Self-Organization of Spontaneous Synchronization while "Maraca-ing"

Alexander P. Demos, Roger Chaffin, & Kerry L. Marsh
Department of Psychology, University of Connecticut

Introduction

- **Dyads coordinate actions with *visual information*.**
  - *Intentionally*: Moving planks of wood (Richardson, Marsh, & Baron, 2007)
  - *Spontaneously:* Rocking chair movement (Richardson, et al., 2007)
- **Individuals coordinate actions with *rhythmic sounds*.**
  - *Intentionally*: Tapping to a beat (Repp, 2006), Keeping step to music while walking (Styns, et al., 2007)
  - *Spontaneously:* Align rocking chair movements to music (Demos, et al., 2012)
- **Dyads coordinate actions with *rhythmic sounds*.**
  - *Intentionally:* Military marches with music and work songs (McNeill,1995).
  - *Spontaneously:* Align Rocking chair movement with sound of other rocker (Demos, et al., 2012)
    - Rocking chairs provide for slow adaption because of their inherent natural frequency.
- **Using a new task, shaking maracas, we measure *spontaneous coordination* through rhythmic sounds.**
- **We examine the properties of the dynamics of coordination.**

Method

Participants
- 27 dyads

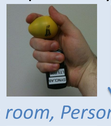
Cover story
- Testing new gym equipment. They are there to see how the equipment functions when alone vs. with others.

Materials
- Libery Latus Polhems :
  - Wireless magmatic tracking system)
  - Sampling rate 94 Hz
- 2 Shakers (mini-maracas)

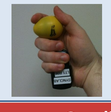
Design

1. Baseline Condition

Shown 120 bpm (2 hz)
Instructions: "Keep a steady pace"

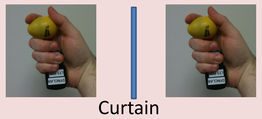
Person 1 with Maraca & Sensor  60 Seconds

Person 1 leaves room, Person 2 enters

Person 2 with Maraca & Sensor  60 Seconds

2. Spontaneous Condition 1

Both people at same time
Instructions: "Do what you did before"



3. Spontaneous Condition 2

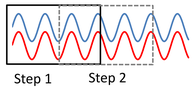
50% of dyads repeat **Spontaneous Condition 1**.
Instructions: "Lets do that again"

4. Intentional Condition

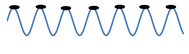
Instructions: "Try to match the other person's pace"

Dependent Measures

Measurement of Coordination
- Windowed cross correlation at 0 Lag
- 4 seconds long windows with 50% overlap



Measurement of Speed of Maraca'ing
- Data cleaned using wavelets and then subjected to peak picking



Measurement of Stability of Movements
- Detrended Fluctuation Analysis (Peng, C.K. et al., 1994)
- Describes long-range correlations in a time series

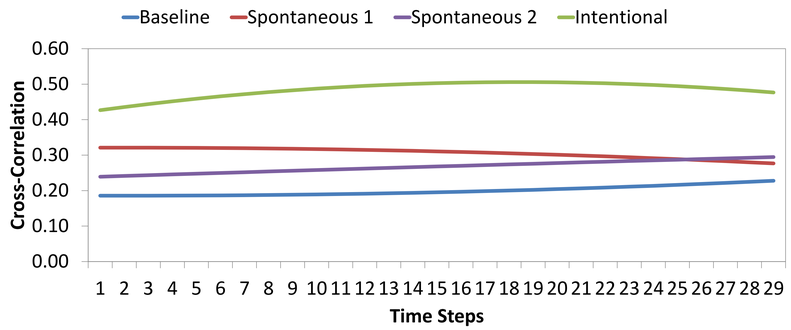
Results

Measurement of Coordination

Testing Methods:
- Coordination analyzed via mixed-effects model:
  - Allows for each dyads slopes to be measures.
  - Best fit using quadratic function to represent time.
  - Maximal random effects structure used.

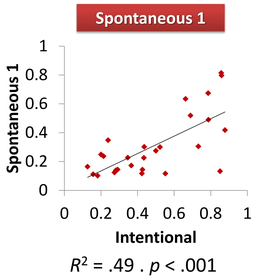
Significant Effects:
- **Baseline** < **Spontaneous 1**
- **Baseline** < **Intentional**
- *Interaction:* **Time** vs. **Intentional**

Model Results:

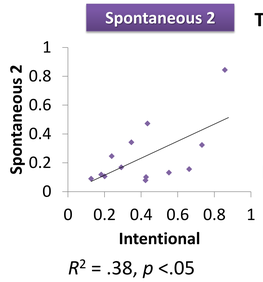


Discussion:
- Dyads spontaneously synced through bi-directional rhythmic sounds (replicating Demos, et al., 2012).
- Spontaneously synchrony did not occur as strongly the second time.
- Only the intentional condition interacted with time, suggesting that maintaining sync is difficult **intentionally**, but not **spontaneously**.

Individual Differences in Overall Coordination



R^2 = .49 . p < .001
R_p^2 = .41, p < .001

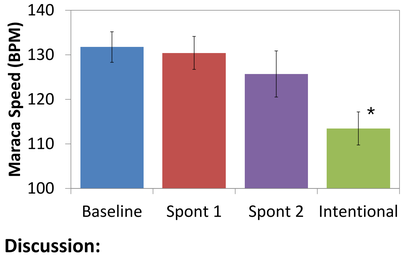


R^2 = .38, p <.05
R_p^2 = .19, p = .16

Testing Method:
- Average cross-correlation between intentional and spontaneous conditions (w/o baseline partialed out).

Discussion:
- The better dyads could sync **intentionally** the more they did **spontaneously**, but only the first time.

Measurement of Speed

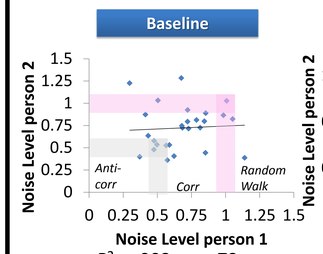


Speed vs Coordination	r	r_p (Partialed out baseline tempo)
Spontaneous 1	-.39*	-.23
Spontanoues2	-.24	-.18
Intentional	-.54*	-.48*

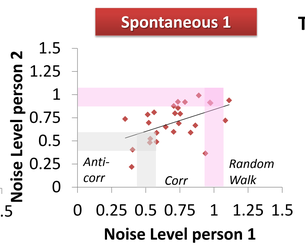
Discussion:
- Dyads slowed down in the **intentional**, but not in the **spontaneous** condition.
- The more dyads slow down to **intentionally** sync with partner the stronger the sync.
- After controlling for baseline tempo, dyads did not slow down to **spontaneously** sync with their partner.

Results, Continued

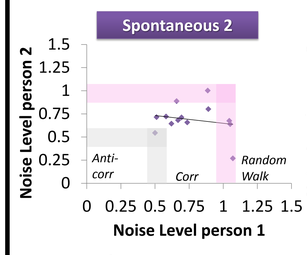
Stability of Movements (DFA)



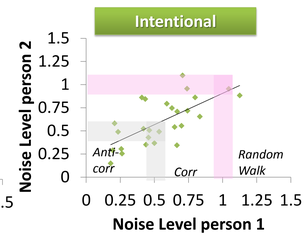
R^2 = .002, p = .73
R_p^2 = .004, p = .67



R^2 = .24, p <.001
R_p^2 = .13, p < .01



R^2 = .05, p =.26
R_p^2 = .18, p < .05



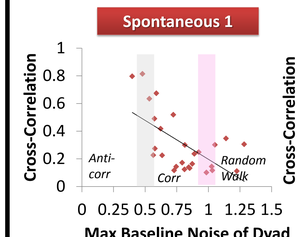
R^2 = .43, p <.001
R_p^2 = .20, p < .01

Testing Method:
- Dyadic Correlation method (double entry) w/o and with average cross-correlation partialed out. (Kenny, Kashy, & Cook, 2006)

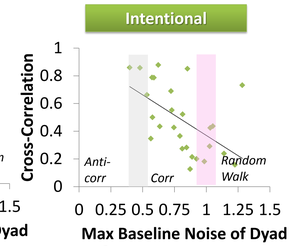
Key to DFA parameters
- 0 - 0.49 - Anti-correlated
- ≈ 0.5 - White noise (uncorrelated)
- 0.6 - 0.9 - Correlated Noise
- ≈ 1 - Pink Noise
- >1 - Non-stationary (unbounded)

Discussion
- Even when controlling for synchrony we see dyads changing their movements as a function of their partner's movements.

Baseline Stability of Movements vs. Synchrony



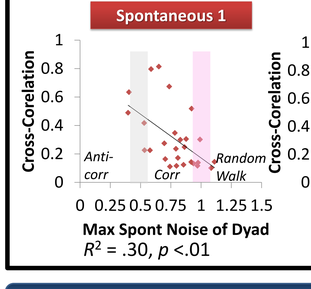
R^2 = .36, p <.01



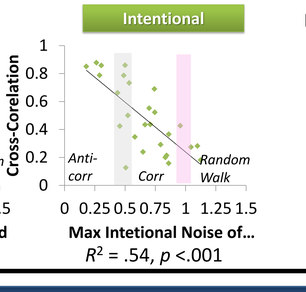
R^2 = .29, p <.01

Discussion
- Dyads with baseline anti-correlated or uncorrelated noise show higher levels of both **spontaneous** and **intentional** synchrony.
- Individuals that have naturally anti-correlated or uncorrelated movements maybe better able to adjust their own movements.

Stability of Movements when in Synchrony



R^2 = .30, p <.01



R^2 = .54, p <.001

Discussion
- Dyads shift to anti-correlated noise when strongly synchronized. This reflects their self-adjustment to their changing partner.
- This adjust is not see as strongly in the **spontaneous** condition.

Conclusion

- Many dyads spontaneously coordinate their movements based on the sound of another person, but only do so when the situation is novel.
- Dyads that spontaneously coordinated did not slow down as they did in the intentional condition. This suggests a more automatic self-organization of neural oscillators (Kelso, 2005).
- Dyads that could spontaneously coordinate exhibited anti- or uncorrelated noise in the baseline condition: Bi-directional dynamical systems with uncorrelated noise can exhibit phase slip, moving between phases without undue constrain on the system, while strongly correlated or unbounded systems stay locked into their limit cycle dynamics (Pikovsky, Rosenblum, & Kurths, 2003).