Do Wii sync while cooperating? An investigation of postural sway

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Some important terms and differences

- Coordination
  - Temporal, but not necessarily spatial
  - e.g., lifting a table together

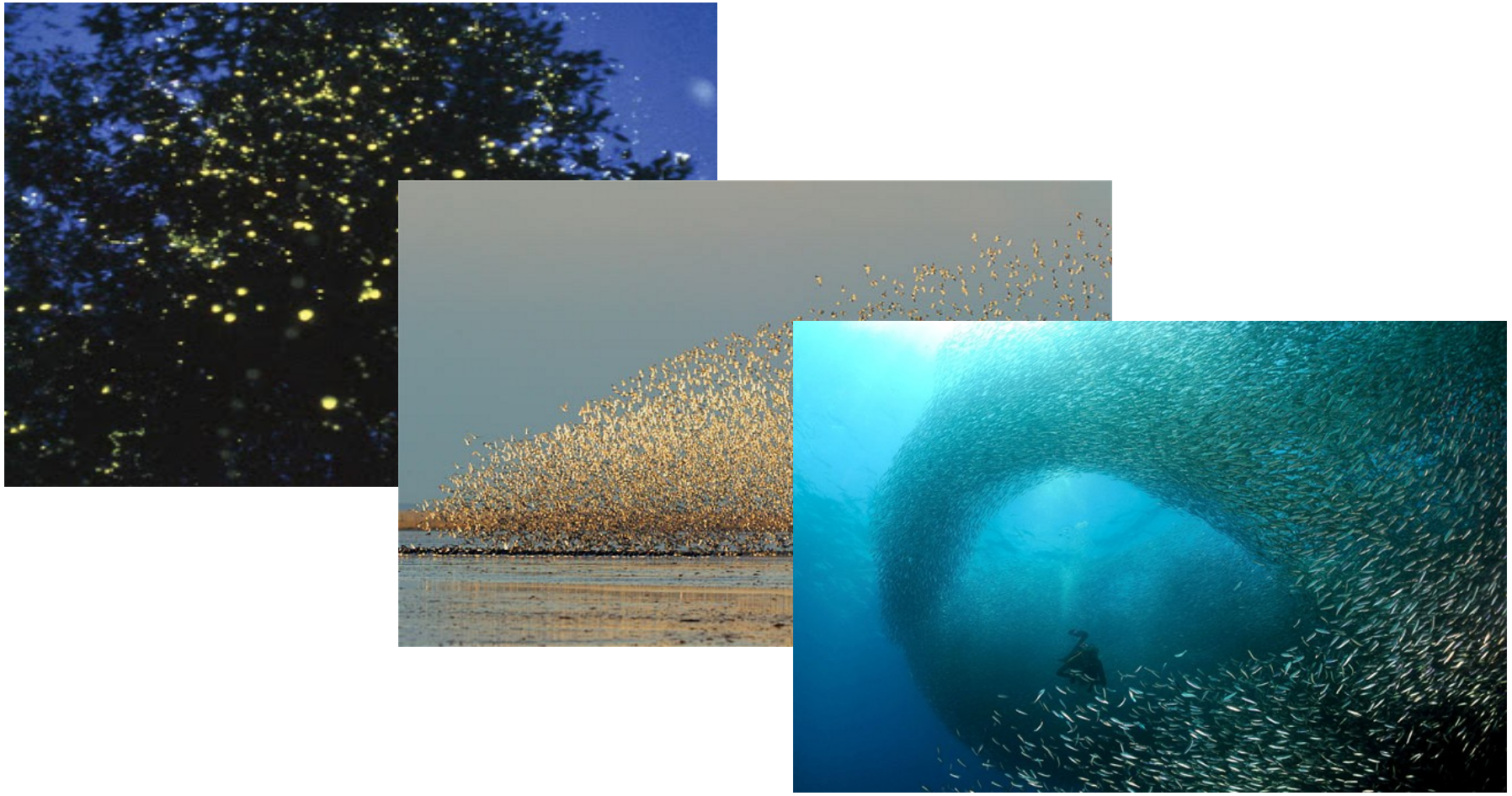
- Imitation/Mimicry
  - Spatial, but not necessarily temporal
  - e.g., mimicking someones mannerisms

- Synchronization
  - Both spatial and temporal
  - e.g., ….

Christiaan Huygens

Synchrony

- Is it ubiquitous in nature? (Strogatz, 2003)



What about humans?

Other examples

- Crowd clapping
- Menstrual cycle (e.g., Graham & McGrew, 1980; Weller, Weller, & Avinir, 1995)
- Maternal-fetal heartbeat (Van Leeuwen et al., 2009; Ivanov et al., 2009)
- Parent-infant synchrony (Feldman, 2007)
- Guitar players' brainwaves (Sänger, Müller, & Linderberger, 2012)

The Present Study

- A more natural interaction
- Field study
- School-aged children

Research questions:

1. Do children synchronize their postural sway while working together on a puzzle task?
2. And if they do, how does this interpersonal synchronization unfold over time?

Hypotheses:

- Increased synchrony when working together
- Increased synchrony over time

Method

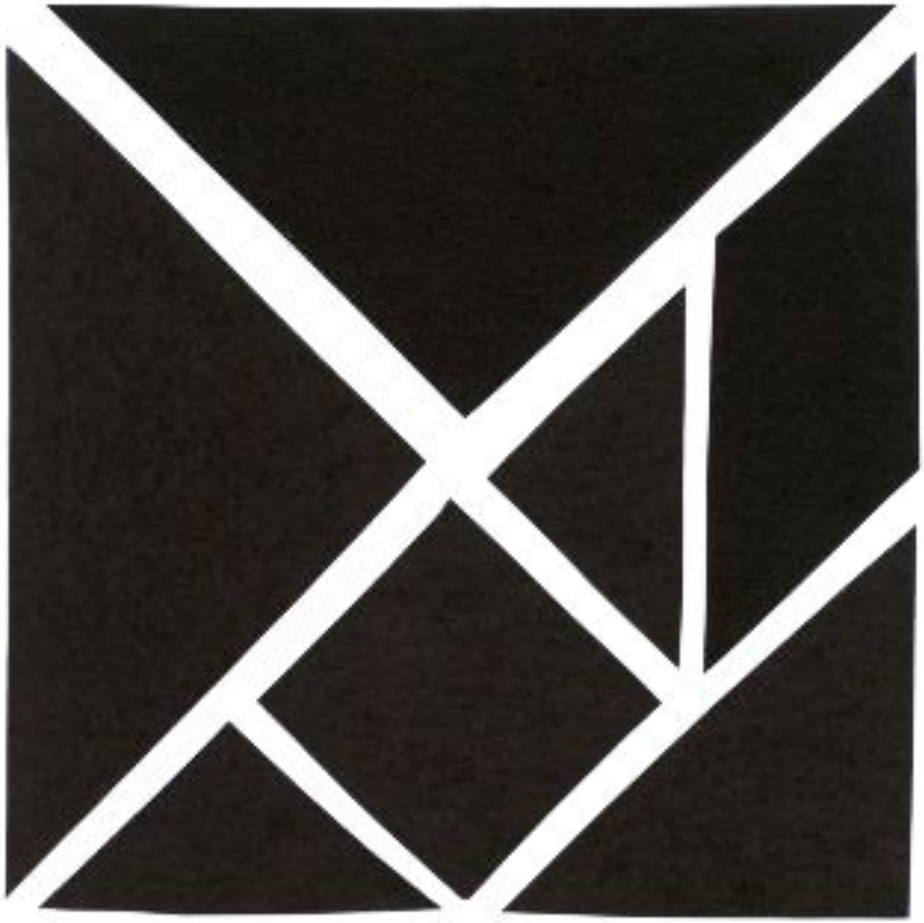
Participants

- 196 randomly assigned, same-sex dyads (101 boys, 95 girls)
- Between 8 and 13 years old (M_{age} = 10.7, SD = 1.04)

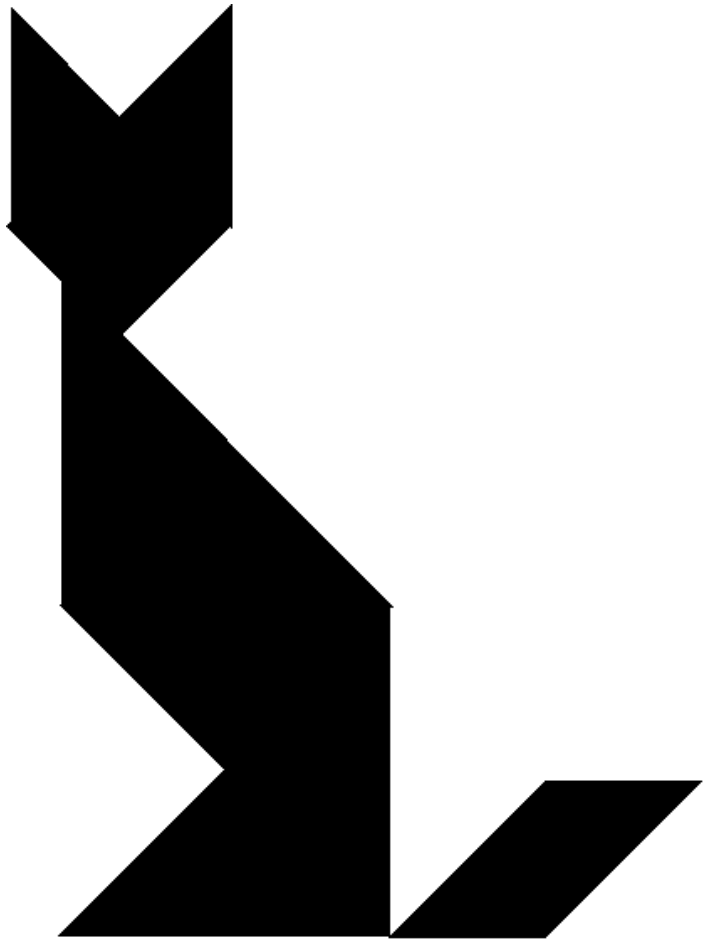
Materials

- Tangram task
- Wii Balance Boards
  - Recorded at 100 Hz
  - Down-sampled to 10 Hz

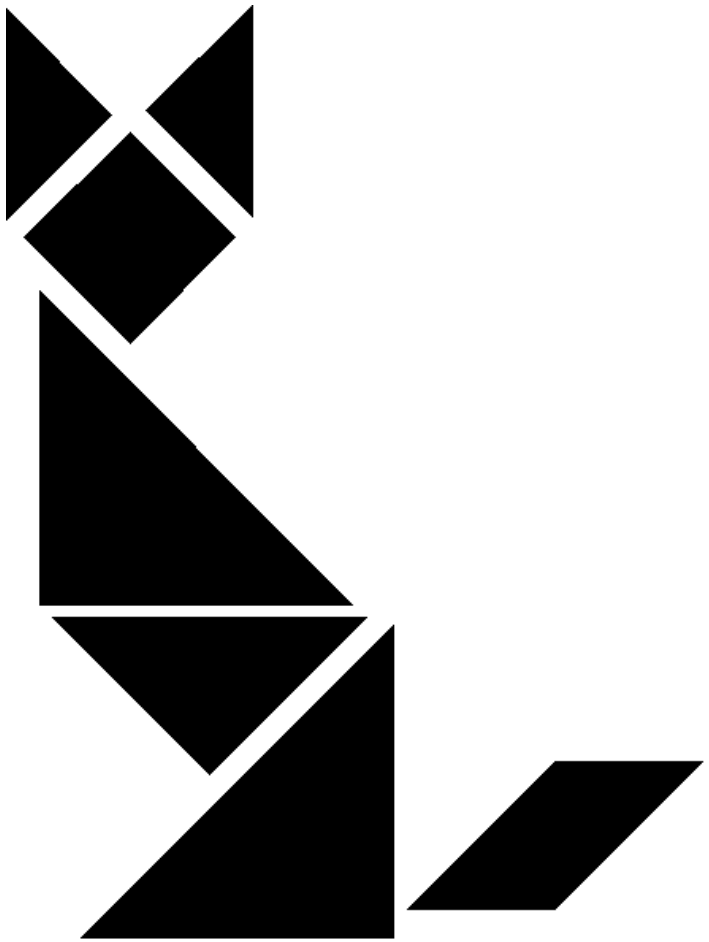
Tangram Task



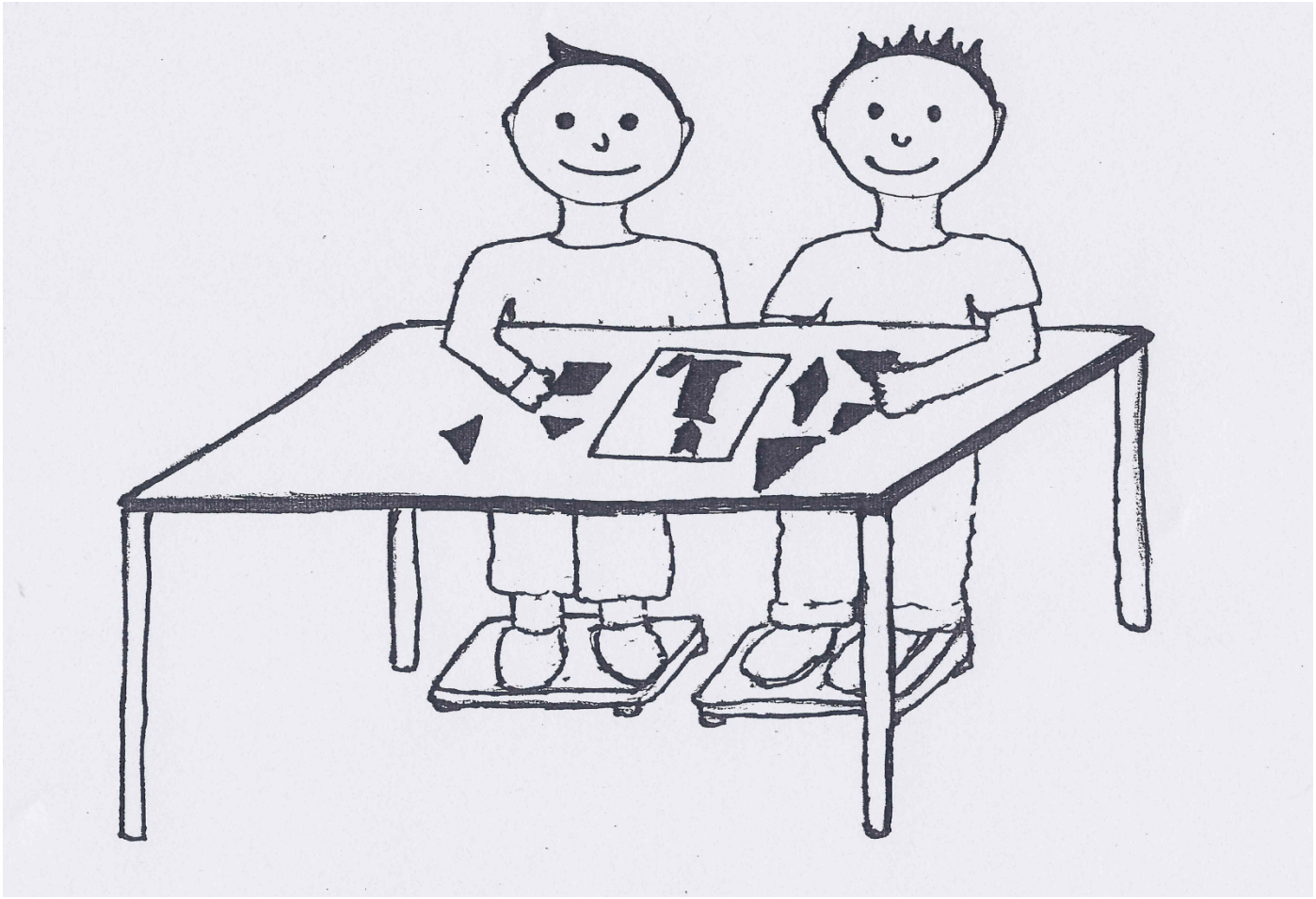
Tangram Task



Tangram Task



Experimental Set-up



Procedure

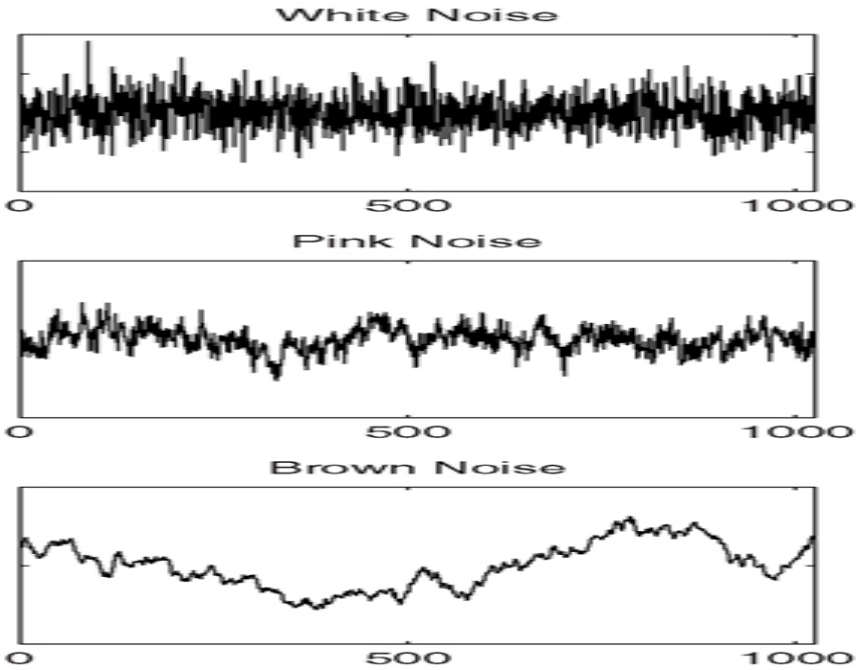
- Finish as many tangram puzzles as possible
- Three times
  - Alone
  - Together
  - Alone
- 10 minutes

- No restrictions

Detrended Fluctuation Analysis (DFA)

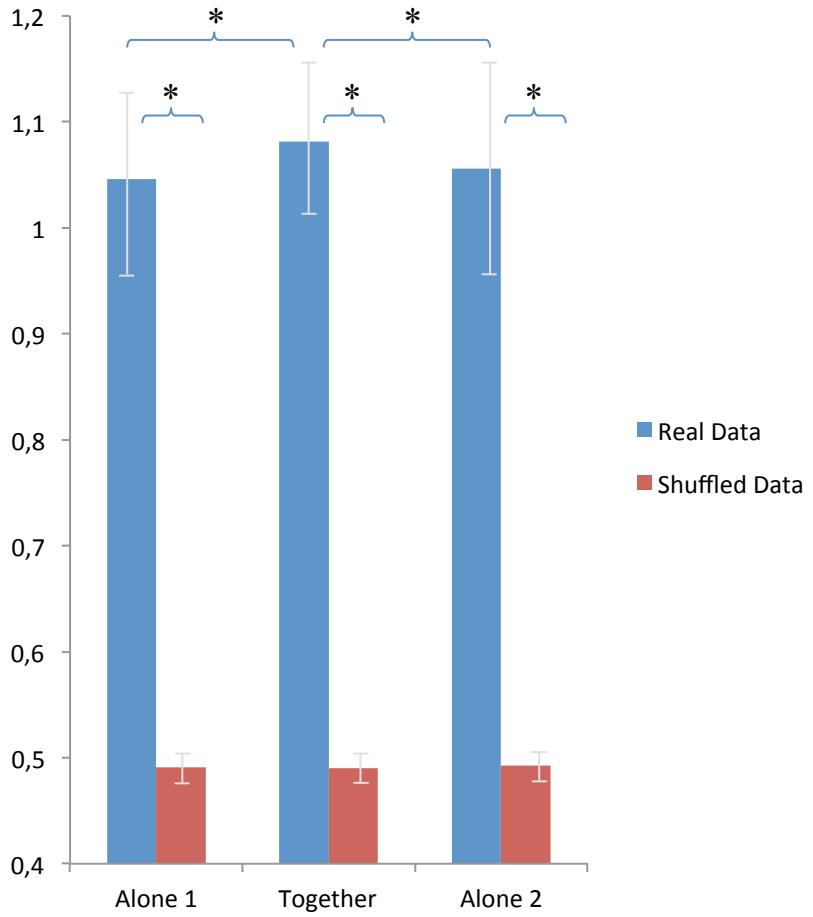
- To examine longterm correlations in the time series
  - Can tell us something about the coordination and voluntary nature of behavior (Van Orden, 2010)

- DFA values:
  - .5 = white noise
  - 1.0 = pink noise
  - 1.5 = brown noise



DFA results

- Paired Samples t-test
  - Real data significantly higher
- Repeated Measures ANOVA
  - Together significantly higher than alone
- Thus, when working together postural sway becomes less pink
  - More voluntary control? (Van Orden, 2010)



Cross Recurrence Quantification Analysis (CRQA)

- To determine the level of interpersonal synchrony

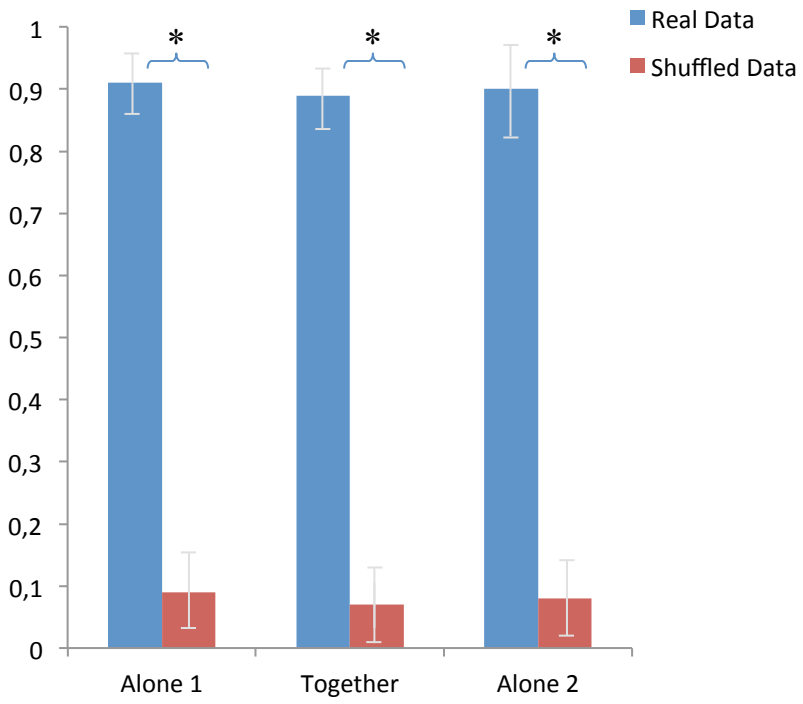
- Delay = 40 and Dimension = 5
- Radius = .75

- For now focus on:
  - Determinism
  - Entropy

Results

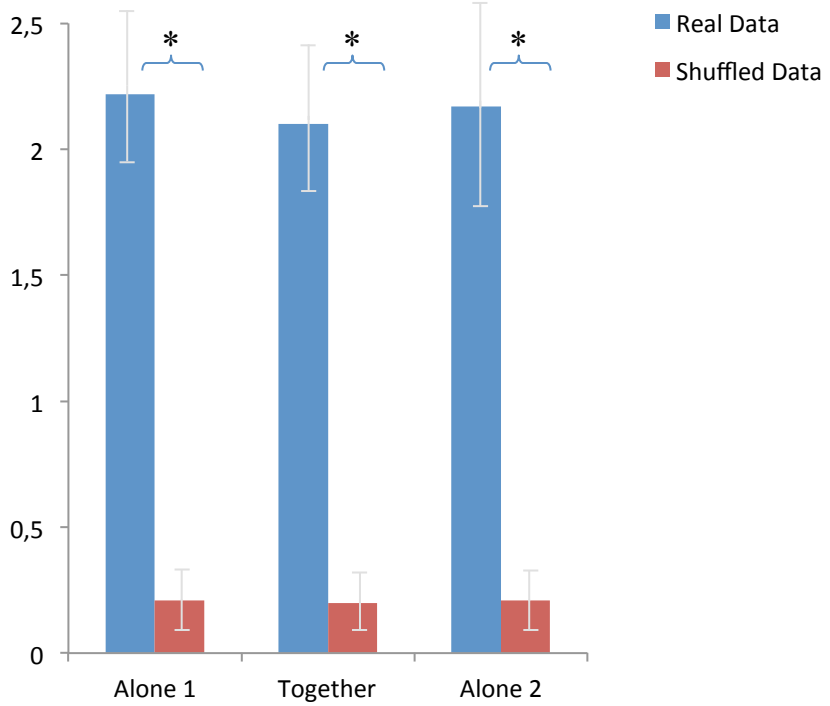
Real versus shuffled data

Determinism



Paired Samples t-tests
Pair 1: $t(195) = 186.06$, $p < .001$
Pair 2: $t(195) = 188.47$, $p < .001$
Pair 3: $t(195) = 153.08$, $p < .001$

Entropy

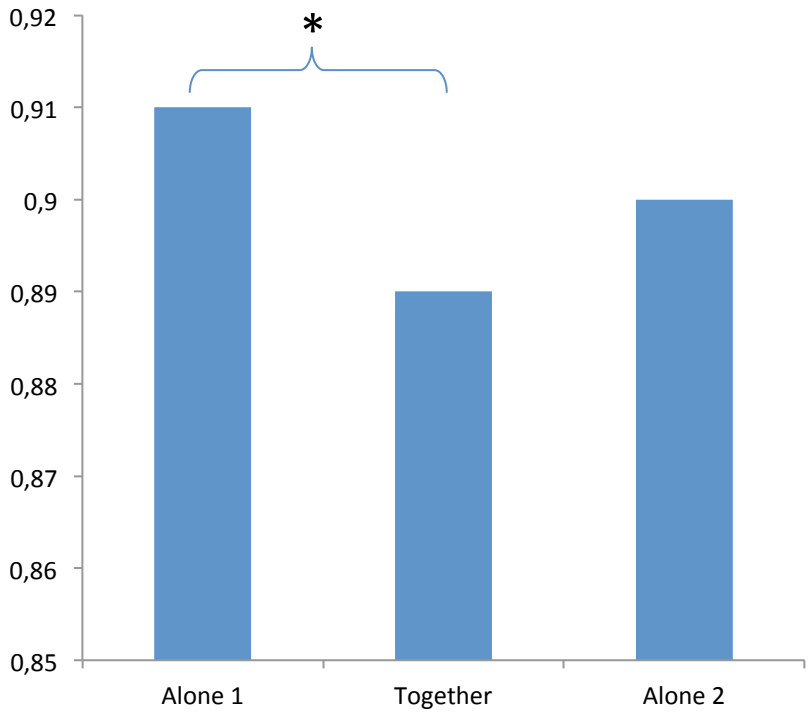


Paired Samples t-tests
Pair 1: $t(195) = 76.08$, $p < .001$
Pair 2: $t(195) = 77.12$, $p < .001$
Pair 3: $t(195) = 69.46$, $p < .001$

Results

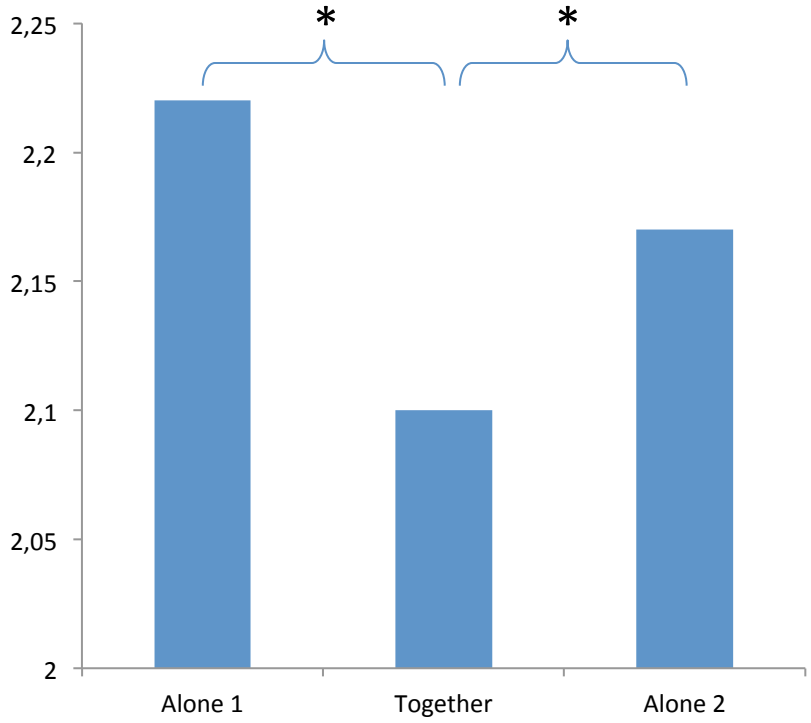
Real Data

Determinism



$F(1.87, 361.65) = 5.28$, $p < .01$, partial $\eta^2 = .03$

Entropy



$F(2,386) = 11.28$, $p < .001$, partial $\eta^2 = .06$

Results

- In sum:
  - Fractal patterns were more regular when working together
  - Interpersonal synchrony less deterministic, but also less complex (i.e., more predictable)

- This raised the question:
  - What happens over time?

- Time series segmented into 10 pieces
- CRQA performed on each segment

- Same parameters used as previously

Determinism Change

Measurement x Segment

- Significant two-way interaction

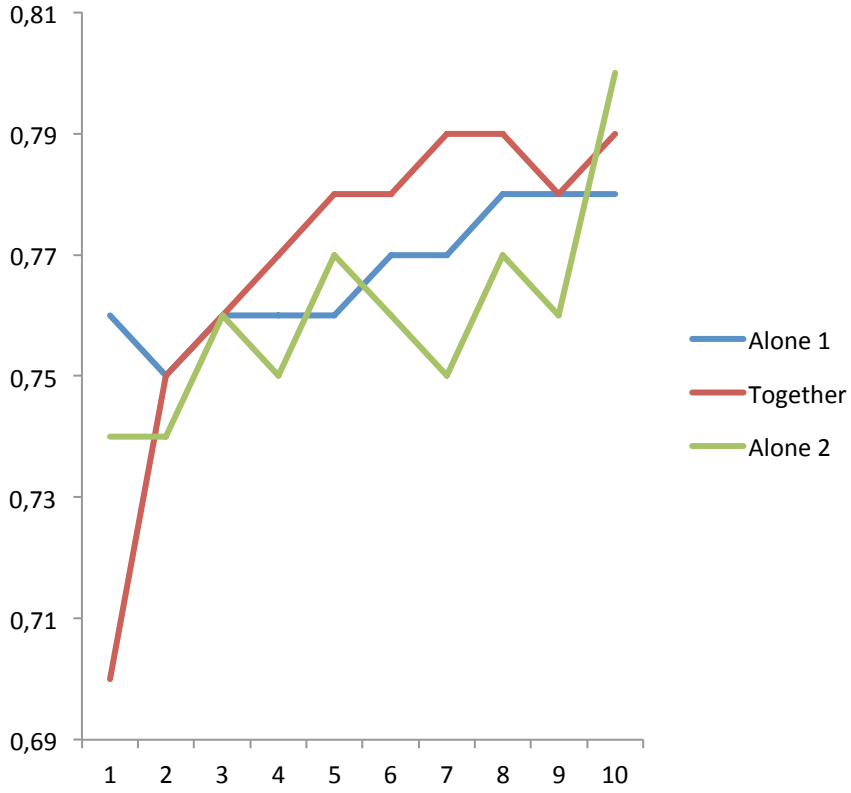
  $F(15.14, 2649.79) = 1.77$, $p = .03$, partial $\eta^2 = .01$

- Follow-up analyses:
  - Alone 1 n.s.

    $F(7.90, 1508.52) = 1.65$, $p = .11$, partial $\eta^2 = .01$
  - Together significant change

    $F(7.85, 1482.99) = 9.10$, $p < .001$, partial $\eta^2 = .05$
  - Alone 2 significant change

    $F(8.09, 1423.48) = 2.66$, $p < .01$, partial $\eta^2 = .02$



Entropy Change

Measurement x Segment

- Significant two-way interaction

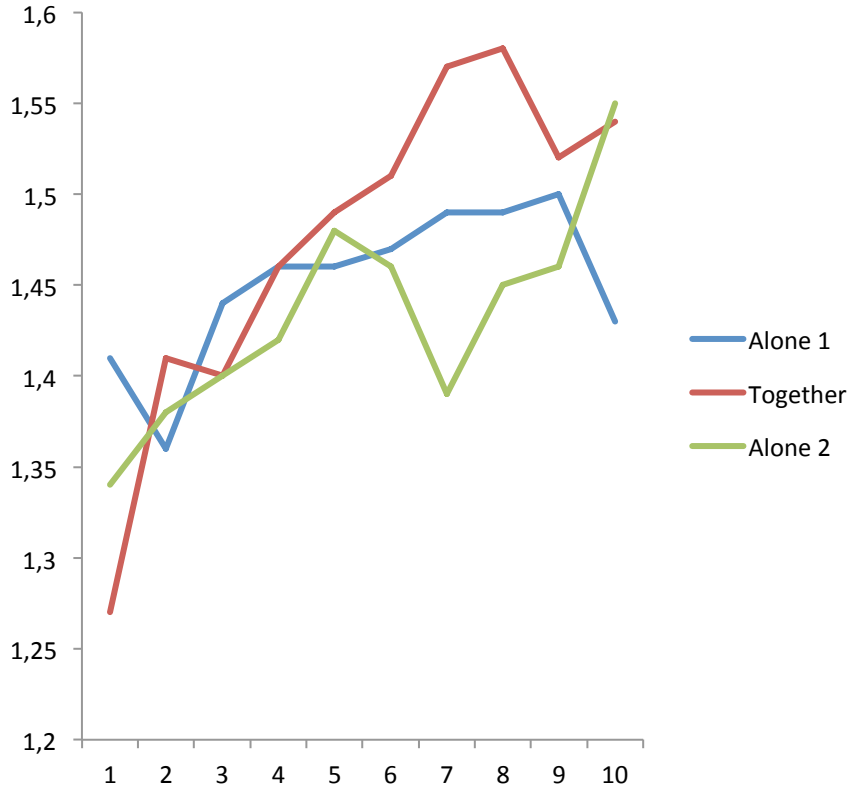
  $F(15.17, 2654.19, p = .049$, partial $\eta^2 = .01$

- Follow-up analyses:
  - Alone 1 n.s.

    $F(8.22, 1569.23) = 1.53, p = .14$, partial $\eta^2 = .01$
  - Together significant change

    $F(7.74, 1461.99) = 7.53, p < .001$, partial $\eta^2 = .04$
  - Alone 2 significant change

    $F(7.96, 1400.26) = 2.36, p = .02$, partial $\eta^2 = .01$



Discussion

- We showed that the patterns of postural sway, measured with the Wii Balance Board, are not random
  - Fractal patterns
  - Interpersonal synchrony
- Fractal patterns are less pink (i.e., more Brownian) when working together
  - More voluntary control needed to coordinate?
- Less interpersonal synchrony when working together
  - More coupling when working alone
  - But less complex when working together
  - Sign of turn-taking?
  - Complementarity?

Discussion

- Over time, the level of interpersonal synchrony increases when working together
  - but also when working alone after working together. Why?
- However, the increase while working together is more gradual and fluent compared to working together
- Thus, it appears that postural sway becomes more synchronized as task duration increases and gradually levels off
- In sum, different timescales tell different stories

Future directions

- Examine changes in fractal patterns over time
- Special education
  - Different from regular education?
    - Synchrony
    - Fractal patterns
- Observation study
  - Video coding
  - Multimodal synchrony?

Thank you!

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