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EMOTION, BODY AND PERFORMANCE

Musical Embodiment and Perception: Performances, Avatars and Audiences

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1. Background

"Body movement can capture every musical nuance." The conviction expressed in this sentence may be regarded as the point of departure for a comprehensive aesthetic theory of musical performance, one that embraces performance, pedagogy, and audience participation. Borne out by several decades of experimentation with hundreds of musicians in workshop settings around the world, carried out by Westney, this conviction has found its crystallization in Westney's non-traditional format called "The Un-Master Class®" (UMC) which has become a potent tool in his practice-based research (Tommasini, 1997).[1] When Westney and Grund began collaborating in 2008, she recognized in his insights an incipient philosophy of intention that dovetailed with work she had been doing for years

1. The article is a profile of the UMC.

on the philosophy of music and meaning.[2] Of particular interest to Grund were the collaborative and synchronous aspects of meaning formation in the context established within a UMC; the contributions to the performance situation made both by performer(s) *and* audience members — contributions that normally receive tacit acknowledgement at best — are here made vivid and observable. Westney's insights stemmed from reflection upon his own performing experience, and from repeated encounters with performances by well-qualified graduates of music training programs; performances that were oddly impersonal and lacking in immediacy, believability and vitality.

The UMC has functioned as a traveling laboratory where non-verbal modes of interaction are used to externalize, articulate and communicate matters of musical intention and understanding. One of the truly unique features of the UMC is an extensive "warm-up" portion at the start, an exercise that sets the stage — and the atmosphere — for the live performances that will follow. The warm-up activities involve a large group including the performers and members of the audience. Some of these interactions are playful and some more serious. They activate the physicality of musical response in the group. It is important that these games of musical response be unrehearsed and unchoreographed; this allows the body to manifest what is heard in an unmediated way, without external guidance or received ideas. The warm-up is inspired by Émile Jaques-Dalcroze's theory of musical expression and understanding. According to this view, the way to grasp the characteristics of music most accurately and comprehensively is through the engagement of the entire body. In Dalcroze-based interactions, one can not only listen to music more insightfully, but also negotiate (non-verbally) its possible meanings with others.

For example, in various mirroring exercises the frequency of the leader-follower alternation begins to blur the distinction between these two roles, and also enhances awareness of the manner in which the resulting physical forms evince the mutual influence of both parties.

2. See, for example, the article "Intentionality, Food and Music. A Fictionalist Approach", a chapter from Grund's 1997 doctoral dissertation.

Fig. 1. From Grund & Westney (2010, p. 47).

In exercises like that seen in Figure 1, the performer is afforded the unique opportunity to see his interpretation embodied by others before his eyes, its musical qualities reflected moment to moment. Note the circuits of meaning formation and transfer that are here established: (1) the couple engaged in the mirroring exercise take turns as to who is leading and who is following, thus opening up for insights of an embodied nature into each other's particular experience of the music; (2) their movements are inspired by the music they are hearing and (3) their movements provide the pianist with input that influences the manner in which he plays — which then influences the circuit described in (2), which in turn inspires (1). As is evident, these processes are synchronously generating and transferring insights among the three participants.

In their article "Why Study Musical Gestures?" Marc Leman and Rolf Inge Godøy make a related point — that both performers and listeners embody musical experience through gesture in various musical contexts. Their view is that gesture lies at the heart of musical significance. "Seeing how ubiquitous music-related gestures are, and seeing the enthusiasm and joy that people express through these gestures, we conceive of musical gestures as an expression of a profound engagement with music, and as an expression of a fundamental connection that exists between music and movement." (Godøy & Leman, 2010, p. 3)

2. An Ideal Performance Situation?

The UMC creates, and works with, what one might call an ideal performance situation. The authors consider it ideal in the sense that there is performer/audience mutuality and the audience *matters* in the exchange; the audience is fully invested, and actively completes and expresses the tacit and palpable aforementioned "circuit of meaning" — something that human beings often *sense* while performing or while raptly sitting in a concert hall.

…but the real world of classical music is not like this idealized construct in a workshop. Performer and audience are in fact physically distant and the audience sits still, often in darkness. In the by now classic book *Musicking* from 1998, Christopher Small laments about the restrictive nature of a typical contemporary concert venue:

> The auditorium's design not only discourages communication among members of the audience but also tells them that they are there to listen and not talk back. The performance is a spectacle for them to contemplate, and they have nothing to contribute to its course. Such occasions as the famous riotous premiere of Stravinsky's Rite of Spring in Paris in 1913, one of the last occasions in the history of the Western concert tradition when the audience talked back to the performers, are now well in the past. Today's concert audiences pride themselves on their good manners, on knowing their place and keeping quiet. (Small, 1998, 27)

So, performer on stage, audience quiet, in their chairs and in the dark. This is the reality in which today's conservatory students will be plying their trade. The idealized world of the UMC can serve as an inspiring subtext for these performers, but in the vast majority of concert venues, the worlds of the performer and the audience remain separated.

Thus, in the empirical study we carried out and will be discussing in this chapter, we turn our focus on performer and audience separately. In each case we are using advanced technology to pursue findings based on exact measurements that were hitherto out of reach. In the case of the performer, three-dimensional motion capture recording and analysis. In the case of audience members, fMRI analysis of brain patterns, as well as data emerging from subjects' answers to a battery of questions about performances they have just seen while in the scanner.

3. Of Avatars, Musical Embodiment and Perception

In our empirical study, we investigated the effects that conscious variations in attitude on the part of the musicians themselves can have on the performance of classical musicians. This was done by:

(i) instructing each pianist first to play a given piece "as correctly as you can" and subsequently to play it again and "just enjoy yourself";

(ii) utilizing 3D motion-capture technology to video-record the light sensor-wearing performers as point-light figures playing in both aforementioned modes;

(iii) showing the videos with these point-light-figures now rendered as 3D-avatars to subjects who are in an fMRI scanner, and asking them to answer questions after each viewing;

(iv) producing three kinds of data analysis: (1) comparative studies based solely on the motion-capture data (2) basic statistical analyses of the answers from iii above as these were provided by musicians v. non-musicians (3) patterns of arousal in the brains of the viewers in the scanner.

The original impetus for our pilot study arose from the piano studio itself, from concerns about different teaching approaches and their effectiveness. Music teachers often find, to their surprise, that it can be counterproductive to give students lots of highly detailed instructions about how to get certain results and about how best to use different parts of their bodies in performance (even when it's all "good advice"); the teaching can backfire for the simple reason that it creates more self-consciousness. It asks the student to consciously supervise body parts, one at a time. When the body functions most naturally and beautifully, however, it does so with a unified and subtle coordination of every part that apparently surpasses what the mind can actually grasp. Physical tension can accumulate when one focuses intensely on outcomes ("I've got to nail every single note in this passage!") or on trying to micromanage specific body parts ("gotta keep the shoulders down, gotta keep the neck relaxed" etc.). The researchers in this study wanted to test the theory that giving students a deliberately non-specific and inviting suggestion — "Just enjoy yourself!" — might in fact take the pressure off, reduce the pressure of perfectionism, and open up the idea that "enjoyment" is valuable and actually *purposeful.* The aim is to experience a more holistic, self-trusting *gestalt* of comfortable, well-coordinated body movement that is more than the sum of its parts.

Philosophies of technique that trust the body's "wisdom" in this way have been well articulated over the years, in various ways — by Abby Whiteside (1961), Barry Green (1986), Eloise Ristad (1982), William Westney (2003) and others — and are certainly not foreign to the realm of piano pedagogy. As an example, in *The Art of Piano Playing*, George Kochevitsky points to the theories of Friedrich Steinhausen, published as early as 1905.

> Steinhausen stated that the body, left to itself, would find the right and sure way and would never go astray. "We cannot teach our body how to move but can only learn from it. … Steinhausen was one of the first theorists of pianism to outline a new and more reasonable approach to problems of piano … He pointed out the importance of purposefulness and force of imagination in the development of technique." (Kochevitsky, 1967, p.13)

Kochevitsky goes on to say, and authors of this article agree, that Steinhausen's statements tend to be too sweeping and simplistic, and thus rather easy to dispute. To be sure, it is never easy to formulate reliable verbal expressions of such experiential phenomena. There is, however, definitely something worth pursuing about the sort of technique Steinhausen tried to describe over a hundred years ago. So many musicians recognize from their own experience the delight and satisfaction of tapping into that which they seem to already "know" physically — even when the experience can never quite be analyzed or explained.

4. Experiment Phase 1: Motion Capture

Our research team included a pianist/teacher, a music philosopher, a mechanical engineer and a neuroscientist. Our work was funded by the Transdisciplinary Research Academy at Texas Tech University and also by Nordforsk (a research funding organisation under the Nordic Council of Ministers) through NNIMIPA: Nordic Network for the Integration of Music Informatics, Performance and Aesthetics.[3]

As indicated in the above, the experiment was based on comparing two "modes" of performance; one we called "correct mode" and the other "enjoyment mode." These terms came from the wording of the instructions given to each pianist in the laboratory. Each pianist played the same two pieces, and for each piece was instructed first to "play it as correctly as you can," and the second time to "just enjoy yourself (whatever that means to you)." The motion capture and fMRI technologies which we had at our disposal enabled us to compare these performances accurately, and from a variety of scientific perspectives.

Four pianists participated in the study, two males and two females, all deemed to be at an advanced level of performance. Three were graduate students, and the fourth an associate professor of piano. All were given the same two pieces to learn and memorize on their own, prior to reporting several weeks later to the motion-capture laboratory. These two pieces, each about a minute long, were "Scherzo" by Johann Nepomuk Hummel and "Cowherd's Song" op. 17 by Edvard Grieg (see Appendix). These were chosen because (1) they are fairly easy to learn and memorize (2) they are not very well known, therefore likely to be unfamiliar to the participants (3) they are contrasting in their character and pianistic demands: the Hummel rather quick and sprightly with several jumps and scalar runs, the Grieg warmer, slower, more heartfelt.

At the time the participants were initially given the pieces to learn, they were told simply that the study would involve a study of body movement in performance, which is why the experiment was being conducted in a mechanical engineering laboratory. They were told nothing of the hypotheses behind the study. The motion capture system used for experiments was an eight Eagle 4 infrared camera system (Motion Analysis®) (Cloutier *et al.*, 2011). Only the upper body was modeled because the piano would obstruct lower-body markers and because there is little movement in the lower body during musical performance. Forty-six surface light-sensing markers were used, from which twenty-three virtual markers were created. Marker placement is shown in Figures 2, 3 and 4.

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3. See www.nnimipa.org.

Fig. 2. The laboratory setup.

Fig. 3. Detail.

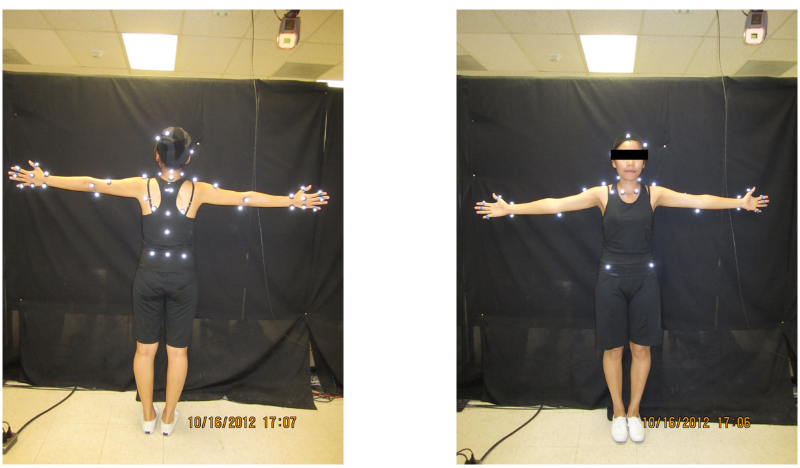
a  b

Fig. 4. Marker placement: *(a)* back, *(b)* front.

When these dots subsequently are connected on the resulting video, a byproduct of this analysis of a performing musician emerges: a 3D video rendering showing an animated point light "stick figure" which may be observed by simple inspection in its own right. This animated avatar is a concrete manifestation of the abstracted formal motion of the musician. This is a truly new tool in the history of methods available to us for empirical music research, allowing for the exhibition of qualities of the performing musician that previously only could be abstracted in our imagination.

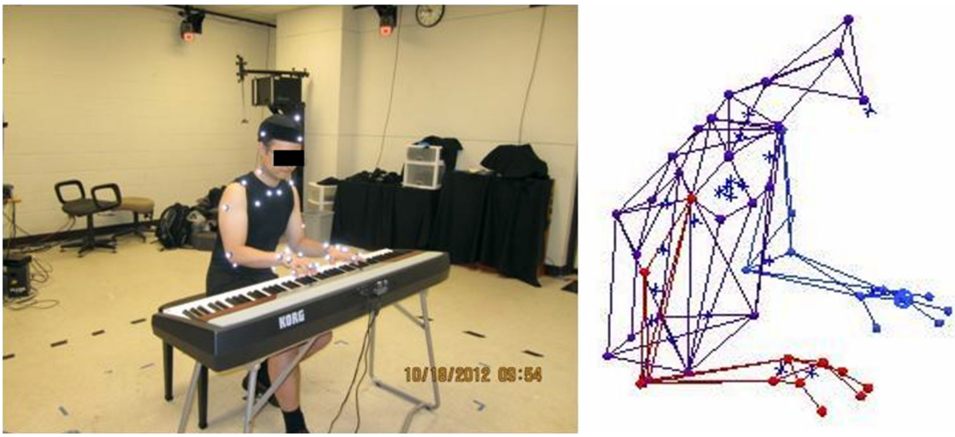


Fig. 5. Dots combine to form point-light avatar.

The pianists were assigned individual appointment times in the laboratory. Once all the markers had been applied, they were seated at a digital piano, ready to play the Hummel piece and awaiting instructions. Their rendition of Correct Mode ("As you play the Hummel, think about performing it as correctly as you can — whatever that means to you") was repeated several times in order to get a good motion-capture recording.

Next, the Hummel piece in Enjoyment Mode ("Just think about enjoying yourself while you are playing — whatever that means to you.") was also repeated a few times. Then the same sequence was applied to the Grieg piece. Thus, each pianist furnished us with four performances for the study: two of Hummel (one in each mode) and two of Grieg. With four pianists participating, we eventually had sixteen recordings to analyze and compare.

The motion-capture recordings distill movement to its three-dimensional essence, and the measurements are made in precise coordinates. Taking advantage of the three-dimensional aspect of motion-capture technology, we chose to rotate the recordings in a consistent pattern in order to afford viewing from different vantage points. Since the right and left sides of the body are color coded, it is easy to keep track of what one is seeing even while the image slowly spins. Thus we could compare and chart how each pianist used his or her body when playing the same piece in each of two contrasting modes. (It is important to note that no reference to gesture or movement was ever made in the instructions they were given). In terms of piano technique we were interested in observing, for example, whether a pianist in Enjoyment Mode would inscribe a more generous arc with the arm when navigating a large jump from one pitch to another. Although piano technique is somewhat controversial, many would consider this a sign of healthy and unconstricted movement. Another theory we wanted to test was that there might be more frequent little "micro" changes of direction in the arm or hand during Correct Mode — a slightly jerky quality, one might say — due to a fussier over-controlling of note accuracy. If so, a case could again be made that there was better technique in evidence during Enjoyment Mode, since performers were less encumbered by those nervous little changes of direction that are very likely to cause muscle tension and fatigue.

5. Data analysis of physical movement

Before any comparisons of physical movement could be carried out, the data needed to be normalized with respect to two important variables. (1) Timing: as one would expect, the performances are not done at exactly the same tempo, and are also inconsistent with regards to use of *rubato*, etc. (2) Physical size and proportions of the pianists: taller, shorter, longer arms, etc. The motion-capture software records at the rate of 120 frames/second, and the technical team was able to achieve normalization so that all the performances of a given piece occupied the same number of frames. This was done by dividing each piece into shorter segments, which permitted direct comparisons to be made. One way to compare performances is to choose one pianist and measure the corresponding movement of a specific joint center at a specific passage in the music. Some examples of such comparisons (note that Enjoyment mode is seen in blue, Correct mode in red); one subject, one joint center (spine end), three different variables during a performance of Grieg:

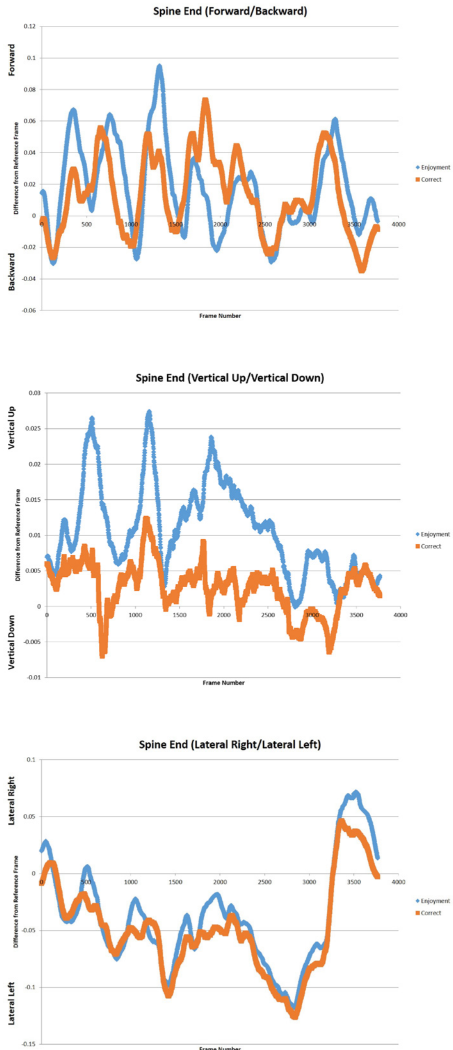


Fig. 6. Spine end movement, Grieg (one subject).
Some signs of larger and "simpler" movement in Enjoyment Mode.

Here is a right-hand arc comparison for one pianist, at a place in the Hummel where the hand must relocate by jumping more than two octaves downward:

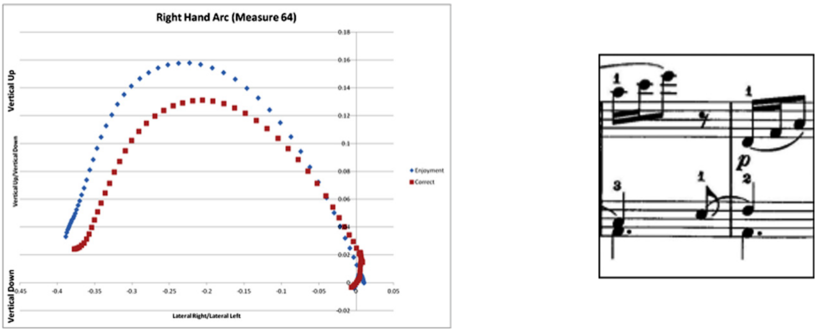


Fig. 7. Right hand arc, Hummel. Enjoyment Mode blue, Correct Mode red. Enjoyment Mode arc inscribes a larger gesture.

Another way we studied the data was by charting aggregates of what all four pianists did with the same music.

Here (fig. 8) we see all subjects, each with a distinctive color, performing the entire Grieg piece in Correct Mode:

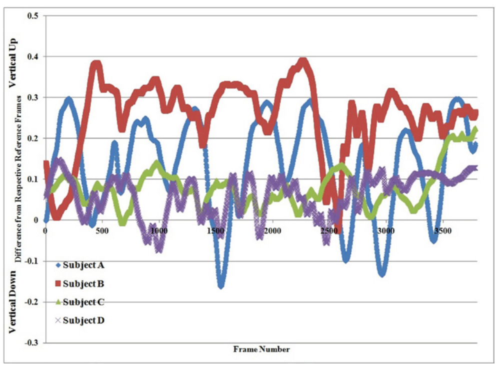


Fig. 8. Correct Mode aggregate (Grieg).

And here (fig. 9) in Enjoyment Mode:

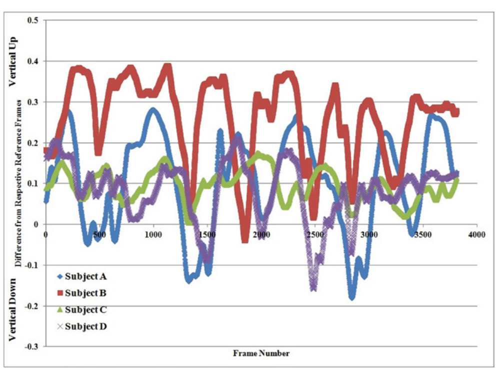


Fig. 9. Enjoyment Mode aggregate (Grieg).

Looking back and forth at the two preceding charts, we find that our hypothesis seems to be generally borne out: that Correct Mode playing is a bit more jerky and constricted on the whole than Enjoyment Mode playing.

Another way to represent the results was with bar graphs, representing all the joint centers that were measured. This shows the amount (not the shape) of movement at a glance. In Figure 10, for example, we have a representation of Subject A playing the Hummel piece:

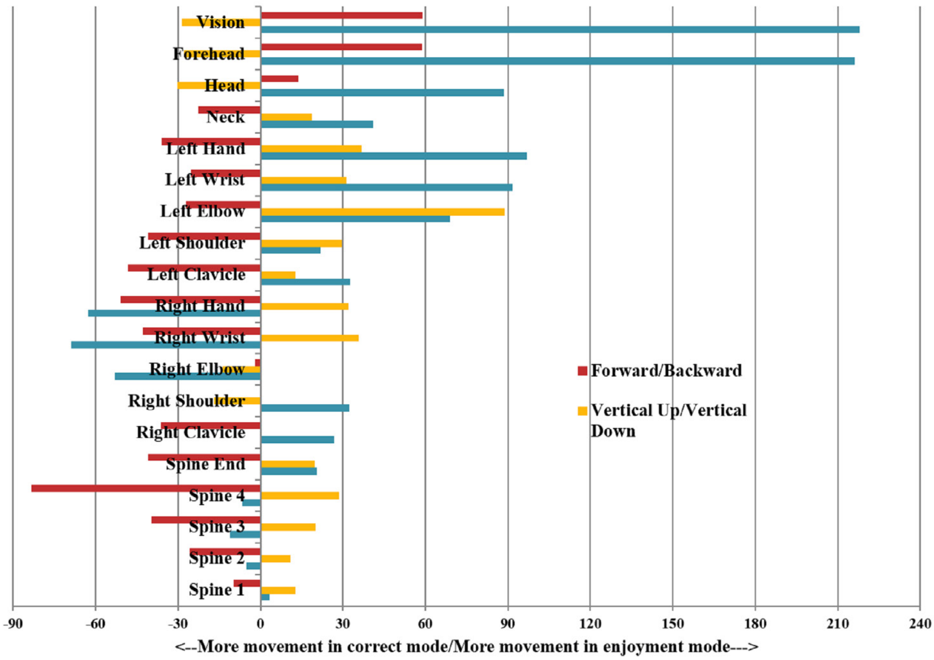


Fig. 10. Magnitude of movement in two modes (Hummel).

Everything to the left of the vertical axis displays where there was more movement in Correct Mode; everything to the right of the vertical axis shows the same for Enjoyment Mode. As we can see, Enjoyment Mode seems to encourage considerably more freedom and movement in several areas and directions, most notably in the head, which is the joint center least involved in the act of playing the right notes.

Figure 11 presents a more extreme example (Subject D playing the Grieg) of much more generous motion in Enjoyment Mode than in Correct Mode.

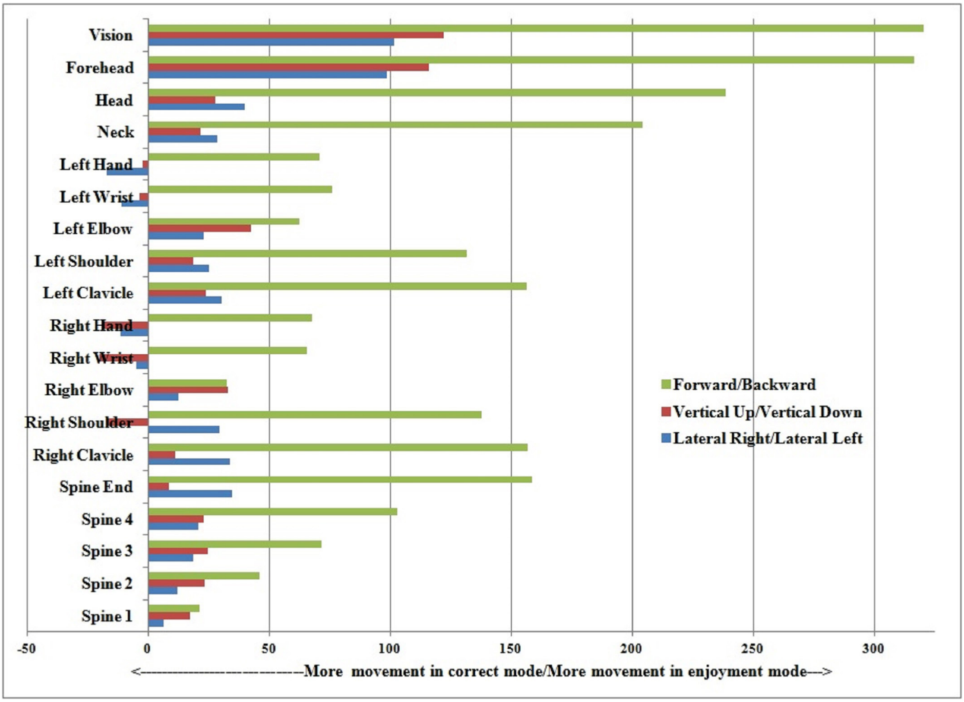


Fig. 11. Magnitude of movement in two modes (Grieg).

Generally speaking, even though the patterns varied considerably among our four pianists, the findings seem to support our hypothesis that gesture and movement at the piano in Enjoyment Mode is more (1) ample and (2) smooth than in Correct Mode.

6. Experiment Phase 2: fMRI scanning

Functional magnetic resonance imaging (fMRI) is a technology that uses differences in the magnetic properties of oxygenated relative to deoxygenated blood flow to reflect the degree of underlying activity in a given brain region. fMRI technology permits us to observe the brain activity of someone watching and listening to an avatar such as the ones described in the foregoing.

Our focus had now shifted from performer to perceiver, *i.e.* the audience. We wanted to know if subjects in the scanner, watching the pairs of motion capture videos (each pair consisting of the same performer, same piece, performed in two modes) would be able to perceive differences between one mode and the other, and in what way. We wanted to know if the quality of "enjoyment" was transmitted from performer to audience, and if the audience recognized musical values associated with this quality. Thus the subjects in the scanner each had to answer a battery of questions after each viewed performance, and those responses were later tabulated. We also monitored their brain activity during the entire process. Since we had recruited two categories of scanner subjects — four trained musicians and four non-musicians — we were curious about how the responses and patterns of arousal in brain regions might or might not be different from one of these groups to the other. This aspect turned out to be among the most interesting results of our analysis.

Eight subjects (for the sake of clarity, none of these subjects were among the four pianists in the motion capture experiment), ranging in age from 21 to 70, were placed in an fMRI scanner: four trained musicians (three males, one female) and four without any significant musical training (males), but who had been identified as appreciators of classical music. Prior to entering the scanner, each subject met with the researchers for orientation about what to expect from the experiment, the importance of keeping still in the scanner, etc. They were told that they would be seeing and hearing videos that would be projected from a computer screen. The videos were described to them as piano performances done by real people, who would appear as dot-line avatars, all playing the same two compositions. Participants were informed in general terms that they would be asked some questions following each video, questions about various qualities of the performance they had just viewed. They were instructed in the mechanism for answering these questions, which was by means of a fiber-optic device held in one hand that would allow them, through miniscule fingertip movements, to select a response to each question on a seven- point Likert-type scale that ranged from "Strongly Disagree" through "Neutral" to "Strongly Agree." (see fig. 14). Thus this phase of the study furnished both behavioral responses to the videos (answering the questions) and neurological (brain) responses, which were monitored constantly.

Fig. 12. Adjusting the reflective viewer.

Fig. 13. The fiber-optic device for answering question.

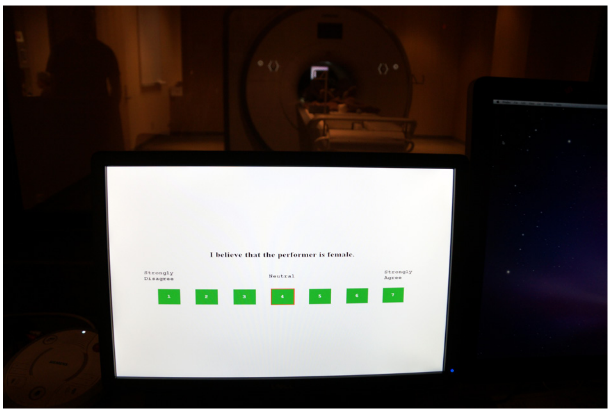


Fig. 14. The scale used to rate responses.

We used a 3T MRI system (Skyra, Siemens) —and acquired T1 anatomical and EPI functional images during task performance. As with all fMRI machines, the mechanical noise is quite loud during scanning. For this reason, subjects were fitted with headphones through which to listen to the performances; while these were helpful and did make the music audible, the phones could not totally remove the intrusiveness of the constant mechanical roar.

Each subject viewed eight videos, *i.e.* four pairs of videos. In this context, a "pair" means one performer playing one of the pieces in both Correct and Enjoyment modes. Each subject got a chance to view each of our four pianists (performing a "pair" of either Grieg or Hummel). The videos were randomized in several respects: the order of the pieces, the order of the performers, and the order of Correct and Enjoyment modes within the pairs. The twelve "questions" were actually statements with which subjects could agree or disagree on a seven-point scale, and while these statements were identical for each video, they too were presented in randomized order.

The twelve response statements:

1. While watching the video I wondered what the gender of the performer might be.
2. I can imagine my body moving in a similar way to that of the pianist in the video.
3. The tempo (speed) of the piece seemed just about right.
4. The performance held my attention throughout.
5. I believe that the performer is female.
6. It seemed that the pianist was enjoying playing this piece.
7. This performance gave me pleasure.
8. Watching the performer's movements made me pay closer attention to the qualities of the music.
9. This video of a performing stick figure is somehow more informative than a conventional video of a performing pianist.
10. There seemed to be a good match between the movements of the performer and the qualities of the music.
11. Despite the presence of mechanical noise in the room today, I can enjoy listening to the music.
12. I am often in situations where I am listening to music while other sounds are intruding as noticeably as they are now.

Fig. 15. Anatomical Brain Scan.

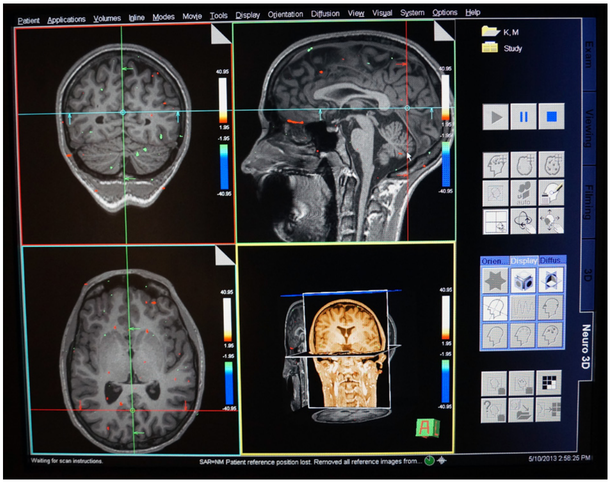


Fig. 16. Functional Brain Scan.

7. Analysis of Observers' Responses

The most straightforward task of data analysis in this part of the study was the tabulation of answers to the twelve response statements. Naturally, our first question was whether or not Correct Mode and Enjoyment Mode performances registered differently with viewers, and, if so, in what ways. Since each subject had also been recruited as either a "musician" or a "non-musician," we were also curious about possible distinctions in response between these two groups.

When results were tabulated as two groups — musicians and non-musicians — the responses were strikingly different in many cases. Not only did the musicians discriminate more keenly between one mode and the other, but their responses about aesthetic qualities were registered much more quickly and decisively than those of non-musicians. In other words, if they discerned satisfying qualities in an Enjoyment Mode performance that the Correct one didn't have, they seemed to report this instantly, without having to contemplate.

Some of the more suggestive sets of answers:

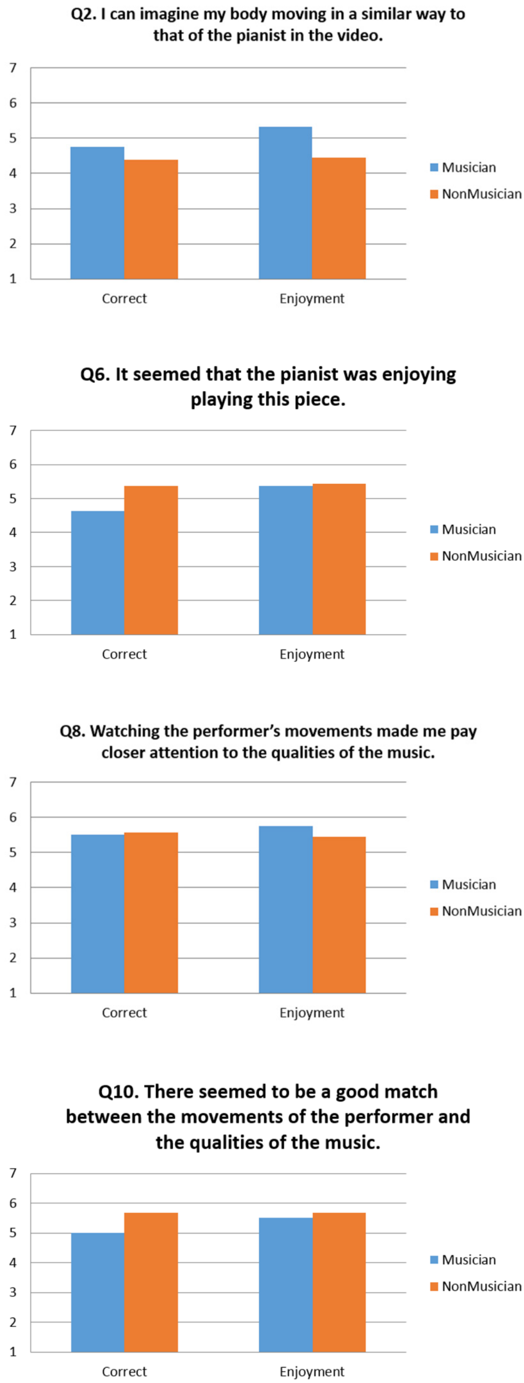


Fig. 17. The numbers on the left of each graph correspond to points 1 – 7 on the response scale: taller bars indicate stronger agreement with the statement, and 4 is a neutral position.

8. Brain Activity

The images of brain activation in the two groups of subjects appear to show distinctions between the responses of musicians and non-musicians. They also demonstrate that the two performance modes did indeed elicit different neurological response patterns, much of the time.

The following is a composite image (Figure 18) of the brains of *all* subjects viewing *all* videos, showing the area more activated in Enjoyment Mode than in Correct Mode. Please note that the images are reversed left to right. The red area in the third image of the top row is the Right Inferior Frontal Gyrus (BA 48). This area is responsible for executive control and plays an important role in emotion processing, as well as some aspects of pitch processing.

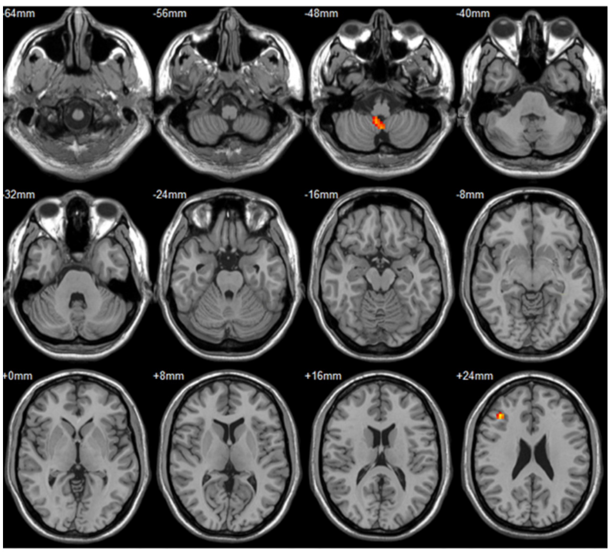


Fig. 18. Areas more activated in Enjoyment Mode than Correct Mode.

In Figure 19 the same composite shows a somewhat different kind of activation more in Correct Mode than Enjoyment Mode (second row, second image). In this case it is the Left Angular Gyrus (BA 39), which plays a role in analytic evaluative judgment and also mediates some aspects of imitation learning. There was increased blood flow to the cerebellum for all subjects, watching both modes; this indicates that a form of motor learning was taking place.

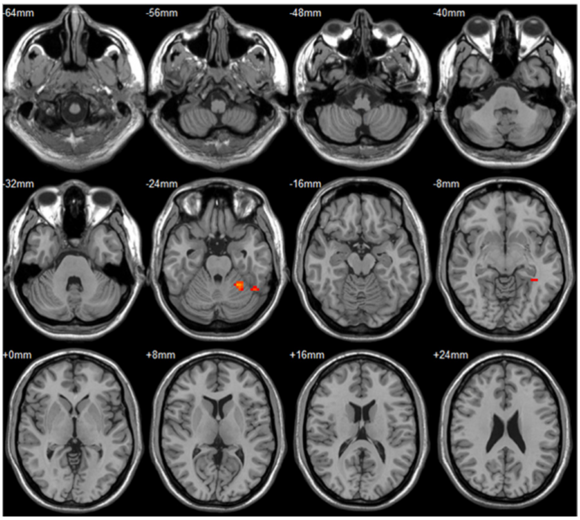


Fig. 19. Areas more activated in Correct Mode than Enjoyment Mode (all subjects).

Perhaps the most striking set of data that resulted from our experiment was the difference in brain response between the musicians and non-musicians. When data for the two groups were separated out and compared, we found that the brains of the non-musicians showed virtually no particular activity patterns that weren't shared by all the subjects. The musicians, on the other hand, responded more comprehensively and in patterns not shared by the non-musicians — most notably while viewing Enjoyment Mode performances. These areas in shown in red in Figure 20:

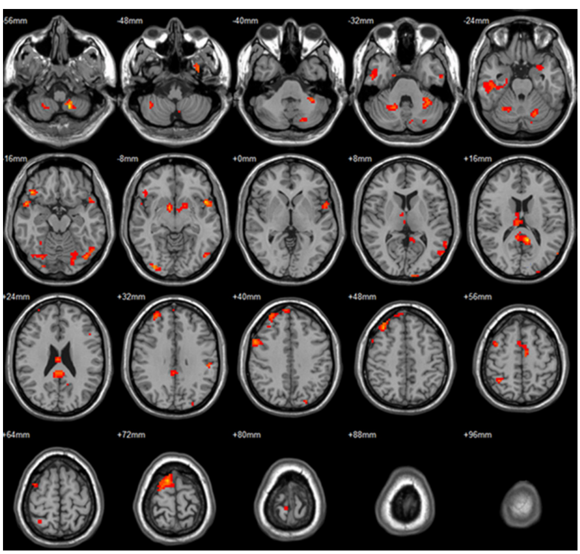


Fig. 20. Areas where only the musicians responded to Enjoyment Mode.

Among the most significant of these is the Right and Left Supplementary Motor Cortex (BA 6): This activation was greatest in the Enjoyment Mode, but there was also some evidence of it in Correct Mode — once again, only for musicians. This region is hypothesized to contain "mirror neurons" which are important for processing and performing actions, and particularly important for learning by imitation. Mirror neurons are also known to play a role in perception/action coupling, skilled movement control and some elements of emotion processing. Other areas of interest in the musicians' response to Enjoyment Mode are the Limbic lobe (Right Parahippocampal Gyrus, BA 30 and the Left Retrosplenial Cingulate Cortex, BA 29): The parahippocampal gyrus is important for memory encoding and retrieval, while the retrosplenial cingulate cortex is important for attentional processes, particularly on-line error checking, and plays a part in emotion processing.

9. Further discussion

9.1. *Correct vs. Enjoyment*

9.1.1. *Are we implying that enjoyment and correctness are by definition different?* – While we set up a dichotomy between enjoyment and correctness for the purposes of the study, as contrasting intentional mindsets that could be observed and compared behaviorally, we do not mean to imply that enjoyment and correctness are mutually exclusive. It is possible (although perhaps not common) for musical performers to have had a sort of training from the beginning whereby every step of development, from the earliest building blocks through the most rigorous discipline of advanced levels, is experienced as enjoyable. In general, though, musicians we have spoken to about this study do find the enjoyment/correctness contrast to be one that makes sense and that does relate to their own experience. On a broader view, the discussion of the correctness/enjoyment distinction leads to some rather provocative questions. Why would the most enjoyable way to do something *not* be the most correct way? Is there an equivocation lurking here with regard to the word "correct", and if so, why? It seems, on the one hand, that well-founded instrumental pedagogy should only concern itself with "correctness" of a kind that leads to better, more body-utilizing performance. What else would it be doing? Maybe the key here is that "correct" is actually embedded in "enjoyable", in the sense that "enjoyable" is correctness-as-integrated-into-the-performer's-bodily-self-understanding. This is why this method of instruction only makes sense after the student has reached a certain level of expertise, so that he or she has become aware — both consciously and on the embodied level — that doing things correctly has a "feel" that promotes enjoyment. All of this raises deeper issues regarding *fun* and *skill*, but rather than wander off topic, we prefer simply to acknowledge that we are aware of these, and that insights generated by the empirical work here described may be brought to bear on them.

9.1.2. *Are we assuming that classical performers should be enjoying what they are doing?* – Let's say we are; what would be wrong with that, unless one were committed to some sort of view that classical performers comprise a kind of priesthood. One can, however, continue to pose questions. Are we conflating *enjoyment* with *fulfilment* or some related concept? On our view, it is rather clear that enjoyment is not unrelated to notions such as "engagement" or "absorption" and we are open to and planning on further conceptual analysis in order to explore these interrelationships.

Does enjoyment imply lack of rigor or low standards? There is surely room for much discussion here, but it is of interest to read what a pianist of no less stature than Charles Rosen relevantly remarks: "If there are still pianists in the twenty-second century, there will be a public willing to listen to them, but it is the physical pleasure of playing as well as hearing the piano that holds the key to the future of the music written for it" (Rosen, location 2336, 2002).

9.1.3. *How advanced does a musician have to be before the invitation to "enjoy yourself" can be a productive one?* – This is a real concern, since an unschooled pianist who happens to prefer (for example) to play in a hunched-over position with collapsed fingers and contorted wrists would probably just do more of the same, perhaps even more gleefully, when invited to "enjoy yourself." The theory behind our experiment was that the pianists had already learned and absorbed some healthy principles of alignment and overall technique. At that point, relaxing and trusting what they know has much more beneficial potential. Teachers of already well-trained students are the ones most ideally positioned to make profitable use of the "enjoy yourself" idea.

9.1.4. *Does the enjoyment/correct continuum hold relevantly in other realms of performance, such as sports?* – In previous work we have considered the relationships between music and sport, going so far as to suggest that the two are connected by a kind of continuum (Grund & Westney 2012). In this spirit, it thus seems that some insight into the issues at hand here with regard to music could be provided by contrasting and comparing with the case in sports. Are athletes before an event ever told "just go out there and enjoy yourself" as a strategy for reaching optimum performance levels? In many cases, perhaps primarily those of individual athletes, the answer to this would seem to be yes. Coaches say it, and top-flight athletes report that they frequently remind themselves to just "have fun," and they do this quite purposefully. This harkens back to the pedagogical philosophy that launched our experiment at the outset — namely that in important respects, the body is more brilliant and subtle in its awareness of technique than the mind is, and that our main intention, at high levels of performance, is to find ways to keep the mind from "interfering." The athlete — whether competing against other athletes or trying to match or outdo his/her previous performance — certainly needs to be engaged at an all-encompassing level, even so as to enter into an almost altered state of being in what often is referred to as a "zone." The widely credited concept of "flow" (Csikszentmihalyi 1990) conflates high performance (whether in sport, music, or any other skilled pursuit) with the sense of ease and bliss.

9.1.5. *So why avatars?* – At this point, the question might arise: Why avatars? — Why did we not simply videotape the musicians and observe the responses of subjects in the scanner to the resulting conventional videos? As noted previously, the avatars produced by the motion capture technology may be rotated for viewing from quite literally any angle and their transparency allows for viewing parts of the body simultaneously that in a natural viewing situation would be in configurations where some would block others. In addition — and importantly — research of very recent vintage (originating within the last two decades) has revealed that our human perceptual abilities seemingly are designed to synthesize information so as to produce quite immediate verdicts in us as to rather "intentional" qualities of a moving humanoid figure when we only are supplied with the moving trajectories of a limited number of points tracked on the figure. (The reader is referred to http://www.biomotionlab.ca/walking.php and http://www.biomotionlab.ca/Demos/BMLwalker.html for some excellent illustrations.) Producing the avatars from the individual musicians permits us to employ this perceptual ability when observing these performances in such distilled form.

This has led us to adopt as a point of departure that the avatars have an informational content that permits more direct recognition of properties on the part of a mere observer, as well as more direct appropriation of them on the part of an observer-student, who wishes to integrate some feature of the movement patterns exemplified by the avatars into his or her own bodily movement.

9.2. *Possible Supporting Evidence for Mirror Neurons*

The existence and function of mirror neurons has been the subject of much controversy during recent years, but appears to be gaining acceptance with the passage of time and the accumulation of empirical data. The neuroscientist with whom we were partnered in this team experiment regards that indeed this experiment itself contributes positive evidence for the existence of mirror neurons: Further analysis of the data suggests that evidence is provided that is consistent with the activation of mirror neurons in the musicians, but not in the non-musicians. Musicians activate this region in both the correct and the enjoyment mode, but more so in the enjoyment mode.

Since we view audience engagement as an active part of the formation of musical meaning in performance, we find a natural resonance in the mirror-neuron theory. It provides a scientific correlate for theories of movement-based interpersonal empathy that already exist in music aesthetics. For example, Roger Scruton, equating musical response with human motion, writes, "In 'dancing with' the music you are also conjuring an imaginary other with whom you move, and taking an interest in his movements, for their own sake, and for what they intrinsically mean. In responding to a piece of music we are being led through a series of gestures which we imagine as the gestures of the 'other' with whom we move" (Scruton, 2009, p. 53). In addition, Marc Leman writes:

> The core mechanism for understanding social interactive gestures can be understood in terms of embodiment. More particularly, it is the mirroring through which "my" perception of "your" movement is grasped in terms of the (overt or covert) deployment of "my own" body movement in the environment, so that "your" movement is corporeally understood as an action. This mirroring may ultimately account for the fact that we perceive the (sonic) moving forms of music as gestures (Leman, 2010, p. 142).

9.3. *Conclusion*

Future studies in this vein would be intriguing, especially if they could involve more performers and more observers. With regard to both the motion capture and the brain scanning phases of the study, a greater number of subjects would lend more reliability to the results achieved; therefore our findings should be viewed as preliminary ones, as indicative of interesting trends, rather than as definitive research results.

It was nevertheless gratifying to discover observable and scientifically measurable changes, of a seemingly positive nature, in the physical performances of pianists who have been invited to "just enjoy yourself". Equally encouraging was the way in which the enjoyment factor could be detected by a good number of observers, whose brains responded with more vivid engagement in such performances. Since the satisfaction derived from musical performance is not a trivial aspect at all — it is the most fundamental reason for music to exist, many would say — piano teachers who integrate "enjoyment" into their vocabulary in the studio, in both technical and interpretive circumstances, are working in a very appropriate context.

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Appendix: Overview of research relevant to this article*

In the literature, numerous studies have examined the relationship between musical performance and body motion. A compendium of philosophical and empirical analyses of musical motions, or "gestures," can be found in Godøy & Leman (2010). Many have sought to analyze what differences in motion may exist when a pianist plays a piece with a greater or lesser amount of expression (Clarke and Davidson, 1998; Davidson, 2007; Thompson, 2007; Shoda and Adachi, 2012; Thompson and Luck, 2012; Castellano *et al*., 2008). Each study concluded that there is a definite connection between what might be termed concrete physical motion and the abstract concept of musical expression.

One study investigated four expressive performance modes: "deadpan, normal, exaggerated, and immobile" (Thompson and Luck, 2012). The researchers used eight subjects and an eight-camera motion capture system to compare how long each performance mode took as well as how much movement there was per measure. An analysis of variance was performed to determine if there was a greater difference in motion in the head and torso between modes than in the wrists and hands. The results demonstrated that there was a difference in movement for body parts such as the head for all mode comparisons except between immobile and deadpan; the left wrist exhibited the least amount of difference in movement among modes. Also, only small differences in movement were found between the deadpan and immobile modes, suggesting that playing with little expression is closely related to playing with little movement. A study by Thompson (2007) used three expressive performance modes—"minimum, normal, and maximum"—with three subjects and a musical piece by Brahms. The motion capture results of the study demonstrated that a pianist's expressive movements were directly related to the amount of expression intended for each mode.

A similar study by Davidson (2007) used three modes with a single performer: in deadpan, normal, and exaggerated modes, in part to analyze the effect that expressive musical performance has on body movements. The results indicated that the subject used specific, identifiable movements that went beyond the usual motion level of his or her musical performance. An earlier study, Davidson (2002), also reported that a pianist who performed the same piece of music using different types of expression had varying amounts and types of associated movement. In another study Clarke and Davidson (1998) had one professional performer play a piece by Chopin six times, two of which were analyzed. These performances were recorded with a video camera. A unique aspect of the investigation was that the subject was never told to play in any particular way. Three types of data were analyzed: Musical instrument digital interface (MIDI) data for expressive timing and dynamics; head position data, sampled five times per second during each studied performance; and expressive head gestures obtained from systematic observation of the recordings. Significant body sway was detected which did not match the piece's musical structure, and, while there were strong similarities between the two trials, there was no fixed relationship between movement and the structure of the piece.

Castellano *et al.* (2008) studied the effects of playing a piece with differing emotions on the part of the performer. The subject played one piece in five different emotional contexts: sad, allegro, serene, over-expressive, and "personally felt affect," the last being a mode of

* This is an adaptation of a review of literature completed by Aimee Cloutier, Jesse Latimer and James Yang of Texas Tech University, and we gratefully acknowledge their contribution.

expression that the pianist thought best interpreted the piece. Upper-body movement and head velocity were analyzed with respect to time. The authors found that sad movement produced less motion than the serene or personal modes. It is also interesting to note that overall quantity of motion was not as indicative of expression in the music as compared to head velocity.

Another motion-capture experiment (Van Zijl and Luck, 2013) focused on audience perceptions of various expressive intentions on the part of four different violinists all playing the same "sad" passage. In this study the various modes of performance (not revealed to the audience) were called technical, expressive, and emotional — in this case "emotional" meant asking the performers to access a deep personal sadness while they played. Watching motion-capture videos, the audiences discerned clear differences among these three modes of performance, and their preference was for the artistically "expressive" mode, which they found the most satisfying.

Shoda and Adachi (2012) sought to discover the relationship between upper body movement and degree of musical expression. Three modes were used, namely deadpan, exaggerated, and artistic, while playing two differently structured musical pieces. The artistic mode was meant to reflect the true nature of the music and was therefore used as an interpretive backdrop to which the other two modes were compared. The more energetic musical piece created more movement differences among the modes of expression, while the slower musical piece produced a motion difference only between the deadpan and artistic modes.

When it comes to the use of fMRI brain scanning in the study of issues relating to musical activity, various approaches have been pursued. Several recent studies in neuroscience have examined the effects of musical training, especially in children. The investigations of Hyde, Lerch, et al (2009) focused on the effect on structural development of the brain, as did the work of Fujioka, Ross and Kakigi (2007). The theory that musical training influences brain plasticity in children was explored by Moreno, Marques and Santos (2009). Pianists, more specifically, have been the subject of studies regarding the qualities of white and gray matter in the brain (Han, Yang *et al.*, 2009), as well as the effects of piano practicing on the development of white matter (Bengtsson, Nagy and Skare 2005).

The present study departs from previous research in several important ways. In communicating with our participating pianists we made the deliberate choice to avoid any terms that alluded to the issue of "expression" or "interpretation" as such. Our focus instead was purely on personal experience and generalized intention — whether to play "correctly" or "with enjoyment." As previously mentioned, the terms Enjoyment Mode and Correct Mode are original and unique to our study. Furthermore, no other study that we know of has melded the same two technologies as we did together in one investigation, *i.e.* placing viewers in an fMRI scanner while they observed the piano playing of the dot-line stick figures, or "avatars," generated by motion-capture software.

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