Themenschwerpunkt
Wirkungen und kognitive Verarbeitung

Understanding the Expressive Performance Movements of a Solo Pianist

Jane Davidson

Abstract

Psychological studies have shown that the performer's body movements provide an important source of information for the perception of a musical performance. Indeed, it has been shown that visual information can provide even experienced musicians with a stronger indication of a performer's explicit expressive intention than sound information. The research in this article focused on a single case study of a solo pianist to discover how the body moves during performances and which movements provide salient visual cues to the observers. Analysis of three differently intentioned performances of the same piece of music revealed that a single pianist used varying types of identifiable movement and degrees of movement. There were connections between the size of movement and the degree of expressive intention in the performances, with the most expressive performance producing the greatest degree of movement. Additionally, certain locations in the musical structure were found to elicit particular types of expressive movements, for example, making a decisive surging forward movement as a cadence point was reached. But links between the type and size of movement and musical structure were not simple. For instance, expressive information was more apparent in certain areas of the body than others; on some occasions movements were of a similar nature across the three performance intentions, whereas at other times the movements were different, despite being at identical structural points in the music. These results are not straight forward, and so the current paper concludes with a discussion of what the findings imply about the nature of bodily expression in performance.

Musikpsychologie Bd. 16, 7–29, © Hogrefe-Verlag, Göttingen 2002

1. Introduction

From the existing research literature on music performance, it appears that there are two broadly identifiable sources of expression. Firstly, there are fixed consequences of the motor programming system. That is, the movement control program elicits effects on the performance that are inevitable, expressive only of the individual's production of the notes (Shaffer 1984). The second source of expression appears in the player's interpretation of the piece where the dynamics, intonation, timbre and timing are deliberately manipulated.

Interpretation varies for a range of reasons from the acoustical, such as adjusting the performance style to accommodate to a particular concert hall, to social and emotional considerations like going on stage just after having received some bad news, or being in personal conflict with one of the co-performers. Empirically, there is a number of research papers which not only shows that individuals can and do change their musical interpretations, but that there is a general understanding between and across musicians and music listeners which demonstrates that despite the individuality of an expressive interpretation, there are trends which people follow and therefore seem to share the meaning of these interpretational devices. For example, Gabrielsson (1995) showed that the overall speed, dynamics, articulation and vibrato of violin playing was varied according to the expressive intention when a range of performers played several well-known tunes each with the following intentions: 'sad', 'happy', 'solemn', 'angry', 'tender' and 'without expression'. But, all the performers varied the expressive intentions in similar ways; for instance, happy was the fastest of each individual's interpretation, whilst sad was the slowest and quietest performance. So, although any one expert's use of expression may differ from any other's and thus allowing for artistic interpretation and individuality, expressive performance is rule-governed.

Sloboda & Davidson (1995) have demonstrated that there are in fact five specific characteristics which govern expressive performance. First, it is systematic: that is to say, there is a clear relationship between the use of particular expressive devices (e.g. slowing, accenting, etc.) and particular structural features of the music, such as metrical or phrase boundaries (Todd 1985). Secondly, expressive performance displays communicability, in that listeners are better able to infer structural features of the music when expression is present than when it is absent. Thirdly, it shows stability. A given expert can very closely reproduce the same expressive performance on occasions which might be separated by some months (e.g. Shaffer 1984). Fourthly, expressive performance displays flexibility. An expert performer can attenuate, exaggerate, or change the expressive contour to highlight different aspects of the music (e.g. Davidson 1993, Palmer 1989). Fifth and finally, it shows automaticity. An experienced performer is not always aware of the details of how an expressive intention is translated into action (e.g. Gabrielsson 1988). This comes about

through the over-learning of consistent intention-performance mappings, which could not be established unless they were systematic and rule-governed.

Much of the literature on the perception of music is concerned with elucidating the structures that people use to store and handle musical inputs (see, for instance, Bharucha 1987, Brown 1988, Butler 1989, Cohen, Trehub & Thorpe 1989, Palmer & Krumhansl 1990). The notion that performances are generated from a structural representation can account for both the stability and the flexibility of expressive performance. Stability in performance can be achieved by re-applying a small set of rules to a structurally marked representation, rather than by remembering a very large amount of analogue information about minute timing and other deviations (a probable psychological impossibility). Flexibility can be achieved by re-setting parameters on some of the rules, rather than by changing the representation of the piece. These may not be the only factors in operation in the perception and production of musical performances, but they are clearly ones that go a long way to describe observable processes.

Like Gabrielsson (1995), research by Kendall & Carterette (1990) also examined interpretational variation by asking performers of different instruments to play the same pieces of music. Here, performance intentions were: 'without expression', with 'the appropriate expression' and with 'too much expression'. Examining the dynamics and timing of the performances, they discovered that the three different intentions had recognisable and distinctive profiles across all performers, though there was much individual variation within and between them.

Kendall & Carterette (1990) explored their results by examining the different intentions in terms of their deviations from the canonical notation of the music. They discovered that all their performers, irrespective of performance intention, signalled salient structural points in the pieces (e.g., cadences, pitch-contour direction changes) by temporal and dynamic contrast. These contrasts were found generally to be least pronounced in the inexpressive performance.

In recent times, one of the most widely accepted theoretical proposals to account for the signalling of structural points has been of the type proposed by Todd (1985), a generative model. Studies such as those by Sloboda (1983) and Clarke (1989) have provided confirmatory evidence where in the performance of the same musical phrases, significant agreement in the position, nature and direction of expressive timing variation is shown across and between performers. Although Kendall & Carterette's (1990) findings broadly demonstrate a relationship between musical structure and expression, they have disputed the strict and invariant nature of the Todd's (1985) proposal, because of the high degrees of individual variability found in their own data.

Although debate concerning an adequate theoretical interpretation of the performance expression literature persists, two major points emerge from the evidence above:

i) expression is the consequence of both inevitable and manipulable features of performance;
ii) a strong link exists between musical structure and the types of intentional manipulations which occur.

Furthermore, an important methodological point emerges. In both Gabrielsson's (1995) and Kendall & Carterette's (1990) work, the experimenter had an explicit knowledge of the performer's intentions which not only facilitated the measurement of these intentions, but also enabled the researchers to link listener perceptions with the performer's expressive goals.

Inspite of the many useful findings emerging from expression research, surprisingly little attention has been paid to the role of the body in both the production and perception of musical performances. Shaffer (1984) looked only indirectly at the body by examining piano key presses, though his work clearly suggests that the assemblage of the performer's body has important consequences on the production of the musical sounds.

Of the small number of existing studies on body movement, two empirical investigations by the author (Davidson 1993, 1995) have demonstrated that musicians' movements communicate much useful perceptual information. For example, adopting Kendall & Carterette's (1990) methodology, it was discovered that exaggerated, understated or normal expressive intentions could be clearly detected from the performers' movements. Indeed, using both aural and visual information as stimuli, it was found that non-musicians relied almost entirely on visual information for their judgements of the performers' intentions.

In two further studies which focused on the performances of a single pianist (published in a single article: Davidson 1994), the author explored what sort of movement characteristics might guide observer perceptions. The first study, using two-dimensional (x- and y-axes) movement tracking techniques to quantify the movements, showed that there was a relationship between movement size and expression – the greater the expressive intention, the larger the movement. This was not a simple one-to-one relationship, however, as there were moments of complete stillness in all performances, and there were also movement forms that were specific to each intention. In the second study, observer judgements explored the extent to which different regions of the body were informative of the performance intention. It was discovered that the upper torso/head region was sufficient for the perceptual judgement to be made, but the most accurate information for differentiating between the three different intentions was when the head/torso and hands were combined.

With the results above in mind, a further key issue to explore is whether the movement information about expressive intention is in fact available in a continuous stream, or whether it is limited to particular moments within a performance. Additionally, whether in piano performances the upper torso and hands contribute equally to both general and local physical manifestations of the performance intention.

The theoretical underpinnings for the questions above come from the research of Cutting & Kozlowski (1977) which investigated walking performance and perception. Their studies showed that any part of the movement cycle in locomotion provides similarly expressive information (in their work the 'expression' was the walker's identity). In further studies, Kozlowski & Cutting (1977) and Kozlowski & Cutting (1978) discovered that by viewing the walkers in point-light display any single body joint provided enough information to allow observers to determine their gender. Cutting, Proffitt & Kozlowski (1978) and Cutting & Proffitt (1981) explained their gender results by demonstrating that there is a point (referred to as 'the centre of moment' – a term from Geometry) within the walker's body which acts as a reference around which movements in all parts in the body have regular geometric relations. The point is located in the torso and is different for men and women, its relative location being determined by the relative widths of the hips and the shoulders. In other words, the body contains a physical centre for expressive information. This centre is not to be confused with the centre of gravity.

Equal distribution of expressive information in piano playing seems unlikely since the body is not engaged to equal degrees in producing the music. The legs and feet, for instance, are required only to make pedalling movements. Also, the body is fixed to the piano stool, therefore, it is likely that a centre of moment would be related to sitting position and would not involve the lower limbs. Thus, the upper body would provide most information.

None of the existing research into body movement has examined how physical manifestations of expression may also be related to moments of structural importance within the performance. Therefore, since the body assembles and articulates the performance, and thus the expression of the musical structures, a further question is whether there will be identifiable movement patterns at key structural features of the music – e.g., cadence points.

Following on from previous research, the current paper focuses on a single case study with the aim of providing as detailed as possible an understanding of how one pianist's performances are organised and perceived by observers.

2. General Method

A male professional pianist with an international performing career provided the performances for both studies described in this paper. He played Beethoven's Bagatelle No. 11 in Bb major. This was a well-learned piece selected from his repertoire and was played from memory. The pianist sat at the keyboard in a right-side profile performing position with a video camera set at a distance of 3 metres from the him with the camera lens

focused at keyboard height so that his whole body was in full-frame camera shot.

The Bagatelle performances were recorded with the three intentions referred to in Kendall & Carterette's (1990) work, though in the current paper these intentions are labelled 'deadpan', 'exaggerated' and 'projected'. These particular intentions were selected as they were regarded as three genuinely performable intentions consistent with public performance and teaching methods. In the 'deadpan' performance, the performer was asked to minimise his expressive interpretation of the music; that is, to reduce dynamic, temporal, and timbral variations to produce a consistently unvaried performance. In the 'exaggerated' performance, the pianist was asked to play the piece in such a way that all aspects of the expressive features would be overstated; that is, to overemphasise dynamic, temporal, and timbral variations in his interpretation of the piece. In the 'projected' performance, the pianist was asked to play as if in a recital; that is, to give his normal interpretation of the score.

No *specific* instructions were given about how to achieve the differences between the intentions since the instructions were viewed as a simple method to get the performer to approach the same music differently. The pianist was asked to confirm that he understood what was required of each performance intention, and that the performances he produced were consistent with the required intentions. No reference was made to physical movement, though the pianist knew that a visual record of the performances was made.

It is important to note that intention is the independent variable here, and objective measurements of the body movements of this pianist in these three performances (published in Davidson 1994) showed that he moved least and the movements were smallest in amplitude in the deadpan performances, and that he moved most and his movements were largest in amplitude in the exaggerated performance. Therefore, there was evidence to suggest that each performance intention was executed differently. In addition, these differences were perceptually available to four independent raters (92 % agreement) who scored the expressivity levels of the three performance intentions. Their scores reflected the differences between the three intentions found in Davidson (1993, 1995) that is: deadpan was judged least expressive, and exaggerated was most expressive.

3. Experiment 1

This study was primarily concerned with establishing whether expressive information about performance intention is constrained to specific moments within the performance, or whether it is evenly distributed throughout the performance. Furthermore, it also examined the relative contributions of the upper torso region and the hands to the overall perception of the expressive intentions.

3.1 Method

3.1.1 Observers

Fifteen postgraduate music students acted as observers for this study.

3.1.2 Stimuli

So that the relative perceptual contributions of each body area could be examined, it was decided that the upper torso and hands regions should be used independently as the visual stimuli for the observers. Since Cutting & Proffitt (1978) had shown that two-second excerpts were sufficient for the recognition of gender, it was decided that observers should rate two-second excerpts from the three performance intentions. As the three Beethoven Bagatelle performances had different durations (deadpan = 52 seconds, projected = 54 seconds, and exaggerated = 58 seconds), and as the upper torso and hands were to be viewed independently, the number of potential excerpts to be presented to the observers needed to be limited in order to reduce the duration of the observation task. A simple random selection of two-second excerpts would not have provided the right kind of observation data, since Davidson (1994) had already shown that the movements of deadpan performances were generally not as large as exaggerated performances. Thus, there was a need to capture the movement variability within each performance intention – most movement in each and least movement in each. This was done by calculating differences in the movement quantity over each two-second excerpt. The calculations were made from data which had been collected from a video position analyser. The analyser samples x- and y-axis positions at a rate of one measurement each 0.2 seconds. (Details of how these tracking measurements were made can be found in Davidson 1994.) Measurements had been collected for head, neck, left and right hands independently, therefore, it was decided to create single values for the upper torso by combining values for the head and neck. Left and right hand values were also combined in order to produce a single value for each two-second hand excerpt. Then, the quarter of all the excerpts with the lowest differences in movement quantity and the quarter of the excerpts with the highest differences in movements quantity were selected for each performance intention for the upper torso and hands respectively. Since the three performance intentions differed in duration, there were 13 quartiles for deadpan, 14 quartiles for projected and 15 for exaggerated for both the upper body and hands. With fifteen seconds of screen blanking between each excerpt, these stimuli were randomly distributed between six video tapes (seven excerpts on each tape).

3.1.3 Procedure

The aim of the study was to examine body movement, therefore, the excerpts were shown without sound. They were presented randomly (i.e., different combinations of the six video tapes – see above) on a prepared monitor with the relevant body region (upper torso or hands) being highlighted with the use of a masking card to blot out the rest of the body.

The observers were not told of the number of different performance intentions, but they were informed in a brief introduction to the test that they would see excerpts taken from recordings of different performances. They were asked to rate the expressivity of each excerpt by circling the most appropriate number on a seven point bipolar scale (deadpan – exaggerated).

Initially, a run of practice trials was shown including six two-second excerpts; three showing the three different performance intentions in upper torso stimuli, and three showing the hand stimuli with the three different intentions. The main test followed. This included 42 two second excerpts from the lower and upper quartiles for the upper torso region, and 42 two second excerpts from the lower and upper quartiles for the hand region of the professional pianist's deadpan, projected and exaggerated performances of the test piece. The tapes ran continuously, observers having a fifteen second gap in which to rate a segment. With short rest periods between tapes, the experiment ran for approximately 55 minutes.

3.2 Results and Discussion

For each observer, mean scores for the segments in each of the six conditions (three intentions and two quartiles) were calculated, and possible differences in the scores for the hands and upper body were examined through two separate 3 (intention – deadpan, projected and exaggerated) X 2 (quartile – high difference value/low difference value) mixed design analyses of variance with repeated measures – one for the upper torso and one for the hands.

The analysis for upper torso reveals main effects for intention [$F(2,28) = 196.21$, $p < 0.0001$] and quartile [$F(1,14) = 110.44$, $p < 0.0001$] and a two-way interaction between intention and quartile [$F(2,28) = 9.56$, $p < 0.001$]. Tukey tests show that all intentions and quartiles are different from each other ($p < 0.01$) except for the projected and exaggerated performances in the low quartiles, and the projected intention in low and high quartiles. Figure 1 shows the mean scores.

These mean scores reveal that for the high quartile sequences of the upper torso, the three intentions are distinguished from one another and that the rank ordering for deadpan, projected and exaggerated performance is as expected. For the low quartiles, the rank ordering between deadpan and projected intention is as expected, but there is no significant

difference between projected and exaggerated intentions. The high difference score quartile segments are awarded higher overall expressivity ratings than the low difference score segments in deadpan and exaggerated intentions, but similar scores in the projected performance.

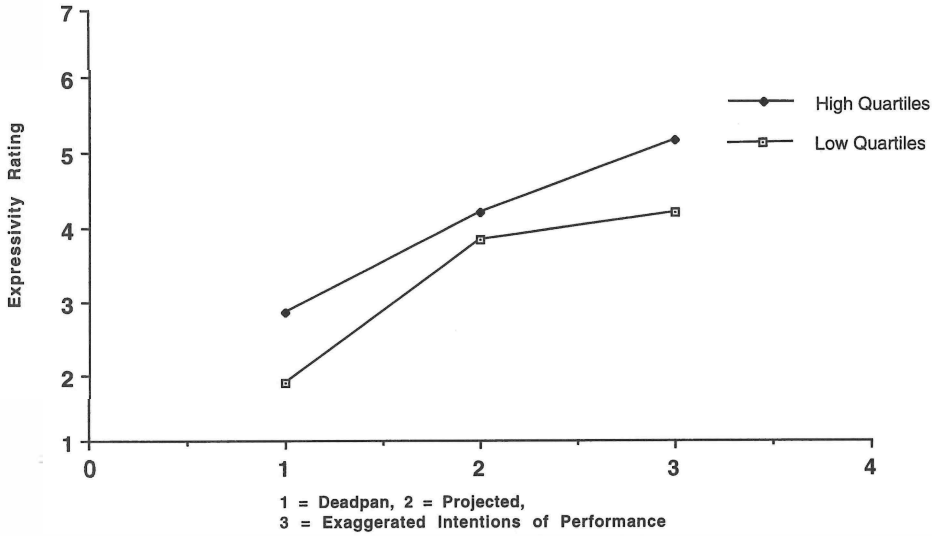


Figure 1:
Means scores for the two-way interaction effects of intention by quartile for upper torso

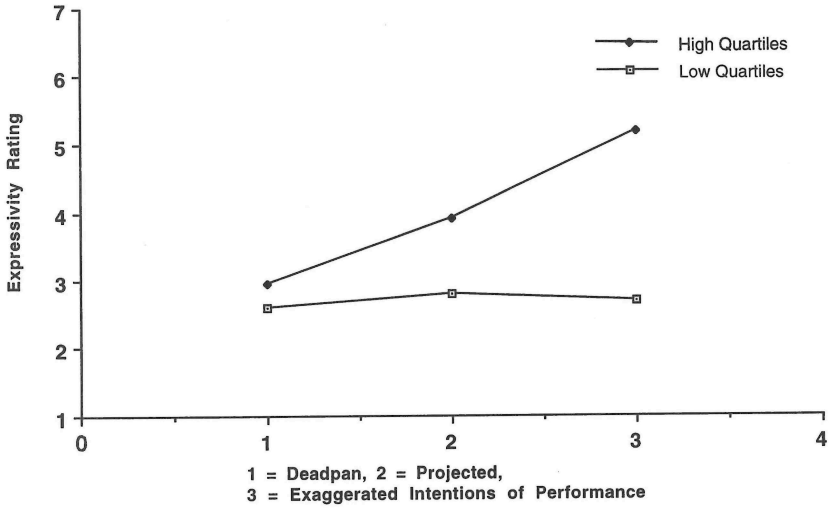


Figure 2:
Means scores for the two-way interactive effects of intention by quartile for hands

The analysis for hands reveals significant main effects for intention [$F(2,28) = 73.11$, $p < 0.0001$] and quartile [$F(1,14) = 129.38$, $p < 0.0001$]. The analysis for hands also reveals an interaction between quartile and intention [$F(2,28) = 36.77$, $p < 0.0001$]. Tukey tests reveal the high quartiles to be responsible for the interaction in that they are different from one another in each performance ($p < 0.01$). There are no other differences between the scores. Figure 2 shows the mean scores.

The mean scores for hands indicate that the rank ordering and range of the scores for intention is the same as for the head in the high quartile segments. For the low quartile segments, all scores are similar and demonstrate that low quartiles are essentially unaffected by intention (that is, they are not differentiated across intention). This suggests that only the high difference score segments become more or less expressive as the intentions change.

Whilst it is clear that the high difference score segments produce rank order judgements of intention equivalent to those of former investigations (Davidson 1993, 1995), the low difference score results do not reflect this result at all for hands, and only show this result between the deadpan and projected intentions for the upper torso. From this result it appears that the observers judge intention in terms of the quantity of movement contained in a segment. The main effect of quartile underscores this point: the high difference score segments are detected as being more expressive than low difference score segments. This would suggest that specific information about intention is perhaps limited to moments where there are larger ranges of movement, and is therefore not continuous.

Of course, another explanation might be that the high difference score segments are the most perceptually obvious or easy moments of expression to extract, and can therefore be judged out of context. The low activity or still moments might require more subtle perceptual judgements which the context of performance may facilitate.

Given these possible interpretations, it is essential to discover whether:

i) observers can identify specific expressive locations within the context of the whole performance;
ii) these locations correspond with any of the quartile segments;
iii) the relationship between these locations and the musical structure.

To do this, a second experiment was undertaken in which observers were asked to view the three entire Bagatelle performances and to identify any features of the performances which they thought were informative about the intention.

4. Experiment 2

4.1 Method

4.1.1 Observers, Apparatus and Stimuli

Six professional musicians participated as observers in the study. They were asked, individually, to view the video recordings of the pianist playing the Beethoven Bagatelle. No modifications were made to the original recordings which were shown unedited – but without sound – on a TV monitor.

4.1.2 Procedure

Each observer viewed the recordings sitting approximately 1.5 metres from the monitor, with the experimenter sitting to the side of the monitor to operate the video controls. Prior to running the video, each observer was told that s/he would see three interpretations of the same piece of music played by the same pianist. From the visual information contained in these recordings of the performances, the observer were requested to identify all the locations which they believed contained expressive information, and particularly whether there was any overall or specific information which enabled them to differentiate between the three different interpretations. First, they were asked to watch the three performances without any pauses. Then, in a second run-through, they were asked to stop the film at the points where they were aware of an "expressive moment" and attempt to explain their criteria for the selection of the location. Thirdly, at the end of viewing all three performances the observers were asked to pin-point similarities and differences in the types of movements observed across the performances. At this point, they were able to re-view any of the performances and discuss specific locations or general features of the performances. All such locations and comments were recorded by the experimenter in terms of bar number, locations within the bar according to the musical metre, and verbatim reports. It took each observer approximately 60 minutes to undertake the test.

4.2 Results and Discussion

The recorded observations showed high level of agreement between observers' judgements for the identification of expressive locations in all three expressive intentions (87 %). This provides evidence to suggest that similar kinds of information about the locations is being detected by all the observers. Figure 3 shows the musical score of the Bagatelle and Figure 4 shows the locations common to all six judgements. It reveals five immediately striking features:

i) all the locations involve either upper torso or left hand movements;
ii) 83 % of these locations are common to both the upper torso and hand areas of the body;
iii) there is a high level of correspondence between the expressive locations across intentions (79 %);
iv) the expressive locations occur in virtually every bar of the performances;
v) whilst the locations are common across intention, the durations of the locations vary.

Additionally, it is important to note that 97 % of the high quartiles from Experiment 1 correspond to the expressive locations in Figure 4, but only 24 % of the low difference quartiles are also identified as expressive locations.

Points i) and ii) confirm the earlier findings (Davidson 1994) to show that the upper torso and hands provide the most useful perceptual information about performance intention, and that there is physical coordination between these two body parts.

In addition, these results provide the first empirical evidence to show that musically trained perceivers can detect specific expressive moments within each intention. The finding that there is a correspondence between these locations across intention suggests a link between the moments, yet the finding that the durations of these expressive moments is different across intention suggests that this link may not be a simple relationship between musical structure and expression since the musical structure will be identical in any expressive intention.

Recalling the results of Experiment 1 that there was a link between movement quantity and expressivity, the observation that there are expressive locations which correspond to low quartiles suggests that movement quantity alone is not the only contributing factor to perceived expression.

In line with the existent literature on musical expression (Todd 1985, Sloboda 1983), the most obvious way to consider these latter two findings is to examine the relationship of the expressive locations with the musical score.

Brief examination of the musical score in Figure 3 and the expressive locations in Figure 4 shows links between all major phrase-ending cadence points (the ends of bars 5, 7, 14, 18 and 22) and expressive locations since these locations are recorded in all intentions. Similarly, major phrase climaxes occur at bars 2, 4, 8 and 17 and correspond to expressive locations in all intentions. A more detailed level of analysis reveals that wherever there is a structural feature within a bar – for instance, the V–I resolutions with the high quaver melody phrasing in bars 11 and 12 – there is an expressive location. The only bars to deviate from this pattern (bars 3 and 15) can also be given a structural explanation: both are overshadowed by significant musical structures in adjacent bars. For instance, bar 3 is preceded by a phrase peak in bar 2 and is followed by a major cadence point in bar 4. Bar 15 follows a major cadence point and precedes another.

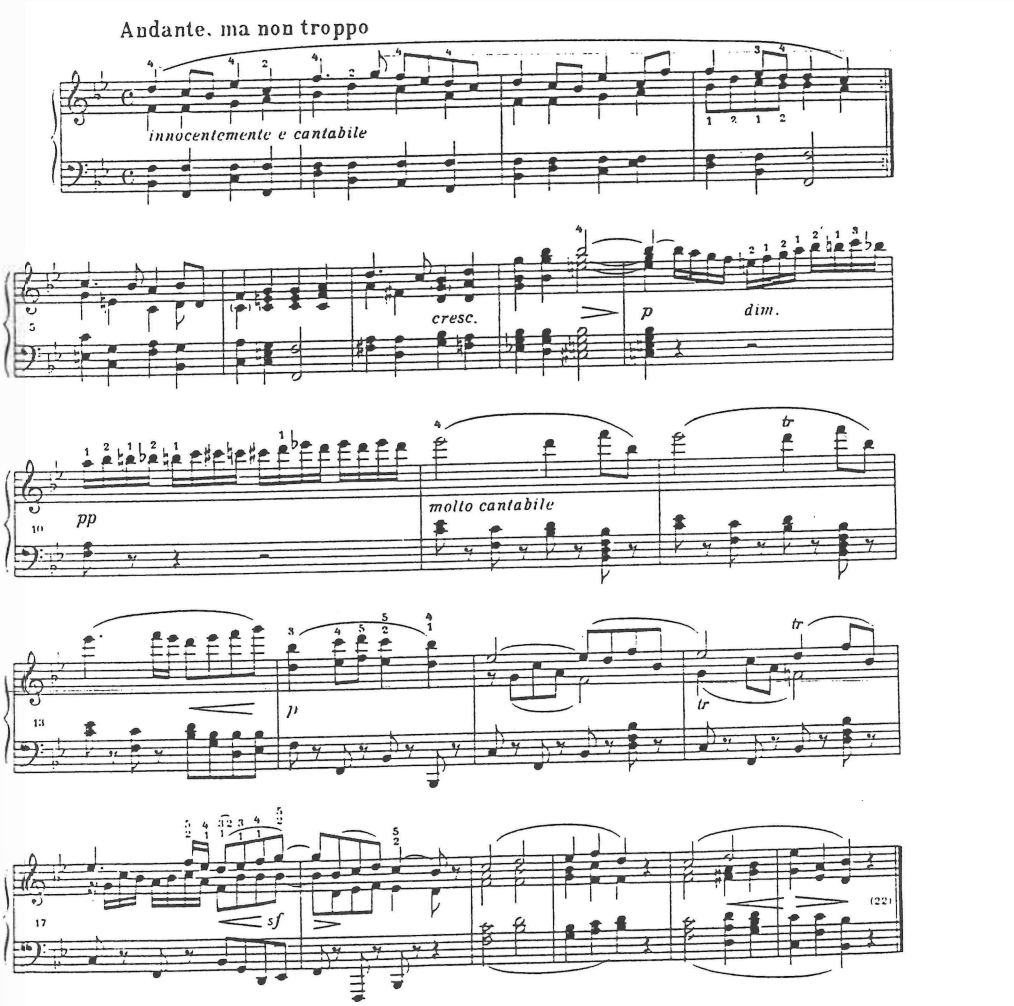


Figure 3:
Score of Beethoven's Bagatelle, op. 119, No. 11 in Bb major

However, the structural explanations alone cannot account for the different durations of these locations across intention (for example, bars 9–12 are perceived as one expressive hand location and six upper body locations in projected and exaggerated intentions, yet four discrete hand locations and only two upper body locations in deadpan intention). However, interesting common explanations for these results emerge out of transcripts of the verbatim reports made by the observers.

For example, all observers stated that in the projected and exaggerated intentions the performer set up a continuous rhythmic forward and back-

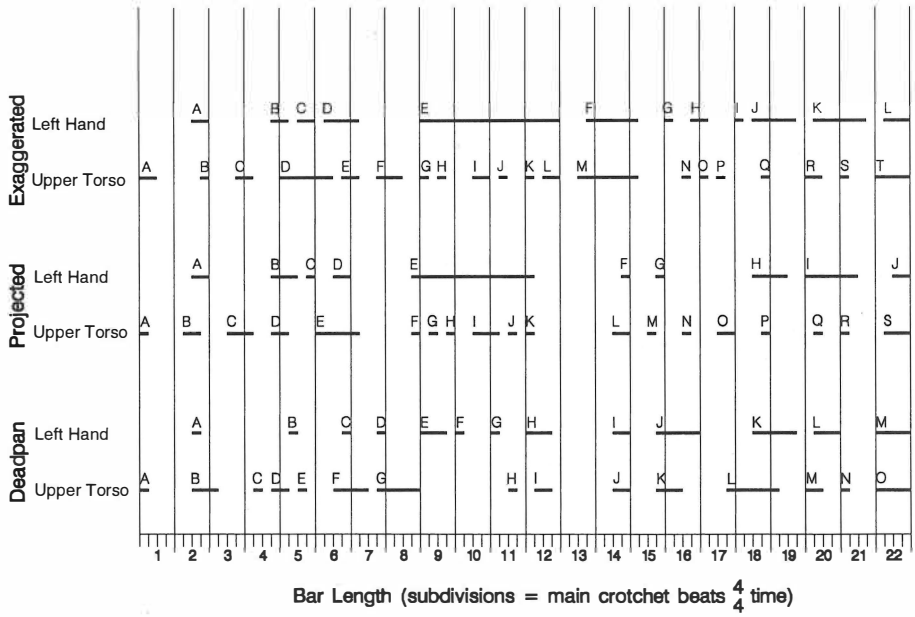


Figure 4:
Expressive locations are labels A to Z with horizontal lines representing the duration of these locations in musical time for Deadpan, Projected and Exaggerated intentions for performances of Beethoven's Bagatelle No. 11 in Bb major

ward swinging motion in the upper body which was in itself expressive. The following single comment captures what this signified to all the observers:

"See that [looking at the projected performance], he's telling me what he's doing through that forward and backward movement. Since all of that swinging is expressive, the specific moments I'm selecting focus on either the initiating impulse or ending to a swing cycle. Sometimes there is a particular movement embedded in the swing, and that sort of gives information specific to that moment. But it isn't any more informative about the expression of the piece than the swing itself. There look, he's sort of shaking his head and torso. [...] In the first performance [deadpan intention], there isn't a swing, just the sort of shake which is the specific movement."

Another observer provided information which resonated with commentaries made by the other observers about the hand's expressive function:

"The hand is interesting because it doesn't swing like the upper body, rather it moves in curvy ways. Sometimes it doesn't move, but it has a fixed shape congruent to that of the rest of its movement. I'd say it contains information very similar to the upper body. One thing I would add is that although the hand gives expressive information, it is not so even as

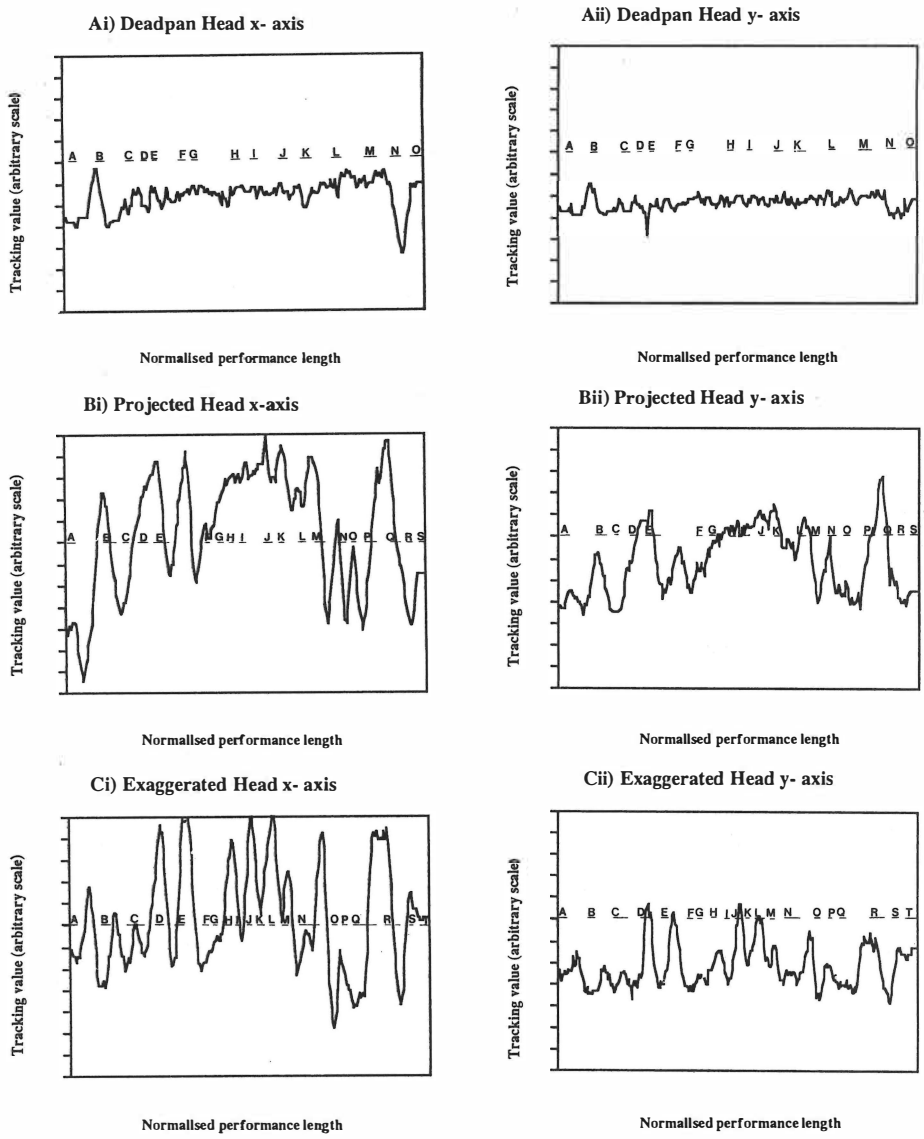
the upper body. I guess it is being constrained to note-playing a lot of the time, so it is really when it has a rest or a pedalled note it becomes free to give emphasis to its expressive message. If you like, its only telling the expressive story at those points, not the note-playing story as well. [...] You can see that in the middle of the performance [bars 9–12, exaggerated intention]. There are several individual hand lifts and curves all of which could be given specific locations, but the pianist is hardly playing any notes in his left hand, so his hand moves between these lifts in the same stylistic way, therefore, I rate it all as the same expressive moment."

Thus, the following key points emerged:

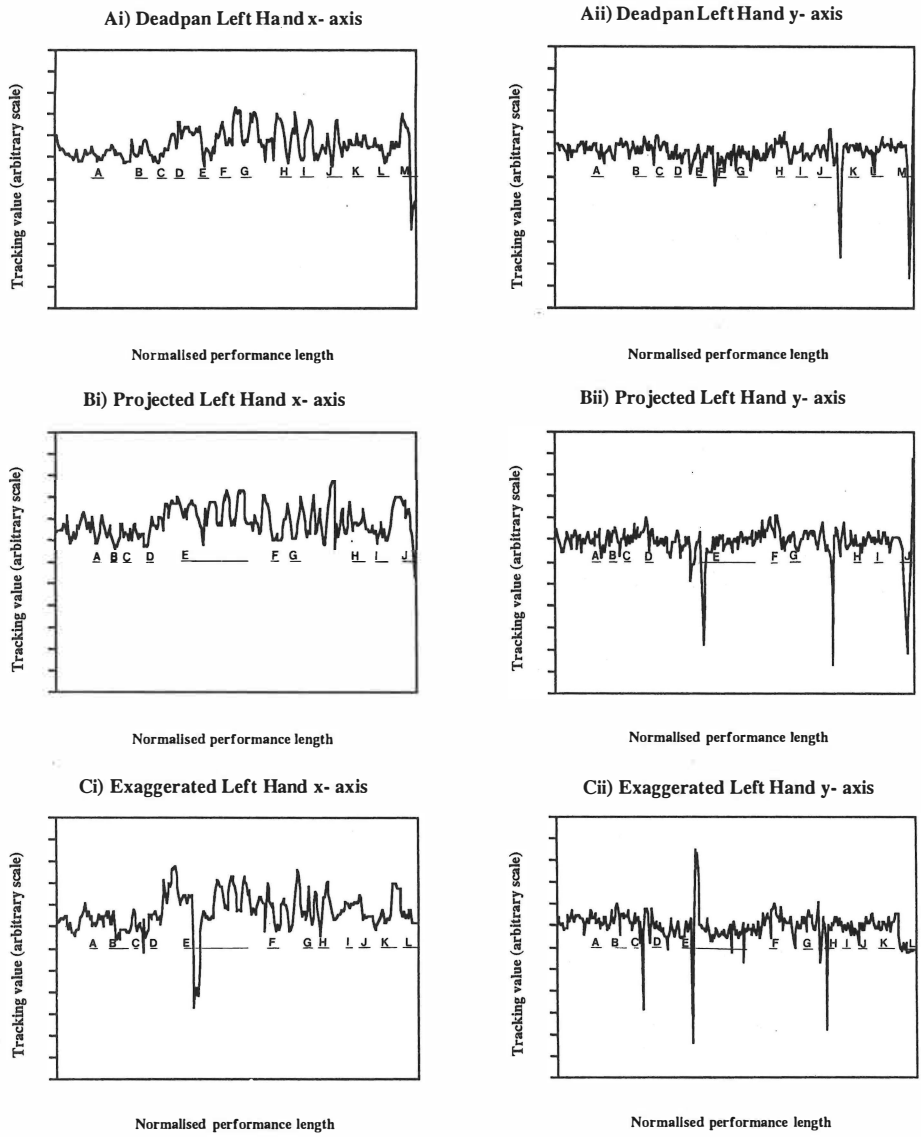
i) in the projected and exaggerated upper torso movements, there are moments that can be perceptually separated out, but these moments are of a similar expressive form as other, unnoted moments in the performance;
ii) the deadpan performance has the distinctive components, but no overall swinging;
iii) the hand is more directly affected by the musical score since it is actually involved with striking the keys, therefore, when it does not have to strike the keys, it has more potential to communicate expressive information alone.

These points provide an account for the differences in the durations of the expressive locations across the intentions. In the case of the upper torso, the performer may swing in a different direction in the different intentions, or at a slightly different rate of acceleration, therefore, the climax or end point of a swing cycle may be of a different duration across the intentions, though the climax and end point may be elicited by the same underlying musical structure. As for the hand, the differences between intentions shown in bars 9–12 seem to result from the hand not having note-playing constraints on it. Thus, once the hand is free to move it will move with varying degrees of expression depending on the intention. Therefore, if deadpan intention is least expressive, only isolated moments within bars 9–12 are perceived to be expressive, whereas in projected and exaggerated, the overall tone of the piece is expressive, therefore the individual movements become integrated as one continuous piece of expressive information.

Objective measurement data provide confirmatory support for these reports. This is done by examining the expressive locations in relation to the tracking patterns of the performer's movements. Figures 5a, 5b, and 5c illustrate the head and figures 6a, 6b, and 6c show the tracking data for the left hand. The head is chosen to illustrate the upper torso since in an analysis of the tracking data (Davidson 1994) was showed that head and shoulder area move to similar degrees. The expressive locations are indicated by solid lines and are lettered to correspond with the letterings of the expressive locations in Figure 4.



Figures 5A, 5B, 5C:
Expressive locations shown as solid horizontal lines on the movement tracks for the Head in Deadpan, Projected and Exaggerated intentions for x- and y-axes. Performances are normalised so that comparisons between the different performances can be made. A to Z labels allow for comparisons to be drawn between this and Figure 4
x-axis: Forward motions are shown as peaks and backward motions as troughs.
y-axis: Upward motions are shown as peaks and downward motions as troughs.



Figures 6A, 6B, 6C:
Expressive locations shown as solid horizontal lines on the movement tracks for the Left Hand in Deadpan, Projected and Exaggerated intentions for x- and y-axes. Performances are normalised so that comparisons between the different performances can be made. A to Z labels allow for comparisons to be drawn between this and Figure 4
x-axis: Forward motions are shown as peaks and backward motions as troughs.
y-axis: Upward motions are shown as peaks and downward motions as troughs.

The head locations clearly show the different rates of acceleration (the steeper the peak, the greater the acceleration), the swing cycles and how the locations correspond with either peaks or troughs in the cycle. The data also reveal that whilst the movements of the deadpan performance are of a much smaller scale, they are cyclical in pattern.

For the hand, much insight can be gained by examining the example of bars 9–12 with its different numbers of expressive locations across the different performance intentions. In the deadpan intention, bars 9–12 correspond to locations E, F, G and H. In terms of amplitude, these locations deviate by more than 1.8 from the mean tracking value for the whole piece, therefore, they represent outstanding physical features of the piece. In the projected and exaggerated performances, bars 9–12 correspond to location E and in both cases the standard deviation from the mean is large at the start of E (4.5 in projected and 6.2 in exaggerated intention), but then the rest of the section never deviates more than 0.3 from the mean, and is therefore far more consistent with the performance as a whole. So, the initial large deviation appears to provide the perceptual signal for an expressive location. But then, the rest of the movements are comparatively large and consistent with the overall size of movements in the whole piece. Therefore, it may be for this reason that they are perceptually easier to group the movements together.

Using the standard deviation from the mean calculation, these tracks also show the link between larger amplitude movements, musical structure and expressivity. Table I provides a summary of the locations with largest standard deviations for the head and hand separately. The specific number of locations selected includes at least the highest two deviations for each performance, plus corresponding deviations if they exist. Thus, there are five for projected intention head, but only two for projected intention hand.

However, this link between movement size, musical structure and expressivity is not absolute. In the case of the left hand, whilst most of the expressive hand movements are lifts, it is important to note that not all lifts are perceived as being expressive. There is a lift between locations G and H in Figure 6b which corresponds to bar 17 (cadence point with a rest in the left hand) which was noted as an expressive moment in both deadpan and exaggerated intentions, though there was no lift in deadpan intention. Whilst the deadpan result might suggest that the freedom of the rest does not elicit a lift since the deadpan performance is more constrained physically, and therefore, the small movement is consistent with the expressive intention of the intention. In the projected performance, however, the result is more difficult to interpret.

It is the verbatim report which provides one possible explanation for this result. Again, all observers commented on the lift. The essence of their commentary is encapsulated in the following statement by one observer:

"[...] that type of hand lift happened in the other performances, but here the performer just lifts his hand in the air for no apparent purpose. In the

Table 1:
Summary of the link between large movements, expressivity ratings and musical structure.

FIGURE	LOCATION	BAR	STRUCTURE
5a	B	2	phrase peak
	E	5	modulation
	N	20	cadence
5b	B	2	phrase peak
	E	6	cadence
	M	14	cadence
	P	16	ornamentation
	Q	17	phrase peak
5c	D	5	modulation
	E	6	cadence
	Q	18	cadence
	R	20	cadence
6a	J	16	rest
	L	20	rest
6b	E	8–12	rests
	J	22	rest
6c	D	6	pedalled minim
	E	8–12	rests
	H	17	rests

[Note that figure 5 shows head movements, Figure 6 shows hand movements and that a = deadpan performance, b = projected performance and c = exaggerated performance.]

other performances his hand communicates its meaning, by that I mean that the hand movement has a clear trajectory, and direction, even a shape."

Thus it seems that there needs to be a certain quality detected before a large amplitude movement is perceived to be expressive.

This explanation would provide further evidence to account for why moments of stillness or moments with standard deviations of less than 0.3 from the overall mean are perceived as expressive locations: essentially because they contain the overall quality of the intention. Indeed, one observer commented:

"There's not much difference in the sizes of these movements. Only in this case [points to an expressive location], there's a grace and dignity that is missing in those other bits."

Here is an example from one observer who is discussing why location A in Figure 5a was expressive:

"Just look at that: the first note is struck, the head nods slightly and then the body position is 'frozen'. This stillness gives the effect of a pose which

seems apart, yet by being detached, the pose is expressive. [...] That lack of movement characterises the whole physical delivery of the piece."

Once again, this commentary points to some qualitative difference which conveys the intention of the piece to the observer.

Together, these commentaries suggest that the style of the movement is important, and that there may be specific movement shapes used by the performer. It could be, therefore, that the qualitative differences between intentions stem from movements of similar amplitudes, but the actual shapes of the movements afford different expressive meanings.

Therefore it appears that whilst there is a high level of consensus between observers in their selections of the locations, and that the majority of the expressive locations occur at the same point in each performance though their durations vary across performance intentions, when the locations are viewed in association with the movement tracks and the musical score, they show:

i) there is a relationship between movement amplitude and expressive location, and a relationship between musical structure, amplitude and expressive location; however
ii) many unremarkable amplitude and still moments are perceived to be expressive whilst other large amplitude moments are not detected as being expressive.

5. General Discussion

The results of these two experiments indicate that expressive information is richly, but somewhat complexly available in the movements of the pianist studied. In the first experiment, for instance, the largest amplitude movements taken from the three differently intentioned performances were generally perceived as the most expressive moments. Even within this large amplitude movement range, the three intentions could be differentiated with large amplitude exaggerated movements being rated more highly than either large amplitude projected or deadpan movements. The low amplitude movements, on the other hand, were perceived as being the least expressive movements, but they were not as easily differentiated across intention. Moreover, the hands were more difficult to differentiate than the upper torso. These findings suggest that information was available variably throughout the performances. Certainly where smaller movements were concerned, it appeared that there was either no information about intention, or that the information was much more difficult to extract, and was perhaps more dependent upon the context in which it was embedded.

It became increasingly apparent in the second study, however, that even though high amplitude movements were the most perceptually obvious as expressive moments, not all large amplitude movements were detected as

being expressive. Conversely, there were many low amplitude movements or even moments of stillness which contained expressive information. Here, quality as opposed to size of movement became a salient perceptual cue.

In sum, these findings suggest that specific information about intention is perhaps limited to specific moments, and is therefore not continuous. Indeed, there is a significant link between identifiable expressive movements and musical structure. Therefore, it could be that it is only at these key structural moments that expressive intention can be found. Indeed, from the qualitative reports provided in Experiment 2, it appears that certain structural features of the music actually 'permit' the body to reveal the expressive intention very clearly – for instance, rests where the hand is free to display movement qualities; or in rubato sections where there is more time available to show the movement quality.

The variability in the informativeness of the upper torso and hands and the ability to identify discreet expressive locations appear to conflict with the principle of the centre of moment. That is, Cutting & Kozlowski's idea that all movements emanating from the physical centre of expression should be equally informative. However, there was some evidence in the second experiment of an overall informative movement in the continuous swaying in both projected and the exaggerated performances. The current study failed to address what caused the swinging motion in these intentions. Furthermore, it was unclear how the swinging patterns of the projected and exaggerated performances may have related to the movement in the deadpan intention, for again it was discovered that although the movements were very much smaller in the deadpan intention they were of a cyclical pattern. Yet, in the deadpan intention no perception of swinging was made. However, anatomically, the pianist's centre of gravity is located at his contact point with the piano stool, therefore, it may be that movements around this point (initiated in the hip region) are the movements from which all the expressive information is generated. Certainly the upper torso swaying has its origin in hip movement. Therefore, it might be that the potential for swaying was present in the deadpan intention, but since movement quantity and expression seem to be linked, the very small amplitude of the movements present in the deadpan intention perhaps meant that the swaying may not have been visible, though the potential to sway was always present. At the current time, this is speculation, but speculation that requires further serious attention.

Linked to the above, a more likely explanation of the variability of the findings might be explained rather more along the lines of Cutting & Proffitt's (1981) description of the centre of moment in which different parts of the body tell similar expressive stories but at different levels: that is, some areas are global indicators whilst others are specific to certain parts of the body. Indeed, it could be that the relationship between the head and hands is of this type: the upper torso being the more global indicator of expression, and the hand being a more local indicator. This

would account for the co-ordination between the body parts and the fact that the movements themselves are of different shapes. It would also account for the hands sometimes being ambiguous sources of expressive information.

The lack of a consistent expressive story for the whole performance, and the general link between the expressive locations and key musical structures, does of course show that expression, movement and structure are linked. Whilst the earlier studies (Davidson 1993, 1995) have revealed that the movement and sound expression are of the same type, a way to strengthen the case to demonstrate that musical sound and bodily movement are indeed inextricably linked is to ask listeners to rate the sound only from these performances to examine the relationship between the movement and sound expressive locations and the musical score.

Similarly, these studies show that movement quantity and movement quality have significant roles in the perception of expressivity. Subsequent work must address the investigation of the qualitative aspects of these movements more systematically. For example, semantic differential scales looking at each expressive location within each intention might provide important clues about the qualities of the movements within and across intentions. Also, movement coding might help to identify some of the particular movements commented on by the observers. These might provide further insights into the movements used by the performer and why these are detected to have particular qualities.

Clearly, a logical next step would be to consider the questions above using a range of pianists, rather than just a single player. However, the current case study, whilst not definitive, provides valuable descriptions not previously made, and raises crucial questions which psychologists, performers and audiences must address if they are to appreciate fully the perceptual role body movements have in communicating expressive information in performances. Moreover, understanding how expressive movements are produced is of great value especially if performance expression is to be more effectively taught.

References

Bharucha, J. J. (1987). Music cognition and perceptual facilitation: a connectionist framework. *Music Perception, 5*, 1–30.

Brown, H. (1988). The interplay of set content and temporal content in a functional theory of tonality perception. *Music Perception, 5*, 219–50.

Butler, D. (1989). Describing the perception of tonality in music: a critique of tonal hierarchy theory and a proposal for a theory of intervallic rivalry. *Music Perception, 6*, 219–42.

Clarke, E. F. (1989). The perception of expressive timing in music. *Psychological Research, 51*, 2–9.

Cohen, A. J.; Trehub, S. E. & Thorpe, L. A. (1989). Effects of uncertainty on melodic information processing. *Perception and Psychophysics, 46*, 18–28.

Cutting, J. E. & Kozlowski, L. T. (1977). Recognising friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society, 9*, 353–356.

Cutting, J. E. & Proffitt, D. R. (1981). Gait perception as a example of how we may perceive events. In: R. D. Walk & H. L. Pick (Eds.) *Intersensory Perception and Sensory Integration* (pp. 131–142). New York: Plenum.

Cutting, J. E; Proffitt, D. R. & Kozlowski, L. T. (1978). A biomechanical invariant for gait perception. *Journal of Experimental Psychology: Human Perception and Performance, 4*, 357–372.

Davidson, J. W. (1993). Visual perception of performance manner in the movements of solo musicians. *Psychology of Music, 21*, 103–113.

Davidson, J. W. (1994). What type of information is conveyed in the body movements of solo musician performers? *Journal of Human Movement Studies, 6*, 279–301.

Davidson, J. W. (1995). What does the visual information contained in music performances offer the observer? Some preliminary thoughts. In: R. Steinberg (Ed.) *Music and the Mind Machine: Psychophysiology and Psychopathology of the Sense of Music* (pp. 105–114). New York: Springer Verlag.

Gabrielsson, A. (1988). Timing in music performance and its relation to music experience. In: J. A. Sloboda (Ed.) *Generative processes in music: the psychology of performance, improvisation, and composition* (pp. 27–51). London: Oxford University Press.

Gabrielsson, A. (1995). Expressive intention and performance. In: R. Steinberg (Ed.) *Music and the Mind Machine: Psychophysiology and Psychopathology of the Sense of Music* (pp. 35–47). New York: Springer Verlag.

Kendall, R. A. & Carterette, E. C. (1990). The communication of musical expression. *Music Perception, 8 (2)*, 129–164.

Kozlowski, L. T. & Cutting, J. E. (1977). Recognising the sex of a walker from a dynamic point-light display. *Perception and Psychophysics, 21*, 575–580.

Kozlowski, L. T & Cutting, J. E. (1978). Recognising the gender of walkers from point-lights mounted on ankles: Some second thoughts. *Perception and Psychophysics, 23*, 73–96.

Palmer, C. (1989). Mapping musical thought to musical performance. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 331–346.

Palmer, C. & Krumhansl, C. L. (1990). Mental representation of musical meter. *Journal of Experimental Psychology: Human Perception and Performance, 16*, 728–41.

Shaffer, L. H. (1984). Timing in solo and duet piano performances. *Quarterly Journal of Experimental Psychology, 36* (A), 577–595.

Sloboda, J. A. (1983). The communication of musical metre in piano performance. *Quarterly Journal of Experimental Psychology, 35* (A), 377–396.

Sloboda, J. A. & Davidson, J. W. (1995). The young performing musician. In: I. Deliège & J. A. Sloboda (Eds.) *Musical Beginnings* (pp. 171–190). Oxford: Oxford University Press.

Todd, N. P. McAngus (1985). A model of expressive timing in tonal music. *Music Perception, 3*, 33–59.

Todd, N. P. McAngus (1991). The communication of self-motion in Musical Expression. *Proceedings of the International Workshop on Man-Machine Studies in Live Performance* (pp. 151–162). Pisa. CUNCE/CNR.