How does nonverbal communication change in a group that learns to play an unfamiliar piece together?

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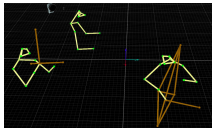
Background

- To play together, ensemble musicians anticipate each other's actions
- Musicians also play without speaking, so they must rely on nonverbal communication
- One way musicians communicate is through the sensorimotor information embedded in their body sway movements, which reveal how they are going to play next



- We previously investigated nonverbal communication in musicians by measuring the body sway of classical musicians with motion capture (Chang et al., 2017, 2019)
- The bidirectional autoregressive technique *Granger causality* allowed us to examine information flow between the musicians' movements

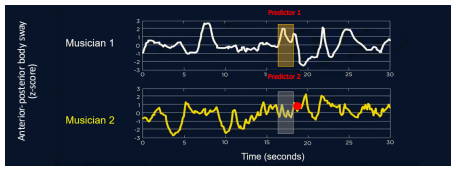


Figure 1. Granger causality analysis of the body sway directional coupling (prediction) from musician 1 to musician 2. This is calculated by taking the ratio of the degree to which the prior body sway time series of musician 1 (Predictor 1, shaded orange area) contributes to predicting the current status of musician 2 (red dot), over and above the degree to which it is predicted by its own prior time series (Predictor 2, shaded grey area)

- Our results suggested that body sway reflects predictive **information flow** (nonverbal communication) among musicians
  - Assigned leaders influenced other performers more than followers.
  - There was more information flow when musicians played with emotional expression than without

Study aims

How does information flow change when musicians learn to play an unfamiliar piece together?

- If body sway helps musicians to play together, we might expect that **information flow** in the group will be highest when the piece is most novel (trial 1), but this should decrease over time as the group learn the piece

Methods

Participants & apparatus

- A professional string quartet's body sway movements were recorded with motion capture during performance

Procedure

- The quartet played two unfamiliar pieces together over eight successive trials
- The quartet alternated between playing the unfamiliar pieces in two playing conditions: **mechanical** vs. **expressive**

Piece 1	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
Piece 2	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8

Measures

- Granger causality **(GC)** measured information flow
- Cross-correlation **(CC)** measured synchrony

Figure 2. The experimental setup. Retroreflective markers were placed on the head of each performer. The anterior-posterior body sway motion time series was extracted from the four performers

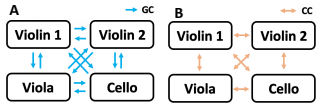


Figure 3. The body sway analyses. **A.** The average of the twelve GC values represents the overall amount of information flow across all possible musician pairings. **B.** The average of the six maximum unsigned CC coefficients represents the overall amount of group similarity, or synchrony, across all musician pairings

Results

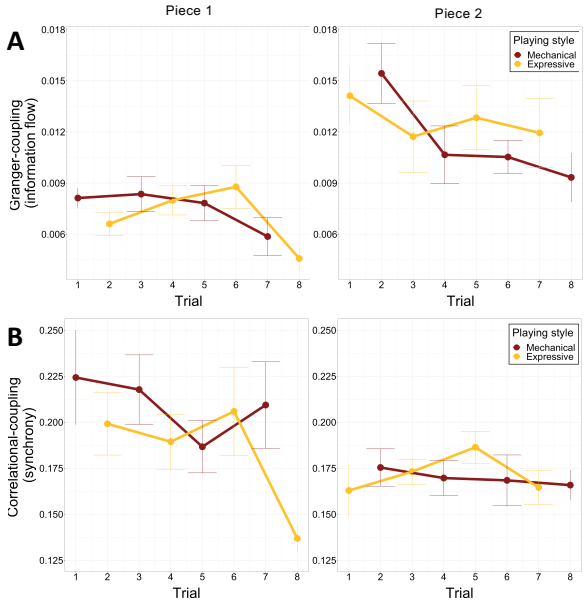


Figure 4. GC and CC of interpersonal body sways. Error bars represent SE. The left column is piece 1 and the right column in piece 2. **A**. Effect of trial and playing style on group GC (information flow). **B.** Effect of trial and playing style on group CC (synchrony).

Statistical analyses

- Linear mixed effect modeling
- For both GC and CC, the best model was one that included trial and piece

Granger causality results

- Information flow decreased across trials (b = -.48e-4, p < .001)
- Information flow was significantly higher in piece 2 compared to piece 1 (b = .005, p < .0001)
- Adding playing condition (mechanical vs. expressive) did not improve the fit of the model

Cross-correlation results

- Group synchrony decreased across trials (b = -.0038, p = .022)
- There was significantly lower synchrony in piece 2 than piece 1 (b = -.03, p < .001)

Discussion

Information flow *decreases* over time in a group that learns to play an unfamiliar piece together

- Musicians may rely on body sway to help them when the pieces are most unfamiliar, but this reliance decreases as familiarity increases
- Piece 2 may have higher GC values because it is a more expressive piece
  - We are currently coding the pieces for expressive vs. steady timing
- The mechanical and expressive conditions may have been too difficult for the musicians when learning the unfamiliar piece
- We are currently collecting ratings of performance quality from external raters
- We are analyzing body sway when musicians played solo vs. together
- We are completing a cross-correlation analysis using bow motion data

Overall, our studies show that body sway reflects nonverbal communication in musical ensembles

Future directions

- How are facial expressions used communicatively in musical interactions?
- Can we observe similar patterns of nonverbal behaviour in children learning to play music?
- How does nonverbal communication change when there is more uncertainty as to what the group will play (e.g., during improvisation?)

References

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