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Effect of short-term piano practice on fine control of finger movements

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ABSTRACT

Background

A number of cross-sectional studies that compared pianists and non-musicians have demonstrated that extensive piano training elicits structural and functional changes in motor-related brain regions, which enables fine control of finger movements (e.g. Jäncke 2009; Münte et al. 2002). Several studies that directly assessed effects of piano practice revealed an increased volume (Hyde et al., 2009) and refined neural activation (Hund-Georgiadis and von Cramon 1999) of motor-related cortical regions. Furthermore, a one-day piano practice facilitated speed and accuracy of finger movements during piano playing (Drake and Palmer 2000). Yet, little has been addressed regarding the causal relationship between piano practice and hand motor functions. To understand this is of significance not only to elucidate neural mechanism behind motor learning of piano playing, but only to establish theoretical basis of piano pedagogy.

Aims

The purpose of the present longitudinal study was to assess effects of daily piano practice on speed, accuracy, and independence of finger movements. Both transfer and retention effects of piano practice were also assessed.

Method

Six adult participants with no history of piano playing were asked to play a short tone sequence consisting of twelve strokes with the left hand synchronized with a metronome (inter-keystroke interval = 500ms) for fifty trials per day over four successive days. MIDI information on each keypress was obtained from an electric piano. Before and after the practice, pretest and posttest were carried out to assess several fundamental hand motor functions. Muscular activities of the extrinsic finger extensor and flexor muscles were recorded using surface electromyography (EMG), and their muscular co-activation was evaluated quantitatively (Furuya et al. 2012).

Results

Following the four-days of practice, the participants exhibited a significant decrease in temporal variability of keystrokes. This indicated practice-induced improvement of movement consistency, being compatible with previous findings (Drake and Palmer 2000). When they were asked to play the trained tone sequence as fast and accurately as possible, the maximum rate of keystrokes also increased after the practice, indicating enhancement of finger movement speed. This was also the case when playing an untrained tone sequence with the left hand as fast as possible, confirming a transfer of training effect to a novel movement sequence. Concerning the untrained right hand, both accuracy and speed also improved following the left-hand practice, which suggests an inter-manual transfer effect of uni-manual practice on the contra-lateral hand.

To evaluate independence of finger movements, before and after the piano practice, each finger performed the fastest tapping task, which required repetitive keystrokes by one finger as fast as possible with keeping the remaining digits depressing the adjacent keys. Results showed that all fingers except for the ring finger showed a significant improvement in maximum movement rate following the practice, indicating selective enhancement of independent control of movements at individual finger. This finding may suggest different plasticity of individual finger in terms of independent movement control.

The amount of the agonist-antagonist muscular coactivation computed from EMG signals was clearly decreased with practice. This finding is likely to reflect training-induced optimization process of energetic efficiency of movements (Huang et al. 2012).

To assess if visual feedback regarding temporal accuracy of keystrokes during the practice boosts the practice effect on the hand motor functions, we asked another six non-musicians to perform the same task with information on the variability of inter-keystroke interval being provided visually. Contrary to our expectation, none of training-dependent improvements of hand motor functions turned out to be facilitated even with accuracy feedback of movements. However, the initial increment of improvement with respect to rhythmic accuracy of keystrokes was more pronounced when providing visual feedback. This suggests that attention might aid for fast but not slow motor learning.

A retention test, being performed two months after the final practice session, revealed no apparent deterioration of the enhanced hand motor functions including maximum speed of keystrokes at the both trained and untrained hand and during finger tapping. This suggests robustness of motor memory acquired through the piano practice, presumably being associated with motor consolidation process (Karni et al. 1995).

Conclusions

Piano practice with a particular tone sequence at a certain tempo had strong and long-lasting impacts on fine motor control of finger movements including accuracy, speed, and independent control. The transfer effect on both untrained hand and untrained tone sequence implies presence of shared motor primitive in piano playing, which is compatible with our recent

finding regarding hand movements by expert pianists (Furuya et al. 2011).

Keywords

motor learning, dexterous finger movements, music education, piano pedagogy, plasticity of motor system

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