THE EFFECT OF ATTENTIONAL FOCUS ON GESTURE AND CHARACTERISTICS OF SOUND AT THE PIANO

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While focus of attention (FOA) has been widely studied in athletic pursuits, it has not been in the performing arts. The purpose of this project was to determine the effects of FOA on kinematic and musical performance while pianists performed Bartók’s second dance from *Romanian Folk Dances*, Sz. 56. Nine pianists participated in the study and prepared the piece. The pianists played the piece 4 times, starting with a baseline (B) performance without any instruction, and 3 subsequent times (in randomized order) focusing on 1) creating the idea of a dance (E: external focus), 2) his/her fingertips and creating a staccato (short) touch (I: internal focus), and 3) the beat of a metronome (M). To better understand the initial effect of each condition, the first note of each trial was analyzed. Using MIDI and motion capture data, musical and kinematic performance were analyzed. We observed significant differences among conditions for onset velocity, and marginal significance for note duration. Post hoc comparisons showed that internal focus yielded greater onset velocity and shorter note duration than B or E. There were no differences in kinematics as defined by the range of movement at the finger, wrist and elbow prior to the first note, but it is likely that differences will be observed across clusters of individual pianists. It was hypothesized that movements might be smallest in the internal condition and most robust in the external condition. Results suggest that each focus condition had a constraining effect on pianists’ movements, although several movement strategies are apparent. These results indicate both the effect of focus but also important individual differences in approach with potential pedagogical, performance, and rehabilitative implications.  
Keywords: gesture; focus; attention; piano
1. Introduction

1.1 The Solo Musician as Conductor: Musical Gesture

In many ways, a solo musician is his/her own conductor. The player assumes a ready posture or position and begins each piece with a preparatory gesture of his/her own. This involves interrelated cognitive, musical, and physical processes, but at the most basic physical level, the idea is that for every action there is an equal and opposite reaction. Consider the differences between the preparatory gestures of a violinist’s bow arm with those of a marimbist. On one hand, the basic gestures of these musicians would be very different due to the structural properties of their respective instruments, and yet their gestures are subject to similar parameters with regard to speed and pressure, for example. Musically therefore, gesture is linked functionally to producing particular kinds of sounds at one’s instrument (loud, soft, bright, warm, etc.) while also communicating in a way that transcends the mechanical aspects of sound production. It is in this way that gesture is intertwined with both movement and meaning.

1.2 Musical Gesture: Components and Function

To better understand the function of musical gestures, researchers have attempted to identify and describe component aspects which might be relevant across a wide scope of musical gestures. Jensenius, Wanderley, Godøy, and Leman (2010) [1] differentiate among four categories of musical gestures: sound-producing [2], communicative [3], sound-facilitating [4], and sound-accompanying [5]. Examples respective to the aforementioned include: 1) a finger pressing a piano key; 2) languorous retraction of the hands from the piano keys mirroring sound dissipation; 3) ancillary movement of the hand vertically away from the piano keys, preparatory to a keystroke; and 4) moving to the beat of music at a concert.

Over the course of recent decades, research has focused on the expressive nature of gestures related to communication. In music-related fields, this work has been spurred by issues related to human performance and audience perception. Several researchers have pointed to the symbolic nature of musical gestures and the potential to communicate meaning transcending that of concrete sound production. Delalande (1988) [7] defined “musical gesture” as the intersection of observable actions and mental images. Metois (1996) [8] differentiated between physical gestures and those gestures resulting from auditory perception, highlighting a similarity in abstraction and the “ability to communicate musical intentions at a higher level than an audio waveform.”

1.3 Gesture, Movement, and Sound

While challenging to determine the interrelationships of gesture, movement, and meaning, general consistencies have been observed. For example, performers move more when playing expressively [9] and when asked to focus on expressing emotion in music as opposed to either technical demands or actually feeling a particular emotion [10]. These movements have been shown to be linked to interpretive elements of a performance [11]. Furthermore, it has been suggested that attempting to suppress movement may affect performers’ movement patterns [12] or timing [13]. What effect do gestures and movement patterns have on the acoustic parameters of sound?

1.3.1 Timbre

One of the salient aspects of music is timbre, or the quality of musical sound that distinguishes the sound of one instrument from another, but also the spectrum of sound possibilities unique to a particular instrument, bright vs. dark sounds on a clarinet for example. Manipulating timbre is one of the ways that musicians communicate affect. To that end, several studies report relationships between physical production of sound and the properties of that sound. Traube et al. (2003) [14] demonstrated a
relationship between the perceived brightness of tone and the distance the string is plucked from the bridge of a guitar. The plucking angle and use of either the nail or finger have also been associated with guitar timbre [15]. Studies of the clarinet have shown that timbre is related to blowing pressure and the force of the lips on the reed [16]. One of the distinctive aspects of playing either of these instruments, the guitar or clarinet, is that the player directly produces the sound with the fingers or with air, respectively. Sound production at the piano is much different, however. The pianist presses keys which in turn activate hammers that hit specific strings inside the piano. The pianist therefore indirectly affects sound quality by his/her ability to control the speed of key descent. Acoustic analysis of single piano tones has shown that piano timbre can be altered by touching the keys in different ways. These differences in timbre relate to the “attack” of the sound in percussive vs. non-percussive touch [17]. Clearly it is possible to create sounds of different color at the piano.

1.4 Recent Work: Analysis and Comparison of Pianists’ Movements

The use of digital motion capture technology in particular, has facilitated a variety of recent methods used to objectively analyze pianists’ gestures at the keyboard. Several studies have examined the height of the finger relative to tempo transformations, for example [18, 19]. Subsequent studies have further examined relationships among the kinematic chain by combining motion capture with EMG [20]. Others such as Tits et al. [21] have utilized motion capture and Principal Component Analysis to compare movements. Increasingly, collection of MIDI data associated with the timing and intensity of keystrokes has facilitated assessment of movement efficiency [18] and consistency [22]. The combination of motion capture and MIDI data with advancing methods of analysis has made it possible to more rigorously examine movements in the context of music performance.

1.5 Current Study

The purpose of the current study was to better understand links between musical performance and perception by determining the effects of pianists’ attentional focus on kinematic and musical performance. Specifically, how does a performer’s focus of attention affect both his/her gestures and the resulting production of sound at the instrument?

Focus of attention has been studied in a wide variety of motor and sport skills. Research has consistently demonstrated that external focus enhances both motor performance and learning relative to internal focus. Examples of greater movement effectiveness and efficiency with external focus include improvement with regard to the following: accuracy [23]; balance [24]; reduced muscle activity [25]; maximum force [26]; speed [27]; and endurance [28].

Although widely studied in athletic pursuits, attentional focus has been comparatively neglected in the performing arts with a single initial study involving the piano to date [29]. The current study is unique in employing pedagogically-relevant foci across all conditions and the quest to determine whether or not the immediacy of a focus instruction influences initial kinematics and sound production. It was hypothesized that focus condition would have a significant initial effect with external focus coinciding with more robust movements and greater range of expressivity.

2. Methods

2.1 Subjects, Music Piece, Preparation

Nine pianists (5 females, 4 males, age = 33.7 ± 10.5) participated in the study. Each participant was asked to prepare and perform Bartók’s second dance from Romanian Folk Dances, Sz. 56. Time spent in preparation varied from 10 to over 300 minutes, depending on experience, prior knowledge of the piece and available time. The level of participants’ overall experience varied with three undergraduates
pursuing music degrees; one graduate student pursuing a music minor; two university keyboard faculty; and one university conductor. All pianists signed an informed consent approved by the IRB of the University of Minnesota.

2.2 Instrument

A Kawai MP11 keyboard was used for this project. It had a full-size keyboard, 88 fully-weighted, touch-sensitive, wooden keys with ivory touch key key surfaces. The action is considered to be the same as that of Kawai concert artist (acoustic) instruments.

2.3 Focus of Attention Conditions

Participants were asked to perform the piece of music described above under four separate focus conditions: Baseline (B): without instruction; External (E): creating the idea of a dance; Internal (I): focusing on the fingertips to create a staccato touch; Metronome (M): focusing on, and synchronizing playing, with the metronome’s beat, which was set at 144 beats per minute. Recorded instructions explaining the imminent focus condition preceded each performance.

2.4 Kinematics Protocol and Data Collection

Participants were fitted with 63 retro-reflective markers to create a hand, finger and upper body model. Hand and finger markers were 3 mm in size and placed on the tip (nail), interphalangeal and metacarpophalangeal joints of each finger, the medial and lateral styloid processes of the wrist, and a point in the middle of the wrist (to form a triangle with the other two wrist markers). Fingertip markers were placed in the middle of the distal nail, but thumb markers were slightly offset to allow for depression of a piano key. Marker locations were tracked with a 14-camera (240 Hz) Optitrack motion capture system (Natural Point, Corvallis, OR) from which position-time data were obtained for all markers. Participants were asked to initially play the piece without any instruction (Baseline condition). They then performed a typing task for one minute in an attempt to “washout” the previous instructions. After completion of the typing task, each participant listened to the instructions associated with one of the remaining conditions, which was randomly chosen. This series of events (perform, type, listen) was repeated until each pianist had performed the piece with each focus. Afterward, participants completed a questionnaire assessing the degree to which instructions were followed, the degree of difficulty associated with each FOA, and a self-ranking of each of the four performances.

2.5 Statistical Analysis

The first note of each trial was analyzed: left-hand little finger (L T5) and right-hand thumb (R T1). The kinematic variables of interest were associated with the range of motion of the chain leading to note production (key depression), specifically angular range of movement for the fingers, wrist, and elbow, and the time associated with the angular range. Angular range was determined by calculating the difference between maximum and minimum angles of the MCP joint and wrist and elbow in flexion/extension. In addition, velocity of key depression and duration of keypress from MIDI data were compared. Repeated-measures ANOVAs and subsequent post-hoc comparisons (when appropriate) were used to assess statistical significance between conditions.

2.5.1 MIDI

Quantification of MIDI (Musical Instrument Digital Interface) has been widely used to measure differences in keyboard performances [18, 30]. MIDI data obtained in this study contained information identifying the note struck, timestamp of note onset and offset, and velocity of both key depression and release. Keypress velocity has typically been interpreted as a measure of intensity [31] expressed within a numeric range of 0-127 with higher values indicating faster key depression. Although there is
not a specific standard of MIDI implementation regarding velocity mappings across instruments [32],
the internal consistency in this study, use of a single instrument used and analysis of the same 2 notes,
facilitates contextual comparison that is particularly useful.

3. Results

Significant differences between conditions were observed for MIDI variables. Only the R T1 onset
velocities differed significantly ($F_{3, 24} = 4.23$, $p = 0.016$), while the L T5 velocities were not different.
Post hoc comparisons highlighted differences in E vs I ($p = 0.0045$) and E vs M ($p = 0.0059$). Note
durations differed significantly for L T5 ($F_{3, 24} = 3.63$, $p = 0.028$) and marginally for R T1 ($F_{3, 24} = 2.61$,
$p = 0.075$). Post hoc comparisons for note duration highlighted differences in B vs I and M ($p = 0.012$
and 0.024, respectively), and E vs I ($p = 0.042$). However, angular range and time to travel through the
range for elbow, wrist and fingers did not differ among conditions. Large variabilities in angular range
were observed as expressed by the descriptive statistics (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Note velocity (MIDI units)</th>
<th>Note Duration (ms)</th>
<th>Elbow</th>
<th>Wrist</th>
<th>Finger</th>
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</thead>
<tbody>
<tr>
<td><strong>External</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>L</td>
<td>69.1 ± 20.2</td>
<td>71.1 ± 21.0</td>
<td>24.6 ± 18.4</td>
<td>22.9 ± 16.5</td>
<td>17.8 ± 12.1</td>
</tr>
<tr>
<td>R</td>
<td>68.4 ± 16.6</td>
<td>96.5 ± 28.0</td>
<td>15.3 ± 12.9</td>
<td>17.2 ± 10.8</td>
<td>20.1 ± 13.6</td>
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<tr>
<td><strong>Internal</strong></td>
<td></td>
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<tr>
<td>L</td>
<td>74.0 ± 16.2</td>
<td>58.2 ± 9.3</td>
<td>13.0 ± 15.4</td>
<td>14.5 ± 13.2</td>
<td>15.3 ± 10.7</td>
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<tr>
<td>R</td>
<td>80.2 ± 9.1</td>
<td>72.8 ± 25.5</td>
<td>16.3 ± 15.3</td>
<td>12.0 ± 9.1</td>
<td>13.4 ± 8.8</td>
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<td><strong>Metronome</strong></td>
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<tr>
<td>L</td>
<td>78.3 ± 8.8</td>
<td>60.0 ± 16.7</td>
<td>19.2 ± 15.5</td>
<td>13.7 ± 10.7</td>
<td>15.1 ± 10.7</td>
</tr>
<tr>
<td>R</td>
<td>79.8 ± 9.0</td>
<td>83.8 ± 31.0</td>
<td>22.2 ± 29.7</td>
<td>15.0 ± 10.1</td>
<td>12.3 ± 4.6</td>
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<td><strong>Baseline</strong></td>
<td></td>
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<tr>
<td>L</td>
<td>66.8 ± 17.5</td>
<td>73.3 ± 25.9</td>
<td>22.6 ± 14.8</td>
<td>20.4 ± 13.7</td>
<td>17.9 ± 7.7</td>
</tr>
<tr>
<td>R</td>
<td>75.6 ± 11.3</td>
<td>100.5 ± 36.4</td>
<td>29.4 ± 34.7</td>
<td>18.9 ± 14.0</td>
<td>18.9 ± 17.1</td>
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4. Discussion

To better understand the initial effect of each condition, the first note of each trial was analyzed.
Using MIDI and motion capture data, musical and kinematic performance were analyzed. It was
anticipated that results might be most similar in the internal and metronome conditions, due to potential
focus on the fingers, and that greater overall movement would be observed in the external condition.

Results indicated significant differences in the R T1 velocity among the four conditions as well as
duration of L T5, but only marginally significant differences in kinematics and right-hand duration.
However, when analyzing performance across each subject individually, different movement strategies
were apparent, resulting in clustering of data across the pool of participants. In comparing the amount
of respective digit vs. hand and elbow movement across conditions, the range of movement was
compared (by subtracting the minimum angle from the maximum angle of the particular joint) from the
time movement was initiated to depression of the piano key. Several movement strategies were
observed (Figure 1). For example, each of the focus conditions following baseline performance appeared to constrain pianist 10’s movements, particularly with regard to the left playing mechanism (L T5, left hand, left elbow). For pianist 12, the external condition seemed to be associated with a greater range of motion compared to either internal or metronome conditions. Pianist 13 demonstrated overall movement stemming from the hands and fingers, difference in the external condition, and an interesting difference between internal and metronome conditions between the hands.

The results associated with greater range of motion, and therefore greater movement, coincide with the external directive to conjure the idea of the dance. This suggests in at least one regard, greater expressivity. These results are supported by MIDI data indicating significant differences in keystroke velocity (and therefore intensity) among the conditions.

![Figure 1: Joint angular ranges for Pianist 10, 12, and 13 in various FOA conditions. (*) Note that elbow data are missing for Pianist 12.](image)

5. Conclusions

It appears that directing a performer’s focus may influence musical performance, the initial keystroke, in this case. Due to the contextual nature of each note, it will be informative to analyze not only individual keystrokes, but longer phrases and the relationships among those keystrokes to determine the extent to which the current observations and patterns persist. The relative homogeneity of the pianist pool might also be considered. While the variety of experience among pianists provided insight into a variety of movement strategies, it would be valuable to recruit a more homogeneous group both in level of playing experience and the comfortability of reading from a score, as opposed to memorized performance, to tease factors associated with the variability observed in this study.
REFERENCES


