

Interpersonal coordination in early interactions: Comparisons of infant-directed singing and speech

Erica Flaten, Natasha Wandel, Susan Marsh-Rollo, Dobromir Dotov, Laurel Trainor
Department of Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, Ontario, CA



Email: flatene@mcmaster.ca; twitter: [@FlatenErica](https://twitter.com/FlatenErica); LIVE Lab website: <https://livelab.mcmaster.ca/>

Introduction

Interacting individuals coordinate their movement, behaviour, and physiological arousal. Such coordination has social consequences across the lifespan, such as greater cooperation¹, prosocial behaviour² and leader-follower dynamics^{3,4}. We are interested in two types of coordination:

- **Information flow** – how much one signal predicts the future of another signal.
- **Similarity** – how similar or correlated two signals are.

Coordinated interactions with caregivers are crucial for infant development. Across cultures, such interactions involve **infant-directed singing** (e.g., lullabies and playsongs) and **infant-directed speech**^{5,6}. Mothers sing *lullabies* and *playsongs* differently, and impact mother-infant arousal differently⁷, perhaps serving different developmental functions.

In caregiver-infant interactions, how do social signals (e.g., body movement), and physiological signals (e.g., heart rhythm or skin conductance), coordinate? How does this differ during infant-directed singing vs. speech?

Methods

Participants

- 3 Caucasian mother-infant dyads from the Hamilton, Canada area
- Biological mothers who sing regularly to their infants (5-6 months)

Demographics Questionnaire

- Language & music background
- Race, SES

Video (Analysis in progress)

- Facial expressions and eye contact recorded from tablets

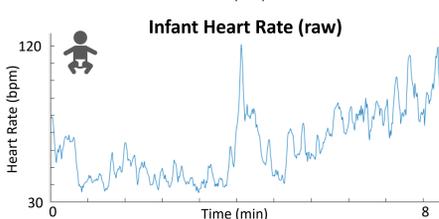
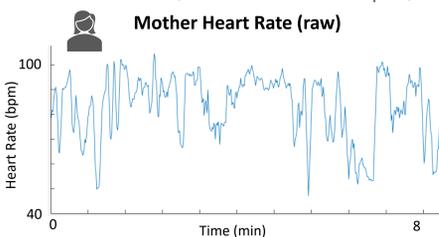
Motion Capture

- Qualisys cameras
- Reflective markers for head, arms and torso



Physiology (Analysis in progress)

- Skin conductance
- Heart rate (see below example)



Paradigm: Mothers prepared songs familiar to their infants, and following a baseline, performed 2 min. blocks (counterbalanced):

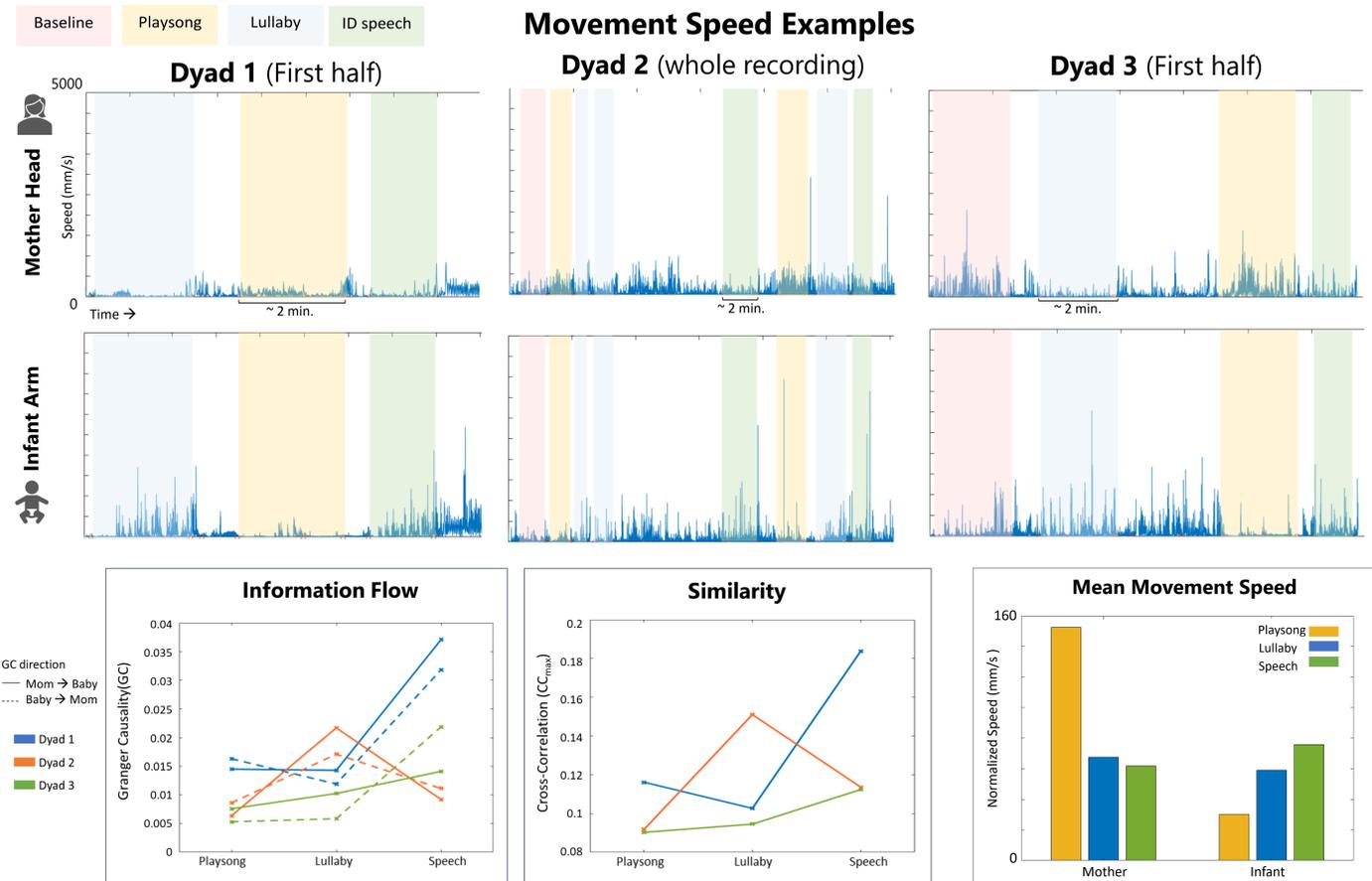
- Singing playfully (Playsong)
- Singing soothingly (Lullaby)
- Telling the story of the songs (Speech)

Coordination Analysis^{3,4}:

1. Movement speed = $\sqrt{(dx^2 + dy^2 + dz^2)}/dt$
 - Downsampled (8 Hz) and Z-scored
2. Information flow (Granger Causality; GC)
 - Using optimal model order from MVGC toolbox⁸
3. Similarity (Lagged cross correlation; CC)
 - The max CC within the time frame defined by the GC model order

Given that the beat of music is typically more regular than for speech, movements during music were expected to be more synchronized, and therefore more similar. Given that speech contains more turn-taking, greater information flow between mother and infant was expected during speech.

Preliminary Results



Conclusions

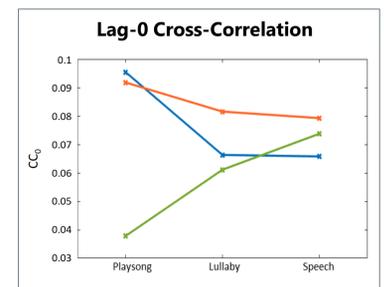
1. Preliminary trend for greater bidirectional information flow in movement speed for speech vs singing.
2. Trend for similarity (cross-correlation) to show a similar pattern as information flow (Granger Causality).

- Here, GC and lagged CC may be showing similar dynamics. We could try instead using a lag-0 cross correlation to get a measure of **phase synchrony**, where the dyad is moving together at the same time. See below.

Limitations/issues:

- Small N so far
- How naturalistic vs. controlled to make the experiment?
- Need to incorporate physiology, gaze, and demographic data
- Best analyses? Future analyses may include non-linear measures of coordination such as cross recurrence quantification analysis and symbolic transfer entropy

This study will significantly improve our understanding of the dynamics of caregiver-infant interactions using a novel multi-modal approach.



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