Interaction, entrainment and musical performance

Martin Clayton (Durham) – ESCOM, Ghent, 1 Aug 2017
1. Introduction: studying entrainment and interaction in music performance

- This talk explores a performance of Hindustani classical music
- It is framed by two quotations, 25 years apart, on significance of embodied interaction and music...
Kendon on Interactional Synchrony

“interactional synchrony is best regarded as an achievement of the interactants that is attained when the participants come to govern their behavior in relation to one another in respect to a commonly shared frame or joint plan of action. Interactants come to be able to behave together as if they share a common musical score and this can make possible a very high degree of temporal coordination between them.” (Adam Kendon 1992, p.115)
Leman et al on Embodied Music Interaction

“...dynamic embodied interactions within a group of people [such as a musical ensemble] raise the problem of how to understand co-representations and collective goals in relation to individual sensorimotor and cognitive performing.”

(Leman, Lesaffre and Maes 2017, p.3)
The challenge...

- How to explore sensorimotor synchronisation in relation to co-representations/ common frames/ joint plans?

- Find methods to study:
  - Temporal dynamics of interpersonal entrainment (sensorimotor synchronisation)
  - Meaningful social and musical interactions of participants in a music event
  - The relationship of both these levels to shared representations and knowledge structures
Interpersonal Entrainment in Music Performance (IEMP)

- How do groups entrain when making music in a variety of cultural contexts?
- Can we measure this using existing audiovisual recordings (audio for event onsets, video for motion tracking)?
- If there are cultural differences, how can we explain them?
- How sensitive are listeners to variations in entrainment – to music of their own and other cultures?
2. Case study: Hindustani classical music

- IEMP research with

Tuomas Eerola & Kelly Jakubowski
with thanks to Peter Keller
to Simone Tarsitani & Lara Pearson
to Paolo Alborno, Antonio Camurri &
Gualtiero Volpe (Genoa)
and everyone else involved in IEMP…

And special thanks to the musicians!
Case study: Hindustani classical music

- Debashish Bhattacharya (guitar) with Gurdain Rayatt (tabla), recorded in Durham, 2016
Rag Miyan Malhar

A. Dhamar tal (14 beats, 75-112 bpm)
B. Teental (16 beats, 142-178 bpm)
C. Ektal (12 beats, 230-310 bpm)
D. Teental (16 beats, 420-686 bpm*)

* Properly, ‘matras per minute’…
Example in dhamar tal

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### Measuring asynchronies

- **Metre marked manually (tapping)**
- **Onsets extracted using dedicated scripts (n=11,600)**
- **Onsets corresponding to beats identified**
- **Asynchronies calculated (n=2,244)**

#### TABLE

| Cycle | Metre Label | Virtual beat | Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower 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Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Lower Low...
What is the spread of asynchronies?

Mean -3ms, SD 26ms

90% within +- 40ms
Do asynchronies vary by section (tempo)?

- Yes: all comparisons except A vs B (p < .001)
- Asynchronies noticeably smaller at faster tempi
Do asynchronies vary by section (tempo)?
Do asynchronies vary by metrical position?

- First half vs second half (Section C. Ektal, 12 beats)

<table>
<thead>
<tr>
<th>Beat Number</th>
<th>Asynchrony (ms)</th>
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<tbody>
<tr>
<td>1</td>
<td>Mean -9ms</td>
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<td>11</td>
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</tr>
<tr>
<td>12</td>
<td>Mean -4ms</td>
</tr>
</tbody>
</table>

\[ p = .002 \]
Do asynchronies vary by metrical position?

Strong vs weak beats (Section C. Ektal, 12 beats)

- Mean -4ms
- Mean -8ms
- p = .008
Does it vary by specific musical features?

- Previous example in dhamar tal
- Cadence (Tihai = 3x repetition)
Asynchrony at cadences

Beat 1 on cadences more –ve (guitar early, M -18ms vs -5ms) and tighter (SD 24ms vs 29ms) than others: p = .003
So does asynchrony vary systematically?

- Mean asynchrony and variability smaller in fast sections
- Effects of metrical position small but measurable
- Guitar earlier and tighter on cadences

- Now it is time to step back a little…
Playing in time in Hindustani music

- Music organised by shared metrical patterns (*tala*)
- Musicians coordinate by *sharing their understanding of these patterns*
- Musicians constantly adapt to each other’s timing
- Knowledge of tala structures is not in doubt – but *understanding what the other is trying to do* may be
Managing transitions: Example in ektal

- Tempo change
- Some transitions are easier with unambiguous signalling
Video analysis: CWT

- What about more subtle movements?
- Movement of musicians’ heads tracked in Eyesweb using Optical Flow
Movement analysis

- Wavelet analysis of each musician’s movement

WT Power (Performer 1)

WT Power (Performer 2)
Movement analysis

- Wavelet analysis of each musician’s movement
- Calculation of cross-wavelet power (how two transforms relate)
- Used to predict independent annotations of visible interaction between musicians
Does it vary by specific musical features (e.g. cadences)?

Cross-wavelet Power (0.3 to 2.0 Hz)

Independent annotation: “Mutual body movement, look and smile”
Does it vary by specific musical features (e.g. cadences)?

Cross-wavelet Power (0.3 to 2.0 Hz)

Independent annotation: “Mutual body movement, look and smile”
CWT collapsed by metrical cycle

Cycles following cadences show a marked cyclical pattern...

Which is absent from other cycles
3. Summary

- Musicians’ interaction and coordination is framed by
  - Error (phase) correction to maintain synchrony
  - Signalling of transitions
  - Shared knowledge structures

- It can be observed in both
  - Asynchronies in audio signal
  - Coherence of movement

- Interpretation requires musical – and often ethnographic – knowledge
## Summary

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Effects</th>
<th>Reflected and/or communicated?</th>
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<tbody>
<tr>
<td>1. Error (phase) correction</td>
<td>Most asynchronies +-40ms (SD 20-30ms)</td>
<td>No conscious reflection</td>
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<tr>
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<td>Tempo drift/ fluctuation</td>
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<td>2. Tempo or section change (with gesture)</td>
<td>Smooth accelerations and transitions</td>
<td>Consciously communicated</td>
</tr>
<tr>
<td>3. Moving together at cadences and transitions</td>
<td>Maintain socio-musical relationship</td>
<td>Can be unplanned, but communicated</td>
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<td>Communicate to audience</td>
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Summary

- Detailed empirical analysis of entrainment and interaction is possible using AV recordings
  - Multitrack audio preferable
  - Static, well-lit video with minimal occlusion required
- This analysis suggests a hierarchical picture of entrainment and interaction...
- ... as sensorimotor synchronisation underpins rich, situated socio-musical interactions
- **But** we have also seen how the *musical dynamics influence the synchronisation* (entrainment)
Final thoughts…

- How to explore sensorimotor synchronisation in relation to co-representations/ common frames/ joint plans?
- It is possible to study these things in ecological settings using simple AV data
- **Sensorimotor entrainment, longer-term interaction and knowledge structures all influence each other**
- We can also ask, “why this knowledge – why these particular structures and processes?”
References


