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The Role of a Pianist's Affective and Structural Interpretations in his Expressive Body Movement: A Single Case Study

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We explored how a pianist manipulates his upper body according to his interpretation of music. We asked a professional pianist to perform artistic, deadpan, and exaggerated renditions of two structurally contrasting pieces. The pianist's affective interpretations clearly differentiated among the three renditions. The artistic rendition, representing the true nature of the piece, was compared to the contrived deadpan and exaggerated renditions. The pianist's range of body movement in the artistic rendition differed from the other two for a fast, energetic piece, whereas it only differed from the deadpan for a slow, romantic piece. The pianist highlighted the structural contrasts within the artistic rendition by manipulating his range of body movement and by coordinating the variations between body movement and temporal/dynamical projection of tones.

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Key words: piano performance, expressive body movement, aesthetic interpretation, musical structure, cross-correlation analysis

Artistic performance in western classical music can be characterized by its liberation from the rigidity and the regularity of musical symbols on the staff notation (e.g., Gabrielsson, 1988/2001; Repp, 1990). This involves manipulating the timing of individual notes and varying rhythms or tempi within a piece (e.g., Gabrielsson, 1988/2001; Nakajima, Nishimura, & Teranishi, 1987; Palmer, 1989; Repp, 1990; Sasaki, Ishikawa, & Yamada, 1989; Seashore, 1938/1967, Shaffer, 1981; Todd, 1985). An artistic performance also projects dynamic variations within a piece (Nakamura, 1987; Repp, 1996; Seashore, 1938/1967; Todd, 1992), or it adds ornamentations that are not necessarily specified in a score (Aldrich, 1950/2007). Such liberties in music performance are often identified as "artistic deviation" from rigid pitch, uniform intensity, and fixed rhythm (Seashore, 1938/1967, p. 29). In order for a deviation from a tonal uniformity to be *artistic*, a performer must control him/herself from exaggeration, staying within an aesthetically pleasing level. Behind such control is the performer's intention of how expressive he/she wishes to sound (e.g., Kendall & Carterette, 1990; Sasaki et al., 1989; Seashore, 1938/1967) and his/her projection of appropriate body movements during the performance (e.g., Davidson & Correia, 2002). To grasp the overall picture of how an artistic performance is achieved, it is important to explore and to identify multifaceted relations among the expert performer's expressive intentions, his/her body movements, and the acoustical features of the produced sound.

Based on the past 30 years of research on the artistic performance, we now know that an expert pianist's artistic manipulations of the sound are primarily temporal (i.e., timing, rhythm, tempo) and dynamical (i.e., intensity) (Palmer, 1997; Povel, 1977). Temporal deviations from the notation can be predicted by the hierarchy of grouping structures in music (Todd, 1985). However, successful execution of the hierarchical grouping structure of a piece can only be achieved with the pianist's right intention: playing musically, i.e., artistically (Penel & Drake, 2004). Such temporal variations can be related closely to variations in dynamics such that "the faster, the louder" and "the slower, the softer" (Todd, 1992, p. 3540). The covariation of timing and dynamics tends to occur at the beginning (Clarke, 1988/2001) and the end of a phrase (Palmer, 1997; Repp, 1996; Seashore, 1938/1967; Todd, 1992).

The performer's artistic manipulations are evident not only in acoustical but also in physical properties: A performer moves the body according to his/her expressive or emotive intentions. For example, the audience can identify the intended level of expressivity (or performance manners)—deadpan, projected/artistic, or exaggerated—more accurately with than without visual cues (Davidson, 1993, 1994, 1995, 2002). The expressive power of body movements can also allow the audience to identify a particular emotion (e.g., happiness, sadness, anger) that the performer intends to portray (Dahl & Friberg, 2007).

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Just as it determines acoustical variations of a performance, the structure of a piece can affect a performer's body movement. According to Davidson's detailed description of a single pianist's body movement (2002), the performer's sway movement was linked with specific structural elements such as phrase peaks and cadences. Davidson also reported the complex relationships among the size of the movement, the level of expressivity, and the musical structure. On some locations of a piece the movement sizes were similar across different levels of expressivity (deadpan, projected/artistic, exaggerated); at other times the movement sizes were different even at identical structural points of the same piece.

Thus, manipulations of body movement and sound production in an expert performance appear to be related to each other while being influenced by the musical structure and the performer's expressive intention (e.g., Davidson & Correia, 2002). A few studies suggest the role of the movement during sound production. Palmer, Carter, Koopmans, and Loehr (2007) reported that clarinetists raised their fingers higher in playing the same melodies faster. Goebl and Palmer (2009), Keller (2007), and Williamon and Davidson (2002) suggest that a performer's body movement plays an important role in temporal synchronization in an ensemble. Although these studies clearly indicate direct connections between the performer's motor activities and sound productions, whether these relationships arise from artistic intentions or other (motoric) sources is still unknown.

Another void in the current literature is how expressivity relates to a performer's aesthetic intentions. In previous studies, the performer's intentions were examined either by the level of expressivity (e.g., Davidson, 1993, 1994, 1995, 2002; Kendall & Carterette, 1990; Wanderley, Vines, Middleton, McKay, & Hatch, 2005) or by particular emotional qualities such as happiness, sadness, anger, fear, brightness, and so forth (e.g., Dahl & Friberg, 2007; Gabrielsson & Juslin, 1996; Juslin, 1997; Laukka & Gabrielsson, 2000; Ohgushi & Hattori, 1996; Senju & Ohgushi, 1987). These two types of expressions should not be considered as mutually exclusive. The different level of expressivity leads to different sets of body movements (Davidson, 1994, 2002; Wanderley et al., 2005) and acoustical outcomes (Kendall & Carterette, 1990; Sasaki et al., 1989); the performer may utilize different aesthetic interpretations while generating different renditions. Moreover, in reality, musical nuances are often associated with multiple emotions, such as "the music sounds bright and somewhat joyful," or sometimes even with two contrasting emotions, such as "the music is happy but fearful" (Asmus, 1985; Hevner, 1936; Taniguchi, 1995). It seems worth exploring multidimensional affective values of a piece in relation to the performer's expressive intentions.

The purpose of the present study was to investigate the relationships between different sources of expression in a single expert pianist's performances by examining relations among the musical structure, intended level of expressivity (*deadpan, artistic, exaggerated*), aesthetic interpretation of each rendition, body movements, and acoustical features of each performance. The level of expressivity was determined by the degree of variations in expressive parameters (e.g., tempo, dynamics). The deadpan and exaggerated expressions project minimal and excessive variations in tempo and dynamics, respectively, whereas the artistic one consists of stylistically appropriate variations in such parameters, aesthetically pleasing the audience. Our goal was to illustrate the detailed mapping of these elements—especially in artistic manipulations of body movements—by studying closely the pianist's performances of two structurally contrasting pieces by the same composer. We predicted that, for the artistic rendition, the musical structure and acoustical features would be linked with the body movement systematically. Moreover, the affective values of a piece, reflecting the performer's aesthetic interpretation, would relate to the pianist's bodily manipulations. Due to its case study nature, the findings of the present study may not be generalized, but we believe that they will serve as a good foundation for future studies in this field.

Method

PARTICIPANT

The participant was an award winning male professional pianist (24 years old) who studied the piano for 20 years and completed a music major course at a university two years before the experiment. He was paid an honorarium for participation.

MUSICAL MATERIALS

To investigate the role of musical structure on the pianist's expressive manipulations, we chose two pieces from the pianist's performing repertoires that were structurally contrasting: Sergei Rachmaninoff's "Etude Tableaux Op. 39-1 in c minor" ("Etude") and "Prelude Op. 32-5 in G major" ("Prelude"). The pianist was given approximately two weeks to prepare these pieces (in all three expressions). The following analyses by Glover (2003) ensured that the contents of these pieces were structurally contrasting. "Etude," marked *Allegro Agitato* in 4/4 time, consists of continuously moving figurations with contrasting block chords (see Appendix A). This piece is in an almost

continual climax, requiring stamina, strength, and flexibility in the pianist (Glover, 2003). "Prelude," marked *Moderato* in 4/4 time, is structurally much simpler than "Etude" (see Appendix B). This piece can be characterized by the smooth melodic line and its accompaniment, requiring the pianist to be sensitive in maintaining the tonal balance between them while controlling rhythm and achieving slow dynamic contrasts (Glover, 2003). We used the same composer's contrasting pieces to minimize the confounding factors that may have occurred across pieces by different composers and/or in different musical periods.

APPARATUS

The pianist's performances were recorded in the Second Studio of May Theater in Suita-city, Osaka, Japan. The pianist performed on a grand piano (YAMAHA G2E) that was equipped in the theater and tuned regularly. The A-weighted sound pressure level (with the time constant FAST) of background noise in the studio was 45.0 dB(A), measured by a sound-level meter (RION NA-20). The sound of each performance was recorded onto a digital audiotape (SONY DT-120RA) using a portable digital audio recorder (SONY TCD-D8) and a microphone (SHURE SM57). The pianist's body movements were recorded at 29.97 frames per s by four video cameras—two CCD cameras (DAIWA SE72F), one HDD camera (VICTOR GZ-MG40), and one digital video camera (SONY DCR-PC110). The sound portion was also recorded onto one of the cameras (VICTOR GZ-MG40) using a microphone (SHURE SM57), so that the video data would be synchronized with the data on the digital audiotape. The pianist was dressed in black clothes, on which markers made of 10 mm × 10 mm white drawing paper were attached in the following nine locations of the body: head, neck, right shoulder, left shoulder, right elbow, left elbow, right wrist, left wrist, and waist. The color contrast of the white marker against the black-themed clothes enabled us to trace the pianist's body movements in three-dimensional coordinates.

PROCEDURE

The experiment consisted of a warm-up session, recording and re-recording sessions, and a semi-structured interview; the experimental session took approximately five hours in entirety. First, the pianist was given approximately 30 minutes to warm up. To create a pseudo-recital situation, six men and three women ($M = 21.1$, $SD = 2.6$ years old) sat as the audience, applauding before and after each performance. Immediately before each performance, the experimenter clapped once in front of the microphones, which served as a cue in synchronizing the data between the video and the audio. The pianist executed a total of six performances, played from memory in the following order: the artistic rendition of "Etude," the exaggerated rendition of "Etude," the deadpan rendition of "Etude," the artistic rendition of "Prelude," the exaggerated rendition of "Prelude," and the deadpan rendition of "Prelude." Each piece in each condition was performed once. For the deadpan performance, equivalent to a mechanical projection of a score, the pianist was instructed to minimize his expressions of each piece. In the artistic performance, the pianist was asked to imagine as if he were performing for a large audience in a concert hall. For the exaggerated performance, the pianist was asked to maximize his expressions. No other specific instructions were given for the three performance manners; body movement was *not* mentioned.

To assure that the pianist achieved each of the three performance manners, he checked the video recording immediately after the six performances. The pianist found the deadpan "Etude" and the exaggerated "Prelude" unacceptable because he had missed several notes in these performances. We re-recorded these two renditions on the same day, in which the first author and his three assistants served as the audience. The number of recordings of these two renditions, therefore, was twice.

After the re-recording session, a semi-structured interview was conducted with the pianist to obtain his interpretations of each piece and his comments about the differences among the three performances of each piece. As part of the interview, the pianist evaluated affective qualities of each performance on 9-point monopolar scales for 24 adjectives (see Figure 3), taken from Hevner (1936). In addition, the pianist provided his own interpretation of structural boundaries of each piece (e.g., A, A', B) being recorded on the score (Appendices A and B). Furthermore, the pianist described how he expressed the structural boundaries in three renditions of each piece.

MEASUREMENT

Identification of temporal units. To obtain data reduction without losing musical meanings of each piece, we analyzed the body movement and two acoustical variables (duration and dynamics of the produced sound) per "temporal unit," which could be considered as the beat (the appropriate temporal grouping of notes). A half note for "Etude" and a quarter note for "Prelude" (Figure 1) were used as the temporal unit throughout each performance of the corresponding pieces, except the final two bars of each piece where the temporal

consistency became lost due to the meter change and fermata ("Etude") as well as rests and dotted notes ("Prelude"). By excluding these bars, 146 units ("Etude") and 144 units ("Prelude") were used for measurements and the subsequent analyses. The first author identified the beginning of each temporal unit by listening to the sound and by examining its waveform with a temporal resolution of 1 ms displayed on Sound Forge 7.0 (Sony Pictures Digital Networks).

The pianist's body movement. The pianist's body movement was measured by tracing the left corner edge of each marker on his clothes (see Apparatus) with the rate of 30 frames per s without filtering on a Windows XP computer using a three-dimensional video analyzer (DKH Frame DIAS II version 3.11 for Windows).[1] We used the pianist's posture angle θ (rad) as an index of his body movement, determined by the head and the waist locations of the pianist (Figure 2). This index could not eliminate the influence of nodding or bobbing, often observed in a performer's head movements (e.g., Davidson, 2002), but it could represent how an upper body would move during a piano performance. The horizontal axis is expressed by $\theta = 0$ (0°), and the vertical axis by $\theta = \pi/2$ (90°). In the present study, the angle θ (rad) varied from 0.83 (47.4°) to 1.57 (89.8°). To determine the accuracy of the motional measurements, the first author analyzed arbitrary 100 frame windows three times for each performance. The absolute values of the differences among the three measurements ranged from 0.003 rad (0.15°) to 0.012 rad (0.71°), indicating the error of measurement to be insignificant.

The raw data of the angle θ were measured per frame, providing 16,518 individual measurements (5,124 for the deadpan, 5,303 for the artistic, and 6,091 for the exaggerated) for "Etude" and 14,478 individual measurements (4,234 for the deadpan, 4,668 for the artistic, and 5,576 for the exaggerated) for "Prelude." These individual measurements indicate the angled location of the pianist's torso. Preliminary examinations of these postural data appeared to show that the mean postural angle was consistent across three performance manners but the range of movement varied. To measure how the pianist manipulated the movement range, we constructed another variable based on the original postural data, "movement amplitude," representing a range of postural change (i.e., the difference between the largest θ and the smallest θ) in each temporal unit (described above) of each piece.

Acoustical features. As typical parameters of artistic deviations in a piano performance (Povel, 1977), and as typical cues of structural boundaries in an artistic performance (Clarke, 1988/2001; Repp, 1996; Todd, 1992), we analyzed duration and dynamics within each performance. The duration was measured per temporal unit (described above) twice by the first author. Pearson's correlation coefficients between the two measurements were .99 for both pieces. We used the mean values of the two measurements as an index of duration. The

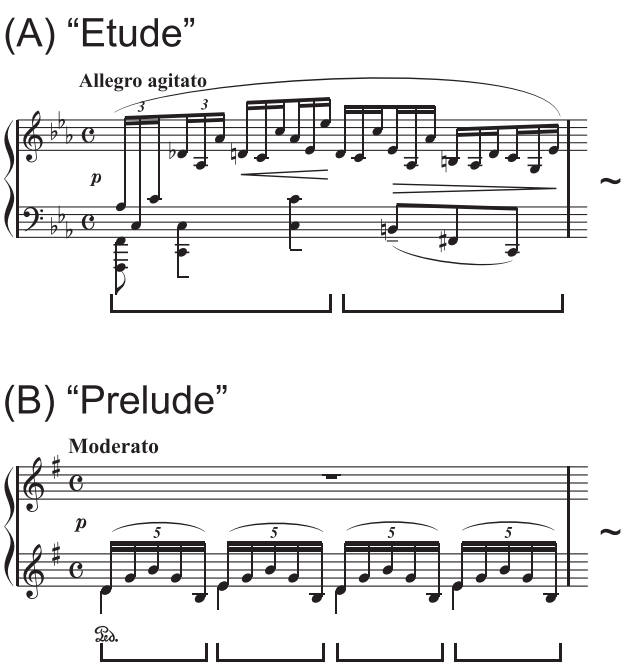
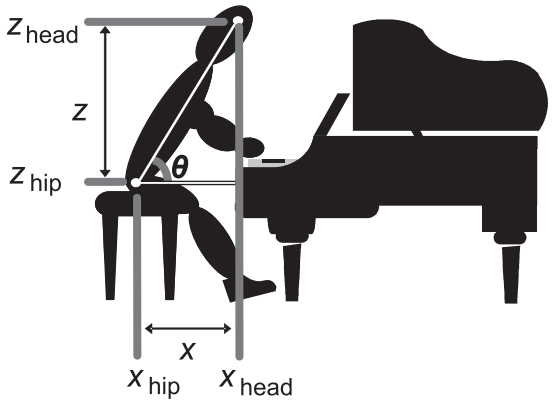


FIGURE 1. The temporal unit of each piece indicated by brackets: (A) one half note for "Etude" and (B) one quarter note for "Prelude."

[1]Since the speed of video-recordings (i.e., 29.97 frames per s) was different from the time unit on the motion-capture software (i.e., 30.00 frames per s), the first author multiplied the time line generated by the software by 30.00/29.97 to adjust the time unit.



$$\theta = \arctan\left(\frac{x_{head} - x_{hip}}{z_{head} - z_{hip}}\right) = \arctan\left(\frac{x}{z}\right)$$

FIGURE 2. A pianist's postural angle θ (rad).

dynamics were determined by measuring the A-weighted sound pressure level per 40 ms, using a 1/3 octave band real time analyzer (RION, SA-29). As a parameter of dynamics per temporal unit, we used the maximal sound pressure level (maximal SPL) within each temporal unit.

Results

Due to the richness of the present data, we report our findings in five subsections: "Affective Qualities of Each Performance," "Overall Patterns of Body Movements in Relation to Musical Structures," "Effects of the Performance Manner on the Movement Amplitude," "Effects of the Music Structure on the Variation of the Movement Amplitude," and "How Did the Body Move in the Artistic Rendition?"

AFFECTIVE QUALITIES OF EACH PERFORMANCE

Figure 3 indicates the pianist's own evaluations of his affective expressions underlying each performance, displayed along Hevner's adjective circle (Hevner, 1936). The pianist's interpretation of each piece was reflected in his ratings of its artistic rendition. For "Etude" (Figure 3A), the pianist gave the maximum rating 9 for solemn, robust, majestic, emphatic, and passionate; he also gave ratings higher than 5 for exhilarated, restless, cheerful, leisurely, dark, depressing, and lofty. For "Prelude" (Figure 3B), the pianist rated 9 for bright and tender, as well as 7 and 8 for joyous, cheerful, graceful, tranquil, leisurely, dreamy, longing, lofty, exhilarated, and passionate, the majority of which were rated relatively low for "Etude." These results indicate that the two musical pieces were, indeed, contrasting affectively in the pianist's own interpretation. To ensure these qualitative insights, Wilcoxon signed-rank tests were performed for pairwise comparisons. For the 12 adjectives highly rated for the artistic rendition of "Etude," the differences of the ratings were significant between the artistic renditions of the two musical pieces ($Z = 2.41$, $p = .02$). For the 12 adjectives highly rated for the artistic rendition of "Prelude," the differences were also significant ($Z = 2.52$, $p = .01$).

Affective qualities of three performance manners within each piece varied quantitatively and qualitatively. For "Etude" (Figure 3A), 14 out of 24 adjectives were rated 5 or above for its artistic rendition ($M = 5.46$, $SD = 2.38$), whereas the number of equally rated adjectives dropped to seven for its exaggerated rendition ($M = 4.08$, $SD = 2.12$), and to four for its deadpan rendition ($M = 3.42$, $SD = 1.41$). Similarly, for "Prelude" (Figure 3B), 16 out of 24 adjectives were rated 5 or above for its artistic rendition ($M = 5.88$, $SD = 2.40$), but only four and seven adjectives were rated so for its deadpan ($M = 2.50$, $SD = 1.75$) and its exaggerated ($M = 3.75$, $SD = 1.70$) renditions, respectively. For both pieces, their artistic renditions tended to show the highest ratings and their deadpan renditions tended to show the lowest ratings in most adjectives, except a few conveying inadequate meanings for the target piece, such as humorous and dignified for "Etude" as well as restless, whimsical, humorous, and depressing for "Prelude."

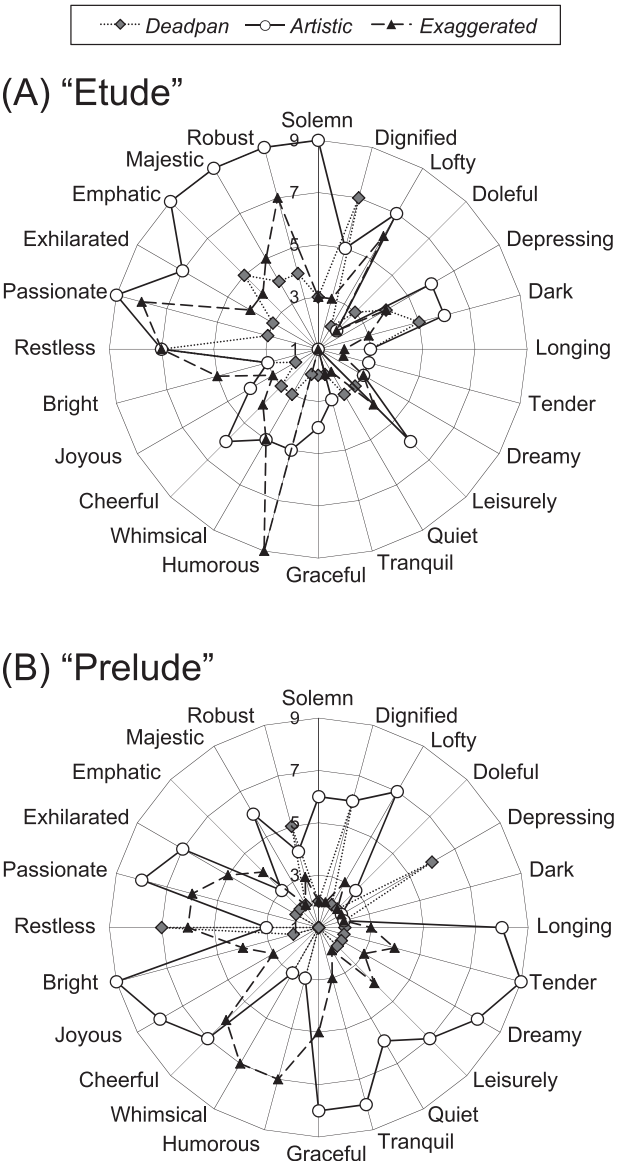


FIGURE 3. The pianist's self-rated affective qualities of each performance along selected items of Hevner's adjective circle (Hevner, 1936).

Affective values between the artistic and each of the other performance manners were compared by Wilcoxon signed-rank tests for each piece. For both pieces, the differences were significant between the artistic and the deadpan, $Z = 3.24$, $p = .001$ ("Etude"), $Z = 3.45$, $p = .001$ ("Prelude"), and between the artistic and the exaggerated, $Z = 3.24$, $p = .006$ ("Etude"), $Z = 2.94$, $p = .003$ ("Prelude"). These results, along with the content of Figure 3, clearly indicate that overall, the pianist interpreted the hedonic qualities of the artistic rendition higher than the deadpan or the exaggerated rendition, regardless of musical piece.

OVERALL PATTERNS OF BODY MOVEMENTS IN RELATION TO MUSICAL STRUCTURES

"Etude" fell into 11 sections and "Prelude" fell into 8 sections based on the pianist's interpretation of structural boundaries (see Procedure, Appendices A and B). Each of the boundaries was identified by the onset of the first tone within the corresponding section. Figure 4 shows a part of the pianist's postural angle θ with section boundaries for each rendition of each piece. An upward-sloping curve depicts the pianist's torso moving backward and a downward-sloping curve depicts his torso moving forward. Peak and trough points indicate directional changes of the torso movement: A peak indicates a backward-to-forward transition and a trough indicates a forward-to-backward transition. An angle of a sloping curve depicts the degree of postural change in the corresponding direction.

In the artistic and the exaggerated renditions of "Etude," the degree of postural change appears to be larger at the end of the main theme (sections A, A', A", and A'"), especially right before introducing a new motif (e.g., the boundary between A" and C in Figure 4A). This tendency, however, was not observed in any rendition of "Prelude."

As can be seen in Figure 4, the directional change of the pianist's torso movement mostly coincided with structural boundaries in the artistic rendition of each piece. To confirm this tendency, we counted the number of structural boundaries that were in phase with the directional changes of his posture (i.e., when the lag between the timing of a structural boundary and that of the directional change was less than the digital video sampling rate, 33.33 ms). All 10 boundaries ("Etude") and 6 out of 7 boundaries ("Prelude") were in phase with the directional changes in the artistic renditions. On the other hand, 3 out of 10 ("Etude") and 0 out of 7 ("Prelude") in the deadpan renditions, as well as 5 out of 10 ("Etude") and 2 out of 7 ("Prelude") in the exaggerated renditions, were in phase with the directional changes. For each piece, Fisher's exact tests were conducted for the pair of artistic and deadpan renditions, proving the differences between the renditions to be significant ($p = .003$ for "Etude," $p = .004$ for "Prelude"). Similarly, the differences between the artistic and exaggerated renditions were confirmed ($p = .03$ for "Etude," $p = .10$ for "Prelude"). Thus, the pianist's body movement was synchronized with the structural boundaries for the artistic rendition, but not for the deadpan or exaggerated renditions.

EFFECTS OF THE PERFORMANCE MANNER ON THE MOVEMENT AMPLITUDE

Figure 5 shows a portion of each piece that represents typical differences in the range of the movement per temporal unit—the movement amplitude—among three renditions. For "Etude," the exaggerated and deadpan performances tended to generate the largest and smallest movement amplitude, respectively, leaving the artistic rendition to be moderate (Figure 5A). For "Prelude," on the other hand, the movement amplitude for the exaggerated rendition was overlapping mostly with the artistic rendition, and the deadpan rendition tended to stay below them (Figure 5B).

These tendencies were statistically confirmed with one-way analysis of variance with repeated measures conducted for each piece. The effects of rendition were significant for both pieces, $F(2, 290) = 111.23$, $p < .001$, $\eta^2 = .45$ ("Etude") and $F(2, 286) = 31.98$, $p < .001$, $\eta^2 = .19$ ("Prelude"). Posthoc comparisons using Bonferroni's correction (overall $\alpha = .10$, the subset's $\alpha = .033$ for each comparison for each piece) revealed that all but one comparison were significant. For "Etude," the deadpan rendition generated smaller movement amplitude ($M = 0.03$, $SD = 0.02$) than the artistic ($M = 0.12$, $SD = 0.09$) and the exaggerated ($M = 0.16$, $SD = 0.12$) renditions, $ps < .001$. The artistic rendition generated smaller movement amplitude than the exaggerated rendition, $p < .001$. For "Prelude," the deadpan rendition ($M = 0.04$, $SD = 0.03$) generated smaller movement amplitude than the artistic ($M = 0.08$, $SD = 0.06$) and the exaggerated ($M = 0.07$, $SD = 0.05$) renditions, $ps < .001$. However, no difference was found between the exaggerated and artistic renditions.

These results indicate that the pianist played the deadpan rendition with the smallest body movement regardless of the piece. In contrast, the relation between the artistic and exaggerated renditions differed according to the piece: For "Etude" (a faster, energetic piece), the range of body movement increased for the exaggerated rendition, whereas such a manipulation was not observed for "Prelude" (a slower, gentle piece).

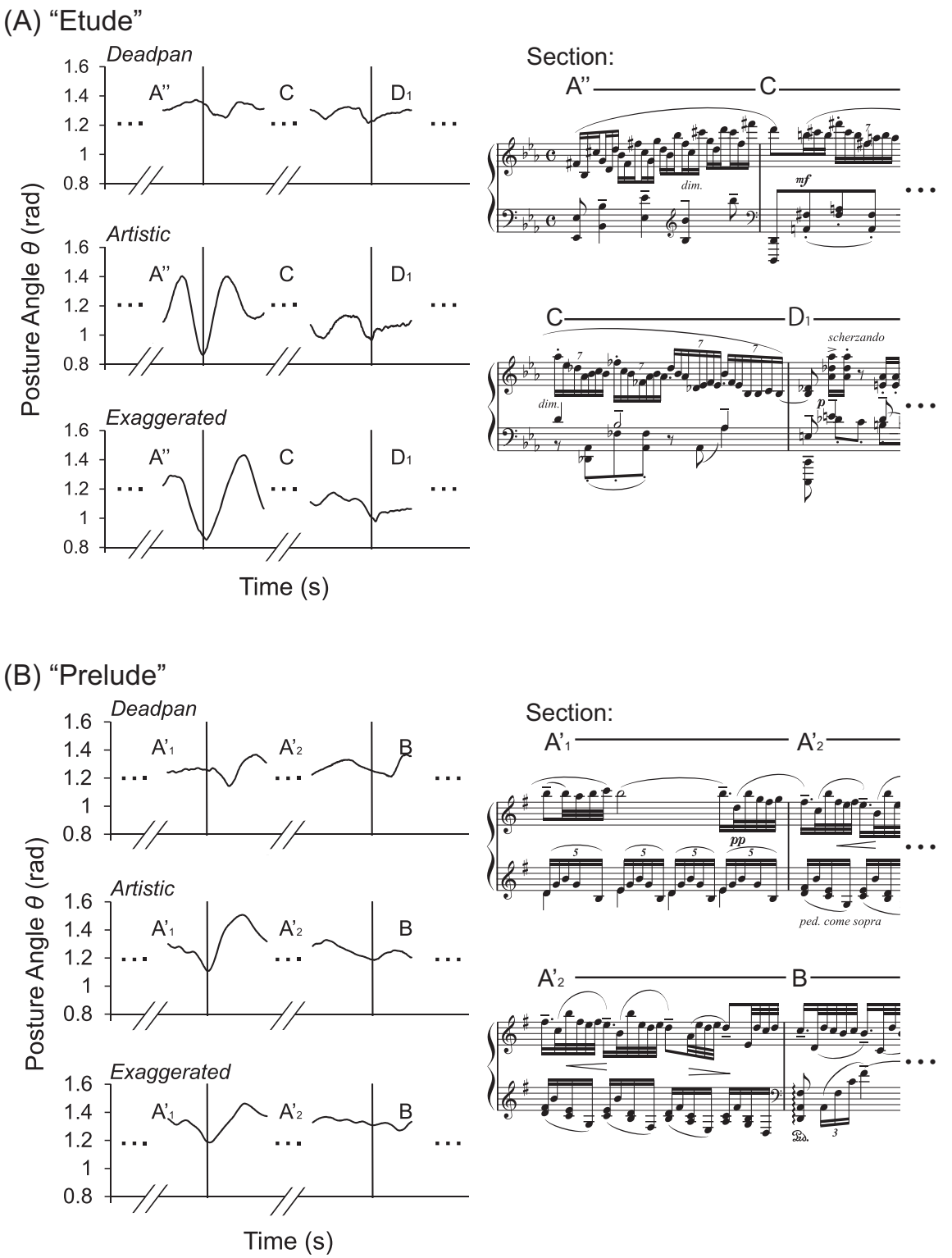


FIGURE 4. Illustrations of the pianist's postural angle θ (rad) among three renditions of each piece. The letters above each graph and those above each score (e.g., A'', C, D_1) are section IDs. The vertical lines within each graph indicate boundaries between sections. The entire illustration of the pianist's postural angle θ (rad) among three renditions of each piece can be obtained from http://cogpsy.let.hokudai.ac.jp/labs/adachi-lab/AppendicesOnline/.

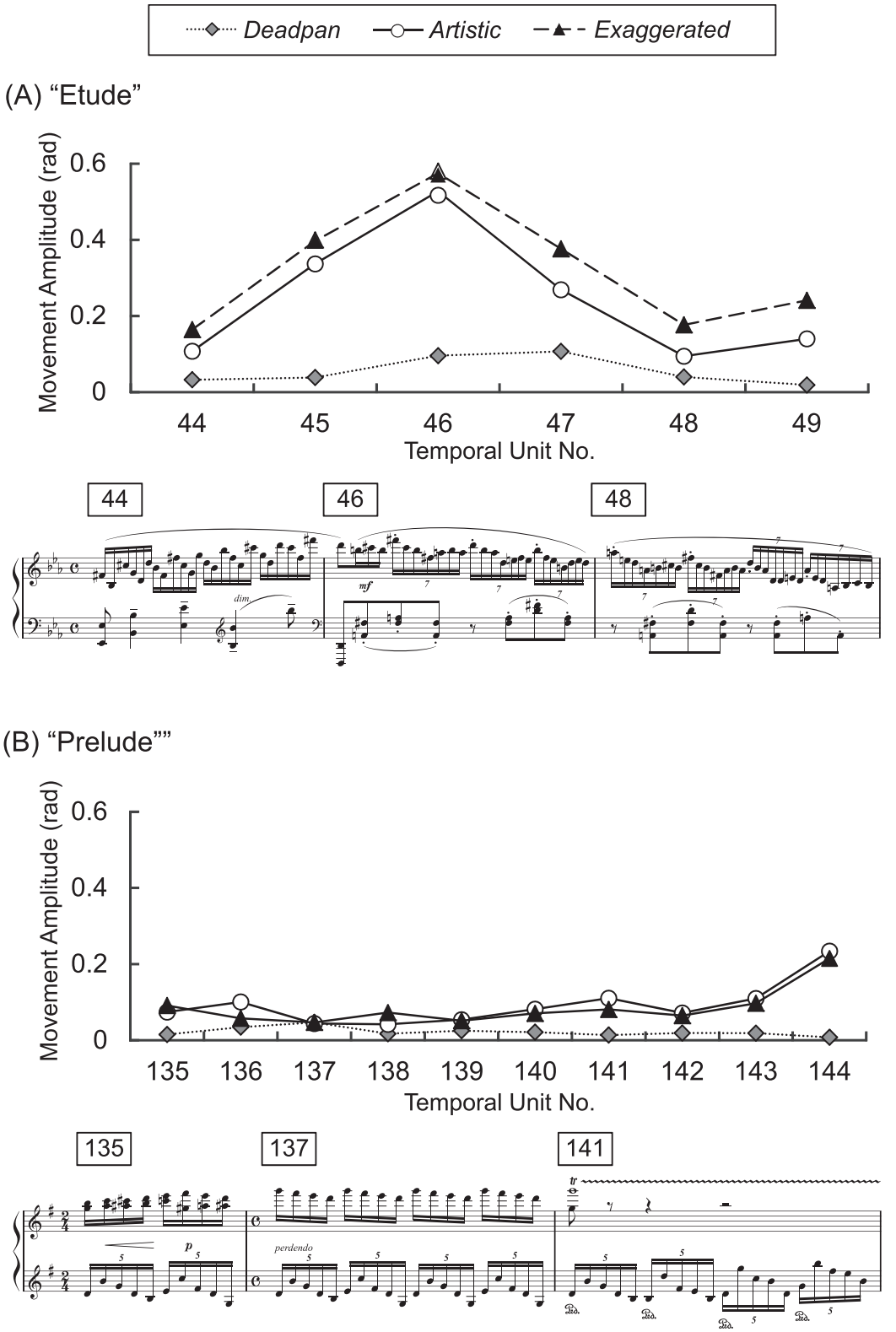


FIGURE 5. The illustration of the movement amplitude (i.e., the range of the postural change per temporal unit) across three renditions for (A) "Etude" and (B) "Prelude."

EFFECTS OF THE MUSIC STRUCTURE ON THE VARIATION OF THE MOVEMENT AMPLITUDE.

The range of the pianist's body movement appeared to vary across the three performance manners and sections. To examine the sectional variability of the movement amplitude, we installed a deviation score as follows. First, we calculated the mean value of the movement amplitude for each section, and then calculated a difference between that mean and each raw datum per temporal unit.

Figures 6 ("Etude") and 7 ("Prelude") illustrate typical patterns in the deviation of the movement amplitude across the three renditions. In general, the deviations were close to zero in the deadpan rendition, indicating the minimal change in the movement amplitude regardless of the piece. The deviation patterns of the other two renditions depended on the section of each piece. For Figures 6A and 7A, the differences among three renditions were clearer than those for Figures 6B and 7B, implying that the pianist manipulated the degree of contrasts among three performance manners within each piece.

To examine the pianist's manipulation of the cross-sectional variability in the movement amplitude, we conducted a one-way Levene test (Levene, 1960) with repeated measures for each section of each piece. This test,evaluated statistical differences among the three performance manners (i.e., deadpan, artistic, exaggerated) within a section. We used Bonferroni's correction (overall $\alpha = .10$, the subset's $\alpha = .009$ for "Etude" and $\alpha = .013$ for "Prelude") for multiple comparisons. The tests revealed the main effects of performance manner in 7 out of 11 ("Etude") and 4 out of 8 ("Prelude") sections. Subsequently, we conducted posthoc *F*-tests with Bonferroni correction (overall $\alpha = .10$, the subset's $\alpha = .003$ for "Etude" and .004 for "Prelude"), representing how the pianist differentiated the three performance manners by fluctuating the degree of body movement within a section (Table 1).

These results indicate that the pianist did not differentiate his body movements across the three performance manners continuously throughout the piece. Rather, the pianist appeared to set a few expressive points in the piece, at which his body manipulations manifested. Such points could not be identified simply by the thematic similarity. For example, the successful differentiation between deadpan and artistic renditions was observed in section A'" but not in section A, A', or A" in "Etude." A similar tendency was also observed in "Prelude" (e.g., sections A_1 and A'_1).

HOW DID THE BODY MOVE IN THE ARTISTIC RENDITION?

In this section, we focus on the pianist's bodily and acoustical expressions in the artistic rendition of each piece. In particular, we report how the manipulations of the body movement and those of the acoustical features (i.e., duration, dynamics) related to each other, as well as how the structure of the piece influenced their relations, in the artistic rendition. As can be seen in Figure 8, the shapes of fluctuations in the movement amplitude and in the duration coincided with each other, and sometimes the peaks of the movement amplitude either preceded or followed those of the duration. Similar patterns also were observed between the movement amplitude and the maximal SPL. To explore systematic patterns of time lag, we calculated cross-correlations between movement amplitude and duration, as well as those between movement amplitude and maximal SPL, for each section of each piece.

The cross-correlation is a measure of similarity between two waveforms as a function of time lag applied to one of them (Kitagawa, 2005). We set the maximal lag as one bar of each piece under an assumption that the pianist's body movement beyond one-bar lag would not make a functional relation to the projection of tones. Since the temporal units of "Etude" and "Prelude," composed in 4/4 time, were a half note and a quarter note, respectively, the installed time lags were between -2 and 2 ("Etude") and between -4 and 4 ("Prelude"). The negative lag corresponds to the peaks of the movement amplitude following those of each acoustical parameter, and the positive lag corresponds to the peaks of the movement amplitude preceding each acoustical parameter. Lag 0 indicates that the peaks of the movement amplitude and each acoustical parameter coincide with each other.

Tables 2 and 3 show the cross-correlations of the movement amplitude and the duration for "Etude" and for "Prelude," respectively. For "Etude," the significant cross-correlation became maximal at lag 0 for 7 out of 11 sections, meaning that the temporal and the movement manipulations mostly occurred together. In contrast, significant cross-correlations were found with negative, positive, and 0 lags for "Prelude." In positive lag sections (A_1, A'_1, C) of "Prelude," where the theme of the piece was presented with slower tempo than in the other sections, indicating that the body moved *before* projecting such tones. In sections A_2 and B, performing with faster tempi as compared with the other sections, the body moved *after* lengthening tones. In section D, the end of the slow piece, the body also moved *after* lengthening tones. The contrasting time lags observed in section A_1 (presenting the theme in a slower tempo), in section B (presenting a new idea in a faster tempo), and in section D (closing the piece) of "Prelude" appear to indicate that the pattern of the body movement

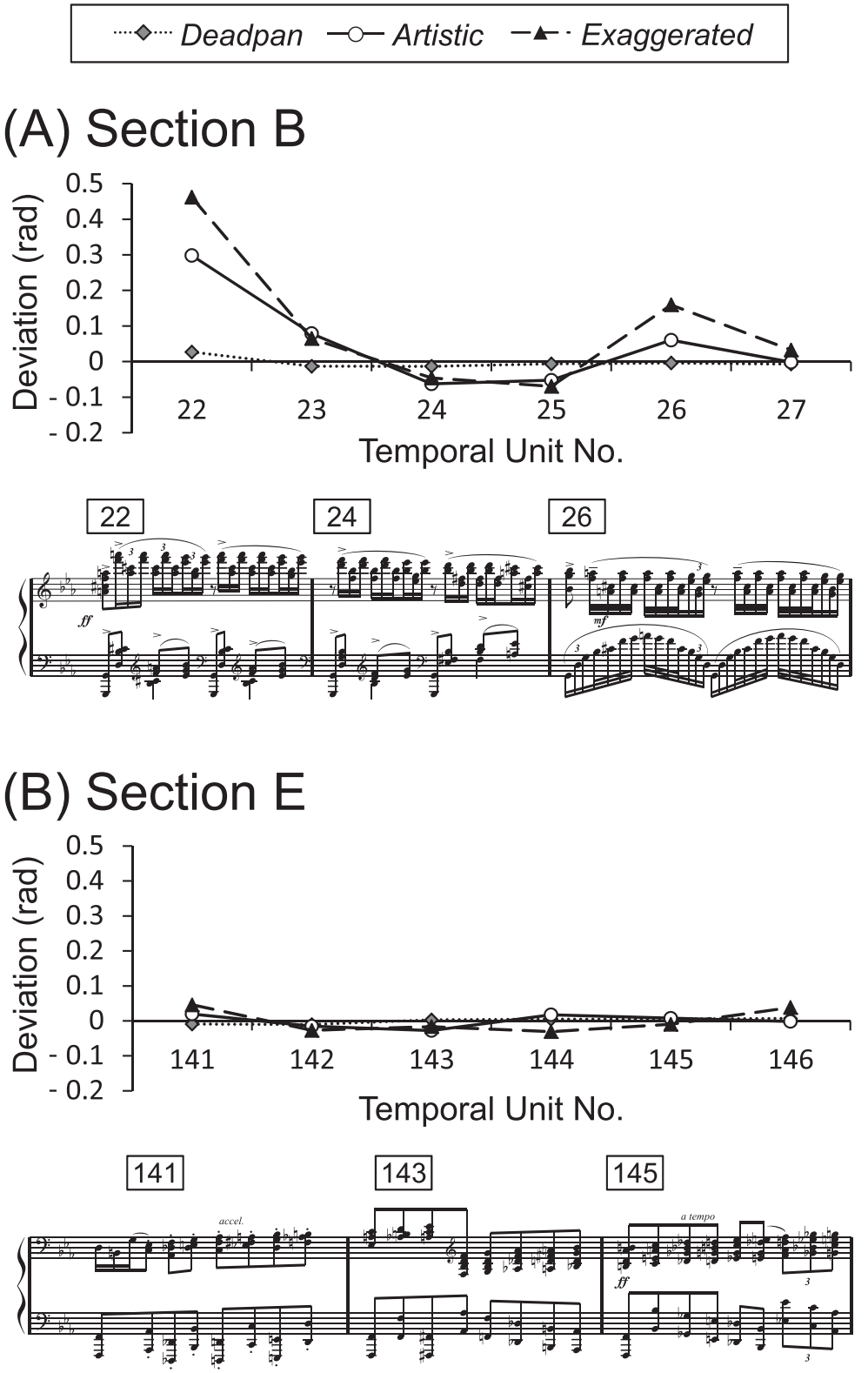


FIGURE 6. The deviation of the movement amplitude in a portion of (A) section B and (B) section E of "Etude." An illustration of the deviation throughout the piece can be obtained from http://cogpsy.let.hokudai.ac.jp/labs/adachi-lab/AppendicesOnline/.

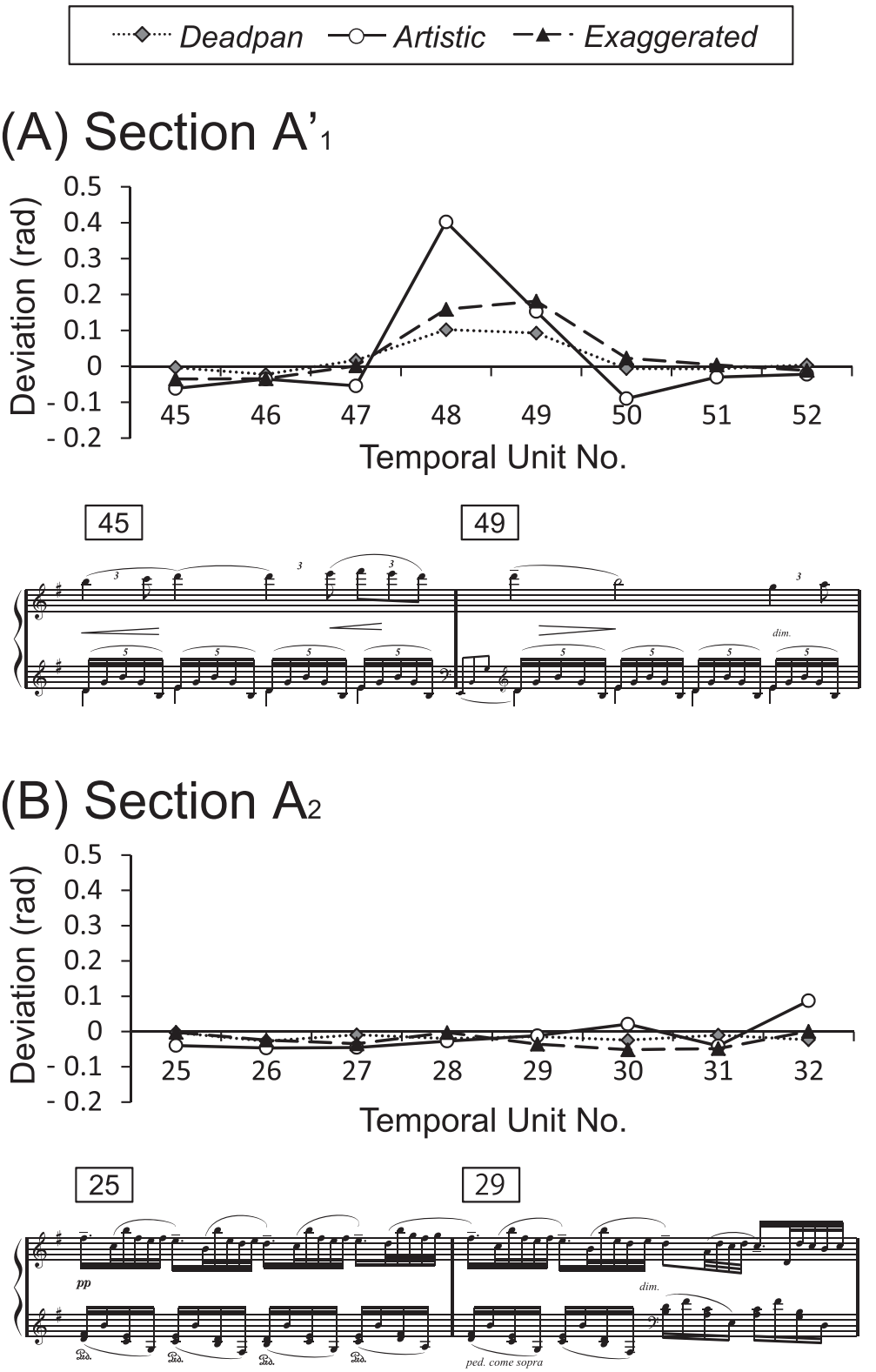


FIGURE 7. The deviation of the movement amplitude in a portion of (A) section A'_1 and (B) section A_2 of "Prelude." An illustration of the deviation throughout the piece can be obtained from http://cogpsy.let.hokudai.ac.jp/labs/adachi-lab/AppendicesOnline/.

TABLE 1. Results of Posthoc *F*-tests (overall $\alpha = .10$) with Bonferroni Correction for Differences in the Variances of the Movement Amplitude Among the Deadpan, the Artistic, and the Exaggerated Renditions for Each Piece.

	"Etude" (the subset's $\alpha = .003$)										
	A	A'	B	A"	C	D_1	D_2	A	A"'	B'	E
Deadpan vs Artistic			+		+				+		
Artistic vs Exaggerated						+					
Exaggerated vs Deadpan		+	+		+	+	+		+	+	
	"Prelude" (the subset's $\alpha = .004$)										
	A_1	A_2	A'_1	A'_2	B	C	A"	D			
Deadpan vs Artistic			*		*						
Artistic vs Exaggerated											
Exaggerated vs Deadpan	*				*		*				

$^{+}p < .003$ ("Etude"), $^{*}p < .004$ ("Prelude")

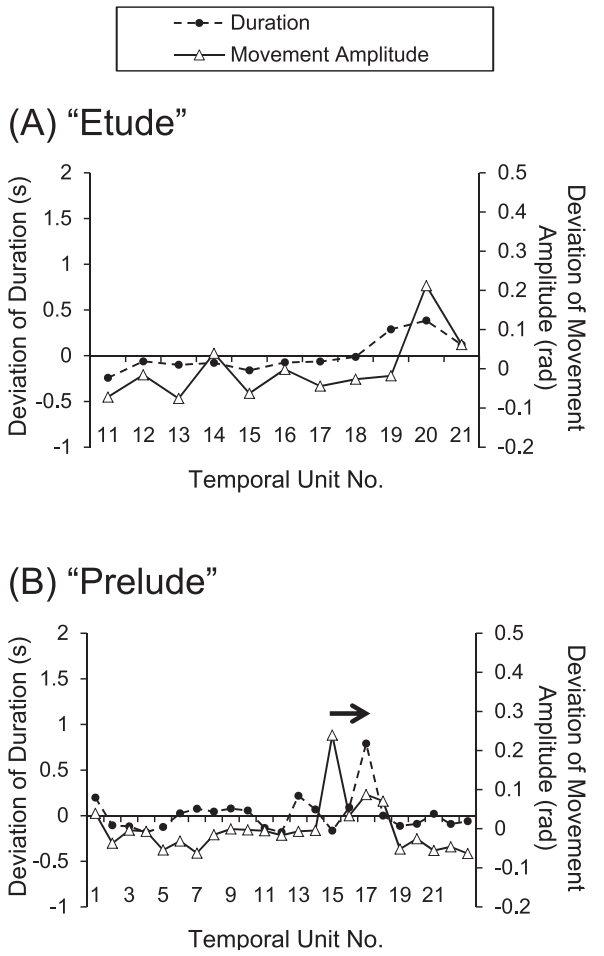


FIGURE 8. The deviations of the movement amplitude and the duration in the artistic rendition of (A) "Etude" and (B) "Prelude," taken from a portion of section A' ("Etude") and of section A_1 ("Prelude"). The arrow in (B) indicates that the pianist manipulated the body movement before the duration.

TABLE 2. Cross-correlations of the Deviations Between the Movement Amplitude and the Duration as a Function of the Time Lag of the Temporal Unit for the Artistic Rendition of "Etude"

Section	Lag of the temporal unit				
	−2	−1	0	1	2
A	−.44	.21	.02	.17	.02
A'	.30	.63	**.76***	.14	−.02
B	.03	−.10	.35	.05	.13
A"	−.39	.03	**.72***	.08	.14
C	−.21	.43	**.53***	−.42	−.35
D_1	.15	−.24	**.59***	−.16	.07
D_2	.16	.24	**.76***	.36	−.03
A	−.27	.31	.08	.01	−.25
A"'	.12	.09	**.52***	.23	.26
B'	.03	.25	**.68***	.29	.24
E	−.09	−.37	.25	.48	.08

$^{*}p < .05$ (only for positive coefficient)

Note: The value in bold shows the maximal significant cross-correlation within each section.

depended on the temporal fluctuation within a piece and on the structural meaning of each section. In other words, the use of the body movement in relation to the durational manipulation appears to be more complex in a slow piece than in a fast piece.

Tables 4 and 5 show the cross-correlations of the movement amplitude and the maximal SPL for "Etude" and for "Prelude," respectively. For "Etude," the time lags with significant cross-correlations were negative or zero in most sections, indicating that the pianist's larger body movement tended to *follow* or to *match* the maximal SPL of each section. In section C, however, the time lag was positive, meaning that the pianist moved

TABLE 3. Cross-correlations of the Deviations Between the Movement Amplitude and the Duration as a Function of the Time Lag of the Temporal Unit for the Artistic Rendition of "Prelude"

Section	Lag of the temporal unit								
	−4	−3	−2	−1	0	1	2	3	4
A_1	−.18	−.15	.11	.21	.21	.15	**.58***	−.02	−.11
A_2	−.23	−.34	−.16	−.18	**.66***	−.06	.46	.23	.11
A'_1	−.16	−.06	−.18	−.06	.57*	**.68***	.13	−.01	−.07
A'_2	.07	.54	−.10	−.34	−.14	−.32	−.18	.01	.03
B	.10	.10	.46*	.59*	**.63***	.04	−.05	−.24	−.25
C	.15	−.21	.01	−.22	−.15	−.27	**.53***	.15	.33
A"	−.24	−.13	−.24	−.12	.17	.21	.17	.12	−.02
D	.26	.01	.56*	**.64***	.18	.17	.28	.10	−.18

*$p < .05$ (only for positive coefficient)

Note: The value in bold shows the maximal significant cross-correlation within each section.

TABLE 4. Cross-correlations of the Deviations Between the Movement Amplitude and the Maximal A-weighted Sound Pressure Level as a Function of the Time Lag of the Temporal Unit for the Artistic Rendition of "Etude"

Section	Lag of the temporal unit				
	−2	−1	0	1	2
A	.05	.16	.15	−.43	−.12
A'	**.70***	.20	.52	.24	.12
B	.13	.23	.50	.47	.37
A"	−.40	.29	**.61***	.20	.01
C	.06	−.07	.40	**.65***	.13
D_1	.51	.19	.10	−.24	−.18
D_2	.46	**.84***	.69	.14	−.11
A	−.48	.25	.13	−.20	−.13
A"'	.32	.33	**.49***	.15	.04
B'	.00	.14	**.62***	.61*	.44
E	.41	.31	.55	.10	−.13

*$p < .05$ (only for positive coefficient)

Note: The value in bold shows the maximal significant cross-correlation within each section.

his body *before* intensifying tones. Section C was projected with the softest tones in the slowest tempo of all other sections of "Etude," a fast, energetic piece. This indicates that the fluctuation of tempo in a fast piece might influence the time lag between the body movement and the dynamics.

As compared with "Etude," fewer sections showed significant cross-correlations in "Prelude," mostly at negative lags; that is, the pianist's larger body movement *followed* his intensification of tones. The significant negative lags

TABLE 5. Cross-correlations of the Deviations Between the Movement Amplitude and the Maximal A-weighted Sound Pressure Level as a Function of the Time Lag of the Temporal Unit for the Artistic Rendition of "Prelude"

Section	Lag of the temporal unit								
	−4	−3	−2	−1	0	1	2	3	4
A_1	.40	.45*	**.45***	.39	.17	.19	.00	−.09	−.01
A_2	.32	.06	.02	−.54	−.45	−.39	−.37	−.13	.08
A'_1	.26	.29	.27	.30	.15	−.13	−.28	−.27	−.38
A'_2	−.17	−.39	−.17	.54	.57	.21	−.11	−.40	−.33
B	−.18	.12	.40*	**.42***	.23	−.03	.07	−.10	.02
C	−.05	.09	.22	**.66***	.61	−.18	−.18	−.07	−.48
A"	.17	.31	.31	.38	.20	.00	−.07	−.19	.01
D	−.15	−.12	−.22	−.19	−.70	−.45	−.38	−.24	−.07

*$p < .05$ (only for positive coefficient)

Note: The value in bold shows the maximal significant cross-correlation within each section.

were observed at the beginning of the piece (A_1), in which the theme was presented, at section B, in which musically contrasting ideas were presented, and at section C, in which the modulation of the theme was presented. In other words, the pianist appeared to emphasize structural contrasts among these sections by lagging his body movement behind his production of intensified tones.

Discussion

In the present study, we investigated how an expert pianist would manipulate his body movement according to his affective and structural interpretations of a particular piece, and how his artistic manipulations of the body movement and the acoustical features would relate to each other. The pianist clearly differentiated three performance manners aesthetically—he interpreted the artistic rendition as aesthetically rich—although the body movements of the artistic and the exaggerated renditions somewhat overlapped with each other. The pianist achieved his aesthetically ideal performance by highlighting the specific structural elements (e.g., thematic presentation, structural transition) within the piece by fluctuating the degree of his body movement. The nature of a single case study, however, does not allow the current results to be interpreted as the general tendency of pianists. The replicability of our findings needs to be tested with many more pianists and pieces.

Nonetheless, our findings have reconfirmed that the emphasis of structural contrasts may be the general principle of an artistic performance, both for the body movement and for the acoustical features. Davidson

(2002) indicates the importance of the structurally salient points (e.g., phrase peak, phrase boundary) on the range of the pianist's movement. Repp (1990, 1996) and others (e.g., Clarke, 1988/2001, Todd, 1992) show that a pianist tends to lengthen a note at phrase boundaries and at moments of melodic/harmonic tension, as well as to intensify the melody at the prominent points. The present study appears to indicate that the time lags between the pianist's larger body movements and his temporal or dynamic manipulations may also covey structural contrasts of a piece.

Moreover, the present study has demonstrated that the pianist's bodily manipulations may not be based only on his structural but also on his affective interpretations of a target piece. The pianist's affective interpretations of his artistic renditions reflected the musically contrasting features of two pieces. The pianist's affective interpretations of the other renditions of each piece—consisting of different sets of affective values from those for the artistic rendition—indicate that the deadpan or the exaggerated performances are neither the reduced nor the overstated expression of the artistic performance; rather, they are qualitatively different from it. Perhaps, the pianist rated the affective values of the deadpan and exaggerated renditions based on the awkwardness he felt in performing these renditions. In fact, in the post-performance interview, the pianist described the exaggerated renditions as unacceptable forms of performance because of its facetiousness (similar to what a comedian or an entertainer would portray), which would explain why the exaggerated renditions were identified as humorous (see Figure 3). Although the movement expression for the exaggerated performance may derive from that of the artistic performance, these two performance manners appear to have little overlapping values affectively. Such differences in the pianist's affective impressions underlying three performance manners may be one possible explanation for inconsistencies in the pianist's body movements across performance manners, even at identical structural points (Davidson, 2002).

In parallel with the affective differentiation, the pianist's manipulations of the movement amplitude (i.e., the range of the torso movement within a temporal unit) were differentiated between the deadpan and the artistic renditions. The pianist regarded the deadpan rendition as the monotonous one both physically and affectively. On the other hand, the range of the body movement was not differentiated consistently between the artistic and the exaggerated renditions. For "Etude" (i.e., fast, energetic piece), the movement amplitude in the exaggerated rendition was greater than that in the artistic rendition, but no such difference was found for "Prelude" (i.e., slower, gentle piece). The undifferentiated body movements between the artistic and the exaggerated performances of "Prelude" were in line with Davidson (1994), in which Beethoven's "Bagatelle" No. 11 in B-flat major was used. Both Rachmaninoff's "Prelude" (Moderato) and Beethoven's "Bagatelle" (Andante) are to be performed in a moderate tempo, contrasting Rachmaninoff's "Etude" (Allegro Agitato). Perhaps in playing relatively slow pieces ("Prelude" and "Bagatelle"), the pianist may spontaneously move his/her body in a full range in the artistic rendition, which leaves little or no extra margin for exaggeration. These results appear to suggest that the manipulation of body movements may be related to the overall tempo, at least in the Classical (Davidson, 1994) and the post-Romantic pieces.

The cross-correlation analyses in the present study have contributed new insights into the function of body movements in piano performance. In the present case study, body movement and temporal manipulation appeared to coincide with each other in a fast piece with a steady beat, whereas the body appeared to move "before" lengthening a tone in a slower section and "after" lengthening it in a faster section of a relatively slow, rubato piece. The body movement tends to follow the artistically intensified tones while emphasizing structural contrasts. Whether this tendency can be generalized in the performance of other romantic pieces or of works from different stylistic periods needs further investigation. Moreover, it is important to examine whether the audience can actually perceive lags between body movement and projected tones and, if they can, how their perception influences their aesthetic impression of the performance.

In conclusion, the present case study has captured an overall picture of how a professional pianist would manipulate acoustical and movement parameters in projecting three performance manners—deadpan, artistic, and exaggerated—with multidimensional affective interpretations of structurally contrasting pieces of music. Whether this pianist's expressive and affective intentions can be communicated to the audience awaits another study.

Author Note

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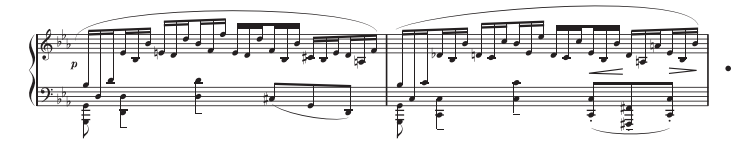
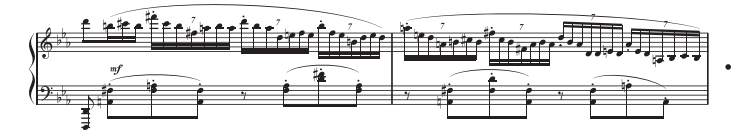
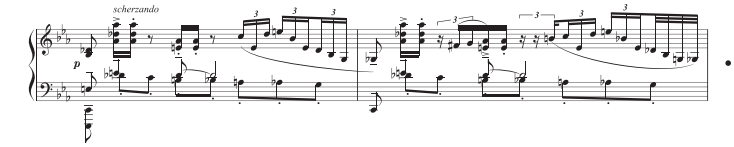
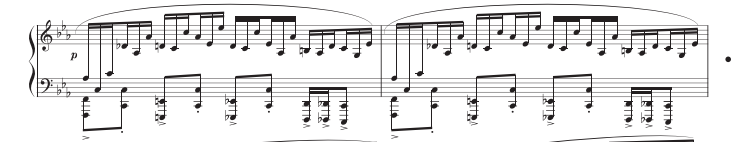
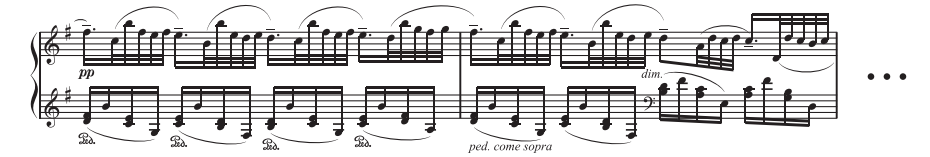
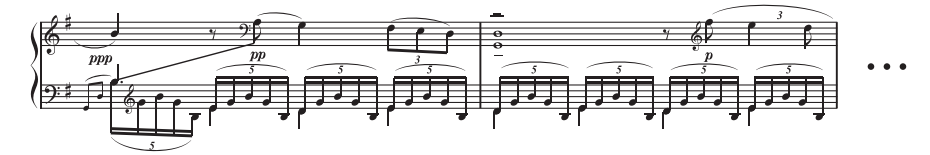
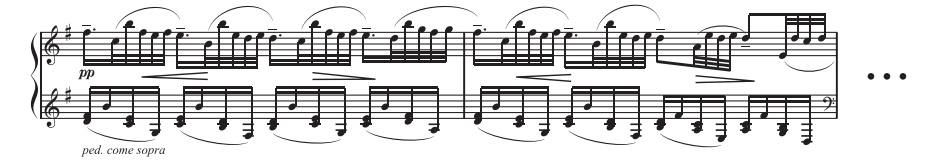
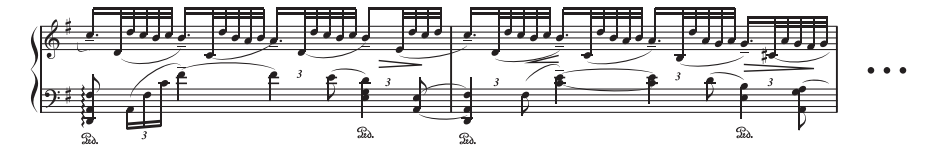
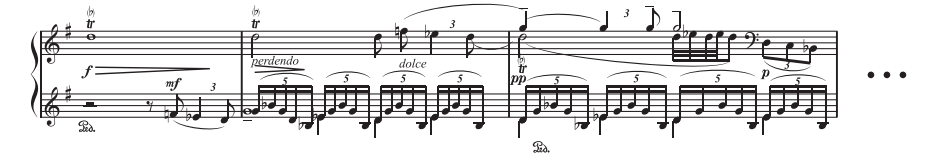
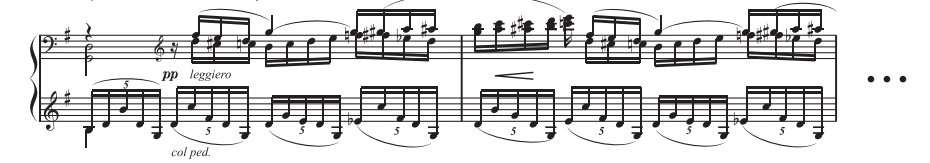
APPENDIX A. Sections identified by the pianist for "Etude."

Section	(Measures)	The first part of each section
A	(1-5)	
A'	(6-11)	
B	(12-18)	
A''	(19-24)	
C	(25-32)	
D_1	(33-37)	
D_2	(38-45)	
A	(46-52)	
A'''	(53-66)	
B'	(67-73)	
E	(74-78)	

APPENDIX B. Sections identified by the pianist for "Prelude."

Section	(Measures)	The first part of each section
A_1	(1-6)	
A_2	(7-8)	
A'_1	(9-14)	
A'_2	(15-16)	
B	(17-22)	
C	(23-28)	
A''	(29-34)	
D	(35-41)