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Tempo and dynamics in piano performance: The role of movement amplitude

Simone Dalla Bella (2) & Caroline Palmer (1)

1. Department of Psychology, McGill University, Montreal, Canada
2. Department of Neuropsychology and Behavioral Genetics, Kazimierz Wielki University, Bydgoszcz, Poland

ABSTRACT

When pianists play a musical piece at a faster tempo, they also tend to play louder. One kinematic property that may be related to increased loudness is the amplitude of finger movements. Larger amplitude would allow higher movement force, thus augmenting key velocities. The goal of this study was to assess the contribution of movement amplitude to changes in loudness at increasing tempo. Four skilled pianists memorized short novel melodies and then performed them from memory, trying to follow the tempo provided by a metronome. The tempo in the first trial was slow (60 M.M, one beat = one quarter note). Then pianists were asked to perform at increasingly faster tempi, including 180, 210, 240, and 245 M.M. Motion capture techniques were used to record finger and hand movements during performance on an electronic piano. Midi data were also recorded and were synchronized with motion data in terms of event onsets. Midi analyses indicated that loudness increased as a function of tempo, and motion analyses showed that loudness increased as a function of the amplitude of vertical finger movements. Interestingly, the relationship between loudness and movement amplitude did not result from a tendency for pianists to anticipate more at faster tempi. These findings are discussed in the light of existing models of movement during music performance.

BACKGROUND AND AIMS

When pianists play a musical piece at a faster tempo, they also tend to play louder (e.g. Gabrielsson, 1987; Palmer, 1996). Such correlations between tempo and loudness have been considered as a natural process that mirrors kinematic properties of movement (Sundberg & Verrillo, 1980; Todd, 1992). One kinematic property that may be related to increased loudness is the amplitude of finger movements that augments key velocities. Larger finger movements at fast tempi should allow higher movement force, thus leading to increased loudness.

The goal of the study was to examine the contribution of movement amplitude to changes in loudness at increasing tempo. Motion capture techniques were used to record finger and hand movements during performance on an electronic piano. If a positive correlation between tempo and loudness is due to kinematic properties of movement, we expect that movement amplitude will accordingly increase with faster tempi and will positively correlate with loudness.

METHOD

Four skilled pianists memorized short novel melodies and then performed them from memory, trying to follow the tempo provided by a metronome. The tempo in the first trial was slow (60 M.M, one beat = one quarter note). In the following trials, pianists were asked to perform at

increasingly faster tempi, including 180, 210, 240, and 245 M.M. The goal was to increase performance tempo until the pianists made errors. Fourteen cameras with fine lenses capable of detecting light reflected from 25 passive markers taped to each pianist's fingers and hands were used to record movement during performance at 120 frames/sec. In addition, keypresses on the piano were recorded as Midi data, with 1ms temporal resolution. The Midi and motion data were synchronized in terms of keypress event onsets.

RESULTS

Data from the captured movements from the fingertips were analyzed relative to piano key movements. Variability of finger movements was greatest on the z-plane (up-down motion from the keys) than on the x-plane (sideways motion on a key) or the y-plane (back-front motion on a key), as expected. Midi analyses indicated that loudness increased as a function of tempo, and motion analyses showed that loudness increased as a function of the movement amplitude in the z-plane. Phase-plane plots indicated consistent velocity-acceleration motion patterns for a given finger across melodic contexts. Further analyses of time of peak movement amplitude indicated the relationship between loudness and movement amplitude did not seem to result from a tendency for pianists to anticipate more at faster tempi.

CONCLUSIONS

These findings 1) supported the claim that dynamics and tempo are associated in piano performance and 2) revealed that movement amplitude, more than movement anticipation, contributed to pianists' change in dynamics when tempo increased, lending support to kinematic explanations of musical dynamics. These findings will be discussed in light of existing models of movement during music performance.

TOPIC AREAS

Music performance
Movement