Challenges for modeling multi-modal team coordination dynamics

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Overview

1. Challenges
2. Overview of Team coordination dynamics
3. Some examples of my work examining forms and functions of coordination

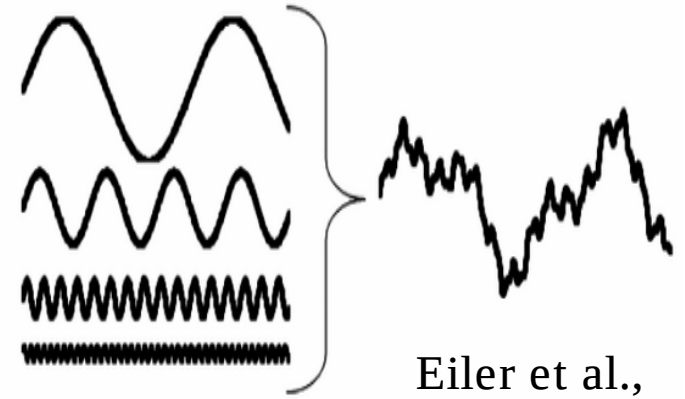
10 Challenges for Modeling Team Coordination Dynamics

- Challenge 1: Making sense of the team coordination dynamics literature
- Challenge 2: Detecting important functions of social coordination in multiple modalities and contexts
- Challenge 3: What should we manipulate to determine the function of certain forms of coordination?
- Challenge 4: Issues with our models of coordination
- Challenge 5: Aggregate vs. continuous measures of coordination
- Challenge 6: How do we know we have observed meaningful change in coordination?
- Challenge 7: When do we maintain/emphasize idiographic information vs. nomothetic?
- Challenge 8: How do we know what time scales and time points are important?
- Challenge 9: Methods for modeling coordination in groups > 2
- Challenge 10: How can we use all of this to augment team interactions?

Team Coordination Dynamics

Team Coordination Dynamics

- A form of multi-scale mutual information exchange between interlocutors (Oullier & Kelso, 2009)
- Effective (collaborative) team interactions require:
  - Coordination of behavior and knowledge
  - Across spatial and temporal scales
  - Both intra- and *inter-individually*
- Social phenomena manifest across individuals':
  - physiology, bodily movements, dialog acts, and technological systems



Eiler et al., 2013

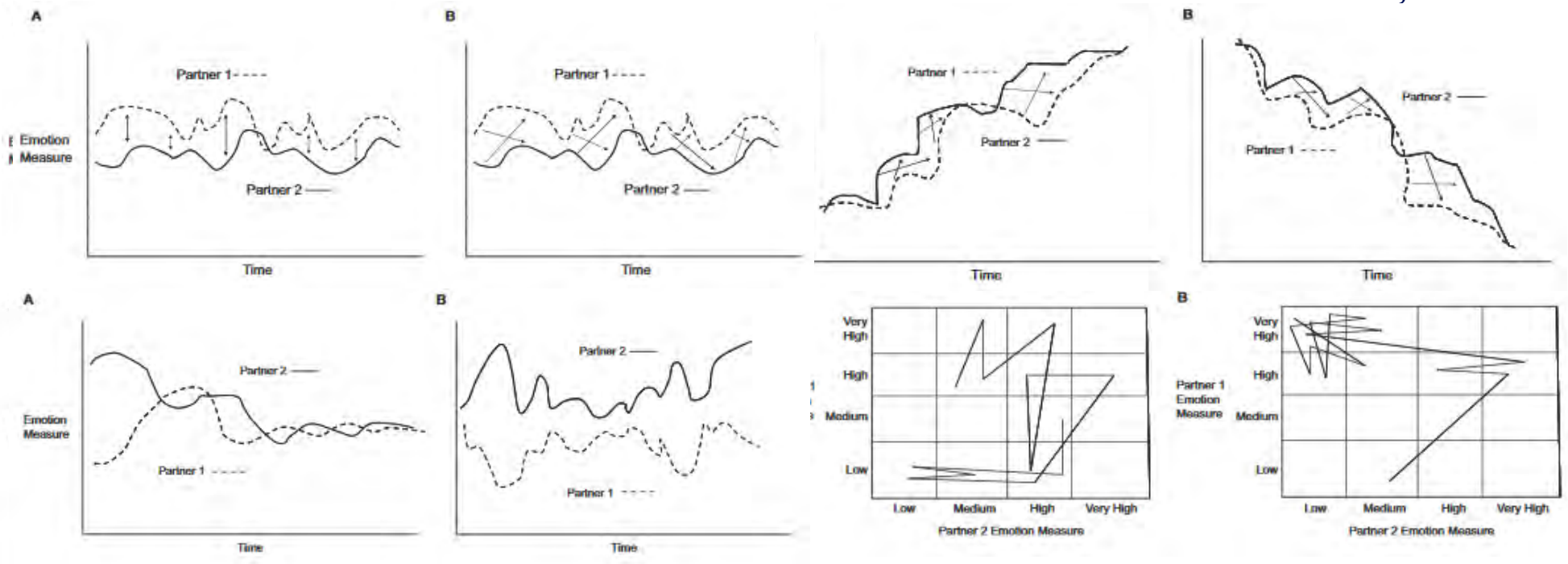
Team Coordination Dynamics

- **The ways in which components and processes of a system change together over time** (Butner et al, 2014)
- Can occur intra- and inter- personally
  - Referred to in different ways(forms): alignment, synchronization, co-regulation, entrainment, coupling, and more
- Observed in many modalities and contexts
- Knowledge of the functionality is limited


Christaan Huygens
(1629-1695)

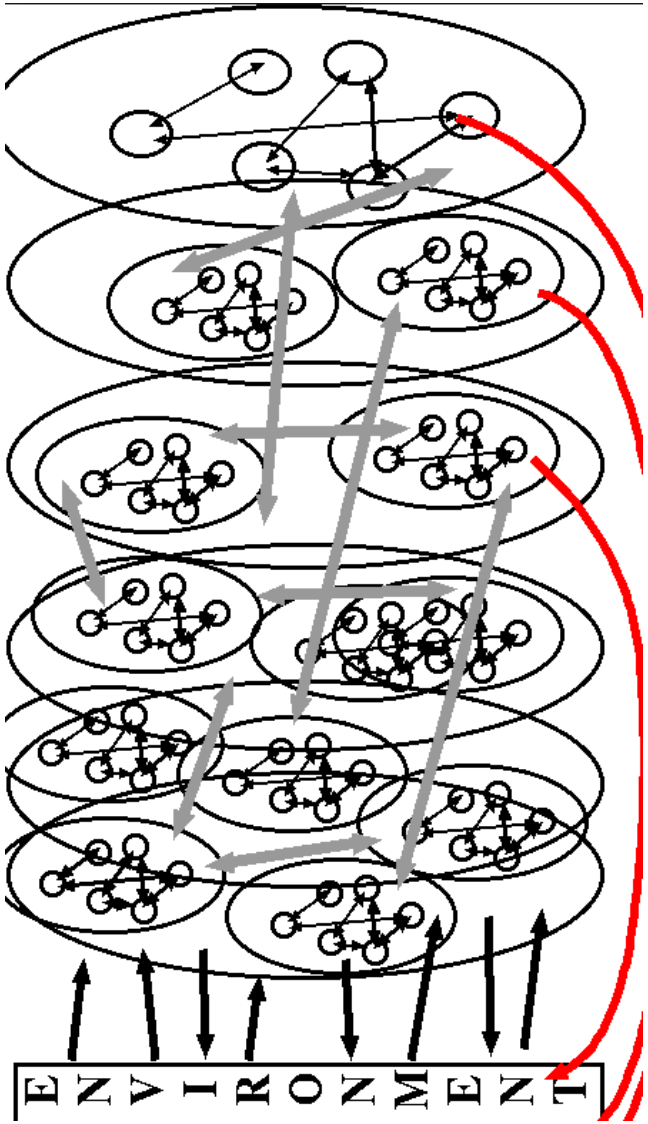
Team Coordination Dynamics (Forms)

Butler, 2011



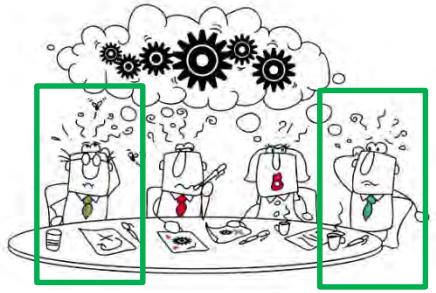
Team Coordination Dynamics

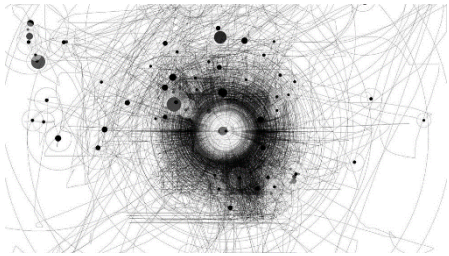
- **Dynamical systems** are:
  - Comprised by a set of reciprocally interacting components (system)
  - Hierarchically and nested structures (complex)
  - Change over time (dynamic)
    - Coordination changes (relative strength, and can breakdown)
  - Reciprocal influence with influence the environment (open)
    - We can in influence coordination

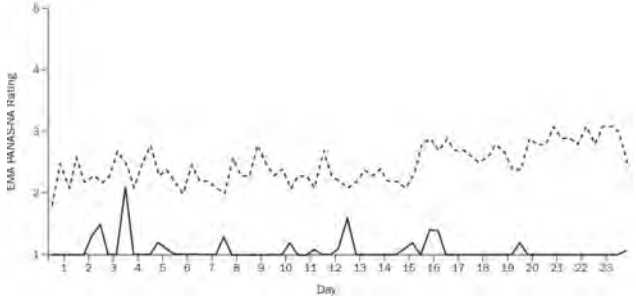


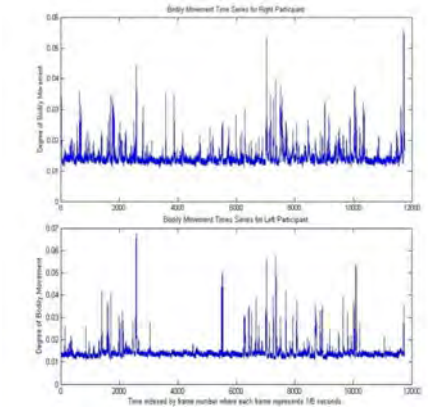
Gelo & Salvatore (2016)

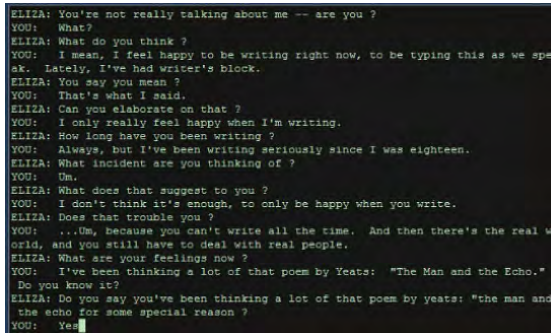
Team interaction data is complex

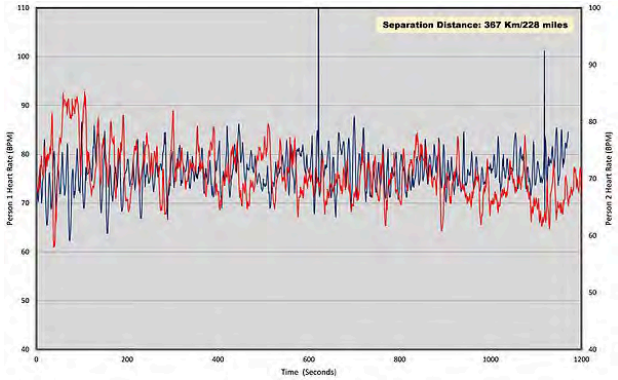


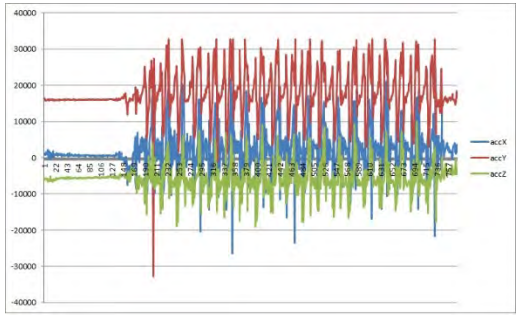


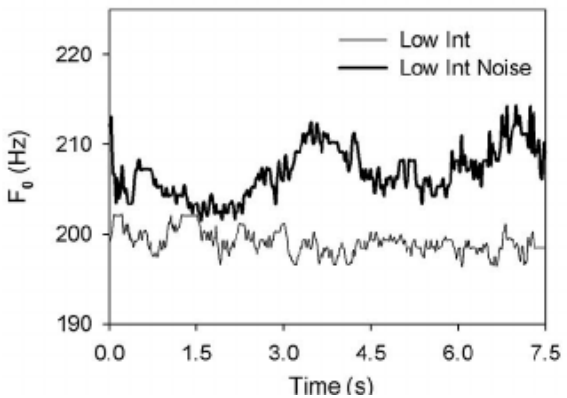


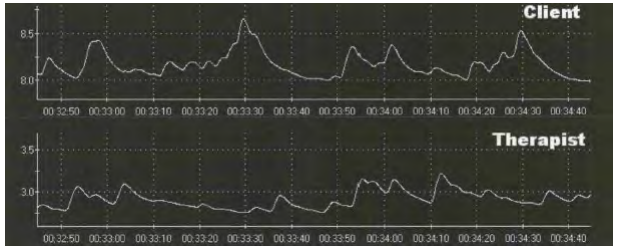


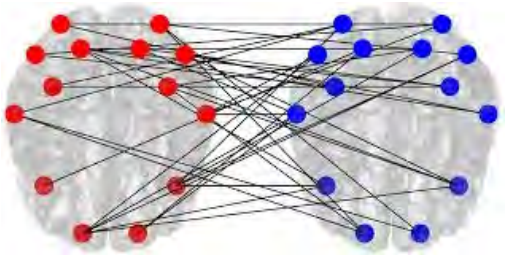












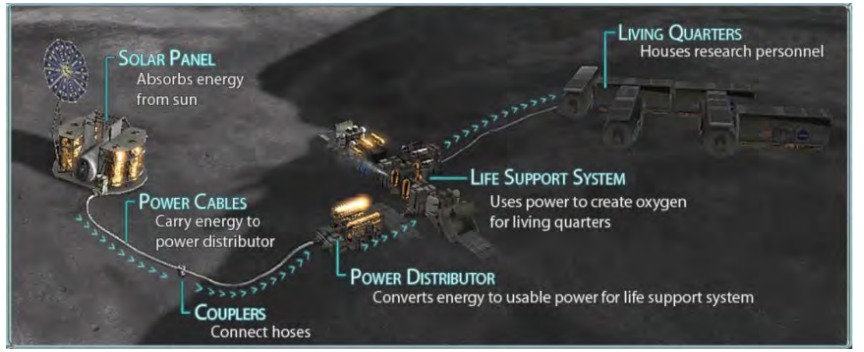
Challenge 1: Making sense of the team coordination dynamics literature

Examples from (mostly) my own work

Modalities, Methods, Form & Function

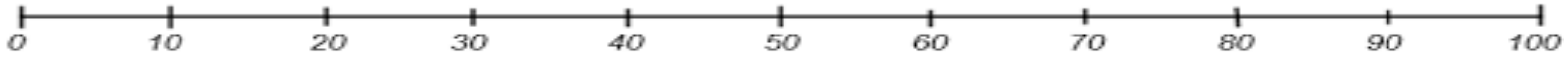
NASA Moonbase Alpha Task

- Meteorite damaged moonbase, must work together figure out how to fix all components
- Allotted 25 minutes of ‘oxygen’ to complete task
- Complex, dynamic, time-dependent, necessitates collaboration
- No predefined sequence for how to solve
- Tools are major task constraint



Team Performance

- Rescaled combination of three variables:
  - (a) the total **time** taken to restore life support (0-25 minutes),
  - (b) the total **percentage of oxygen** restored (0-100%),
  - (c) a ratio of completed **object repairs** to the total possible repairs (0-25; only for teams that restored zero oxygen).
- Each team got a score from 0 - 100
  - Also used grouping variable for performance



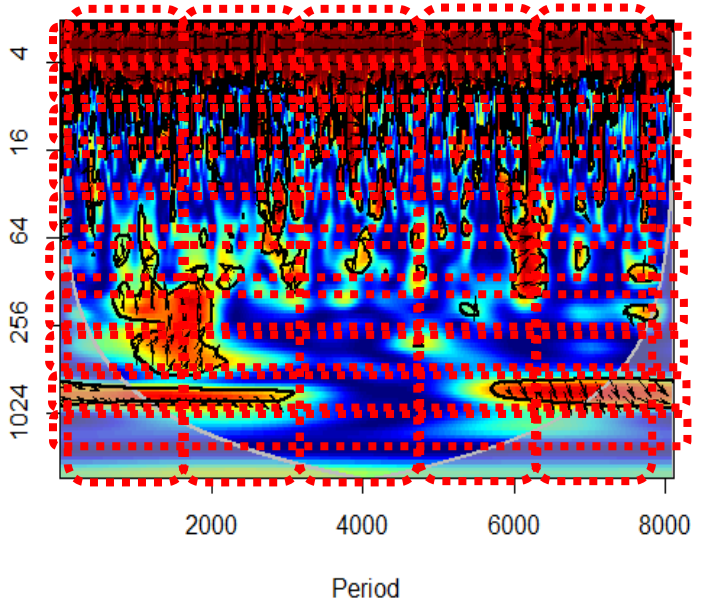
Movement coordination at certain time scales predicts CPS performance

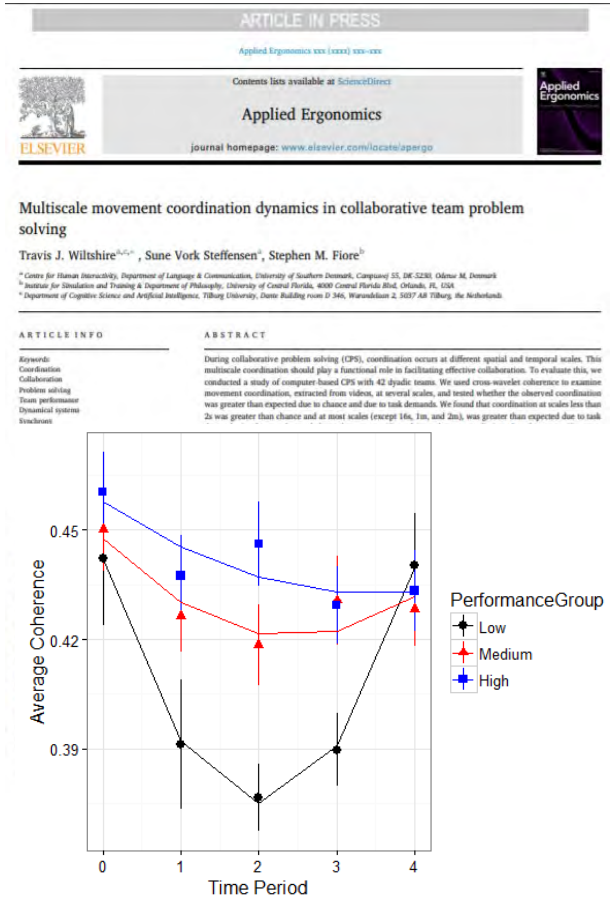
Modality: Bodily movements extracted using video-frame differencing

Methods: Cross-wavelet coherence, surrogate/virtual pairs analyses, growth curve analysis

Form: Bodily movement coordination emerges at a level greater than expected due only to chance and task demands at **2s time scales and lower**

Function: Teams with high **in-phase** coordination at 1s time scale performed better





Changes in Coordination

- Over duration of the task, the average coordinate across scales changes and is moderated by task performance.

Changes in coordinated communication patterns relate to CPS performance

- **Modality:** Semantic content of speech (CPS processes)
- **Method:** Sliding window entropy can be used to identify transition points in team communications
  - Entropy is an information theoretic quantification of order in the system
- **Form:** General measures of order disorder in communication states
- **Function:** Separates distinct phases of collaborative cognition (based on distribution of communication states)

- **Lower average levels of entropy at transition points significantly predicted CPS performance (more ordered transitions)**

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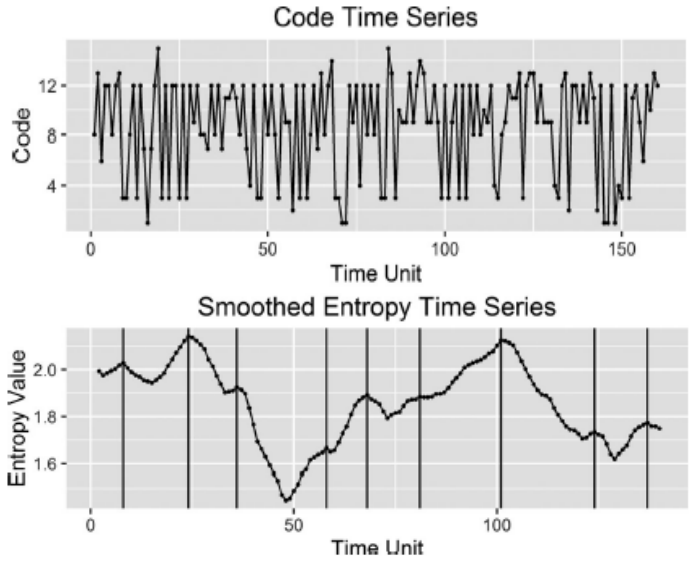
Problem-Solving Phase Transitions During Team Collaboration

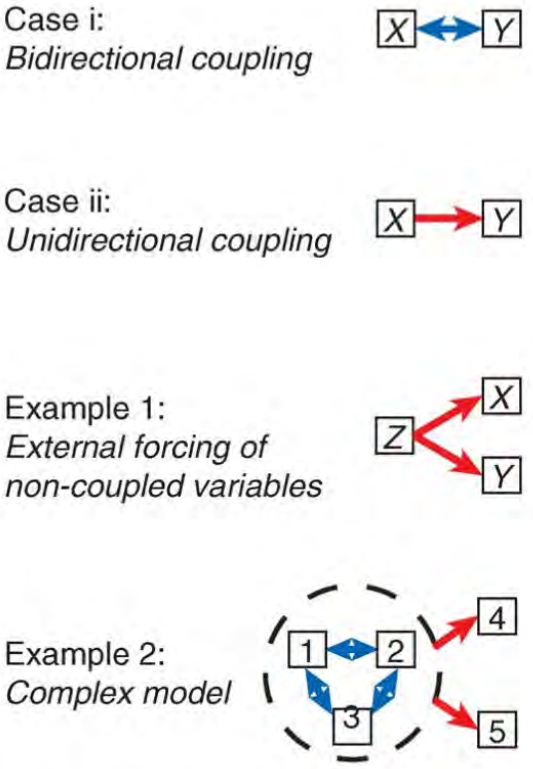
Travis J. Wiltshire,[a,b] Jonathan E. Butner,[a] Stephen M. Fiore[c]



Behaviors can drive (dynamically cause) behavior and physiology of others

- **Modalities:** Behavior, skin conductance, and RSA during a conflict interaction between mothers and daughters
- **Method:** Convergent cross mapping – a method for detecting 'causality' in complex systems
- **Form:** Unidirectional driving/coupling
- **Function:** Mothers of self-injuring teens drove their daughters behavioral and physiological trajectories

Relevant to individual performance and teamwork



Sugihara et al., 2012

Empirical Article

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Clinical Psychological Science
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Evaluating Emotional and Biological Sensitivity to Maternal Behavior Among Self-Injuring and Depressed Adolescent Girls Using Nonlinear Dynamics

Sheila E. Crowell[1], Jonathan E. Butner[1], Travis J. Wiltshire[1], Ascher K. Munion[1], Mona Yaptangco[1], and Theodore P. Beauchaine[2]
[1]University of Utah and [2]The Ohio State University

Table 2. MCCM Analyses Showing Directional Effects From Mother to Adolescent or Adolescent to Mother Behavior or Physiology

Group	Variable	*p* value	Embedding dimension	Proportion of replication of *p*
	Behavior outcomes			
Control	TeenBeh → MomBeh	.41[a]	3	1.00
	MomBeh → TeenBeh	.54[a]	2	.86
Depressed	TeenBeh → MomBeh	.45[a]	3	.90
	MomBeh → TeenBeh	.04*	5	.17
Self-injuring	TeenBeh → MomBeh	.37[a]	2	.72
	MomBeh → TeenBeh	.00**	6	.42
	Electrodermal outcomes			
Control	TeenBeh → MomEDA	.43[a]	3	.80
	MomBeh → TeenEDA	.38[a]	2	.97
Depressed	TeenBeh → MomEDA	.36[a]	3	.76
	MomBeh → TeenEDA	.45	5	.86
Self-injuring	TeenBeh → MomEDA	.23[a]	2	1.00
	MomBeh → TeenEDA	.01**	6	.41
	Respiratory sinus arrhythmia outcomes			
Control	TeenBeh → MomRSA	.15[a]	3	.36
	MomBeh → TeenRSA	.16[a]	2	.83
Depressed	TeenBeh → MomRSA	.85[a]	3	.98
	MomBeh → TeenRSA	.18	5	.50
Self-injuring	TeenBeh → MomRSA	.08[a]	2	.79
	MomBeh → TeenRSA	.01**	6	.84

Note: Beh = observed behavior during conflict; EDA = electrodermal activity; Mom = mother; RSA = respiratory sinus arrhythmia; Teen = adolescent daughter.
[a]Hypothesized nonsignificant result.
*$p \leq .05$. **$p \leq .01$.

Multimodal coordination predicts collaborative processes

- **Modalities:** Movements, speech rate, and changes in user interface
- **Method:** multidimensional recurrence quantification analysis (mdRQA), mixed effects modeling
- **Form:** Regularity of them temporal matching between multiple signals
- **Function:** Less systemic regularity predicts collaborative processes of constructing shared knowledge as well as negotiation/coordination.

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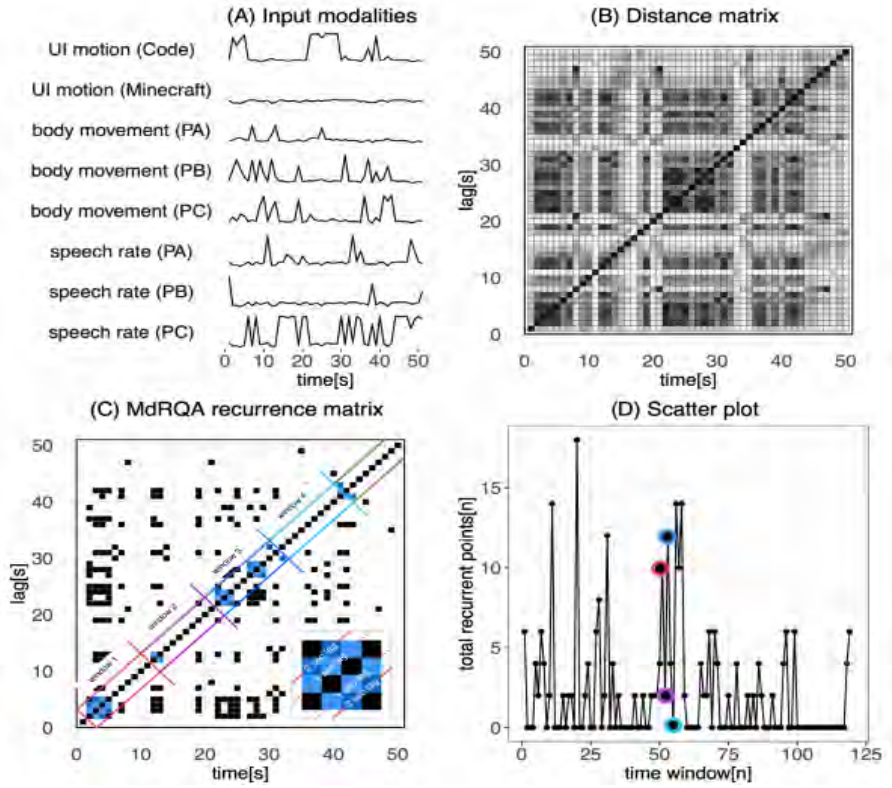
Beyond Dyadic Coordination: Multimodal Behavioral Irregularity in Triads Predicts Facets of Collaborative Problem Solving

Mary Jean Amon, Hana Vrzakova, Sidney K. D'Mello



Team Coordination Dynamics Recap

- Mutli-scale
  - Coordination occurs **and spans multiple modalities** and certain **time scales** in those might have particular functions
- Multi-methodological
  - There are many methods we can use to quantify coordination
- Coordination can have different **forms** and it can change over time
- The **function** of coordination can be examined as:
  - A predictor of task performance (outcomes)
  - A comparison of the levels of coordination between conditions/contexts

Want to investigate teamwork dynamics with me and my colleagues?

4 year - PhD position in Cognitive Science, Complex Systems, and Team Dynamics
Tilburg University

4 year - PhD-position Field Research in Team Coordination and Wearable Technology
Eindhoven Technical University

Application DUE December 1, 2019

****Masters degree required

Email me or come chat for more details:

t.j.wilthshire@uvt.nl

Thanks to my collaborators!

Contact me:

t.j.wiltshire@uvt.nl

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Thanks!