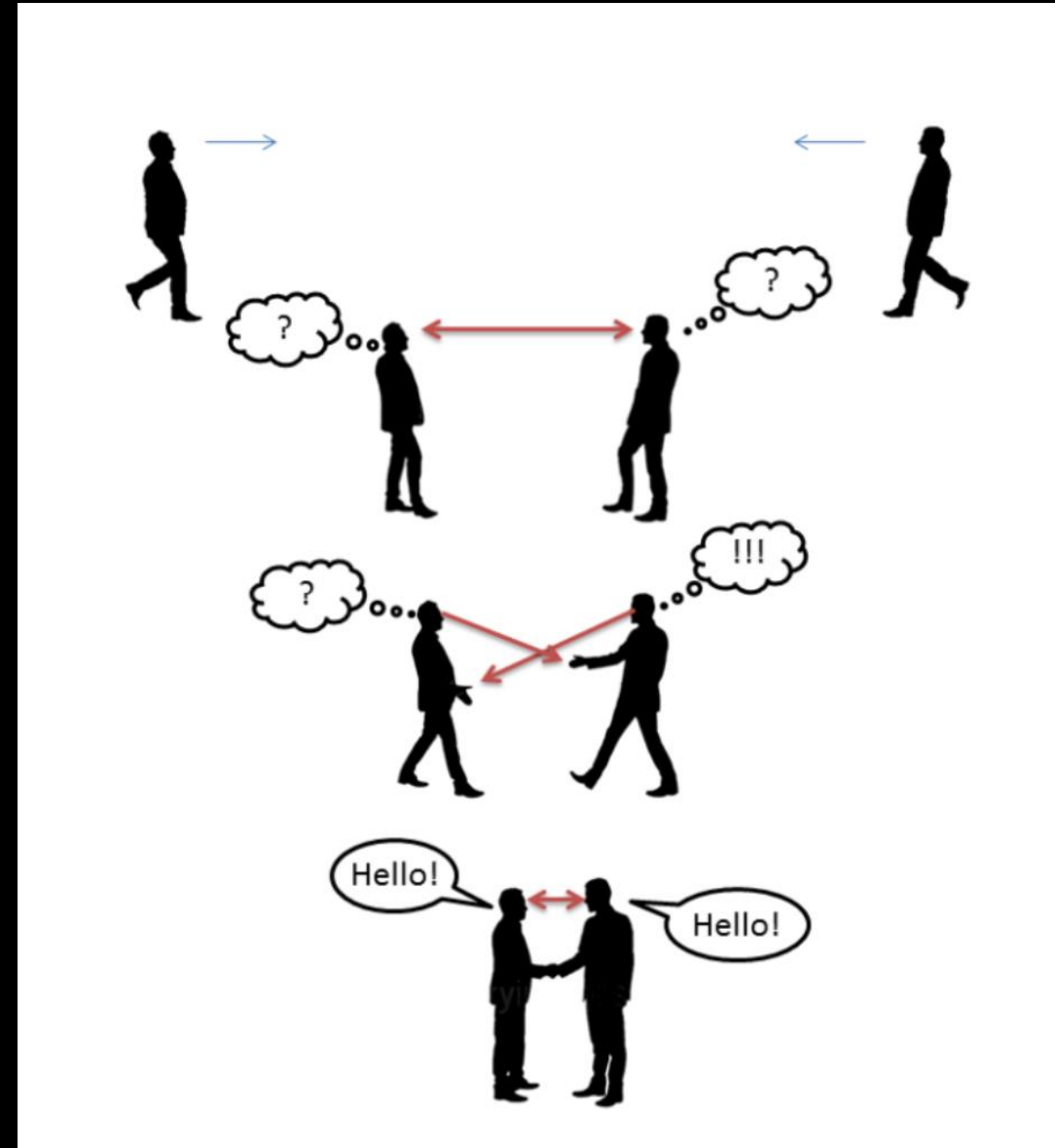
Physical Sensors



Proxy Sensors

Different levels of Description of Social Behaviors

- Discrete scales, mostly based on opinion (Likert scale)
- May use instruments like video recordings (manually decode them) very subjective too but captures more than by naked eye
- Video based analyses of kinematics
- Physical sensors “listening” to biorhythms (heart, cortical neuronal spikes, EMG, EEG, etc)
- Mathematical models to simulate aspects of behaviors



Social Behaviors Measured (Discretely) by Clinical Tests

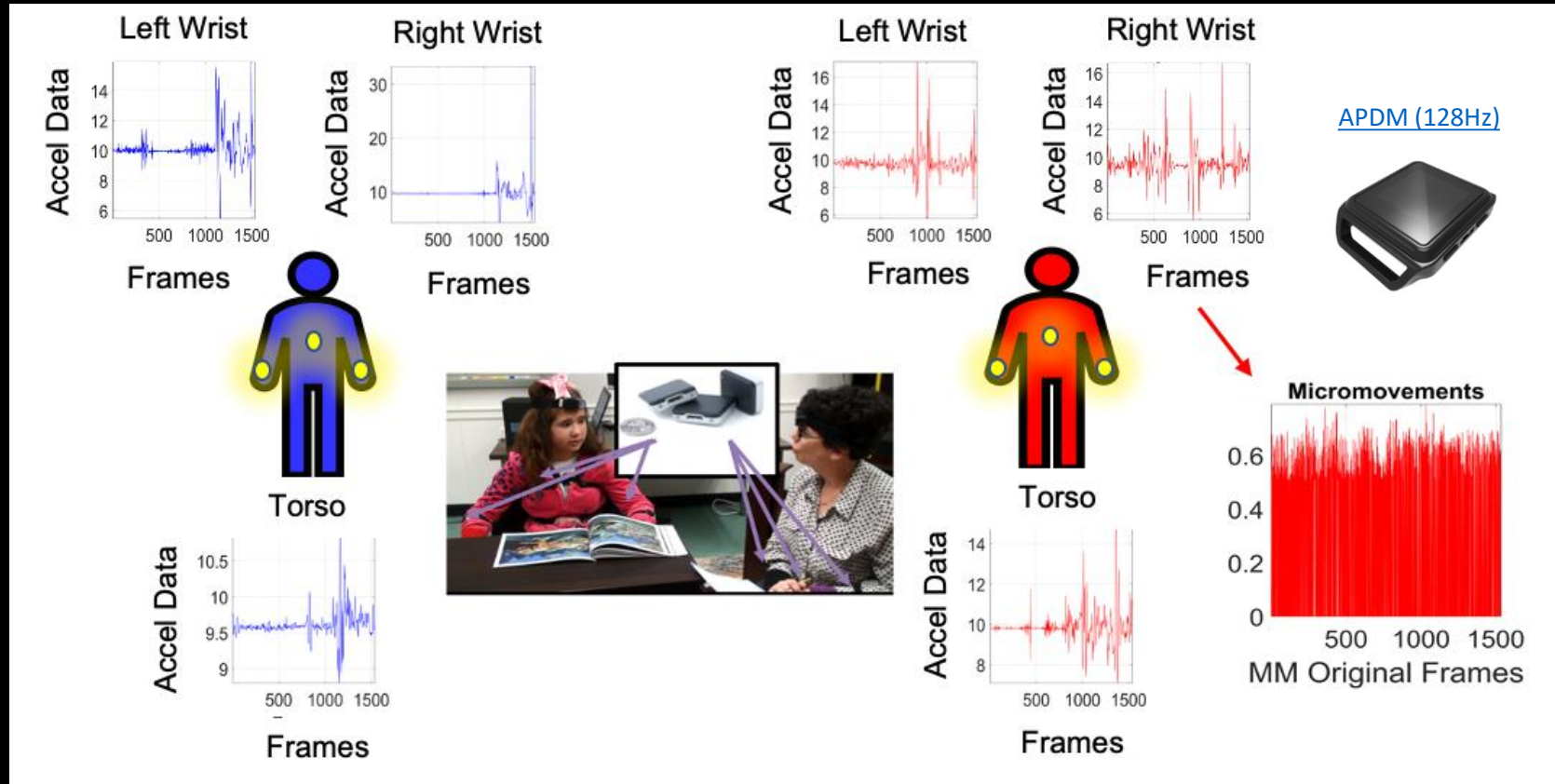
The image shows the ADOS-2 Toddler Module form. It includes sections for 'Pre-Verbal/Single Words' and 'Observation/Coding'. The 'Observation/Coding' section lists 12 items for observation, such as 'Free Play', 'Imitation', 'Response to Name', etc. The form is titled 'ADOS-2' and 'Toddler Module'.

The Certified Clinician Evokes, Responds, Rates Social Overtures

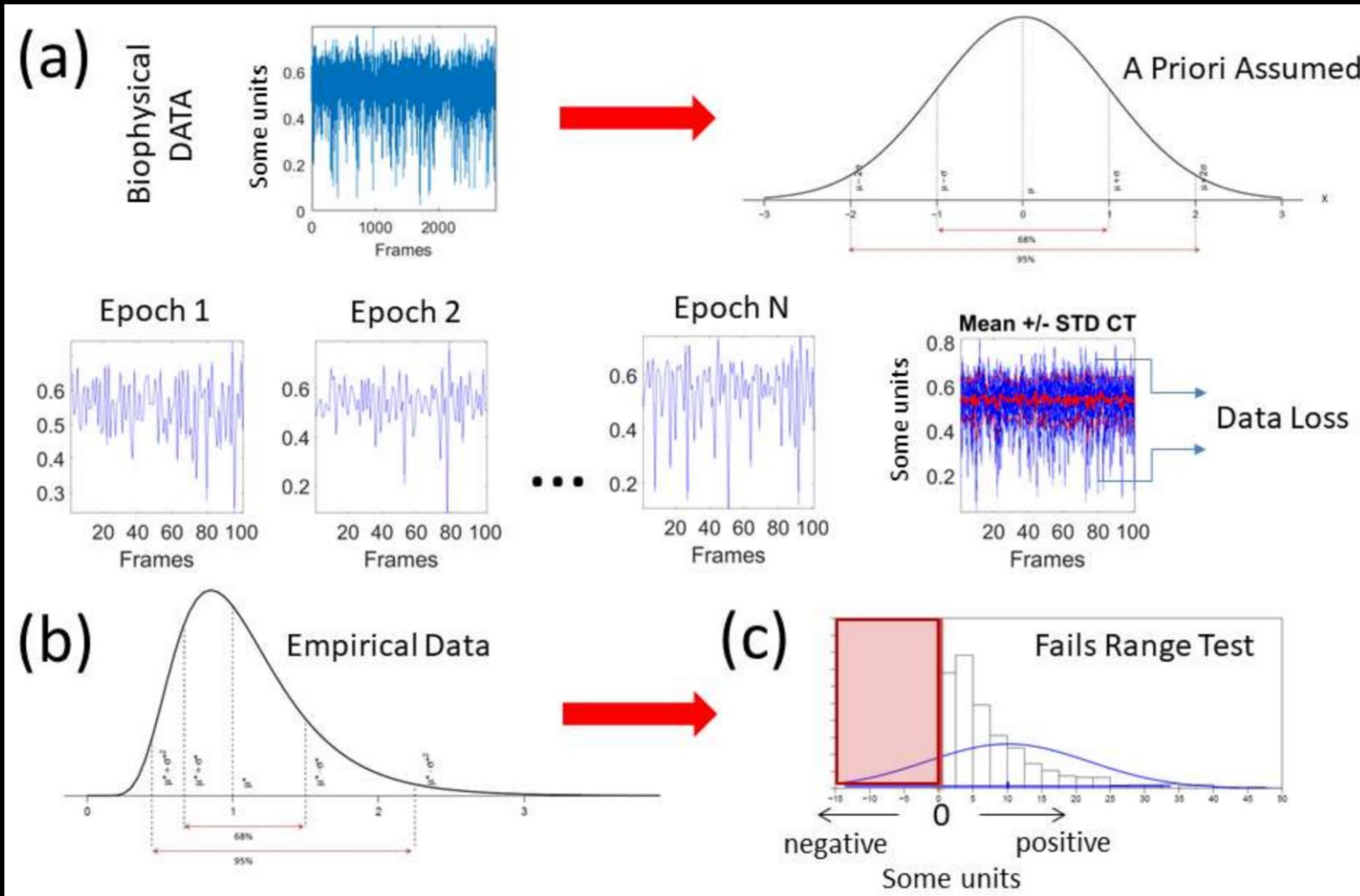


- Evoke responses through social presses
- Observes child's social overtures
- Responds to the child
- Rates the child's responses
- Inevitably misses important information
- Micro-level digital technology to the rescue

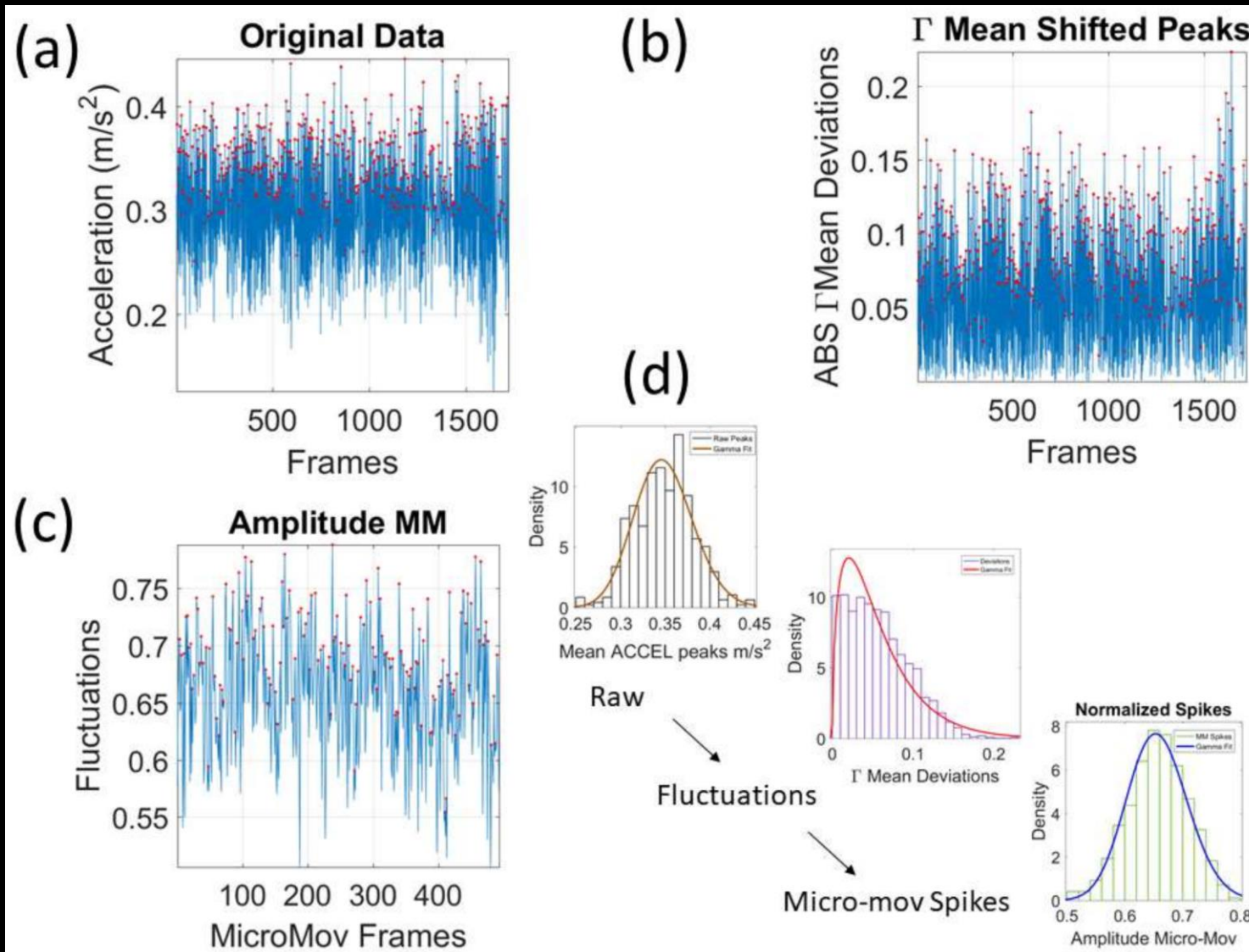
Integration of Macro- and Micro-Level of Behavioral Description



From Raw Data to Micro-Movement Spikes



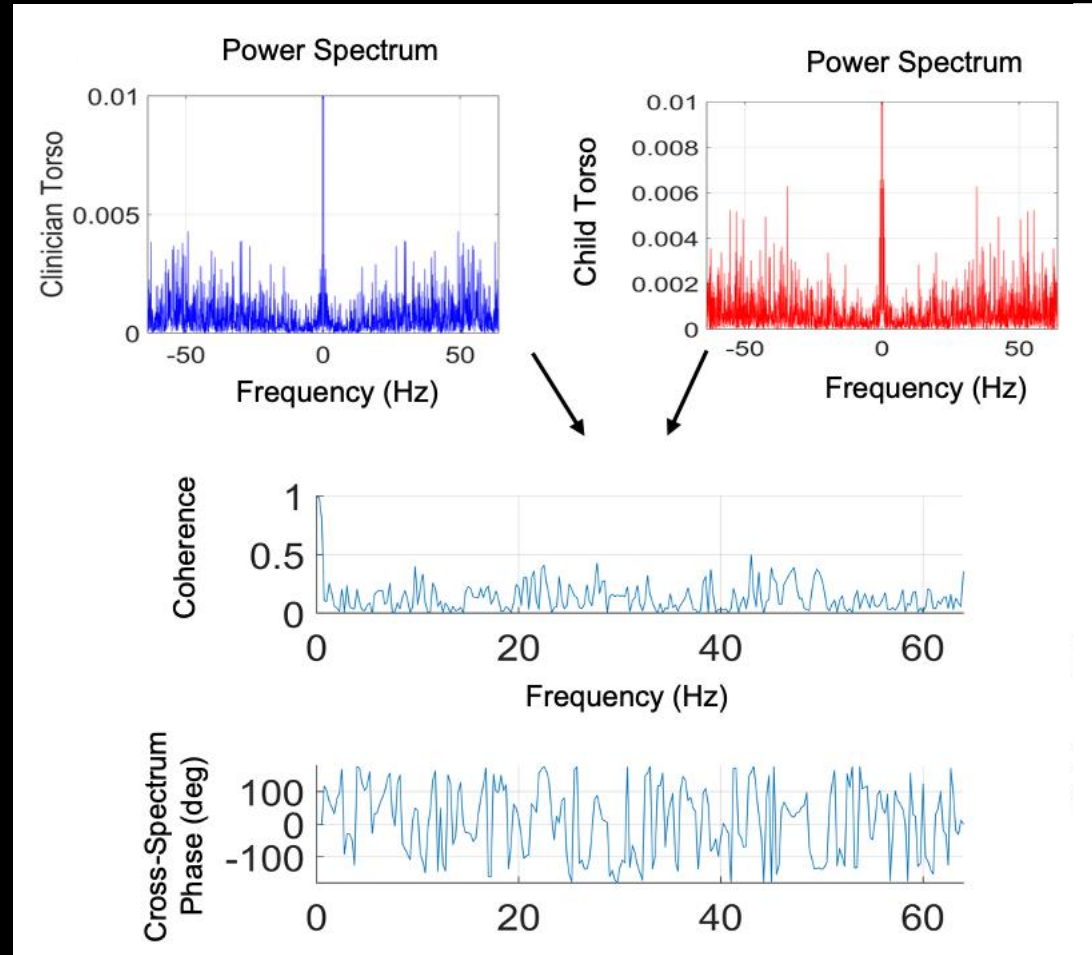
Sample Pipeline to create Micro-Movement Spikes



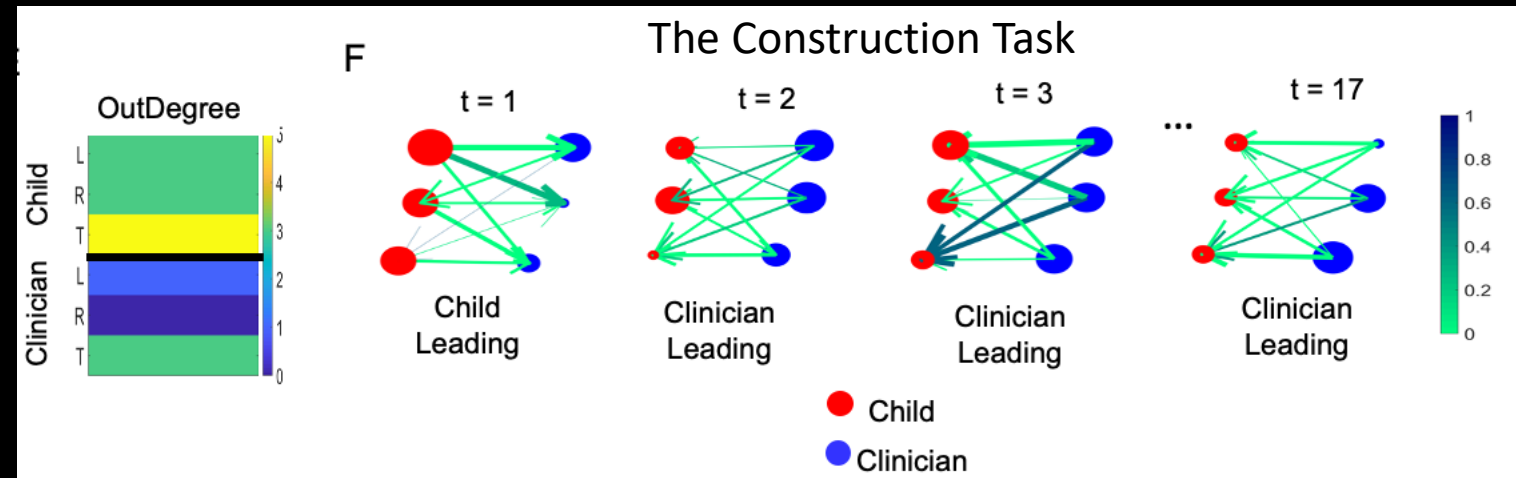
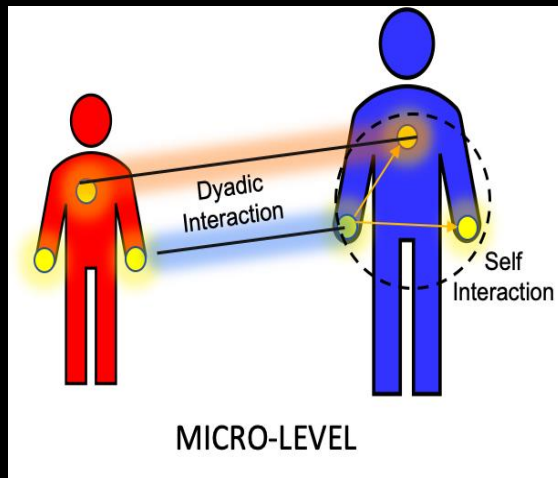
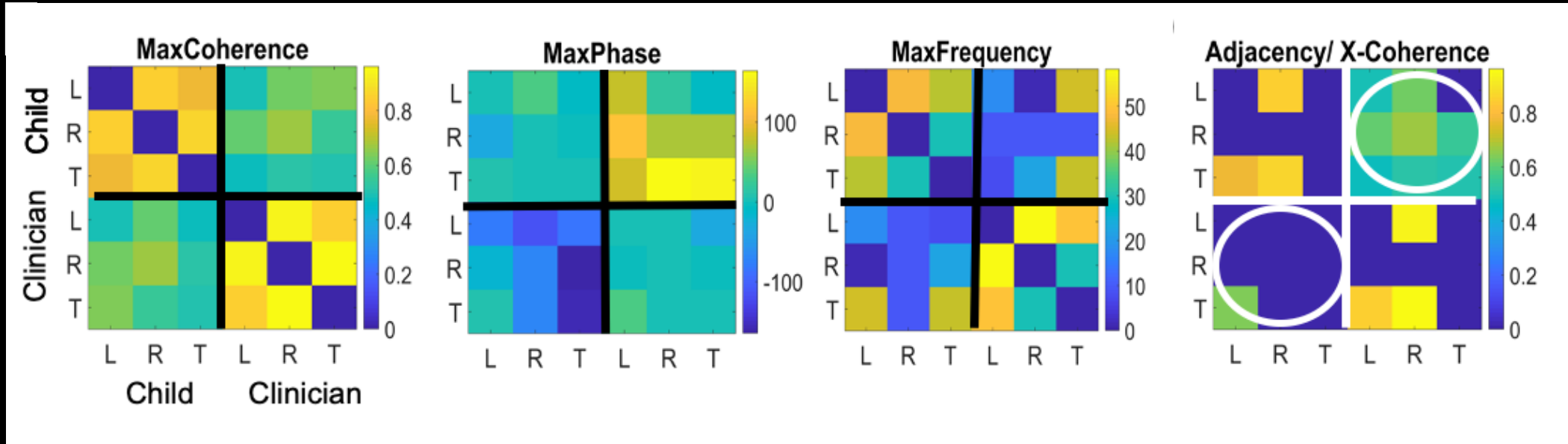
$$MMS = \frac{\max}{\max + \text{aver}_{\min \text{ to } \min}}$$



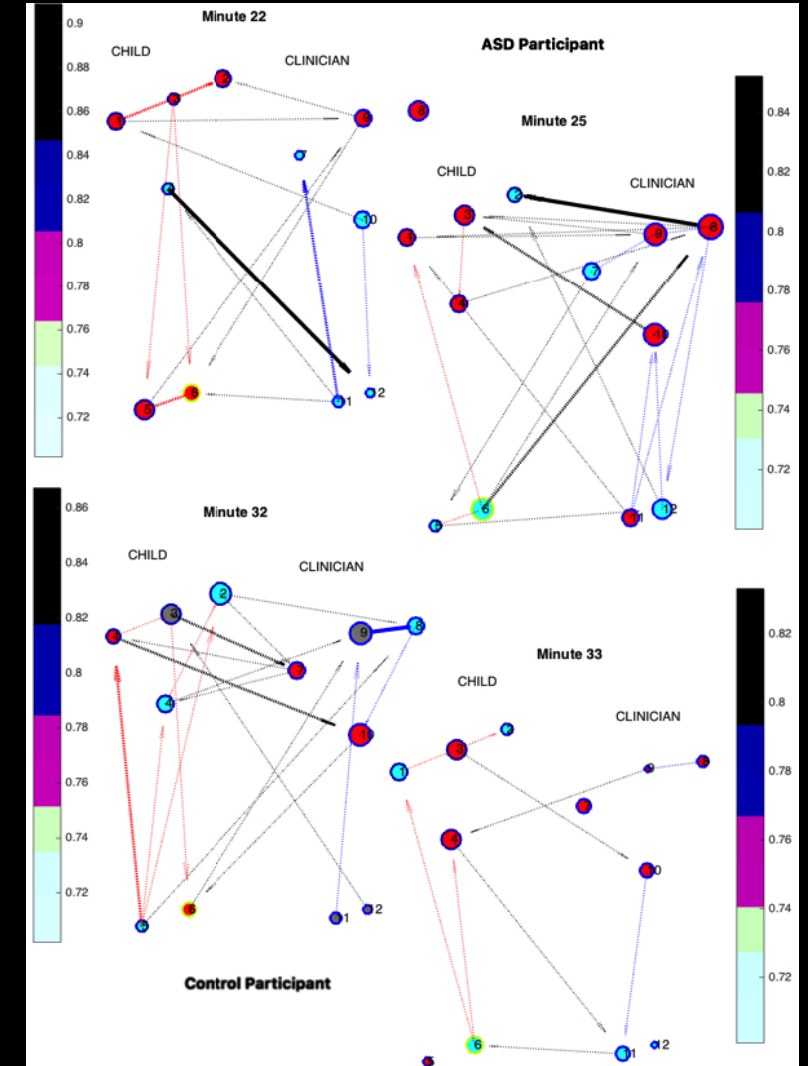
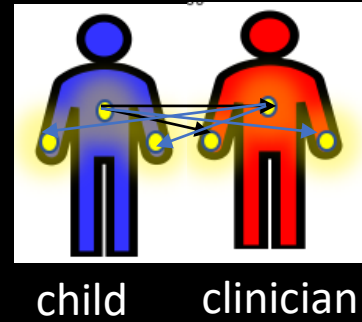
Torso



A Parameterization of Digital Data (Frequency Domain Analyses)



Digitized ADOS Network Representation



Digitized Autism Diagnosis Observation Schedule (ADOS)



MODULE 3 Task Order

Construction Task

Conversation

Demonstration Task

Description of a Picture

Telling a Story from Book

Cartoon – Cards

Emotions

Social Difficulties and Annoyance

Friends, Relationships and Marriage

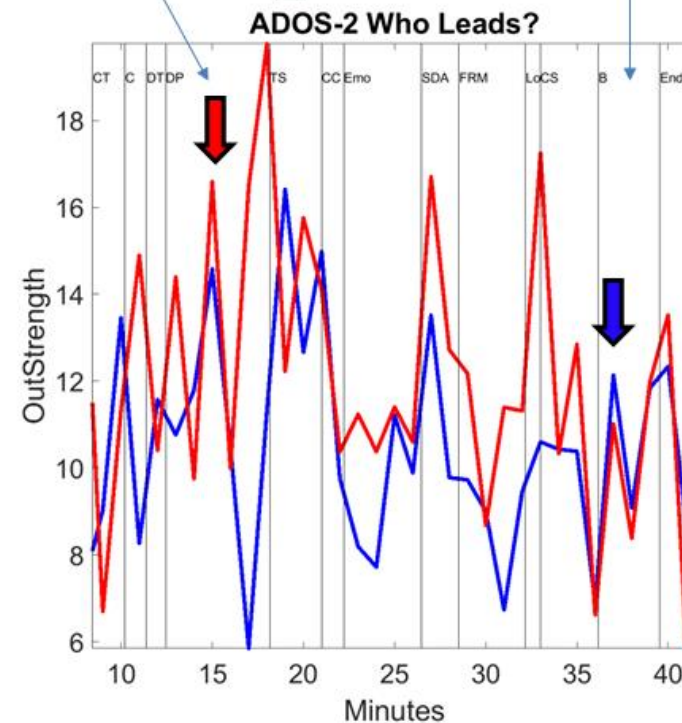
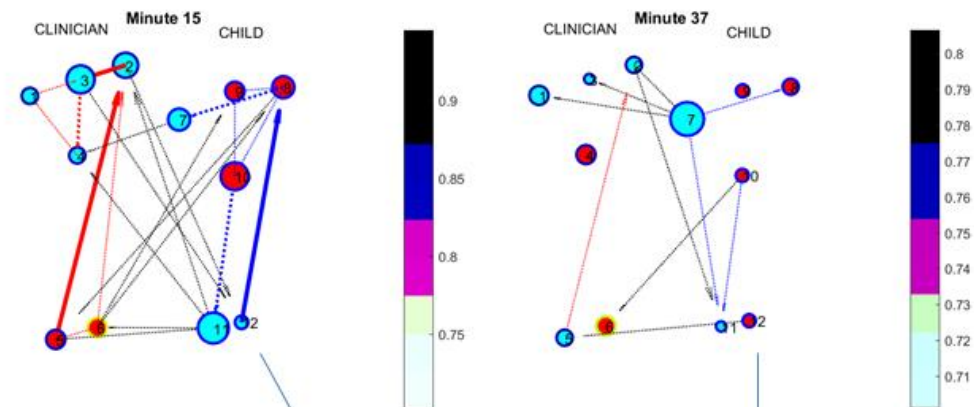
Loneliness

Creating a Story

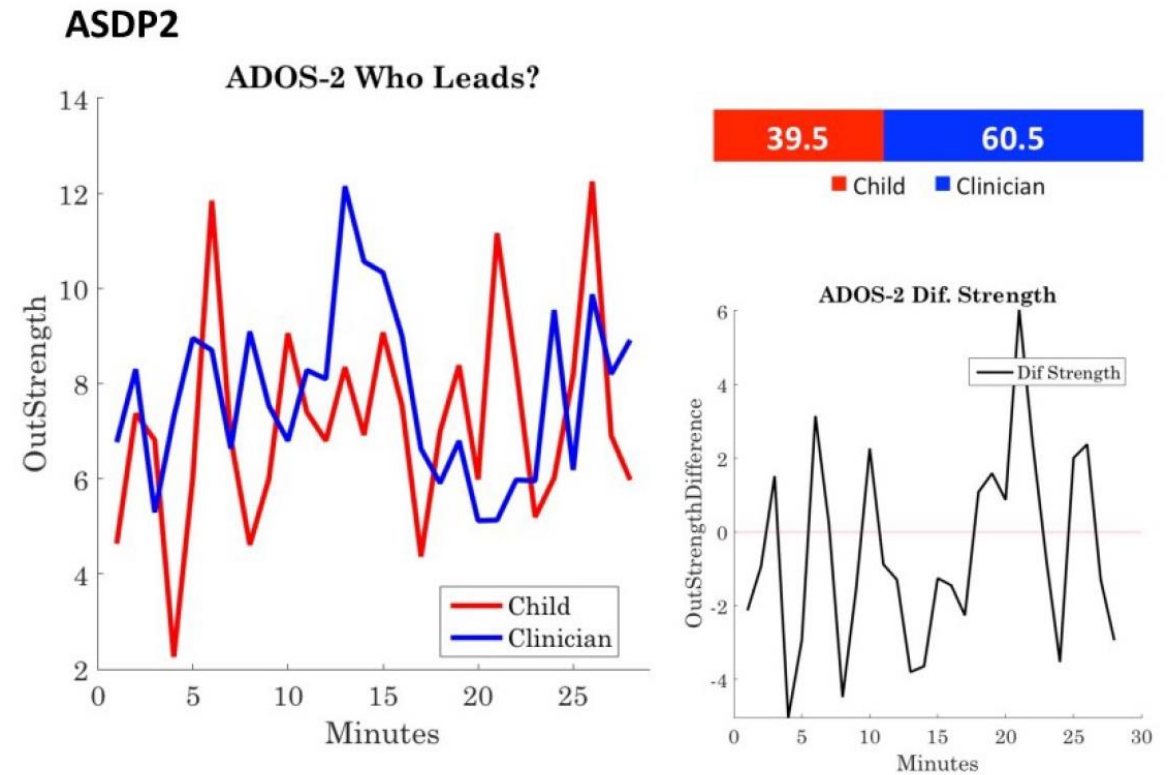
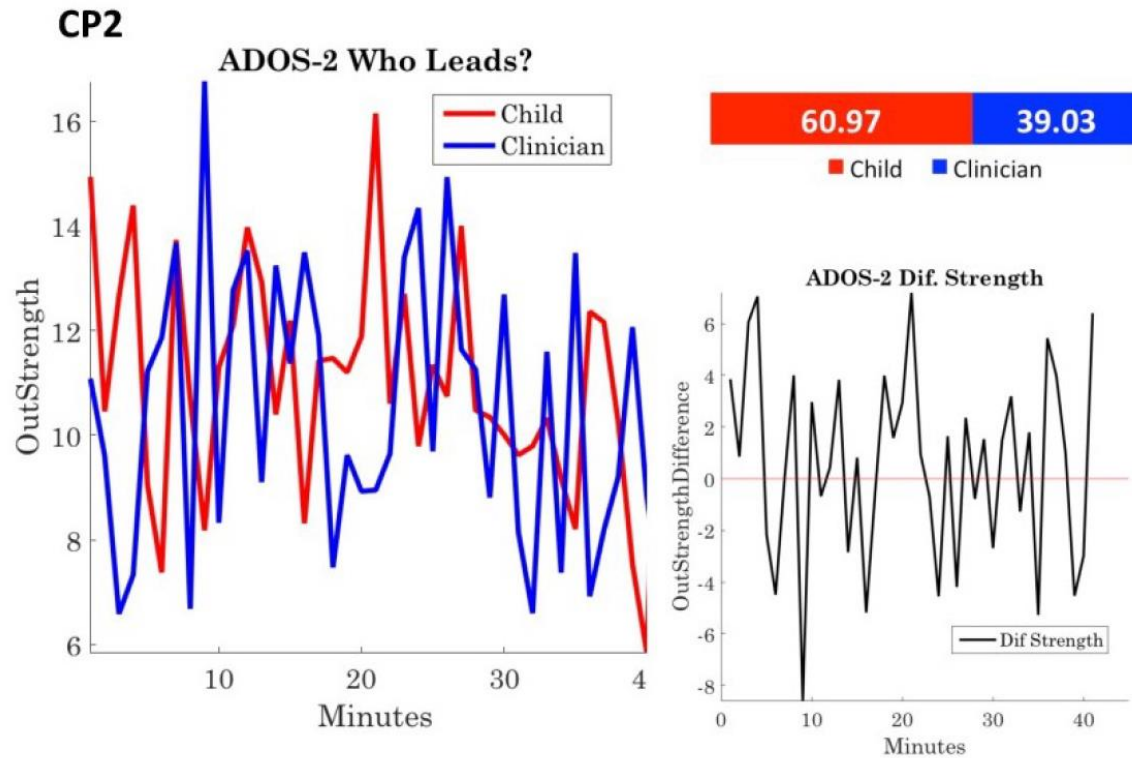
Break

END

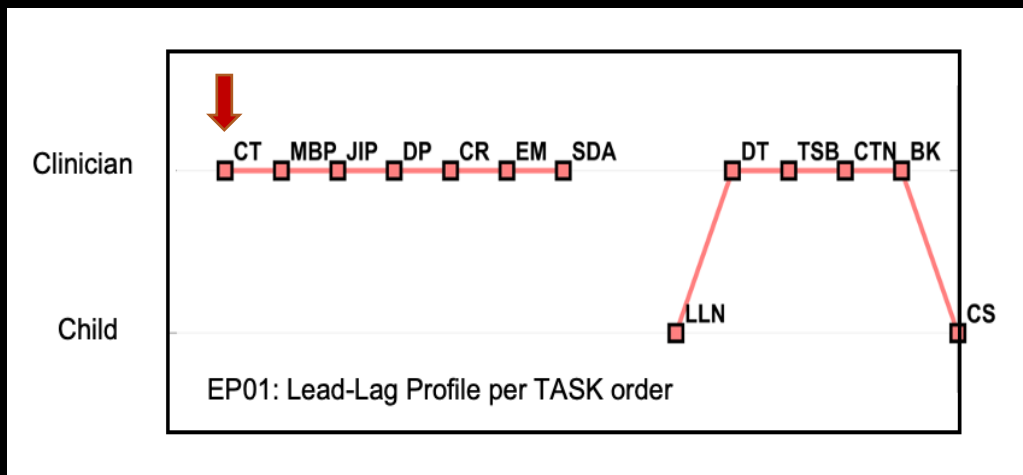
— Clinician
— Child



Digitized ADOS Lead-Lag Profile



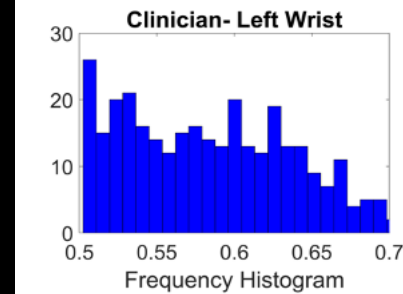
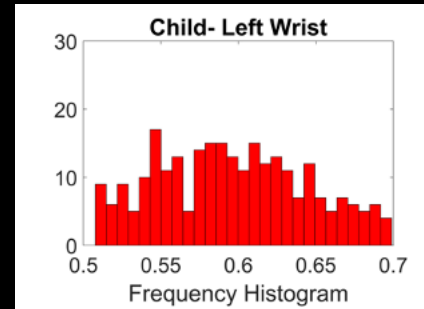
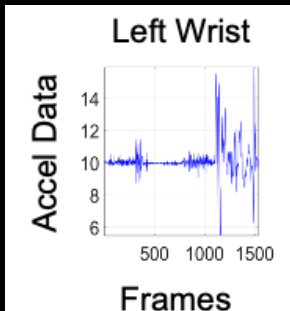
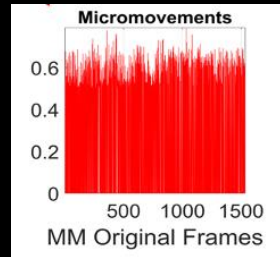
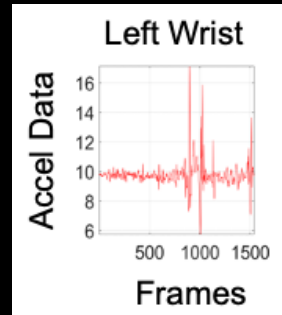
An Index of Lead-Lag (% time who leads the conversation?)



In this task, the child is asked to assemble blocks to construct a design shown on a printed form.

The purpose of the task is solely to create an opportunity for the child to ask for help, not to measure his or her motor or visual-spatial skills.

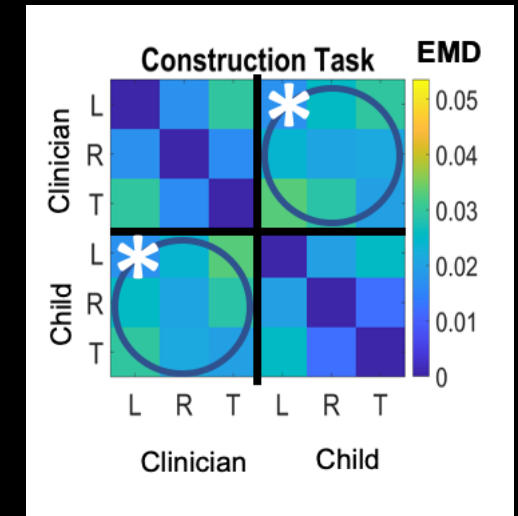
How do we Measure Dyadic Variability at the Micro-Level?



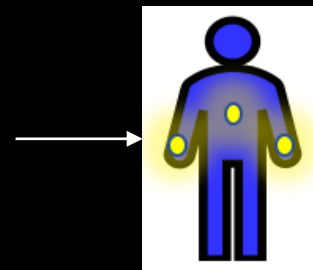
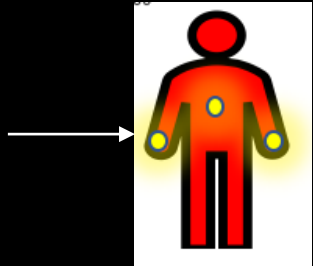
The Earth Mover's Distance

What is the amount of work required to convert the red into the blue histogram?

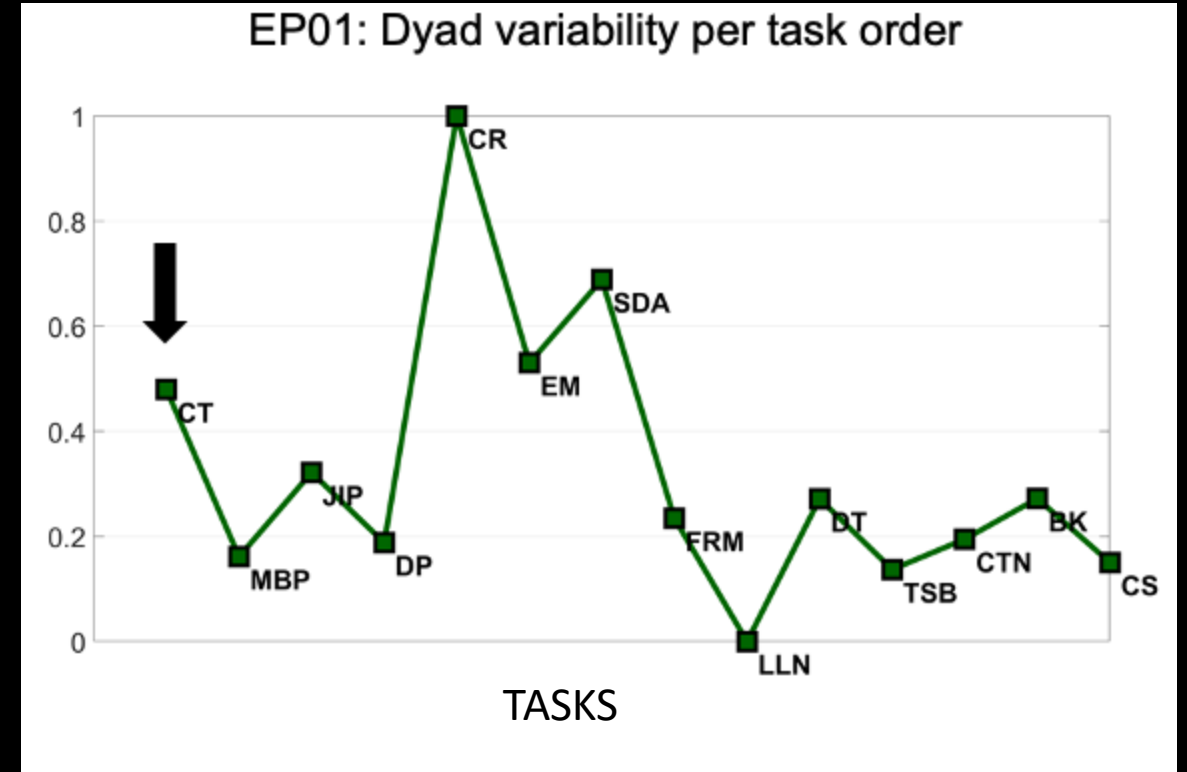
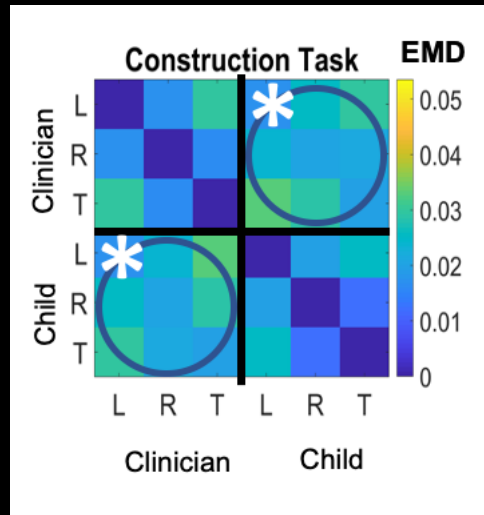
Pairwise Computation
Build Matrix



An Index of Micro-movements Variability (temporal domain)



Sum over Dyadic Entries



An Index of Dyadic Cross-Coherence (Frequency Domain)

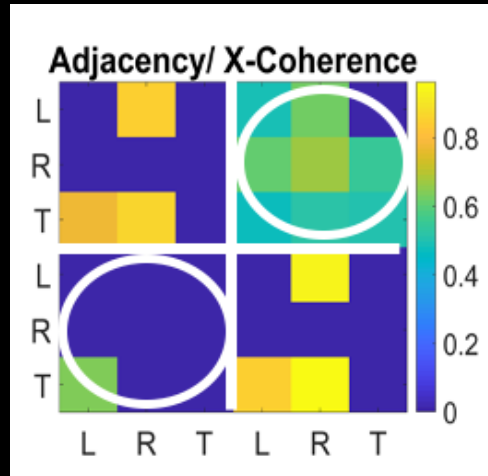
Clinician



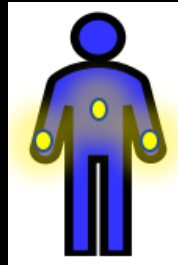
Child



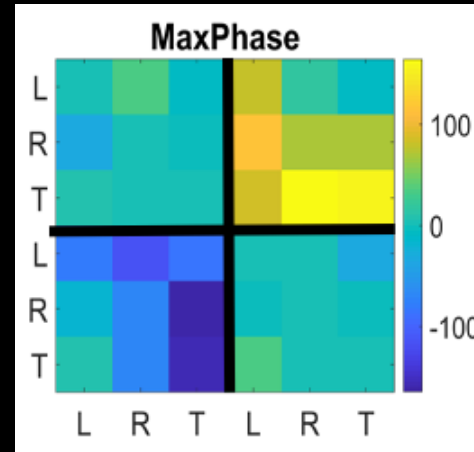
Sum over Dyadic Entries



Clinician

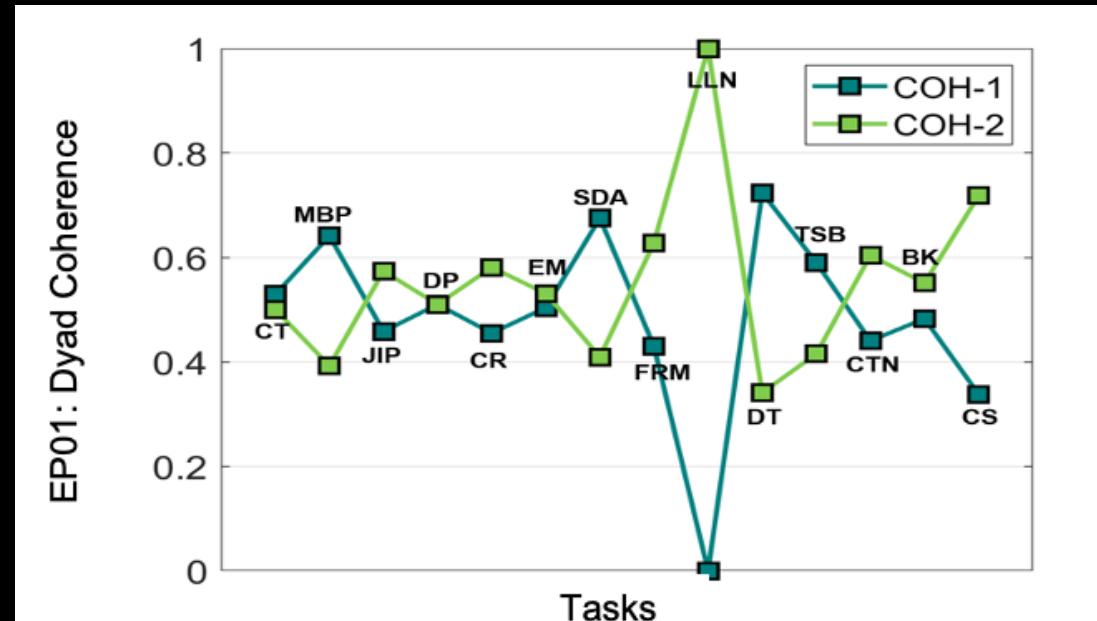


Child



Delay in Cohesiveness
Use the Lag Values

Leading Cohesiveness
Use the lead values



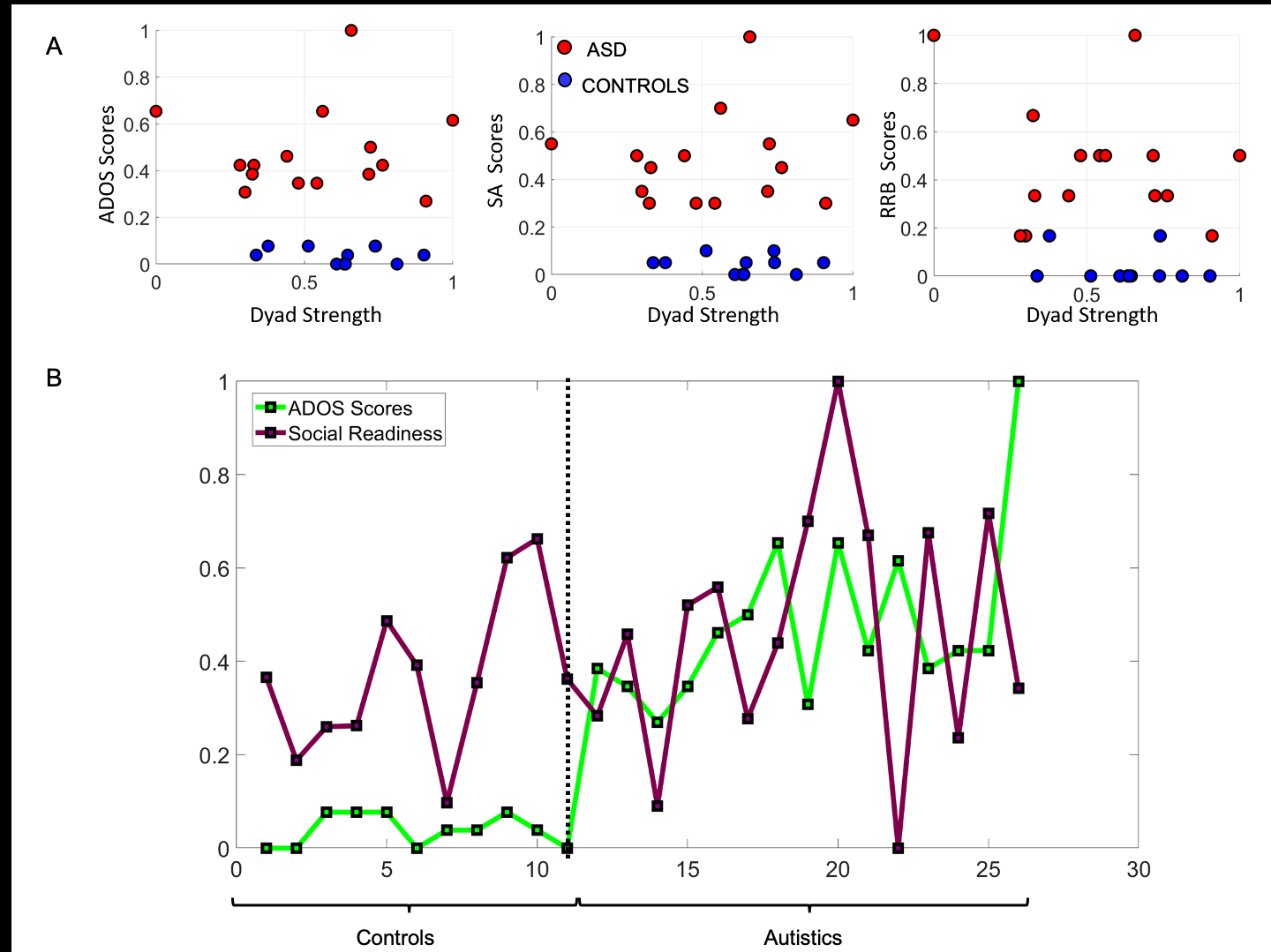
An Example of Combining Macro- and Micro-level Data

$$DyadicStrength = \frac{DyadicCoherence}{DyadicVariability}$$

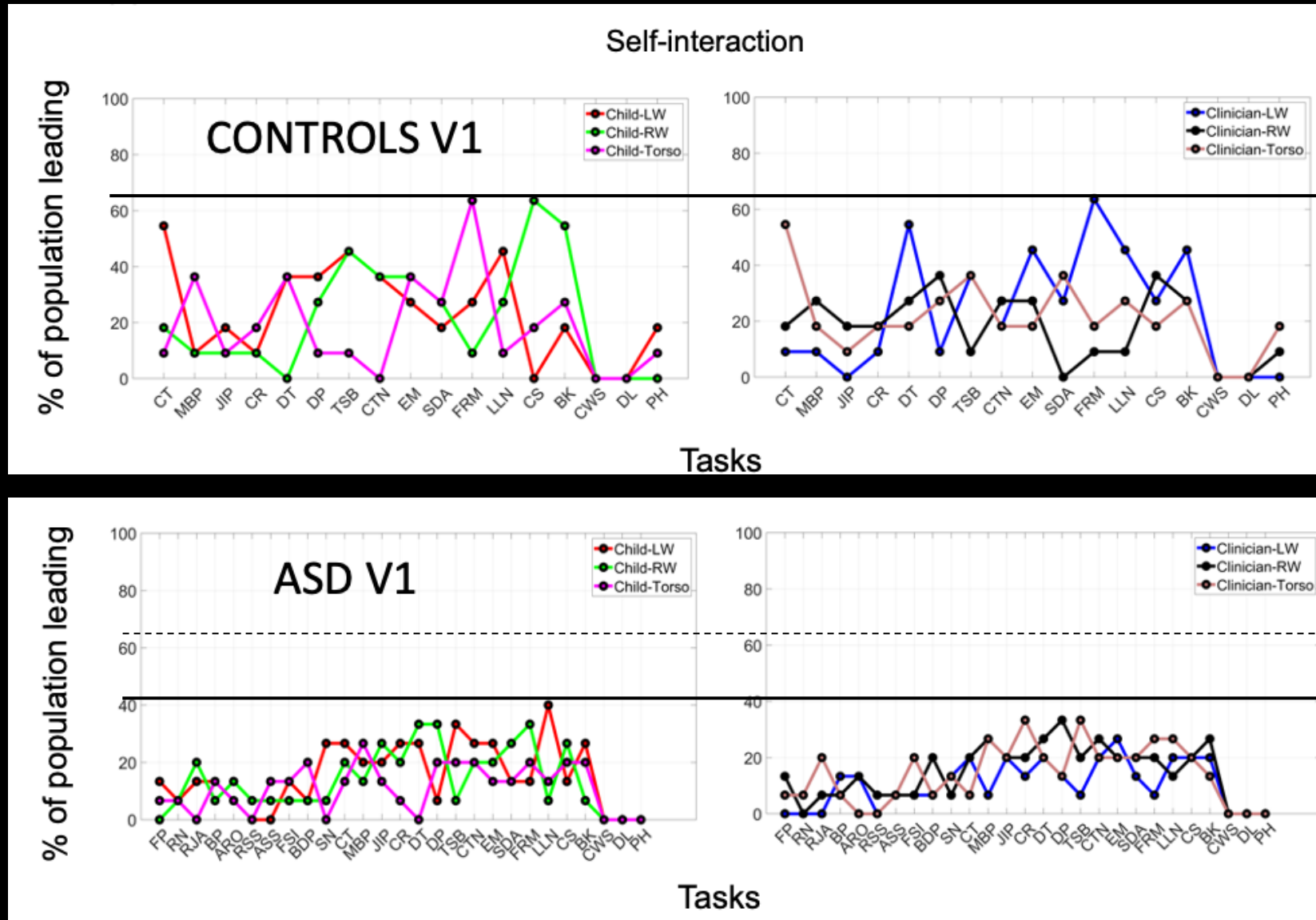
Hidden Potential for Social Readiness

Missed when you do not examine

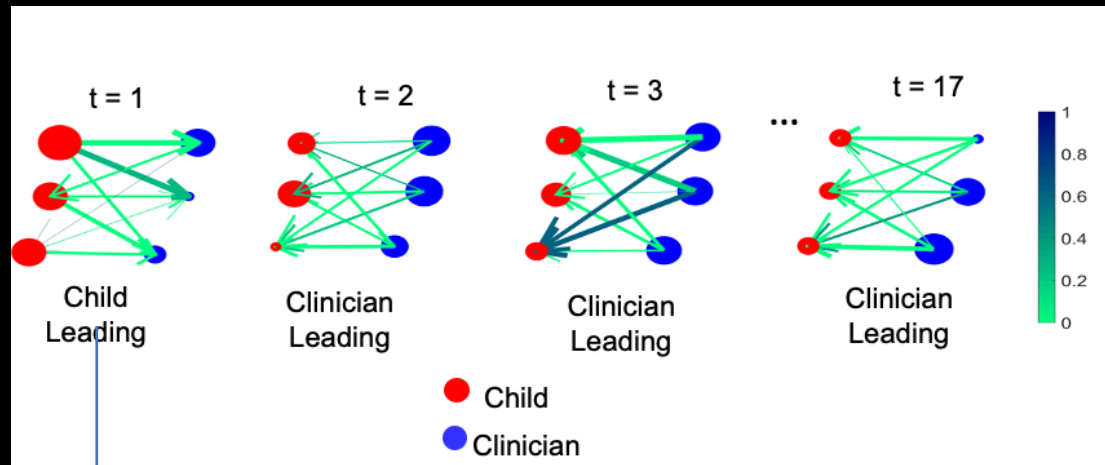
Neurotypical patterns



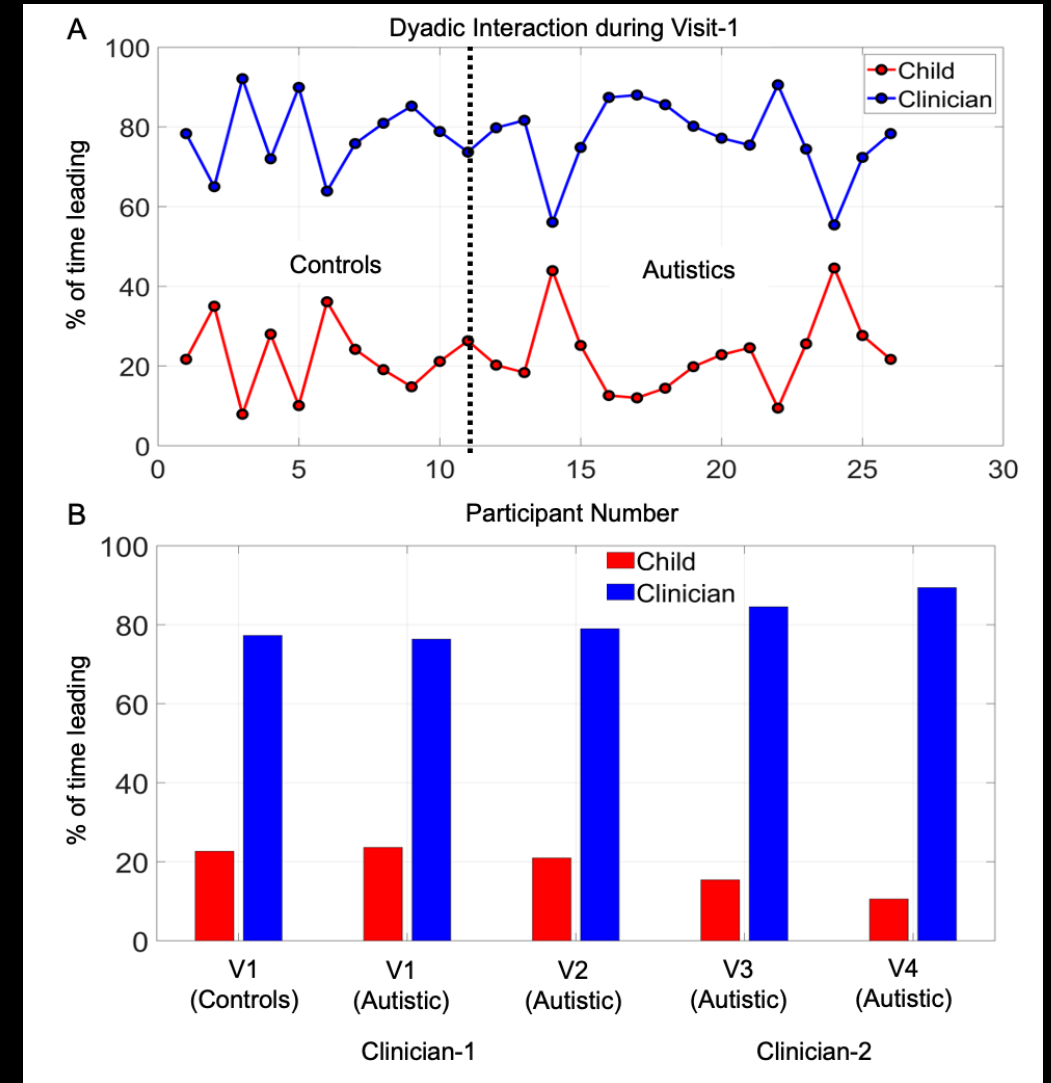
Implicit Mirroring Effect Induces Bias in the Rater



Temporal Dynamics of Leading Patterns



12-second-long windows



How can we scale this basic science experiment to e.g. 10,000 users?

- Need to educate health professionals on the neuroscience of nervous systems development
- Create certification programs that combine many different players ranging from educators to health professionals to researchers across many fields
- Need to translate the science to layman terms
- Need to engage the community to create legislation that brings science to the forefront
- Learn and help others; apply your knowledge; take control; create opportunity for agency

Summary

- Bodily biorhythms can reveal hidden aspects of social behaviors
- Normalizations that account for anatomical differences are important in motion analyses
- These type of data provide information about bodily biorhythms shared between two people and about those owing to synergistic activities of the person's body.
- Both temporal and frequency domain based indexes are informative
- Combining discrete scores from observation and micro-level signals brings a more complete, broader and deeper picture of the complex unfolding dynamics of a social exchange.

SCIENTIFIC



Research
Findings



Clinical
Practices



New
Treatments



Improved
Outcomes

ADVANCES

Class Objectives

- Learn about natural behaviors from a biorhythmic perspective
- Learn about levels of behavioral description and their applications
- Translate existing methods in brain science to behavioral science
- Learn about biosensors
 1. What types of wearable biosensors are out there at our reach
 2. What are some caveats
 3. How to scale their use from lab basic science to e.g. 10K+ users

In class

- We will watch another example of data analyses for dyadic interactions (Lecture Part II)
- We will play with the data to learn how to plot it
- We will learn about kinematics and variability
- We will learn about the micro-movement spikes MMS and the Gamma estimation process
- We will learn about network connectivity analyses
- Goal of the class → Learn how to plot data, how to process it, how to analyze it, how to visualize it and how to interpret it