Introduction

Music ensemble playing

- Realizing a common musical goal
- Synchronizing timing, expression, and movements

High cognitive & motor demands

- Auditory imagery, prioritized integrative attention, adaptive timing (Keller, 2007)
- Synchrony better within a pianist than between pianists (Shaffer, 1984)
- Body movements used to communicate at structurally important locations (Williamon & Davidson, 2002)

Research Questions

How does auditory feedback influence synchronization?

- Timing between pianists
- Finger movements (sound-producing or "effective gestures," Delalande, 1988)
- Body movements ("ancillary gestures")

How does note density between parts influence synchronization?

- Is it easier to synchronize to more notes than to fewer?
- "Subdivision benefit"? (Repp 2003)

Do musicians adopt strict roles as leader and follower?

"Hunting" vs. "Cooperation" (Goodman, 2002)

Participants & Equipment

- 16 skilled pianists (8 duets)
- 14.4 years of lessons (10–27)
- 21.9 years old (18–32)

Markers on all finger tips of right hand, wrist and head of each pianist



1) alone

- 2) full
- 4) self

II) Note Ratio (Upper : Lower)





Metronome indicates rate (450 ms IOI)



Synchronization of Timing and Motion in Piano Duet Performances Werner Goebl & Caroline Palmer Department of Psychology, McGill University **Sequence Production Lab**

Method

Independent Variables

(Fully crossed within-subjects design)



R.H

 543531
 454325
 3543
 4432
 543

 R.H.
 6432
 6432
 6432
 6432

R.H. (1 3 5 2 4 5 1 2 5 1 3 5 2 4 1 2 1



III) Musical Role (Instruction) "Upper part leads, lower follows"



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Note ratio affects asynchrony





Height above keyboard

Position (m) Velocity (m/s) Acceleration (m/s²) 7.9

FK Def: Max. finger acc > 10 m/s^2 n a def time window before KB (Goebl & Palmer, 2008)

References

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Timing Results

Note Ratio

Upper : Lower)

1:1 = = = =

2:1 5-5-

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Reduced auditory feedback increases asynchrony



Dneway



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Finger movements determined by task (note ratio, part)

% Keystrokes with FK

- Upper Part = more FKs
- Note Ratio x Part:
- More notes = more FKs



Finger Movement Duration

- Note Ratio x Part: Longer in lower part, but shorter for 1/8 notes
- Effect of feedback: longer with reduced feedback (hesitations?)







Head Motion

Reduced auditory feedback increases







synchrony of head motion Head motion in y Dimension for the second se Auditory Position (mm) Acceleration (m/s²) Feedback Oneway $r_{max} = .324^{***}$ $r_{max} = .578^{***}$ Time (s) Maximum Cross Correlation 0.4 of Head Accelerations 0.25 alone

Oneway Self **Auditory Feedback**

Discussion

Reduced auditory feedback influences ensemble synchrony

- Worse tone onset synchrony
- Better head motion synchrony Body communication as alternative

Note ratio affects synchrony

- Whoever has more notes, leads
- Beat subdivision benefit / cost under constrained feedback (oneway)

Musical role affects timing precision

- Both performers mutually adjust
- Follower adjusts more than leader
- Reduced feedback decreases adjustment

Action goals, more than auditory feedback, affect finger motion

Contact

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