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Examining finger-wrist joint-angle structure in piano playing with motion-capture technology

Werner Goebl,[*1] Caroline Palmer[#2]

[*]*Institute of Music Acoustics, University of Music and Performing Arts Vienna, Austria*
[#]*Department of Psychology, McGill University, Canada*
[1]werner.goebl@mdw.ac.at, [2]caroline.palmer@mcgill.ca

ABSTRACT

Background

Piano technique is acquired over decades of practice and piano educators disagree about the nature of a "good" technique and the way to achieve it. The various pianistic schools give different advice regarding finger curvature, hand and wrist position and the origin of movement in order to reach high efficiency and fine tone control. Particularly when performing very fast passages, movement efficiency seems to be an important factor. This study investigates the movement structure of highly skilled pianists performing simple passages faster and faster until they reach their individual limits.

Aims

In this study, we examine the finger and wrist movements of highly skilled pianists who perform simple melodies at different speeds. In particular, we look at the joint angles between adjacent segments of the fingers, the hand and the forearm to identify the contribution of each joint rotation to a particular keystroke movement. We focus on the effects of tempo on the particular movement properties, on measures of timing precision and accuracy, and on individual differences between pianists.

Method

A three-dimensional motion capture system tracked small reflective markers placed on all finger joints, the hand and the forearm of twelve highly skilled pianists performing a simple isochronous melody at different tempi. The pianists started with a medium fast tempo (7 tones per second, TPS, timed by a metronome in a synchronization-continuation paradigm) that was increased after each trial until the pianists decided to stop. They performed on a digital piano recording the onset timing for subsequent analysis. Joint angle trajectories were computed from the three-dimensional marker position for all adjacent finger phalanges (DIP, PIP), and the hand (MCP) and the forearm (wrist angle and wrist rotation).

Results

Three of the 12 pianists were able to perform up to a tempo of 16 TPS, while others had to stop at 11.7 TPS. We compare timing measures (CV and timing error of IOI patterns) with finger and wrist kinematics to identify motion features that are typical for successful fast performers. The rounded finger shape was stable and showed slight extension in "fast" pianists, but showed large variability in "slow" pianists. Regression analyses on angular kinematics showed that MCP contributed more to fingertip motion than other joint angles. For each keystroke, we calculated the individual joint contribution to the final fingertip movement and defined from this a keystroke efficiency measure. Movement efficiency could explain some of the individual differences of slow and fast pianists.

Conclusions

This study delivers detailed insights into the joint angle structure of skilled pianists performing at fast tempi, focusing on the individual differences between performers, and proposes kinematic markers of successful performers.

Keywords

Motion capture, piano performance, movement efficiency