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Attentional foci in piano performance

Felicia P.-H. Cheng, Philipp Heiß, Michael Großbach, and Eckart Altenmüller

Institute of Music Physiology and Musicians' Medicine, Hanover University of Music, Drama, and Media, Germany

Studies investigating the influence of the learner's focus of attention suggest that, in general, directing performers' attention to the *effects* of their movements (*external* focus of attention) is more beneficial than directing their attention to their own movements (*internal* focus of attention). It has been shown that different attentional foci are associated with different motor control processes, and internal focus may act as interference in the maintenance of a highly automated motor coordination. As an example of highly automated motor coordination, the present study aimed to investigate the effect of different attentional foci associated with expert piano playing. To this end, both the external focus (auditory feedback) and internal focus (fingering) were manipulated in order to explore their possible effects on piano playing. The main finding was the timing irregularity brought by manipulating the external focus (auditory feedback), but not the internal focus (motor pattern).

Keywords: attentional foci; pianist; auditory feedback; motor pattern; scale analysis

Studies investigating the influence of the performer's focus of attention suggest that, in general, directing one's attention to the *effects* of the movements (*external* focus) is more beneficial than directing their attention to their own movements (*internal* focus) (for a review, see Wulf and Prinz 2001). It has been shown that different attentional foci are associated with different motor control processes (McNevin *et al.* 2002), and internal focus may act as interference in the maintenance of a highly automated motor coordination. The beneficial effect of external focus is also supported by common-coding theory: if an action is planned based on an external focus, the action is planned on

the basis of distal events that are more similar to this common representation.

The current study aims to examine the external and internal foci of professional pianists by manipulating the distal effect of movement (auditory feedback) and the movement itself (fingering). We therefore designed an experiment with variation either in internal focus or external focus. As a paradigm, we selected scale playing in highly skilled professional pianists. Here, we expect, on one side, a high degree of automaticity and, on the other, various susceptibility to interfering variables such as variation in finger or auditory feedback.

METHOD

Participants

Twenty-five healthy professional pianists (13 men, 12 women, mean age=25.8 years) participated in this study. Twenty-four were right handed, and one was left handed, according to the Edinburgh inventory (Oldfield 1971).

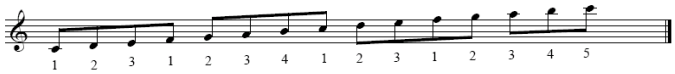
Materials

Participants were instructed to play two octaves of C major scales (from C4 to C6) in legato-style at a tempo of 80 beats per minute with sixteenth notes (four notes per beat, inter onset interval=187.5 ms), same as in the scale-paradigm (Jabusch *et al.* 2004).

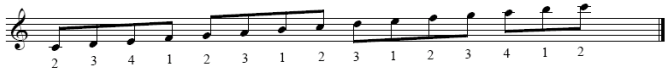
Procedure

Participants completed a questionnaire on music expertise and musician's health before the experiment started and then were informed that the task was to play repeatedly both upward and downward scales on a MIDI digital piano as accurate as possible according to the metronome. There were three types of auditory feedback (normal, silent, and delayed feedback of 200 ms) and there were two types of designated motor patterns (conventional fingering and new fingering). Therefore, there were six conditions in the study:

- Normal feedback x conventional fingering
- No feedback x conventional fingering
- Delayed feedback x conventional fingering
- Normal feedback x new fingering
- No feedback x new fingering
- Delayed feedback x new fingering



Conventional fingering



New fingering

Figure 1. New fingering designed for the experiment. The fingering 1-5 refer to thumb, index, middle, ring and little finger, respectively.

The participants were allowed to try out the delayed auditory feedback and the new fingering for five times at most. In each condition participants had to play at least 25 times of complete upward and downward scales. The order of conditions was randomized, and all playing was synchronized to the metronome indicating a tempo of 80 beats per minute. In the third and sixth conditions, the participants were explicitly instructed to synchronize the piano sound to the metronome, not the movement. The onset, offset, and the velocity of each key depression was recorded, and video recording was made during the performance.

Data analysis

The analysis aimed to evaluate the evenness of scale playing. Four parameters were analyzed: velocity of each key depression (VEL), duration of each key depression (DUR), the inter-onset-interval between two consecutive key depressions (IOI), and the overlap between two consecutive key depressions (OVL). The last key depression of every scale was not analyzed because it was frequently delayed according to the pianist's expressive playing. In each condition, the medians and the standard deviations of all four parameters for each key were computed from at least 25 sets of upward and downward scales, and then the median of these standard deviations were calculated to indicate the irregularity of timing and loudness of a condition. Finally, the medians of all four parameters of different conditions from 25 pianists were analyzed with multivariate analysis with PSAW SPSS Statistics v.18.

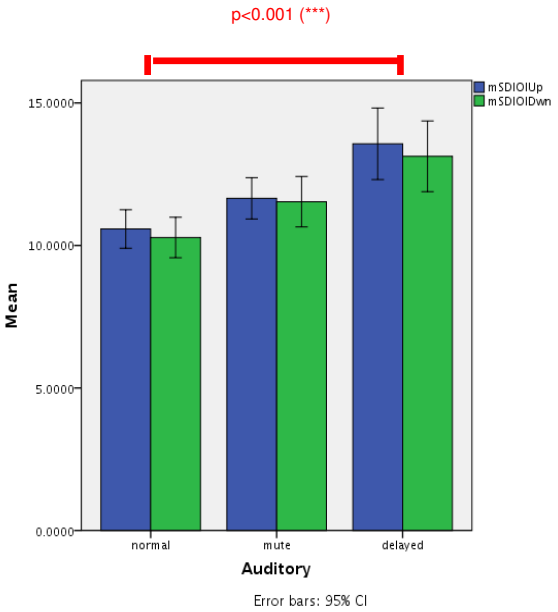


Figure 2. Mean variability of inter-onset-intervals (IOIs) under different auditory feedbacks. The blue bars represent the IOIs of upward scales and the green bars represent the IOIs of downward scales.

RESULTS

Multivariance analysis revealed a highly significant main effect of auditory feedback on all the variables (F_{18}=1.93 [Pillai's Trace], p=0.018), especially the effect of auditory feedback on IOIs (F_2=10.68 for upward scales and F_2=8.60 for downward scales, p<0.001 for both), disregarding the type of fingering. Pairwise comparisons for IOIs between normal and delayed auditory feedback (p<0.001 for both upward and downward scales), between muted and delayed auditory feedback (p=0.004 for upward scales and p=0.022 for downward), and between normal and muted auditory feedback (p=0.103 for upward scales and p=0.07 for downward) showed that this highly significant main effect was based on the effect of delayed feedback (see Figure.2). There was no significant effect brought by different fingerings (F_8=1.37, p=0.213), and pairwise comparisons did not show any significant difference between two types of fingering (all p>0.05) under any kind of auditory feedback.

DISCUSSION

Altered auditory feedback can cause different types of disruption to several dimensions of music performance (Pfordresher 2006). The deprivation of auditory feedback in this study had negligible influence on the evenness of scale playing, which is in accordance with the conclusion of previous studies (Repp 1999, Pfordresher 2006). As for the delayed auditory feedback used in this study, it created a profound effect on participants' timing, which is also in line with the results of previous studies.

While one might reasonably think that the long-trained motor pattern for scale playing would manifest its advantage by showing much lower deviations, the result of the present study showed that professional pianists are in fact very flexible in terms of motor planning and re-planning. This is the first study demonstrating the flexibility of motor programs in order to obtain a hierarchically higher, specific motor goal. It should be noted, however, that altered fingerings of fragments of the C-major scale playing may be part of daily life pianistic literature playing.

Previous studies showed that for both expert performers and novice learners, paying too much attention to one's own movement instead of the effect of movement may decrease the quality of certain well-practiced skills (Wulf and Prinz 2001). The advantage of external focus of attention is that it facilitates self-monitored, low-level, automatic processes required to achieve the motor control for the desired effect at a higher level, thus results in fast movement adjustments and enhances performance and learning. This effect is especially pronounced during the performance of relatively challenging tasks that require a greater degree of automaticity in movement control (Wulf *et al.* 2007). Being arguably one of the most challenging tasks, piano playing is suitable for examining the effect of different attentional foci. In the present study, in the fourth and sixth conditions (see Method), although the participants' attention was directed to the internal focus while playing with an unfamiliar fingering, the auditory feedback still existed as a powerful reminder of the external focus. Therefore, it was possible for the participants to perform the task by utilizing both internal and external foci concurrently. The utmost priority of external focus in expert musicians comes from the extensive auditory-sensorimotor training that enables musicians to have a reorganized neural network highly efficient in performing motor control over the acquainted musical instrument. This well-established, automatic co-activation of both the auditory and the motor cortical representations is likely to be on the top levels of motor control hierarchies, and only by disrupting the crucial properties (e.g. timing between action and auditory feedback) of this net-

work can the motor control be disrupted. Unlike the facile adaptation to an unfamiliar motor pattern, this automatic auditory-sensorimotor co-activation is so robust that it cannot be easily modified according to the new association of movement and effect of movement, as in the third and sixth conditions. Moreover, the complete deprivation of auditory feedback in the second and fifth conditions can be regarded as tasks based solely on internal focus because of the lack of external focus. Since the performance did not deteriorate for these conditions, it can be explained that internal focus serves at lower levels of modules, as a prerequisite for further performance refinement.

Address for correspondence

Felicia P.-H. Cheng, Institute of Music Physiology and Musician's Medicine, Hanover University of Music, Drama, and Media, Emmichplatz 1, Hanover 30175, Germany; *Email:* phcheng@gmail.com

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