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The Pedagogical Value Of "Enjoyment" In The Classical Piano Studio

A Research Report On A Transdisciplinary Study

The impetus for our study arose directly from the piano studio, from a fundamental question about teaching and how it can be most effective. We wanted to investigate the extent to which "holistic" suggestions on the part of the teacher might engender beneficial outcomes in the student that would be specific and measurable.

It is our view that piano teachers often find, perhaps to their surprise, that when they give students lots of highly detailed physical instructions about how to get certain results in this measure or that—what exactly to do with their wrists, elbows and the like—things don't work out quite as successfully as they would like. Such teaching may backfire for the simple reason that, despite achieving certain localized improvements in technique, it might actually create more self-consciousness in students. It directs the student's attention in a certain way, asking him to consciously supervise individual body parts, one at a time, to render each passage in the desired manner. But such movements can end up seeming oddly isolated, perhaps a bit exaggerated or manipulated, not exactly what the teacher had in mind. Physical tension can be another byproduct of such deliberate self-supervision. Tension—from holding on to things too much instead of letting them flow—can accumulate when one focuses intensely on very specific outcomes ("mustn't miss a single note in this passage, and every note must be perfectly *pianissimo*") or on over-controlling specific parts of the anatomy ("must keep my shoulder down, must keep my hand rounded" and so on). Such micromanaging can also give rise to a sort of generalized self-doubt in the student, lack of self-trust and uneasiness about doing it "wrong." These were some of our concerns.

The authors of this study believe that when the body functions most naturally and beautifully at the piano, it does so with a unified, effortless self-coordination that actually surpasses what the mind can grasp. Putting it another way, we propose that when it comes to musical performance, the body is ultimately smarter, subtler and more sophisticated than the mind. We wanted to find some way to test this concept empirically.

Have you ever found yourself in a wonderfully natural technical "groove" at the piano, when you knew you were playing your best and everything felt efficient, flowing and confident? If so, you may have wondered exactly how you got there and wished you could somehow "bottle" that *gestalt* and pop it open whenever you wanted. But that's not so easy to do, as musicians often discover. The mind might not be capable of fully grasping the phenomenon, since the mind tends to think in more reductionist concepts, while the reality it is trying to understand is not a single concept *per se* but a total experience—an experience that is primarily physical. Thus, trying to *understand* one's happy "groove" can be frustrating, perhaps even futile. But perhaps it's not so crucial for us to analyze the groove itself; what's really important is finding

ways to *activate* it. How can we awaken and put to use that integrated skill that seems to lurk inside of us, intact and ready to go? How can teachers help their students find it?

The researchers wanted to test a theory that giving students a deliberately non-specific and inviting suggestion—in this case, "Just enjoy yourself!"—might relax them, connect them with their bodies, reduce the pressure of perfectionism, open up the idea that "enjoyment" has real value, and thus encourage within them a more holistic, self-trusting gestalt of comfortable, well-coordinated and expressive body movement that is more than the sum of its parts.

Pedagogical approaches such as this abound in fields of endeavor outside of music. The realm of sports coaching provides good examples, most notably the "inner game" philosophy as put forth in compelling fashion by W. Timothy Gallwey. Music and sport clearly have much in common, both in terms of their highly refined levels of physical training and in the fact that advanced skills, in each case, are often performed before an audience. Clearly, classical piano performance incorporates artistic elements that expand far beyond sport—most notably the music itself, its notated precision and its exalted expressive potential. In the fields of tennis and piano performance alike, however, many would agree that the key to achieving brilliance is finding effective strategies for simply "getting out of our own way."

This is certainly not a new idea in the realm of piano pedagogy. Philosophies of technique that trust the body's own "wisdom" have been well articulated over the years, in various ways, by Abby Whiteside, Barry Green, Eloise Ristad, William Westney and others. In *The Art of Piano Playing*, George Kochevitsky (1967) 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 technique… He pointed out the importance of purposefulness and force of imagination in the development of technique."[1]

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 dismiss. To be sure, it is never easy to formulate reliable verbal expressions of such experiential phenomena. However, there is definitely something worth pursuing about the sort of technique Steinhausen tried to describe more than 100 years ago. Many musicians know 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.

The Present Study

Our research team was comprised of 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. The experiment was based on comparing two "modes" of musical performance: one we called "correct mode" and the other "enjoyment mode." These are the terms used in the instructions given to each pianist in the laboratory. The simple instructions in each case were to play a given piece in two ways: the first time "as correctly as you can," and the second time "just enjoy yourself (whatever that means to you)." Because we had access to two advanced technologies, namely (1) motion-capture recording of body movement and (2) functional MRI brain scanning, we also had the ability to compare these performances empirically and with precision from different scientific perspectives.

The motion-capture recordings distill movement to its three-dimensional essence, and the measurements are made in precise coordinates. Thus, we could compare and chart how each pianist used his or her body when playing the same piece in each of the two contrasting modes. It is important to note that participants were not told anything about the study hypothesis, and no

reference to gesture or movement was ever made in the instructions they were given. We were interested in observing, for example, whether a pianist in the Enjoyment Mode would inscribe a more generous arc with the arm when navigating a large jump from one pitch to another. Some would consider larger movements to be a sign of healthy and unconstricted technique. Another theory we wanted to test was that there might be more frequent little "micro" changes of direction in the arm or hand during the Correct Mode—a slightly jerky quality, one might say—due to a fussier over-controlling attention to 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 with those nervous little changes of direction that are very likely to cause muscle tension and fatigue.

Access to a brain scanner allowed us to go even further, however. Here the focus shifted from performance itself to perception—what could be perceived by others regarding performances in either mode. We wanted to know if subjects while in the brain scanner, watching the pairs of motion capture videos, would be able to detect differences between one mode and the other, and in what way. These pairs of videos each consisted of the same performer, same piece and performed in the two aforementioned modes. It should be noted that pianists in a motion-capture recording look like dot-line, stick-figure avatars, not fleshed-out persons; thus all that is seen is their quality of motion in its purest, most distilled form.

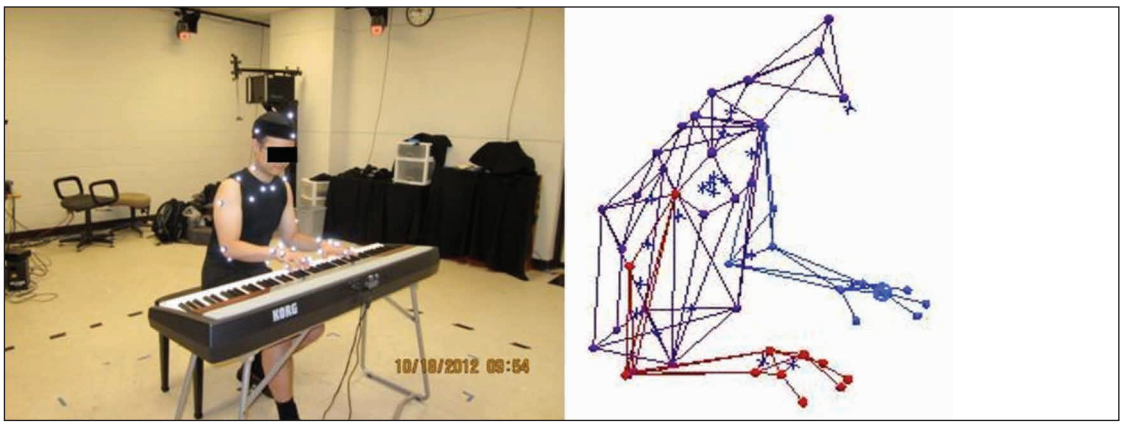
We wanted to know if the quality of "enjoyment" communicated itself from performer to audience and if there were perceived musical values associated with this quality. Therefore, each subject in the scanner had to answer a battery of questions after viewing each performance, and those responses were tabulated. We also monitored their brain activity during the entire process. Since we had recruited two categories of subjects—four trained musicians and four non-musicians—we were curious about how the responses and patterns of brain activity 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.

"Correct" Versus "Enjoyment"

The choice of these terms, original to this experiment, merits a bit of discussion. Among the questions that may arise:

(1) Is it appropriate to set up Correct Mode and Enjoyment Mode in contrast to each other as some sort of dichotomy? Why couldn't a pianist enjoy everything about playing in the most correct way possible? Ideally, this would be the case. Our theory, however, was that mindsets are very powerful and that for most pianists, these two mindsets would indeed engender rather different experiences of playing, both mentally and physically.

(2) How advanced does a student have to be before the invitation to "enjoy yourself" can be a productive one? This is a real concern, since an unschooled pianist whose preferred style, for example, might be to play in a



A pianist with motion-capture sensors attached to his body and his avatar in the motion-capture recording.

hunched over posture with collapsed fingers and contorted wrists would probably just do more of the same 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.

Review Of Relevant Research

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 and Leman.[2] 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.[3] 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."[4] 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 were indeed differences in movement for specific body parts between the modes. Results indicated that 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 performance modes, suggesting that playing with little expression is closely related to playing with little movement. Another study by Thompson[5] used three expressive performance modes—"minimum, normal, and maximum"—with three subjects playing a 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 used three expressive modes with a single performer—deadpan, normal and exaggerated—as a technique for analyzing the effect that musical intent has on body movements.[6] The results indicated that subjects used specific, identifiable movements in each mode. In another study Clarke and Davidson[7] video-recorded a professional performer playing a piece by Chopin six times, two of which were analyzed. A unique aspect of the investigation was that the subject was never asked to perform 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 that 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. studied the effects of playing a piece with differing emotions on the part of the performer.[8] 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 expression 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 was head velocity.

Another motion-capture experiment focused on audience perceptions of various expressive intentions on the part of four different violinists all playing the same "sad"

passage.[9] In this study the various modes of performance (not revealed to the audience) were called technical, expressive and emotional—in this case "emotional" was achieved by 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 sought to discover the relationship between upper body movement and degree of musical expression.[10] 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 motion differences 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 et al[11] focused on the effect on structural development of the brain, as did the work of Fujioka, Ross and Kakigi.[12] The theory that musical training influences brain plasticity in children was explored by Moreno, Marques and Santos et al.[13] Pianists, more specifically, have been the subject of studies regarding the qualities of white and gray matter in the brain,[14] as well as the effects of piano practicing on the development of white matter.[15]

The present study departs from previous work in several important ways. In communicating with our participating pianists we made the deliberate choice to avoid any terms that alluded to "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 we know of has melded the same two technologies as we did in one investigation, that is placing viewers in an MRI scanner while they observed the piano playing of the dot-line stick figures, or avatars, generated by motion-capture software.

Methodological Details

Four pianists participated in the study, two males and two females, all deemed by the researchers to be at an advanced level of performance. Three were graduate students, and the fourth was 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 musical character and pianistic demands: the Hummel rather quick and sprightly with several jumps and scalar runs, the Grieg warmer, slower and more heartfelt.

At the time the participants were initially given the pieces to learn, they were told simply 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 about the hypotheses behind the study. The motion capture system used for experiments was an eight Eagle 4 infrared camera system (Motion Analysis).[16] Only the upper body was modeled because the piano would obstruct lower-body markers and also because there is little movement in the lower body during piano performance. Forty-six surface reflective markers were affixed to the body, targeting bony landmarks that would allow for finding the locations of the 23 joint

centers relevant to the motion analysis. Marker placement is shown in Figures 1, 2 and 3.

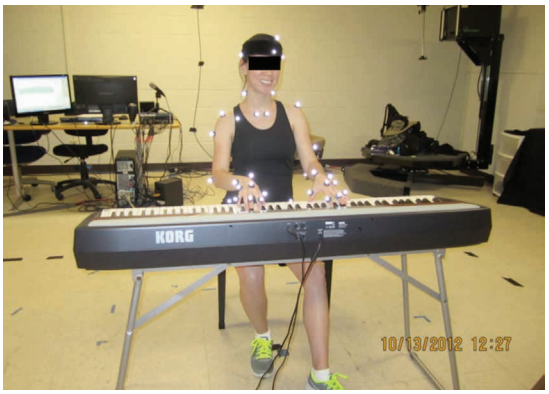


Figure 1: The laboratory setup.

Figure 2: Detail.

(a) (b)

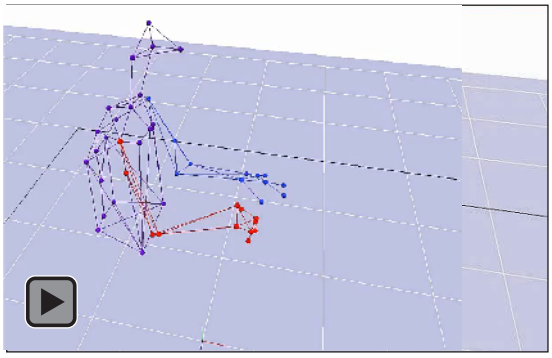
Figure 3: Marker placement: (a) back, (b) front.

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. They were told: "As you play the Hummel, think about performing it as correctly as you can—whatever that means to you." Their rendition of Correct Mode was repeated several times to ensure a good motion-capture recording. Next, they were asked to play the Hummel again, this time "Just think about enjoying yourself while you are playing—whatever that means to you." Enjoyment Mode 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 16 recordings to analyze and compare.

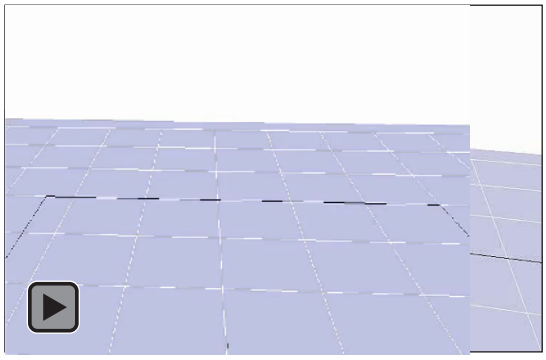
Taking advantage of the three-dimensional aspect of motion-capture technology, we chose to rotate the viewing angle on all the recordings in a certain sweeping pattern. This allowed us to observe the pianists from all sides as well as from directly above their heads. Since the right and left sides of the body are color coded, it is easy to keep track of what one is seeing. The next page shows a comparison of the two performances of the Hummel *Scherzo* given by one of the pianists and the contrasting pair of Greig performances.

Video 1: Hummel: Correct Mode, Subject A.

Video 2: Hummel: Enjoyment Mode, Subject A.



Video 3: Grieg: Correct Mode, Subject A.



Video 4: Grieg: Enjoyment Mode, Subject A.

The follow-up, brain-scanning phase of the study involved eight participants ranging in age from 21–70: four trained musicians (three males, one female) and four without any significant musical training (all males). Prior to entering the scanner, each subject met with the researchers for orientation about what to expect during the study—the importance of keeping still in the scanner, the operation of the response button and the like. We explained that they would be seeing and hearing videos that would be projected on 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 to assess various qualities of each performance, right after viewing it, by responding to a series of questions. They were instructed to indicate their responses by pressing fiber-optic buttons held in one hand that would allow them, through miniscule fingertip movements, to select a response rating to each question on a 1–7 scale that ranged from "Strongly Disagree (1)" through "Neutral (4)" to "Strongly Agree (7)." (See Figure 6). Thus this phase of the study furnished both behavioral responses to the videos (that is, answering the questions) and neurological (brain) responses, which were monitored constantly.

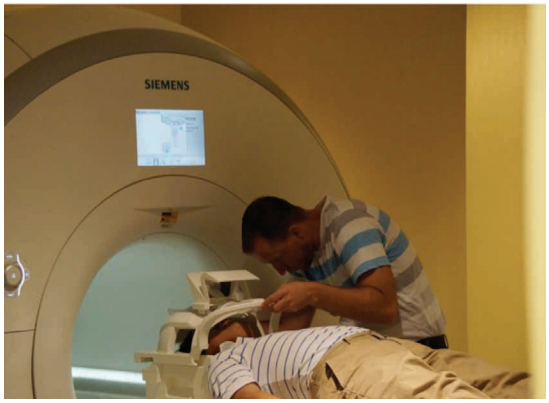


Figure 4: Adjusting the reflective viewer.

Figure 5: The fiber-optic device for answering questions.

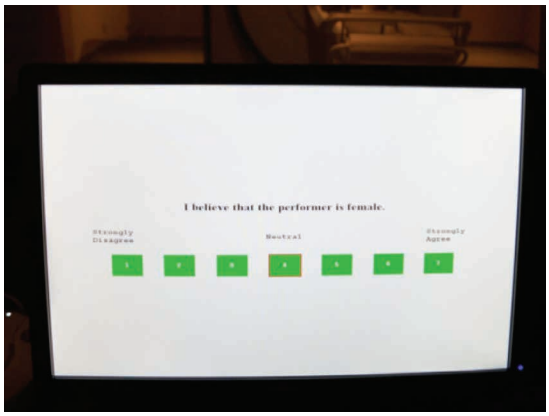


Figure 6: The scale used to rate responses.

A 3T MRI system (Skyra, Siemens) was used to acquire T1 anatomical and EPI functional images during task performance. As with all fMRI equipment, the mechanical noise is quite loud during scanning. For this reason, subjects were fitted with headphones to listen to the performances; while these were helpful, the phones could not blot out the ambient roar of the machinery.

Each subject viewed eight videos, that is four pairs of videos. In this context, a "pair" means one performer playing one of the pieces in both the Correct and Enjoyment modes. Each subject viewed each of our four pianists (performing a "pair" of either Grieg or Hummel). The videos were randomized and balanced in several respects: the order of the pieces, the order of the performers, and the order of Correct and Enjoyment modes within pairs. The 12 "questions" were actually formulated as statements with which subjects could agree or disagree on the aforementioned seven-point scale. And while these questions were identical for each video, they were presented in randomized order for each condition.

The 12 response statements ("questions"):

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.

Figure 7: Anatomical Brain Scan.

Figure 8: Functional Brain Scan.

Data Analysis And Discussion

A: Physical movement

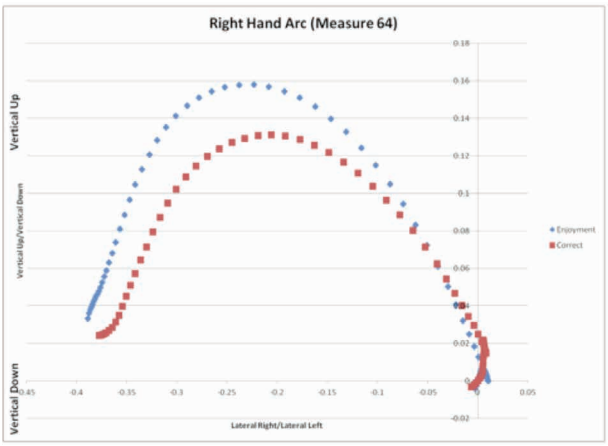
Before any comparisons of physical movement could be carried out, the data needed to be normalized with respect to two important variables. (1) *Timing*: as one would expect, the performances are not done at the same tempo and are also inconsistent with regards to use of *rubato* and the like. (2) *Physical size and proportions of the pianists*: taller, shorter, longer arms and the like. The motion-capture software records at the rate of 120 frames per second, and the technical team was able to achieve normalization so 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 (such as right clavicle, left wrist, neck and so forth) at a specific passage in the music. Below are 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:

Figure 13: Spine end movement, Grieg (one subject). Some signs of larger and "simpler" movement in Enjoyment Mode (blue).

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:



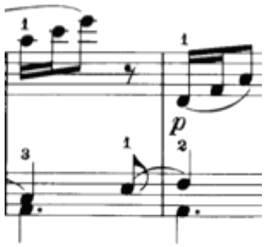


Figure 10: Right-hand arc, Hummel. Enjoyment Mode blue, Correct Mode red. Enjoyment Mode arc inscribes a larger gesture.

Another way we studied the data was by charting aggregates of what all four pianists did in the same mode with each piece.

Here (Figure 11) we see all subjects, each with a distinctive color, performing the Grieg piece in Correct Mode:

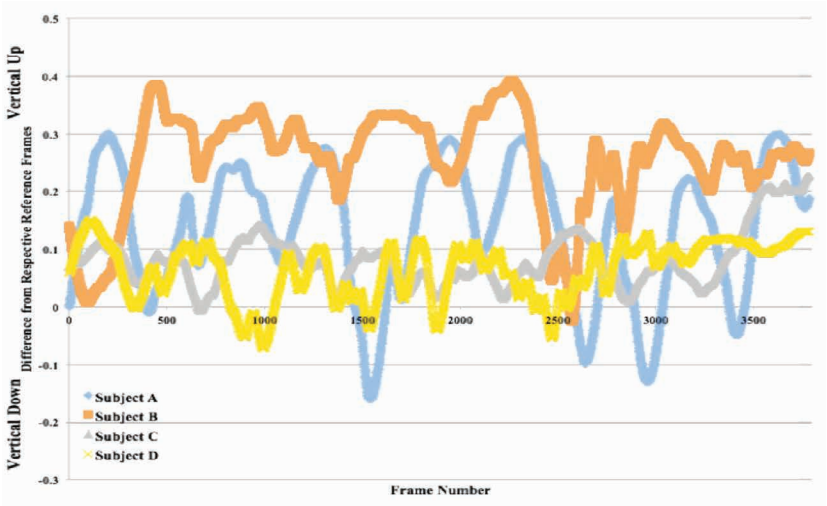


Figure 11: Correct Mode aggregate—front of head ("vision") joint center (Grieg).

And here in Enjoyment Mode:

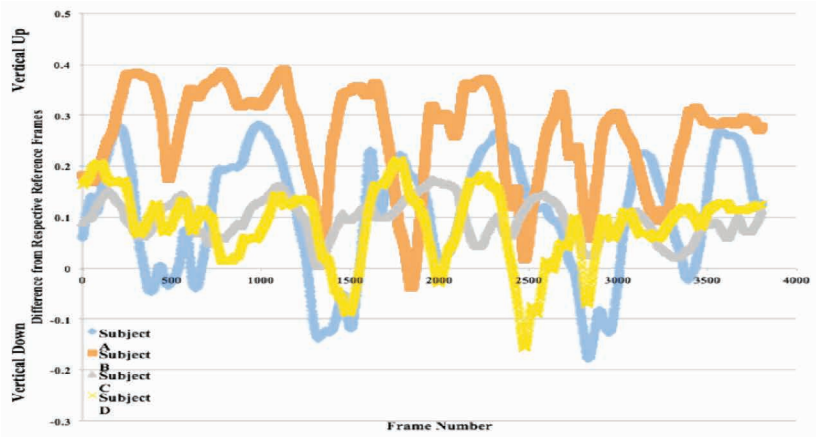


Figure 12: Enjoyment Mode aggregate—vision joint center (Grieg).

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

Another way to show the results was with bar graphs representing all the joint centers that were measured. This shows only the amount (*not* the shape) of movement. In Figure 13, for example, we have a representation of Subject A playing the Hummel piece:

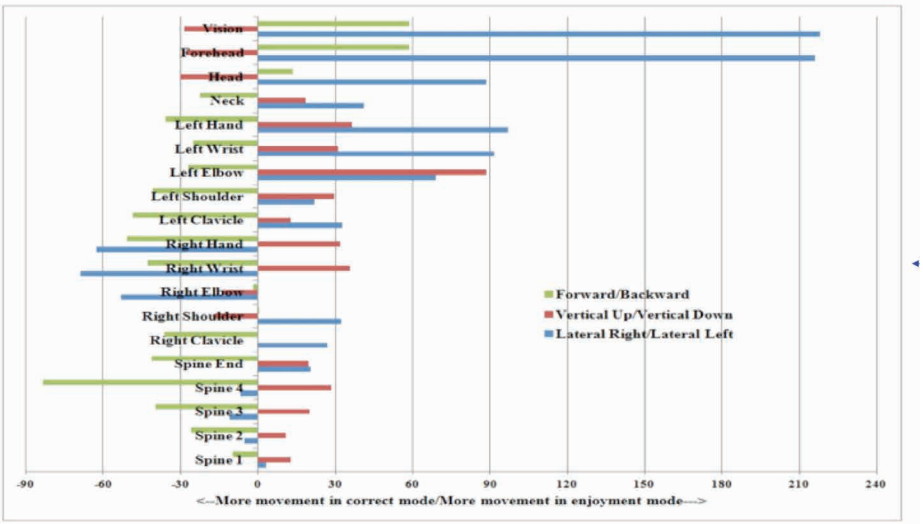


Figure 13: Magnitude of movement in two modes (Hummel).

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 the head, which is the joint center least involved in the act of playing the right notes.

Figure 14 presents a more extreme example (Subject D playing the Grieg) of much more expansive motion in Enjoyment Mode:

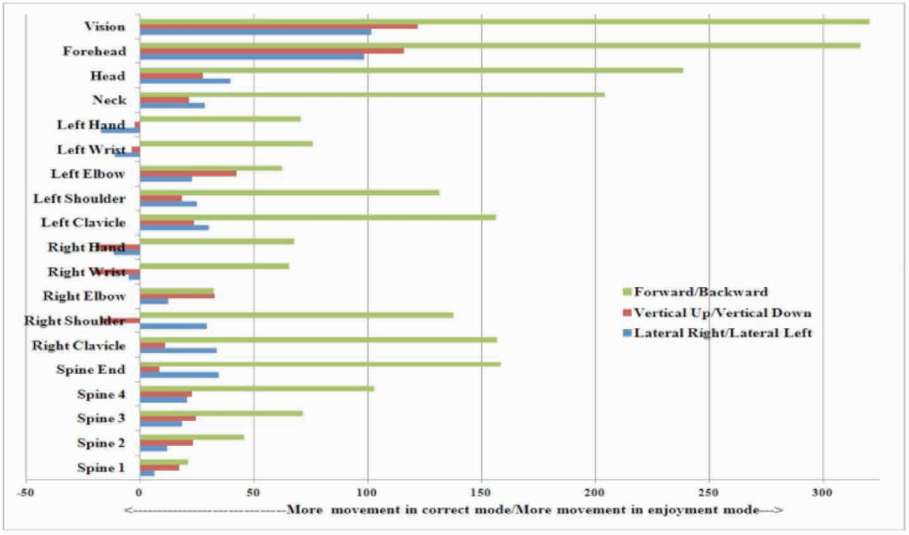


Figure 14: Magnitude of movement in two modes (Grieg).

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.

B: Observers' Responses

The most straightforward task of data analysis in this part of the study was the tabulation of answers to the 12 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 did not possess, they could report this virtually instantaneously without having to contemplate.

The following graphs show some of the more definitive differences between the responses of the musicians and non-musicians. It is important to bear in mind that while these graphs are suggestive, they do lack statistical significance due to the small sample size. Nevertheless, one can discern a clear pattern of keener responses to many questions on the part of the musicians. The numbers on the left of each graph correspond to the points 1–7 on the response scale: taller bars indicate stronger agreement with the statement, and 4 is a neutral position.

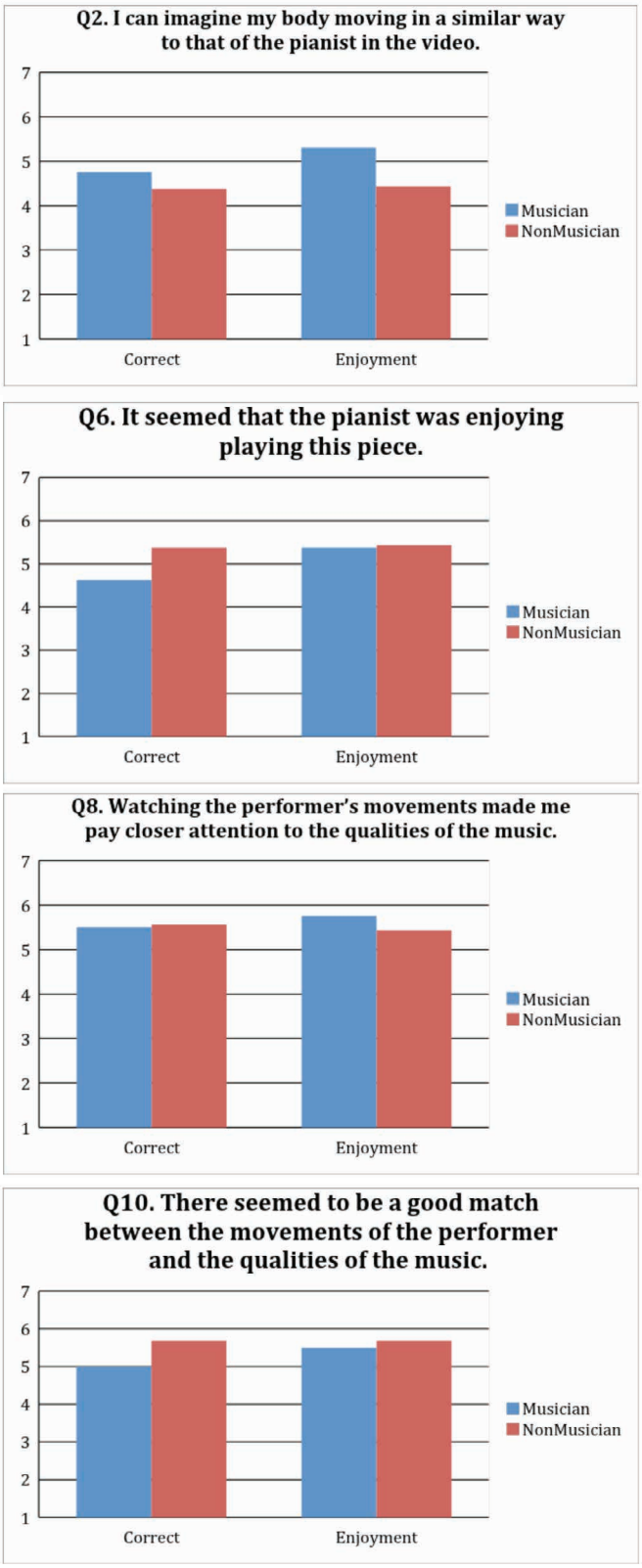


Figure 15: Selected answers on 7-point scale.

These charts seem to indicate that the non-musicians often detected little difference between the two performance modes in a video "pair," while the musicians' opinions were rather distinct for each of the two modes.

Brain Activity:

The images of brain activation in the two groups show marked distinctions between musicians and non-musicians. They also demonstrate that the two performance modes did indeed often elicit different brain response patterns. Here is a composite image (Figure 16) of the brains of *all* subjects viewing *all* videos, showing the areas more activated in Enjoyment Mode than in Correct Mode. Please note that the images are reversed (that is, left is on the right and right is on the left). 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 functioning and plays an important role in emotion processing, as well as some aspects of pitch processing.

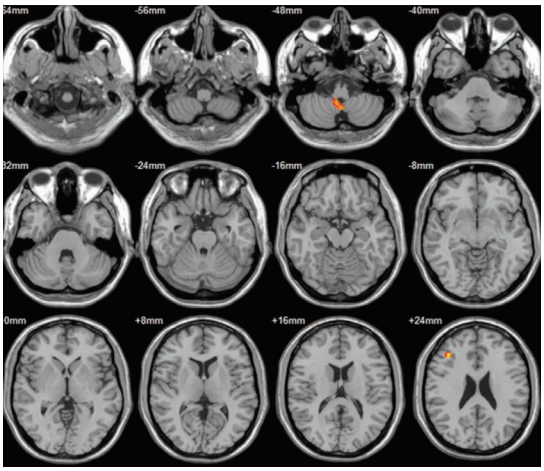


Figure 16: Areas more activated in Correct Mode than Enjoyment Mode.

In Figure 17 the same composite map shows a somewhat different kind of activation, with more activity 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 in both modes, which suggests that some form of motor learning about each piece was taking place.

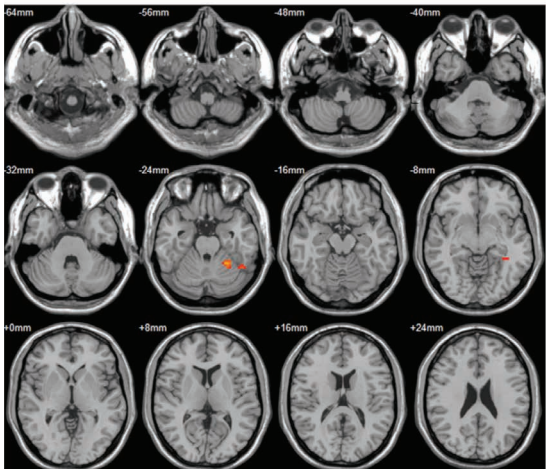


Figure 17: Areas more activated in Enjoyment Mode than Correct Mode (all subjects).

Perhaps the most striking set of imaging data is the difference in brain responses between the musicians and non-musicians. When data for the two groups were separated and compared, we found that the brains of the non-musicians showed no unique activity pattern relative to musicians. However, the latter responded more comprehensively and in patterns not shared by the non-musicians—most notably while viewing Enjoyment Mode performances. These particular areas are shown in red in Figure 18:

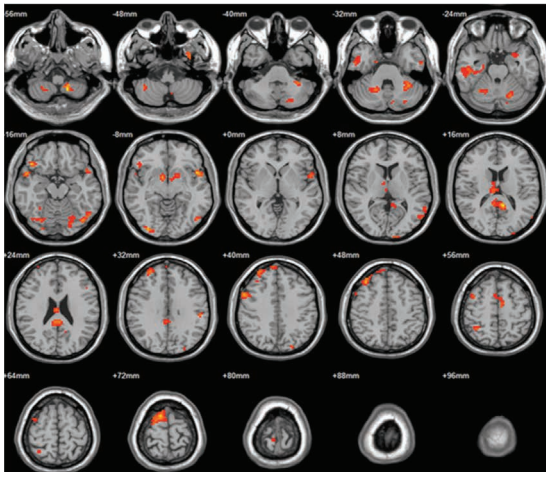


Figure 18: Areas where only the musicians responded to Enjoyment Mode.

Among the most significant of these is activation of the Right and Left Supplementary Motor Cortex (BA 6): This activation was greatest in the Enjoyment Mode and almost exclusively on the part of musicians (although there is also some evidence of this activation in Correct Mode—once again, only for musicians). This region is hypothesized to contain many "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 activation primarily in the musicians' response to Enjoyment Mode were 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 for on-line error checking, and it also plays a part in emotion processing.

Conclusion

Future studies in this vein would be intriguing, especially if they could involve more performers and observers. With regard to both the motion capture and the brain scanning phases of the study, a greater number of subjects would afford more confidence in the results obtained. Therefore, our findings should be viewed as preliminary ones, with interesting trends, rather than as definitive results. The quality of musical preparation by our four volunteer pianists was somewhat more variable than expected, and this too may have compromised some of our comparative analyses. One possibility for future studies might be to include a financial incentive for all pianists, so as to strengthen their commitment to preparation.

Nevertheless, it was 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 when viewing such performances. Since enjoyment in musical performance is a central and precious aspect—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 contexts, are serving their students very productively indeed.

Acknowledgement

A presentation of the empirical findings contained in this article also appears in the *SIGNATA* publication cited below, "Musical Embodiment and Perception: Performances, Avatars and Audiences."[17]

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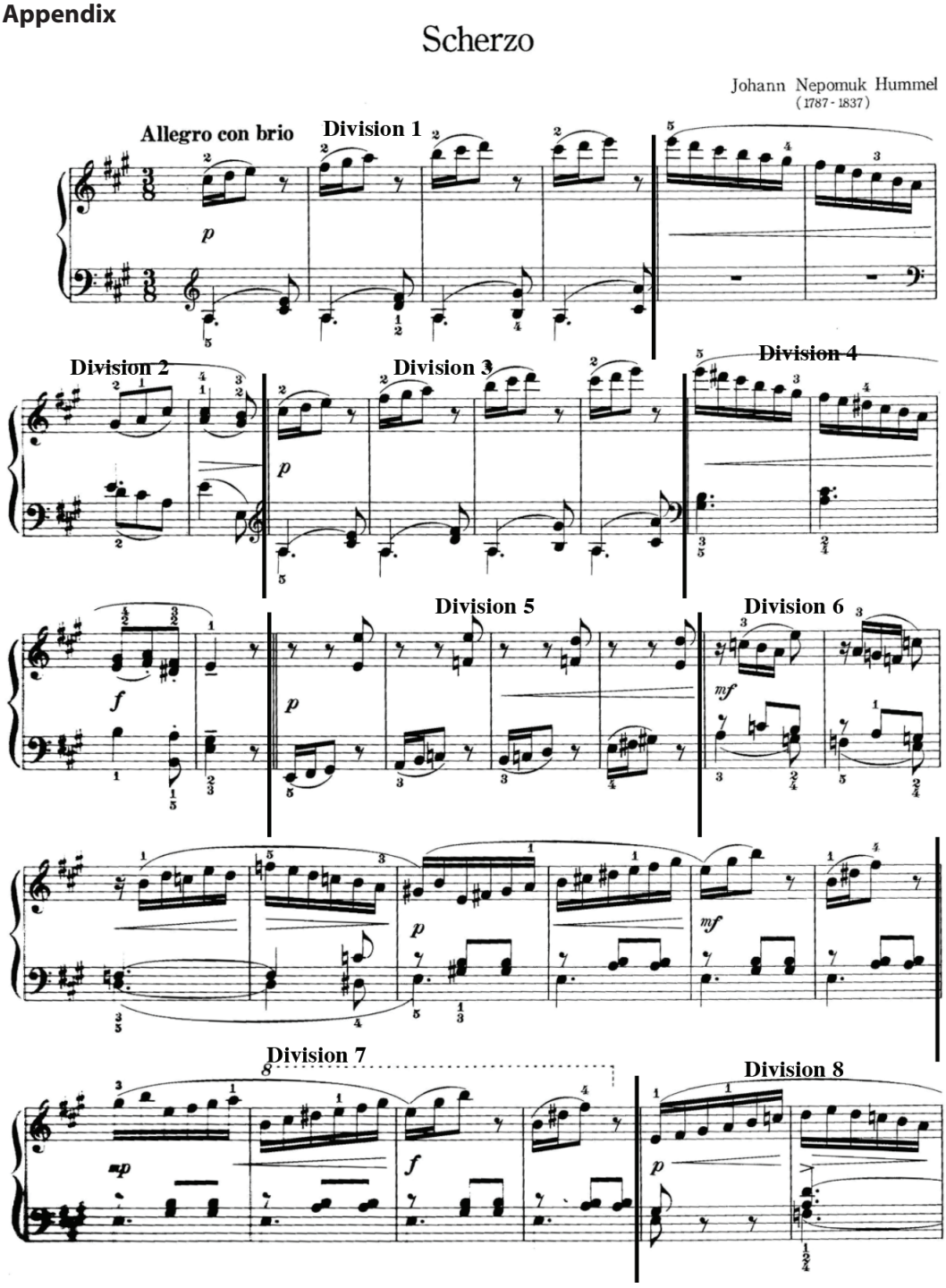
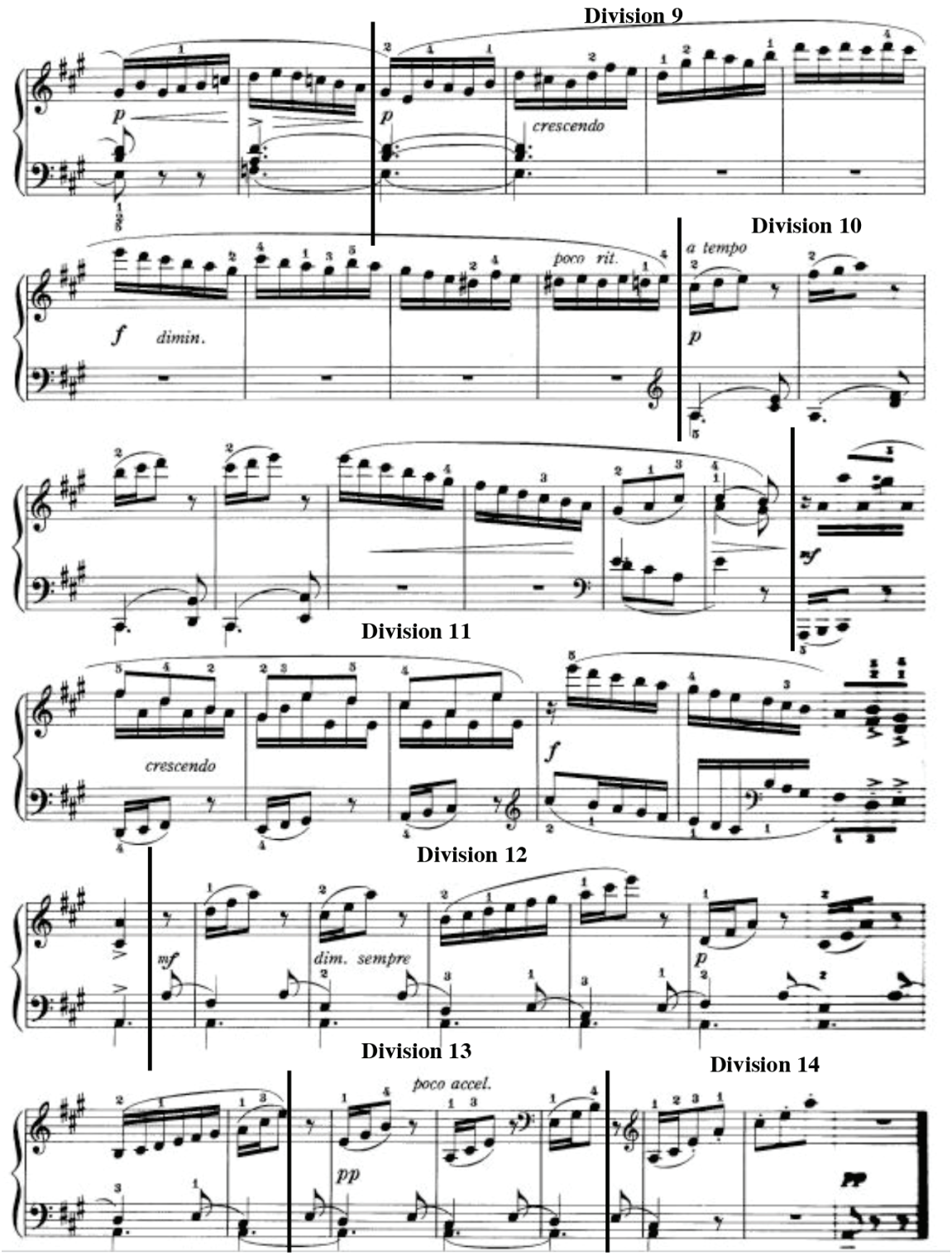
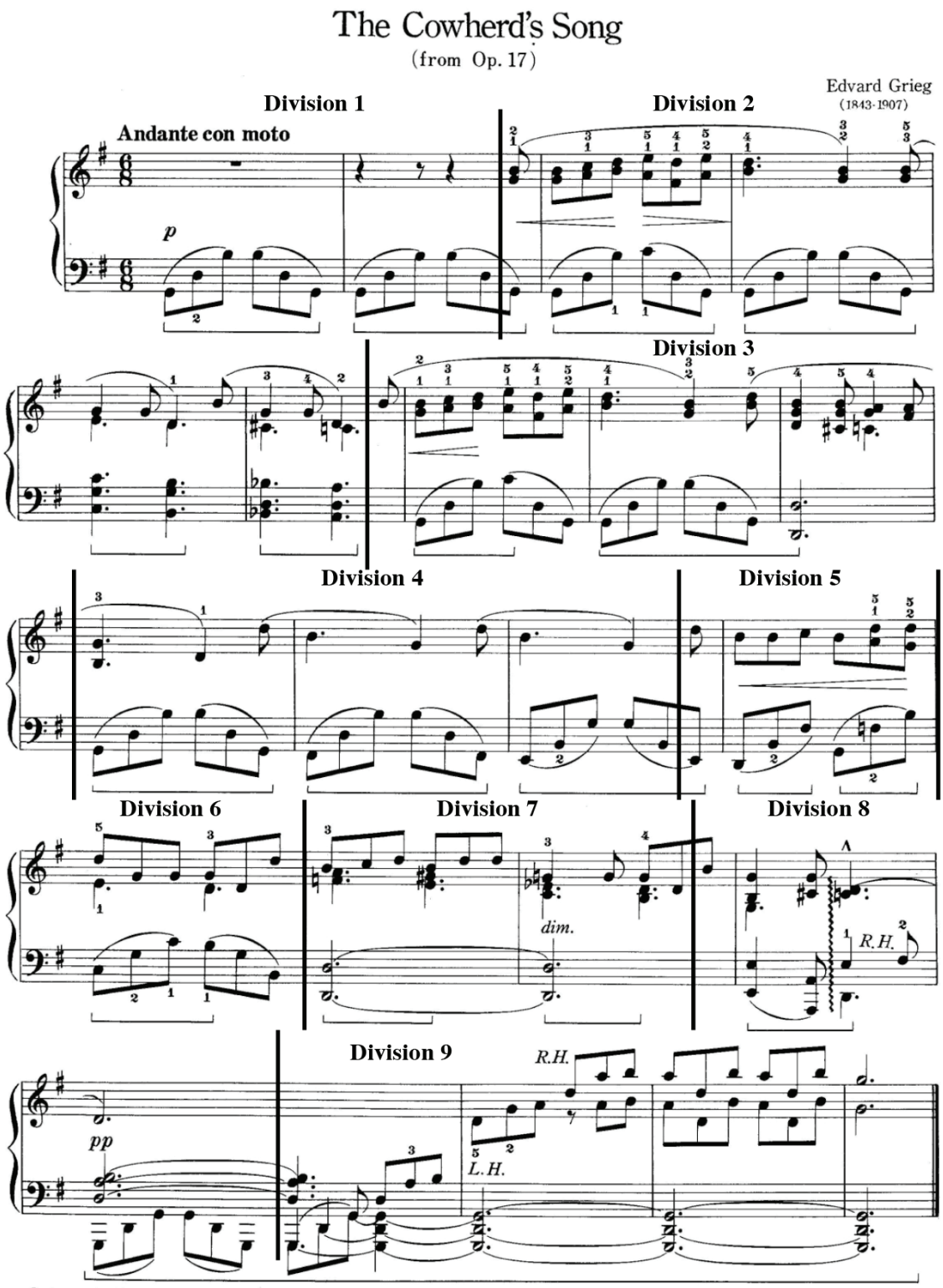
Appendix

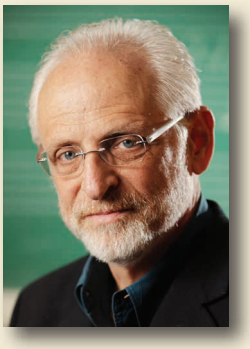




Hummel piece showing divisions used for normalization of motion-capture data.



Grieg piece showing divisions used for normalization of motion-capture data.



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