

Hanon Hands: Examining timing variability in pianists’ hand and finger motion at fast and slow tempi

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Background

Highly-skilled pianists demonstrate fluent and efficient hand and finger motion. They show greater independence of hands and fingers than intermediate pianists and are better able to adapt their degree of finger independence to the demands of the music. The current study is concerned with how pianists’ hand/finger motion changes according to performance tempo. Prior research has shown that pianists struggle to maintain finger control at fast tempi, while slow tempi challenge general timekeeping abilities.

Aims

This study investigates how tempo affects pianists’ hand and finger kinematics using markerless motion capture. Specifically, we test the hypothesis that finger motion is smoother, more stable, and less variable at moderate tempi than at slow or fast tempi. A secondary goal is to evaluate the efficacy of a low-cost, multi-camera markerless MoCap system for capturing detailed piano performance data.

Method

Multimodal recordings of audio, video, and MIDI were collected from ten pianists (4 advanced, 6 intermediate) who performed seven Hanon technical exercises with a metronome at up to nine different tempi (40–120 bpm, though some intermediates only performed up to 90 bpm). A three-camera setup captured the performances from different angles. Using Google’s Mediapipe Hands for 2D hand pose estimation and Direct Linear Transform for triangulation of the estimated positions on the three video angles, we reconstructed 3D keypoints for 21 hand landmarks per frame. From these data we extracted features relating to quantity and smoothness of finger motion, joint angles, and hand posture. Using MIDI data we computed variability in timing, inter-hand synchronization, and synchronization with the metronome.

Results

Analysis is still underway, but preliminary results show that quantity of finger motion decreased with increasing tempo, suggesting more efficient motion at faster tempi. Finger motion smoothness increased with tempo, particularly between 40–60 bpm, but plateaued above 60 bpm. Preliminary results from MIDI analyses show that timing variability was greater at slow tempi (40–60 bpm) than at moderate or fast tempi (70–120 bpm), and that left hand timing was more variable than right hand timing. Variability in between-hand asynchronies was greater at fast tempi than at slow tempi. Pianists achieved stable synchronization with the metronome almost immediately at tempi above 80 bpm, but required 3–4 bars for synchronization to stabilize at 40 bpm.

Conclusions

Our findings suggest distinct performance challenges at both tempo extremes and a “sweet spot” at moderate tempi where control is optimized. Our ongoing analyses will identify some of the strategies that pianists use to compensate for the difficulties of playing at extreme fast or slow tempi. Along with these empirical findings, this study makes a technical contribution by outlining an effective procedure for applying markerless, video-based motion capture to the study of musicians’ motor control.

Keywords

Markerless motion capture, piano performance, finger kinematics, tempo effects, musical motor control

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