Frame-differencing methods in video analysis: A MATLAB script to measure bodily synchrony

@xallysie

How to study bodily synchrony?

- Hand-coding
  - Labour-intensive
  - Time-consuming
- Holistic ratings
  - Inherently subjective
- Automated video analysis
  - Rater-free, coding-free
  - Motion-tracking
  - *Frame-differencing methods (FDMs)*

Frame-differencing methods (FDMs)

- Tracks changes in pixels from one frame to the next
- Background of an image remains static
- Pixel changes are only caused by movement
  - Background subtraction / Foreground detection
  - Quantitative

Frame-differencing methods (FDMs)

Frame-differencing methods (FDMs)

- Cost-effective data collection setups

- Pre-Analysis
  - Videos transformed into grayscale images
  - Normalized for brightness

- Existing FDMs used in diverse areas of research

A simple FDM for MATLAB

- Script to analyze bodily synchrony in conversations
- Analyzes overall body movement
- Simple to use
- Full colour!

A simple FDM for MATLAB

- Roadmap

1. Pre-analysis
   (Data collection & Preparation)
2. Go through the script
3. **Demonstration!**

Pre-Analysis

Data Collection

- Mounted digital camera
- Stable light source
- Record both participants in frame
- Recommend participants face one another in front of camera

Image Segmentation

- Upload videos to a computer
- Segment into image sequences (PNG)
  - Mac Users: Apple's QuickTime
  - PC: MATLAB & VideoReader

Sampling Rate

- Varies
- 8 Hz = good balance between detail & storage space

Full-colour frame differentiation

- Calculate frame differences using RGB code
- MATLAB's image arrays
- Detect movement of an object of one colour against a background of a different colour
- Accounts for colour intensity

Data analysis with MATLAB (The Script)

Paxton & Dale (2013)

- Adapted Paxton & Dale's (2013) script to analyze our videos
- Added image segmentation functionality
- Using a "for loop", the MATLAB script sequentially loads each image of a given frame sequence

Paxton, A., & Dale, R. (2013). Frame-differencing methods for measuring bodily synchrony in conversation. *Behavior Research Methods*, *45*(2), 329–343. https://doi.org/10.3758/s13428-012-0249-2

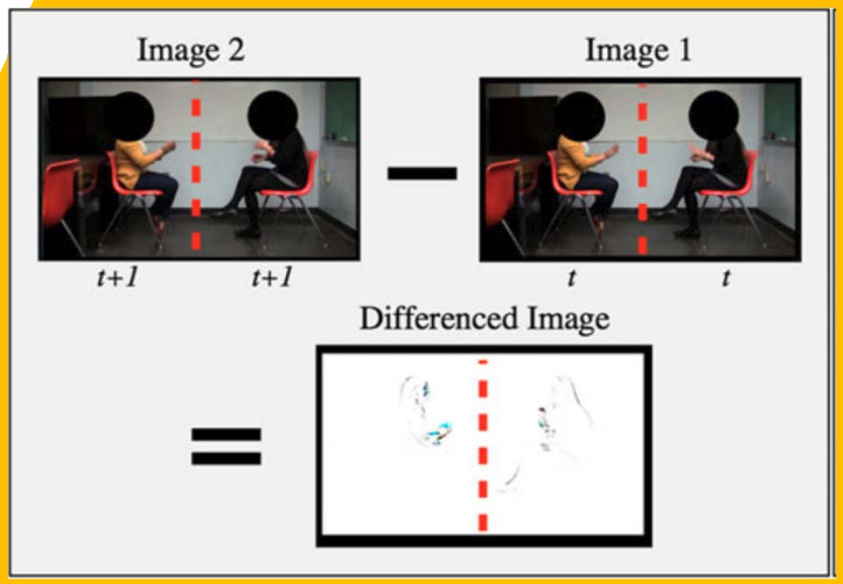
Designating the halfway point

- Images are halved
- Each participant's movement is only on one half
- If dyads have different halfway points, must manually designate for each video

Differences between frames

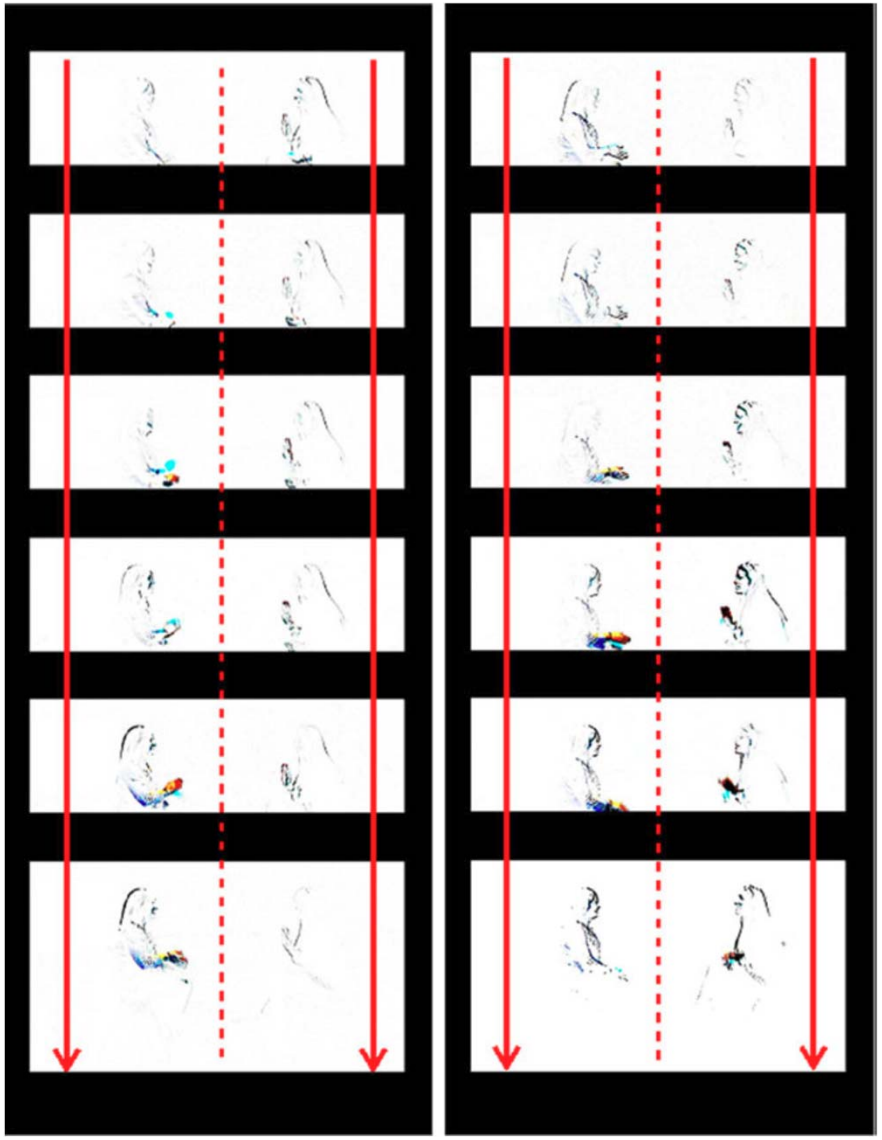
- Compares pixels of each half-frame
- Raw pixel change score ➔

  Standardized difference score



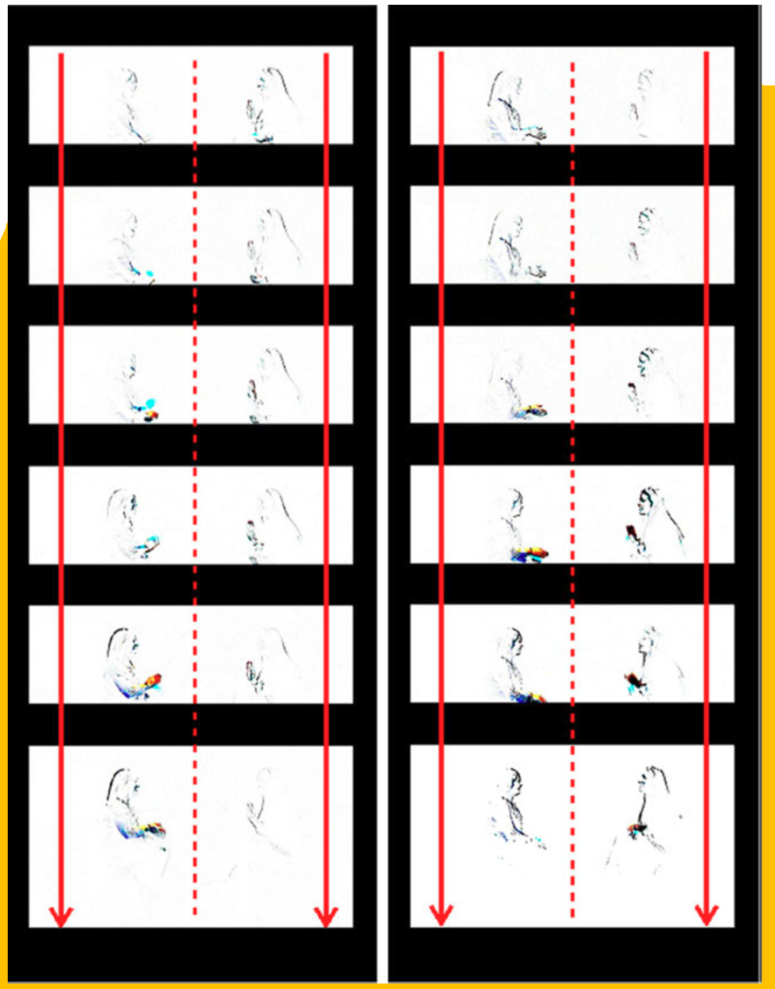
Sample Sequence

➔ Differencing process applied to 1.5s of interaction



Differences between frames

- 2nd-order Butterworth low-pass filter
  - Normalized cutoff frequency
  - Maximally flat passband
  - Stopband that slopes down to 0
- Maximize detection of **movement**, minimize co-occurring **noise**



Differences between frames

- Combines standardized scores for the two sequences of half-images
  - (i.e., the movement of each individual within the dyad)
- Calculate cross-correlation coefficients at various time lags
  - Measure for interpersonal synchrony
  - Pearson's correlation coefficient

Cross-Correlation Coefficients

- A correlation coefficient is calculated for each relative time lag between the two participants' time series

1. **A lag of 0** = Pearson correlation coefficient (*r*) between the 2 sequences

   (Pairs participant A's movement at time *t* with participant B's movement at time *t*)

2. **A lag of -1** = shifts one time series by one step, then calculate *r*

   (Pairs participant A's movement at time *t* with participant B's movement at *t* + 1)

3. **A lag of +1** = shift in the other direction, and then calculate *r*

Cross-Correlation Coefficients

- **If two individuals' movements are synchronized:**

  r will be highest closer to a lag of 0

  (Changes in their movement coincide in time)

- Individuals spontaneously synchronize

  (Miles, Lumsden, Richardson, & Macrae, 2011; Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007; Schmidt, Carello, & Turvey, 1990)

Cross-Correlation Coefficients

- Objective quantification of bodily synchrony
- Allows for greater exploration of trends of leading & following
- Can be used in a variety of statistical tests

  → E.g., entire time series, portion of time series, average synchrony score, etc.

- Validation analyses (Paxton & Dale, 2013)

Demonstration! (The Present Study)

"B-face Project"

- Examined link between:
  1. Ratings of targets' faces on *Warmth*

     (e.g., Friendly, Trustworthy)
  2. These targets' smiling behaviour in real-world interactions

Method

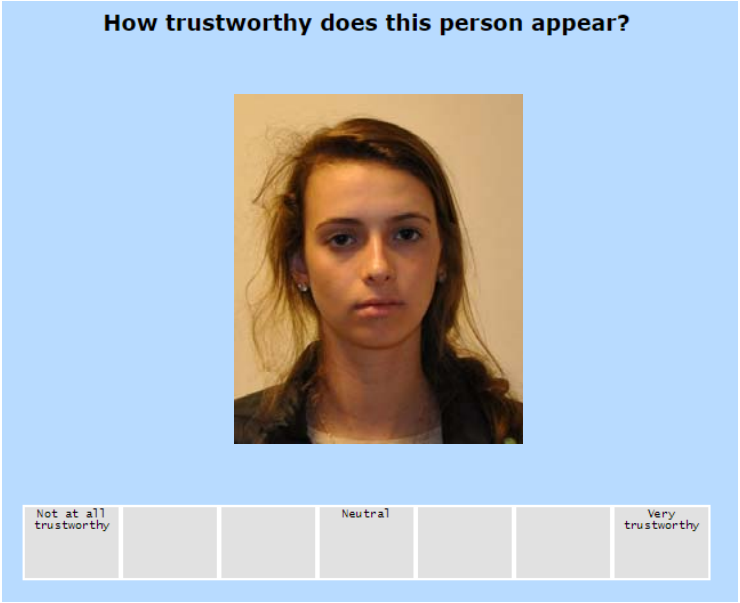
Part 1

- Took photos of 74 participants (undergraduates; 51% female)

Method

Part 1

- Independent observers rated still photos of these participants on traits that load highly on the 'Warmth' dimension ("Friendly" and "Trustworthy")
- *n* = 93, MTurk workers
- 1-"Not at all" to 7-"Very much" Likert scale



Method

Part 2

- Sorted undergrad participants into 37 participant dyads
  - Same-Gender only (19 F)
- Interacted while being filmed with a hidden camera
- Videos were coded for smiling behaviour (3 independent observers)

Bodily synchrony between interlocutors

- Run one video through the script
- Examine bodily synchrony
- Potential hypotheses:

  → Dyadic "warmth" and synchrony?

  → "Warmth" of individual and leading/following behaviour?

  → # of Smiles and synchrony?

Hypothesis #1

1. Synchrony as a function of time lag

   ➔ Are individuals more likely to move together in time?

   Predictor: Absolute time lag (from a lag of 0 – matching in time – to lags reflecting greater temporal disparity)

   DV: Bodily Synchrony (*r*)

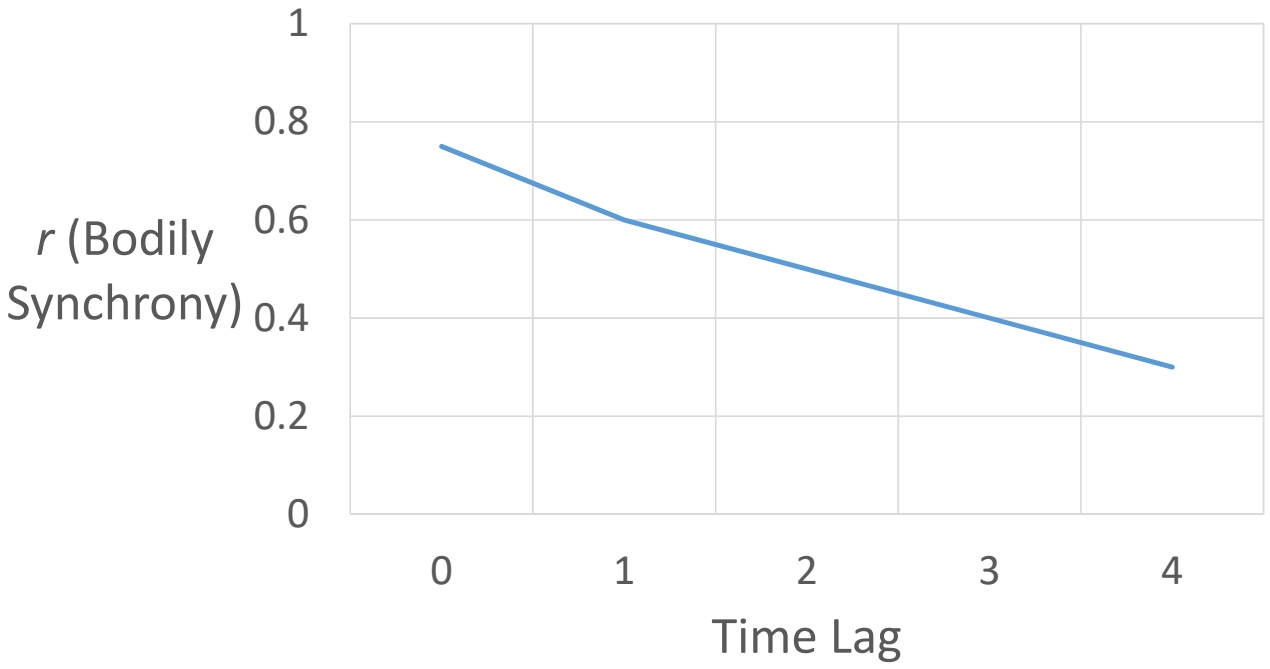
➔ As time lag increases, *r* should decrease

(Basic Model: Evidence that people move together in time)

Hypothesis #1

➔ As time lag increases, *r* should decrease

(Basic Model: Evidence that people move together in time)



Hypothesis #2

2. Ratings of **Warmth** moderates the relationship between Time Lag and Synchrony

   ➔ Are dyads with individuals perceived as "Warmer" more likely to move together in time?

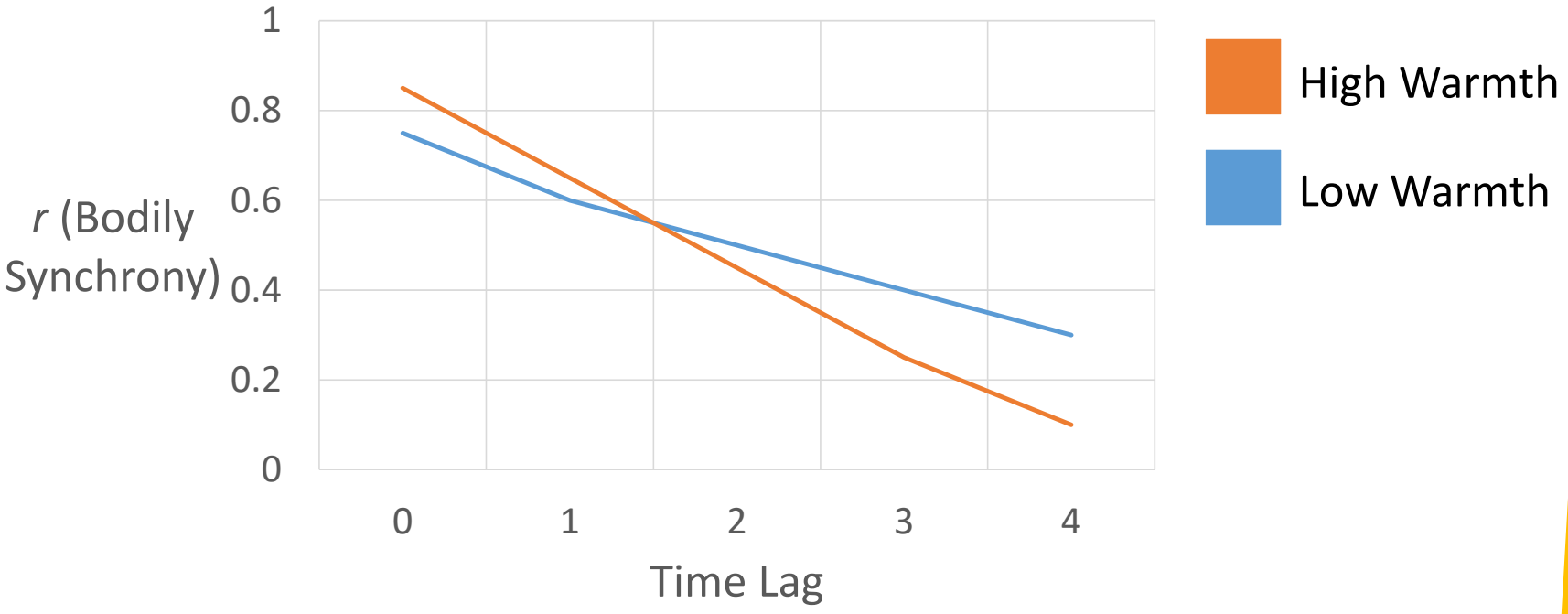
- **Predictor:** Absolute time lag

  DV: Bodily Synchrony (*r*)

  Moderator: Warmth of Dyad

Hypothesis #2

➔ Prediction: as time lag increases, *r* (bodily synchrony) decreases, but this effect is larger for High-Warmth dyads



THANKS FOR LISTENING!