EXPRESSIVE GESTURES IN PIANO PERFORMANCE

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Tiivistelmä – Abstract

This Graduate Thesis focuses on expressive body movement in piano performance. The first portion discusses topics related to musical gestures, including musical semiotics and music movement perception, culminating in a case study on the performance gestures of a famous pianist (Glenn Gould). After detailing how musical gesture research can affiliate with other research disciplines (music education, musical interface technology and music cognition), an empirical study is outlined and presented.

This study reports on the playing of three pianists and their performances of a sixteen-measure excerpt from the Brahms Intermezzo Op.118 # 2. Each pianist participated in three or four sessions where they were asked to play the excerpt in different levels of expression: minimum, normal, maximum. Recorded using the Qualisys Motion Capture System, the data was analyzed in MATLAB using the Qualisys Toolbox. The analysis focused on the length of the performances between expressive manner and pianists, range of movement in accordance to expressive manner, correlating expressive gestures with musical structure such as phrasing and melodic direction and development of movement through multiple sessions. Interviews conducted during and after the data collecting process provided insight concerning the implicit and explicit knowledge musicians have of expressive gestures and possibly how the level of expressiveness used in a performance can predict personality.

The main findings include that among the three pianists: there was a linear relationship between a performer's expressive intentions and the amount of expressive body movement during a performance, acceleration in head movement was observed between the start and end of adjacent musical phrases and head gestures correlated with the melodic structure with both complementing and reinforcing expressive movements.

Although not conclusive, this thesis asserts that it has successfully established a framework for the commencement of future comprehensive and elaborate empirical study.

Asiasanat – Keywords gesture, expressive body movement, piano performance

Säilytyspaikka – Depository

Muita tietoja – Additional information

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

This thesis investigates the origins and significance of meaningful body movement in Western music piano performance. It has long been observed that gestures executed by musicians during recitals add an extra-musical parameter to the performance. What point would there be in attending a concert if not to witness the dancing bows in the ballet that is a string section, or to cheer on the heroic conductor as he controls the will of dozens of musicians by moving his bâton? Indeed, music is a social experience that thrives in a situation where the listener can see the performer and vice versa. It is in this context that music achieves its most zealous inter-subjective communication.

Since the age of Antiquity, music has been thought of as a mediator of expression; with an ethos so powerful it could affect emotions, behavior and even morals. In his Doctrine of Imitation, Aristotle argued that music imitated the state of the soul (gentleness, anger, courage, temperance and their opposites). When these states are perceived during performances, they may be transferred back to the listener's soul. This cycle between musician and observer is no coincidence. Indeed, Pythagoras and his followers believed that music was a construct of the same mathematical system responsible for the periodic motion of the planets. Thus, music has its place in the world as a natural form of communication, tightly knit to the rest of the world.

Music as both a visual and auditory experience had for a long time been the only way in which music could be perceived. Those lucky enough to have attended a concert given by Franz Liszt or Niccolò Paganini wrote of their performances as a transcendent experience augmented by the fact that the spectators were able to *see* the virtuosity in action. Collectively, The visual and audible channels of music formed an intricate mesh of expression in which both parties (performer and perceiver) benefited greatly.

However, over the past century, music's visual channel has been emancipated from music's audible channel. This change, brought on mostly by technology, has forever changed the way in which music is perceived and consumed. Originally, a musical experience consisted of a human producer and a human perceiver[1]. But currently, the most common way to experience music is through a recording. This act is predominantly a passive experience where the listener has no direct perception with the original production of the music. The listener has no input or impact on the musical experience's outcome. As Roland Barthes wrote, 'technology has relieved the listener of all activity' (Barthes, 1977, 150).

Throughout this transition to technology where music is more accessible than ever, the concert experience has remained the preeminent way to experience music. A jazz aficionado may romanticize over having seen Miles Davis perform with John Coltrane live and rarely does this memory carry less emotional weight than the memory of simply listening to the 'Kind of Blue' album. In the digital age where the most beautifully performed Aria is available at the click of a GUI button, there is still an intrinsic need to attend concerts. To witness a musical experience with one's own eye provides the extra-musical component needed to make Aristotle's musical cycle complete.

The fact that there would still even have a need to see live performances with so much music already at our disposal begs the question, what is it about the concert experience that makes it so special? It has been suggested that the visual aspect of a musical performance is largely responsible for the expressive communication that occurs between the musician and perceiver and may even play a larger role in conveying expression than the music itself (Davidson, 1993). This additional expressiveness, which conveys meaning and emotion, is perceived in the musician's gestures. In other words, movements that occur during performances are analogous to the hand and face gestures that give speech additional meaning.

This thesis investigates the role of musical gestures that occur during such musical performances. Three pianists participated in a research study whereby their performances were recorded by a Motion Capture (MoCap) camera system. The goal is to search for implicit and explicit relationships between bodily movement and music.

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[1] The two could be the same person.

The study of musical gestures encompasses different areas of scholarship including semiotics, music theory, musical perception, and embodied music cognition. **Part 2** presents a comprehensive review of the literature concerned with the study of musical movement and gestures. The review progresses from theoretical topics towards practical topics, from the abstract to the tangible.

Sections 2.1, 2.2, 2.3 and 2.4 discuss musical semiotics and the perception of musical movement, with the central argument that body movement during performances can symbolize features found in the music being played. These meaningful movements are re-defined as musical gestures, which act as a gateway to the musician's impression of the music being performed. This is followed by an appraisal of the term *musical gesture,* and then, a state of the art look at musical movement perception research.

Section 2.5 presents a short case study on the late pianist Glenn Gould, who poured expressiveness into every note he played. His outlandish musical gestures on stage caused uproar in the world of classical music when he was young. As Gould grew older, he developed a fondness for recording and spent the last portion of his career as a studio artist. Yet even in seclusion, his extra-musical behavior remained an integral part of his performance style. It will be argued that his musical gestures demonstrated absolute expression. That is, his musical gestures did not serve to communicate a message to an audience; so much as they were performed *for the sake of expression itself*. Literature concerning his gestural tendencies will be presented and then supported by a comparative study conducted in 2005.

Section 2.6 of the literature review demonstrates how the study of musical gestures can be applied to various disciplines either for research or for commercial products: Music Education, Musical Device Interaction and Music Cognition Modeling. A brief section in which the hardware and software used in the empirical portion of the thesis follows this up (**Section 2.7**).

Part 3 details the empirical portion of the thesis. The research questions, methodology and goals are explained and the most relevant and interesting examples of the results are cited. The analysis section is broken down into two sections:

quantitative and qualitative. The quantitative section deals with comparisons in performance between performance manners, participants and development of musical gestures within a number of sessions. The qualitative portion features outtakes from interviews with the participants concerning the use of movement, musical gesture and symbolism in their playing. Observations and inferences are made based on how the participants' comments relate to the movement data. An overview of the results is presented, followed by a critical review of the thesis as a whole.

2 MUSIC AND MOVEMENT RESEARCH

2.1 Semiology: the Signifier and the Signified

The science of semiology is concerned with the study of signs; one object acts as a symbol for another object. The linguist Ferdinand de Saussure suggested a model that shows the relationship between two units, the *signifier* and the *signified*. The signifier is the form the sign takes while the signified is a represented concept (Chandler, 2006). Although the model is simple, it can be applied to a large variety of systems of signification including images, gestures, musical sounds and objects and their complex associations (Barthes, 1968).

In Saussure's original intention, the dyadic model is meant to be a link between a *concept* and a *sound pattern*. This is not a physical sound, but a psychological impression of a sound that appears within the perceiver's mind when a connection is established between the signifier and the signified. While Saussure's aim was for the signifier and signified to be purely psychological, the model has been adapted in such a way that the signifier may be a physical symbol for something that is sensed. An example of this could be a traffic light or a 'no smoking' sign, etc.

Whichever interpretation is applied, the signifier is paired with a meaning because the perceiver attributes a signified unit to it. In linguistics, the model is represented by writing (signifier) and speech (signified). For a sign to be interpreted the perceiver must have a preconditioned mind-set with the symbol and the symbol must be placed within a certain context. Some signs are universally understood but may not necessarily elicit an emotional response for all (e.g. for most a cross symbolizes Christianity, but for Christians, it has a deeper emotional meaning). Roland Barthes used semiology to examine how the signifier could be interpreted with different meanings[2]. In one example, he used it to expose the phony facade of the bourgeois culture. A dark full bottle should be a signifier for a signified fermented alcoholic drink. But in the eyes of a certain bourgeois culture, it becomes a symbol of health, robustness and quality. To explain the full sphere of semiotics is well beyond the

[2] *From* http://en.wikipedia.org/wiki/Roland_Barthes

scope of this thesis. The most important thing to understand is that no symbol exists on its own. A symbol can only exist when an exterior force (the perceiver) casts a meaning upon it. Quite appropriately and by definition, a sign has meaning.

2.2 Musical Semiotics

This section delves into semiotics and symbolism applied to music. From there the goal is to demonstrate how body movements exhibited by musicians during performances have special meaning for both performer and perceiver.

Semiotics applied to music emerged in the 1960's and 1970's as a way of interpreting music scores through audio-mining and focusing on new outlooks of musical aesthetics (Leman, 1999), and since then has grown into an independent research discipline (e.g. Tarasti, 2003). Through this novel approach of understanding music came a portion of literature dedicated to understanding the *musical gesture.* Simply put, a gesture is a significant movement.

A musical gesture, read on a score, heard as sound, or seen as a bodily movement attains its significance through an acknowledgment bestowed upon it by the subject producing the object (agent) or the subject perceiving the object (interpreter). Robert Hatten, cited in Gritten & King (2006), argued musical gestures are biologically grounded, that they 'intermodally synthesize the energetic shaping of motion through time into significant event with expressive force' (Gritten & King, 2006, xxi). From this point of view, musical gestures are gestalts in which otherwise unrelated elements are constructed 'into continuities of shape and force' (: xxi). For example, a musical score can be seen as having discrete elements (harmony, meter) with analog elements (dynamics, articulations). The cognitive pairing of these dichotomies is what we come to interpret as music. Another example is seen in rhythm perception. Studies in sensorimotor synchronization have shown that the perception of an inter-onset interval (IOI) is lost if the interval is longer than two seconds (Repp & Doggett, 2007). This shows how the case for interpreting music as a set of gestalts is quite strong. It is through our cognitive processes that sound becomes music at all. If our cognitive processes can cause the perception of music to be expressive and meaningful, the same can work for bodily movement. In other words, movement, if aligned within the correct temporal sequence and within a specific social situation (e.g. music performance in a concert hall), movement is tremendously successful at communicating expression and emotion.

Musical gestures enable a musician to embody the music being played. Marc Leman stated:

> Movements of the body are particularly connected to the perception of the beat and phrase and the apperception of emotion and affect is associated with kinesthetic and synesthetic processes (apperception of movement and colors) (Broeckx, 1981), (Leman, 1999, 20).

Musical gestures therefore add an extra-musical parameter to the perception of music, creating a multi-modal experience that caters to more than one sense. These bodily gestures are made consciously or unconsciously and serve to communicate with one's self or another (Nöth, 1990).

To transfer Saussure's model to the field of music research, it may be useful to re-interpret signifier and signified with more musical terms. François Delalande has suggested referring to the signifier and the signified respectively as 'a level of expression and a level of content or yet again, a written or sound musical object and a meaning' (Delalande, 1995, 219).

Music itself is organized sound perceived by a composer, musician and listener (at times, this may all be the same person). Without our perception at work, music is nothing more than sound waves traveling in different phases within a time period. But our perception of music as an expressive experience does not end at making sense of sound waves; musical expression is also experienced through the *visual channel*.

The way a musician moves during a performance communicates to the perceiver expressive content, not so much as a subordinate feature to a sound event but a complement to the performance. If a movement has attained a level of human significance, either from the performer or from the perceiver, the movement can be called a gesture. Hence, a gesture is a movement with a meaning (Iazzetta, 2000; Cadoz & Wanderley, 2000; Gritten & King, 2006). In this sense, movement is related to sound as gesture is related to music.

2.3 Gesture Classifications

Researchers and scholars have given a large range of definitions for the phrase *musical gesture*. All begin with the idea that a gesture is a 'movement with a meaning'. A comprehensive review of the different variations on the term musical gesture is given in Cadoz & Wanderley (2000) and Gritten & King (2006).

The term musical gesture in this thesis will be used to describe the meaningful bodily movements that musicians make when they perform a piece of music. Delalande (1988) offered a model for classifying three main performance gesture categories that range from the purely functional to the purely symbolic. The descriptions were translated in Wanderley et al. (2005, 97) and are listed below.

Effective gesture: Those that make the sound (fingers on piano keys, bowing of strings, etc.)

Accompanist gesture: Body movements that act as subordinate or supporting gestures to the effective gestures. (Swaying of the torso, facial contortions)

Figurative gestures: Sonic gestures perceived by the audience by means of the produced sound that have no direct correspondence to physical movement (Changes in notes articulation, melodic variations)

The last classification can also be seen as a 'mental gesture' to use Bernadete Zagonel's definition, as cited in Iazzetta (2000). It is purely subjective as it relates to an image of a physical gesture. It could also be thought of as what the composer sees before writing the first note of a musical piece.

For the effective gesture and the accompanist gesture, Wanderley has suggested the synonyms, *instrumental gestures* and *ancillary gestures* respectfully (Wanderley, 1999; Wanderley et al., 1999; Cadoz & Wanderley, 2000; Wanderley et al. 2005).

The explanation regarding the role of instrumental gestures in music performance is quite simple. They are the bodily movements that trigger musical events such as bowing, plucking, blowing and pressing a key. Ancillary gestures, on the other hand, are much more problematic in the sense that they are not involved in the production of sound (Wanderley, 1999). In terms of practicality, the purpose of ancillary gestures in performances is unclear and yet, they are characteristic of all musical performances. Wanderley suggested that ancillary gestures are responsible for conveying musical expressiveness in the visual channel. Therefore, ancillary gestures can be seen as analogous to the paralinguistic gestures, which are a part of speech in day-to-day life. In other words, performing without such subordinate elements would bear a resemblance to a monotone speaker. This does not imply that instrumental gestures are incapable of expressing emotion in music for different types of instrumental gestures can cause different tones. Different ways of blowing into a clarinet mouthpiece can elicit varied tones, each having a sophisticated relationship with the specific instrumental gesture used (Rovan et al., 1997).

The terms ‘ancillary’ or ‘accompanist’ are used to denote the type of musical gesture that most accurately communicates expression in the visual domain. However, These terms imply that this category of musical gesture is subordinate or inferior to instrumental gestures and are thus problematic. Godøy et al. (2005) have detailed playing ‘air’ instruments through the process of ‘motormimetic sketching’. In these performances, the performer uses imagination to recreate a musical performance without the instrument. If ancillary gestures are used to symbolize musical structure with gestures, then these types of performances, the line between what is instrumental and what is ancillary is very blurred because in this case, the entire performance is made of gestures referring to something else. Ancillary gesture in ‘air performances’ could be an interesting topic for further study, and what better place to study air musicianship than in Finland, which is world renowned for its air-guitar virtuosos.

The different types of gestures will be discussed once more in **Section 2.5.** Additionally, musical gestures, both instrumental and ancillary will be emphasized in **Part 3**, the research study, as a way in which the musician conveys expression and symbolizes musical structure in their performances.

2.4 Perception of Musical Movement

Patrick Juslin has stated that the ‘psychological approach to music performance should be used to explain performance expression’ and that ‘expression is largely what makes music performance worthwhile' (Juslin, 2003, 273). As suggested in the introduction, this *musical expression* is best conveyed through the visual channel. This suggests that there is an implicit relationship between the ways a musician moves and the *musical expression* communicated to the audience. The fact that a musician is able to communicate *expression* and *emotional* content in their playing is the main reason most people have a stronger emotional attachment to *seeing* a live performer than *listening* to a recording of the same piece.

Juslin goes on to say that musical *expression* helps the listener make musical evaluations. For example, when assessing two expert musicians, we use *expression* as a criterion for evaluating the quality of a musical performance. This criterion often surpasses other elements such as technical fluency (e.g. playing all the right notes).

Evoking *emotion* and *expression* through movement is something that comes naturally in musicians. As a musician increases in skill level, the movements and gestures become increasingly refined. This is due to the musician's enhanced instrumental motor skills that the general population does not have. Often performed sub-consciously, these gestures originate from the cognitive workings of the musical mind.

Prior to the 1990's, the visual aspect of music performance had not been widely studied in music psychology literature. However, with a growing interest in musical interfaces, modeling and virtual environments, not to mention better access to data collecting tools (e.g. Motion Capture camera systems), the last fifteen years has seen an increase in studies concerning the visual aspect of music performances. Jane Davidson's seminal work on the role of the visual channel in the perception of music performance focused on showing observers a video of performances by a pianist and four violinists (1993, 1995) in a point-light display technique based on Johansson (1973). Reflective tape was attached to the performer in front of a black background and the video's contrast was fixed so as only to perceive moving points of light. The performers played in three different expressive intentions, *deadpan, projected* and *exaggerated.* It was the condition of vision without sound in which observers could best distinguish the expressive intentions.

Dahl & Friberg (2003) observed the different emotional states of a solo marimba player. Subjects watched videos of a marimba player performing in different emotional states (happy, sad, angry and fearful) with no sound. The subjects had to judge which of the emotional states was being communicated. It was found that all states except for fear could be communicated through movement alone. The result was supported when the footage of a bassoonist and soprano saxophonist yielded the same results.

Music perception can make use of advanced statistics used in other types of perception research and apply them specifically to music research (Windsor, 2004). Several researchers have asked subjects to rate expressive musical communication using a continuous judgment framework. One such study by Sloboda & Lehmann (2001) correlated the listener's perception of emotionality with the interpretive choices made by a performer. It was found that timing and loudness deviations from the score attributed to a subject's increased awareness of emotionality. In another study making use of both sound and vision (Krumhansl & Schenck, 1997), a piece by Mozart accompanied by a dance performance was exposed to subjects either without sound or without vision. The subjects were asked to detect phrase and section boundaries within the performance. The results revealed that the dance component accurately depicted section boundaries set by the structure of the music.

Krumhansl also participated in a study where subjects were asked to continuously rate the bodily movements in clarinet performances for tension and phrasing (Vines et al., 2006). It was shown that gestures associated with tension were related to expressivity while gestures associated to phrasing indicated musical structure. This finding could be related to research from Clarke & Davidson (1998), who contended that global body movements such as back swaying are related to the interpretation of phrase boundaries while head movements and facial expressions represent more local musical features (e.g. musician re-acting to local harmony). And most recently as an example of the continuous rating technique, Luck et al. (2007) enlisted vocal teachers to rate posture in vocal performances, aimed at determining if proper posture can be a predictor for a good vocal performance.

In addition to laboratory settings, musical communication through movement has been studied in the context of co-performer communication in Williamon & Davidson (2002). This study followed two pianists as they prepared for a performance. The subjects, whom did not know one another prior to the experiment, spent up to 90% of rehearsal time expressing musical ideas through non-verbal communication in the form of gesture and body language.

As was seen in the section concerning musical semiotics, if musician movements have meaning, it is because they are presented in a social or idiosyncratic context. Musical communication through movement between performers and an audience in a social cultural context (e.g. a concert) was discussed in Thompson, Graham & Russo (2005). They argued that media and genre affects the perception of music both aurally and visually. The authors presented case studies in which they showed that expressive body movement affected the perception of a musical structure (e.g. B.B. King's facial expressions in re-action to his own guitar playing) and how these expressions help spectators empathize with the musician's expressive intentions. More focused case studies on a variety of famous musicians and their movements also exist in the literature. For example, Eldson (2006) studied the jerky movements of jazz pianist Keith Jarrett, Davidson (2006) studied the performance styling of Robbie Williams and as will be seen in **Section 2.5,** Delalande (1988, 1995) studied the semiotic gestures of Glenn Gould.

In addition to musical movement being able to communicate emotion and expression, Marcelo Wanderley and colleagues has provided evidence that musical gestures, including ancillary gestures (see **Section 2.3**) can affect the tone of an instrument (Wanderley, 1999; Wanderley et al., 1999). As a clarinetist performed a piece of music, it was shown that the musician's subtle gestures were directly correlated to modulations of sound partial amplitudes within the sound spectrum. Wanderley argued it was these subtleties that account for the naturalness of traditional instruments versus the artificiality of sounds produced through synthesis techniques. The applications of these findings towards musical interface design are discussed in **Section 2.6**.

Rationale for using the piano in this thesis

The literature cited above represents a small portion of the studies dedicated to the perception or cognition of musical expression through movement. This thesis serves as a comparative study with works such as Davidson (1993) and Wanderley et al. (2005) but also as a novel attempt to investigate the development of expressive movement throughout the course of learning a piece of music. The central idea is to come closer to determining if the musician's increasing knowledge of a piece of music can be detected through changes in his or her musical gestures. The idea of using pianists and piano music for the study stemmed from the fact that I am myself a pianist and therefore, could produce more reliable observations and inferences. However, the piano makes for an interesting instrument to study for several other reasons.

Although popular in ensembles, the amount of music written for solo piano is colossal. In terms of size, polyphony and varied tone color, much of the music from this canon has traits comparable to orchestral works. Pianists are often told to imagine they are playing several instruments at once. In fact, it is not uncommon for piano teachers to recommend to their students to pretend they are actually playing a different instrument. To hum like they were playing an oboe or imagine a phrase being sung to understand how it should sound musically. In discussing the breathing patterns of pianists, King (2006) stated that although breath is not required to play the piano, pianists breath in accordance to the phrasing of the music, as do wind instrumentalists.

On the piano, a note begins to decay as soon as it is played. But certain music and instructions indicate the note should be heard for a longer time than physically possible. To help this, pianists often perform expressive gestures, which give the impression that the sound is not decaying but is being held for a long crescendo, as is possible on a violin. Pierce (2003) explained ways in which the body could demonstrate inwardly imagined music. She contends that certain movement principles can help musicians achieve better tone quality and therefore a better performance. Also, because of the pianist's position in relation to the instrument, they are free to rock their upper body back and forth, make facial contortions or simply sing along.

The framework for the empirical section of this thesis follows the model set by Davidson (1993). Three pianists were asked to play the same piece (Brahms: Intermezzo in A major, Opus 118 # 2) three different pre-determined expressive dispositions: *minimum expression, normal expression and maximum expression.*

Because there had been very little research done in musical movement perception prior to the 1993 study, Davidson referred to Runeson and Frykholm (1983), who studied expression in human movement patterns. This pioneering study showed that observers could easily detect an individual's mental disposition even with the minimum amount of visual stimulus (e.g. a point light display). It was Runeson and Frykholm's Kinematic Specification of Dynamics principle that influenced Davidson to have musicians perform the same piece with three different expressive intentions or performance manners.

The next section is a brief study of Glenn Gould and how he used musical gestures in his performance style.

2.5 Glenn Gould and musical gestures: a case study

A logical approach to going further into understanding musical gestures and their correlations to the music is to study a subject whose gestures are clear and contrasted. We must observe the playing of a musician who exuberates expression and puts meaning and drama into every note he plays. A musician who fits this description is the famous Canadian pianist Glenn Gould. Through an understanding of Gould, his eccentric personality and playing style, it can be understood why a performer feels compelled to move while they play.

2.5.1 Gould: Background and Personality

Glenn Gould (1932-1982) showed virtuosity early in life, able to read music before he could read words. His landmark recording as a young prodigy is that of J.S. Bach's Goldberg Variations. He would go on to record the work again at the end of his career. This would be his last commercial recording of his life as his died of a stroke shortly after.

On the onset of the first recording, Gould was seen as a fresh new voice in the classical world. The pianist Elyakin Taussig described young Gould's performance of the Goldberg variations as 'boney, tough, very rhythmical, clean and transparent, [and] a new way of playing Bach and the piano that no one had quite heard before' (Langer, 1998, DVD). Indeed, Gould's technical fluency and innovative approach to Bach's work, largely at the time considered a dusty old gem, enthralled audiences, making the recording a surprise best seller.

However, Gould's virtuosity was overshadowed by his eccentric behaviors; wearing two sweaters and a trench coat in summer, sitting on the same folding chair for every public performance and of course, his bodily movements. Hunched down, legs folded, singing to himself, conducting himself with whichever hand was free, Gould's performances were as stimulating for the eyes as they were transcendent for the ears. Dr. Helen Mesaros, Gould's biographer, termed these gestures and movements as 'extra-musical behavior'. According to Mesaros, his eccentric movements had been born from the fact that Gould was trying to mask his tension and nervousness about performing live (Langer, 1998, DVD). Although it is generally contended in the music world that too much movement on the part of the performer distracts the perceiver from the music itself, the extra movements played in Gould's favor as it added a sense of virtuosic mystique to his playing. In other words, it was Gould's virtuosity that made the critics accept such psychological aides.

Growing ever disenchanted with performing in public, in 1962 at the age of 32, Gould abandoned concert life forever. Despite claims that Gould's exaggerated stage presence was the result of performance anxiety, it is well documented in many films and television appearances that the older studio musician Gould performed with as much flamboyance as he did when he was a young prodigy (Baron, 2006). Detesting audiences, Gould felt that in the recording studio, he could play with 'a more direct, more personal manner than any concert hall would ever permit' (CBC Archives, 2007). He revered the studio for its 'womb-like security' and considered the microphone as a friend.

It could be said that although no live audience, Gould continued to perform for the camera and the microphone. However, this is hardly a substitute for real ears perceiving and sharing the expressive experience of attending a recital. Musicians tend to get excited when performing in front of an audience and attain some kind of showmanship that is expressed through gestures, both intentional and unintentional. They perform in ways they would not if they were alone in a studio. This does not seem to be the case for Gould who gestured whether or not others were around to communicate with his art. In this sense, Gould's expressive movements were not to communicate expression but performed for the sake of expression itself. He communicated to the music itself. Even when he did perform live, it would seem that any communication with another human taking place was simply a by-product of Gould's absolute expression.

2.5.2 Gould's Gesture Types

It can now be established that Gould's expressive gestures were not directed at communicating with an audience as much as he was communicating to the music. When investigating the gestures of pianist Glenn Gould, Delalande discovered five interconnected psychomotor organizations, which he named *gesture types* (Delalande 1988, 1995). The gesture types each demonstrate an expressive behavior and are each affiliated with different postures:

Composed: *Back is immobile and hunched over with chin touching chest.*

Vibrant: *The torso sways back and forth, pivoting on the middle section of back.*

Flowing: *The entire back sways back and forth pivoting on the lower back accompanied by eyebrow movement.*

Delicate: *The head is sticking out on top of the keyboard, stretching away from the shoulders.*

Vigorous: *The entire torso in immobile with the head slightly forward. Used during faster passages.*

In studying unedited footage of Gould performing Bach's *The Art of the Fugue'*, Delalande observed these gesture types manifested themselves at different parts of the score. Delalande stressed the solidity of these gestures, signaling out the sharp transitions between gesture types and sequences in which he could state in all certainty that the gesture was 'pure' at 75% of the time the gesture occurred (sometimes it is unclear which gesture type is being used).

Delalande argued that each gesture type is a realization of an expressive characteristic. In this way, the signifier and the signified are so closely correlated that there can be a distinction placed above that of expression and body movement.
The production and reception or a musical object is inherently the same thing. In other words, the musical gesture encompasses a psychomotor organization and an expressive content to represent unified *expressive schemata*.

In a comparative study (Thompson 2005), another filmed performance of Glenn Gould was analyzed with the goal of seeing if Delalande's Gesture Types (DGTs) could be found in different piece, although in the same style (the video analyzed was that of Gould's 2nd recording of the Goldberg Variations. A graph was developed in which movement in different parts of the body could be observed temporally beneath the score. Although no statistical method was applied, the DGTs are clearly seen throughout the performance. It could be hypothesized that Gould has a repository of gesture types, each having a different purpose for different musical affects.

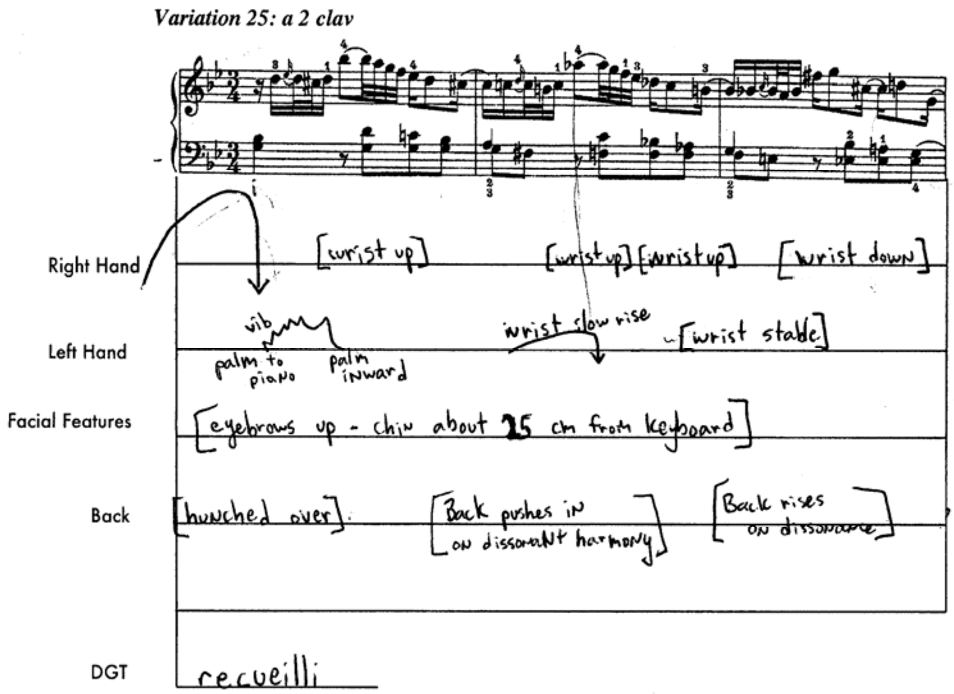

FIGURE 1. Gestural Analysis for Glenn Gould's performance of Goldberg Variations.

It is tempting yet very dangerous to generalize the playing style of Gould to other pianists. He was an individualistic personality who shunned crowds, lived a solitary mostly nocturnal life and constantly feared germs. His eccentric personality was reflected in his playing. If any generalization can be made at all, it is indeed this: A musician's personality is reflected in their performance. The empirical research portion of this work presents three case studies of pianists and how their expressive gestures are engrained into their performances. It will be seen that personality can be used as a descriptor of how someone will move during performances.

2.6 Applications of Musical Gesture Research

This section delves into three related areas of research that may benefit from musical gesture research. They are Music Education, Music Controller Design and Music Cognition modeling.

2.6.1 Music education and memory

The ability to learn a piece of music efficiently requires a culmination of knowledge, strategy and effort (Chaffin, 2007). The performer uses past knowledge of musical idioms (arpeggios, scale pattern, chords, structural features) and groups these into chunks and sequences, creating a conceptual map of the piece in their mind. But what separates music from other applications of memory (e.g. a waiter memorizing dinner orders) is its emphasis on auditory and motor memory.

This motor memory could be thought of as a series of movements, elaborately timed and organized to properly play a piece of music. The process of developing a motor sequence for a particular piece is usually not learned in a systematic way and is not fully understood by music teachers, let alone music students. The way a musician learns a piece of music can be very individualistic and may require many years of developing a perfect system. Much of what musicians know about music represents an implicit knowledge (Kendall & Carterette, 1990). Terms that represent musical quality like a *sharp* sound, or *flowing* are abstract and subjective terms. Like many musical concepts, the motor sequence required to perform music involves an implicit memory, much like typing at a computer.

Consider the great contemporary pianist Maurizio Pollini. In a 2006 interview, the maestro stated that his memory had been essential for his ability to learn large difficult pieces of music within a short time period and particularly useful in learning more contemporary works such as those by Boulez and Schoenberg. Hailed by critics as having a *photographic* memory, the virtuoso renounced the comment by stating his memory was not so much visual as it was *musical* (Piel, 2006). Speculating on the Pollini's comments, musical memory, as he calls it, could be said to be a balance between explicit and implicit memory.

The explicit aspect of memorizing a piece of music deals with thinking of the structural aspects of the piece. The musician must know the content of the piece and use structural elements such as phrase boundaries as retrieval cues. This explicit knowledge of the piece is what saves musicians when they suffer from a memory loss while performing. They are able to seamlessly jump to the next retrieval cue.

Equally as important to performing music is implicit memory, which refers to auditory and motor memory. This is this type of memory that allows a musician to learn a piece of music with the help of movement cues occurring throughout a sequence of motor movement. The movements become affiliated with a structural aspect of the piece and become integral to that piece's performance. Interestingly, evidence shows that motor memory applies to both instrumental gestures and ancillary gestures.

In Wanderley et al. (2005), it is reported that five clarinetists played a Stravinsky piece in different performance manners. In the manner deemed *immobilized*, players were asked to restrain from moving as much as possible. Four out of five players performed the immobilized renditions faster than the standard or expressive renditions. Interestingly, the musician who played slower thought he was actually rushing through the piece and showed some of the same ancillary leg movements as he did in the other performance manners but in a reduced manner. It was speculated that the movements 'were so engrained or habitual that it was not possible to inhibit them completely, or the body movement that remained in the immobile performance were essential for executing the instrumental gestures involved in accurate sound production' (Wanderley et al., 2005, 103). This may prove that ancillary gestures are part of a motor program that the performer uses implicitly to correctly play a piece of music.

As for the rest of the players who played faster than the standard performance, it was speculated that that motion must be related to the rhythmic structure of musical phrases. Without gestural motion, the performer's timing ability was altered. Without the psychological aide of tapping the foot or periodic movement of the clarinet's bell, the performers rushed through the piece. This is another indication that ancillary gestures stored in long-term memory implicitly enhance performances.

If ancillary gestures are indeed an integral part of a performance, it is possible that studying their exact function can be applied in musical instrument tuition. For example, a reliance on implicit memory (motor memory) can result in loss of memory during performances, which many novice performers will attest to. It may be useful for music educators to emphasize the importance of gestures to their students by explicitly linking an ancillary gesture with a structural component of the music.

The study of gestures may also be relevant in promoting a healthy playing style for musicians. Improper movements and tenseness can be dangerous for performers and can lead to physical health problems such as critical wrist and forearm pain (Eller et al., 1992; MacIver et al., 2007), which in turn can lead to loss of motivation and short careers. Proper movements lead to a better performance and a healthier musician.

Indeed, an emphasis on musical gestures in musical pedagogy may help transfer what is thought of as being passive knowledge to active knowledge. In other words, direct correlations could be made between a musical gesture and some kind of musical idiom. One method proposed to determine which gestures are the most beneficial involves having professional music teachers rate the point-light displays of performers (Luck, et al., 2007). Through continuously rating the posture of a vocal performance, from good to bad, and then correlating the results with a continuous rating of the vocal performance, it could be determined if (a) good posture can predict a good singing performance and (b) what postural position in a singer is the most effective for a good singing technique. This is just one way in which the general knowledge of music can shift from being implicit to explicit.

2.6.2 Musical Device Interaction

Human Computer Interaction has been an important field of research and development since the onset of the personal computer. As technology becomes more reliable and as the cost of manufacturing commercial products decreases, the field will surely expand in the next years. The end result is to create interfaces in which the user can interact with a machine in an intuitive way, using natural human gestures to navigate through the device's functions. In order to develop devices that can be used intuitively, human cognition and ergonomics are applied to these new designs. Many examples of this technology exists both in the academic and commercial arenas.

Currently, the world eagerly awaits the Apple iPhone[3]. This telephone/mp3 player/web-browser features a single button. The user interacts with the iPhone through a touch sensitive screen with the world's most ergonomic pointer, the index finger. The gaming industry has also played a crucial role in developing new gesture-controlled interfaces. One of the main features of the new Nintendo Wii[4] gaming console is a game controller that uses a combination of accelerometers and infrared detection to sense its position in 3D space, creating a virtual in environment in someone's living room. Accelerometer technology has also been used in developing tools for people with limited motor movements. The company BT currently has a prototype for a 'motion-sensitive' PC named the BT Balance, which works by being turned, shaken or knocked by the user.[5]

One could easily see how these examples of gesture-controlled devices could be applied to the field of music. As a specific example, the applicability of game control technology to the gestural control of music has already been demonstrated in Jensenius et al. (2006a). Thus, the same technology can be applied to many industries.

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[3] www.apple.com/iphone

[4] http://www.nintendo.com/channel/wii

[5] http://www.btplc.com/

The main motivation for developing gesture-controlled interfaces for musical applications is due to the fact that traditionalists often shun electronic or computer-produced music because it lacks expressivity (Rovan et al., 1997). It seems that traditional instruments have a universal appeal to audiences. The reason for this may be that when a musician plays the piano or when we listen to an orchestra, there is a very close correlation in the way that the player is moving their body and the expressive quality of the sound being produced. The expressive intentions are not only *heard* in the music but also *seen* visually in the demeanor of the musician. The expressive intentions of someone controlling a black box on stage are arguably more difficult to interpret. This is not to say that the music itself is not expressive, but the performance will lack the visual semiotic imagery between performer and instrument.

For composers, much of the 20th century was spent discovering new sounds and new forms of musical expression. The late Romantics had brought tonality to its knees and composers of serialism and atonalism had killed it off completely. Instruments of the orchestra were soon deemed inadequate to create the timbre sought by composers. At first, composers created new timbres by altering existing instruments.

John Cage, for example, developed the prepared piano, which enabled new sounds to be generated on the piano without altering the way in which the piano is manipulated. The sounds to come out of the prepared piano were at times inharmonic or percussive in nature. The notes on the score no longer represented a pitch in the traditional sense so much as they indicated which button to push (Thompson, 2003). The prepared piano was a success in the way that one could achieve the same level of expressivity a new instrument without compromising the visual aspect of music.

Over the last 50 years however, it has been electronic music that truly allowed composers to develop new sounds. Composers became not just the composers of music, but also the composers of timbre, whereby any sound could be achieved through synthesis methods. Even though this meant a new way for composers to express ideas, the tools developed to produce this music created an abstraction between the instrument manipulator and the sound itself. This has been seen in music of the avant-garde (e.g. Electro-acoustic tape music, computer-driven compositions making use of the Max/MSP software) and the popular music world (e.g. Moog synthesizer, drum machines, synth rock, etc.). At first unbeknownst to the composers (or not taken into account), the effect of playing from a *black box* instrument was drastically different from traditional music where the bodily gestures of the musician play a large role in communicating expression.

Music makers came to understand this problem and electronic music started to be placed in venues other than the concert hall. The Edgar Varèse electronic piece, Poème électronique was famously included in the Phillips pavilion at Paris's 1958 World Fair as part of a sound and space exhibition. This was a new way to experience music in a context entirely abstracted from the actual music production. Experiencing sight and sound this way may have masked the fact that the music was no longer performed by a live performer, but was not able to completely replace the traditional recital hall setting of a visually appealing musical experience.

Thus, music performed in the traditional sense by a recitalist or an orchestra continues to be the flagship way of perceiving the expressiveness of music. For designers of new instruments, it is detrimental that human expressivity be taken into account when designing the interface of such devices if they are to be as appreciated as is the traditional way of perceiving music. To maximize the level of expressiveness within, for example, a computer music performance, it would be valuable to have Juslin's and Wanderley's cognitive approaches to music incorporated into these devices. The reason this was not done before had to do with the lack of the role of musical gestures, let alone the vast amount of computations involved in synthesizing such extensive data.

2.6.3 Music cognition modeling

Studies that focus on the expressive gestures of musicians can develop a model for music cognition of gestures. Through analyzing how musicians interact with a *musical instrument,* it is possible to develop mapping strategies for a *musical controller.*

A *musical instrument* is a mechanical object that relies on physics and mechanics to output its sound. Whether this mechanism consists of blowing, pressing a key or striking a bow, the input and output are integrated within the same object. A *musical* *controller* on the other hand, implies that there is an abstraction between the control of sound and the piece of equipment that produces the sound (Levitin, 2002).

On a musical instrument, mapping is a function of how the instrument is manipulated by the musician. The sound has a direct and perceivable connection with the action of the musician. For example, a high note played on a trumpet is the result of the musician's breath and lip tension (Roads 2000).

Musical Instruments have a tradition of being designed with what Roads calls, good ergonomics. They are easily and intuitively used through the handling of human gestures. Levitin et al. (2002) go even further and point out that the design of specific musical instruments is directly related to human cognition and motor processing skills.

Indeed, the most enduring instruments that have survived for centuries have done so because of their playability, learning curve and vast range of expressive dynamics. Many instruments have not survived because of their inability to convey an expression that the musicians wanted to communicate. This is no different with new electronic instrumentation; the life of a musical controller can be as short as the performance (Iazzetta, 2000).

Musical controllers should be designed with mappings that are intuitive and take a musician's natural movement and motor limitations into account. However, a good mapping model implies that a single gesture can control multiple parameters of sound. For example, a conductor is able to simultaneously control the volume and tempo or an ensemble with just one gesture. The rhythm of the gesture represents the tempo and the size of the gesture represents the volume (Kurtenbach & Hulteen, 1993).

Rovan et al. (1997) offer three different mapping strategies to use when implementing the use of meaningful gestures into musical controllers.

One-to-one: one gesture controls one aspect of sound.

Convergent: one gesture controls more than one aspect of sound.

Divergent: more than one gesture is used to control one aspect of sound.

In using this strategy, it should be remembered sound is instigated on a physical musical instrument based on the human gestures involved, the physical characteristics of the instrument and the human's motor and cognitive skills. Herein lie the limitations shared by every musical instrument. These restrictions should be taken into account when designing new interfaces in order to maximize the expressivity of the player and also make the transition to playing a musical controller as intuitive as playing a musical instrument.

In order to maximize the expressive qualities of music using musical controllers, there needs to be emancipation from traditional musical controllers such as the piano MIDI keyboard. This would give the opportunity to designers to re-think the way in which musical gestures can be mapped into controllers. Arfib et al. (2005) point out that the types of mapping involved should be based on the amount of expression involved. As previously observed in this work, ancillary gestures offer valuable insight into musical expression and the musical mind.

The discipline of understanding expressive gestures will expand as public interest continues to grow in virtual reality environments. Already with the Nintendo Wii, the virtual environment has entered the living room. But researchers are expanding towards more elaborate settings where humans can interact with machines in a dynamic and creative way making use of non-verbal, cross-modal communications. The research done for this purpose can serve as interaction design as it can develop new models for music cognition. As Gualtiero Volpe wrote:

> On the one hand, research on gestures allows deep investigation into the mechanisms for human-human communication: this knowledge can, for example, be successfully exploited in interaction design. On the other hand, the gesture-processing capabilities can open new and unexplored frontiers in the design of a novel generation of multimodal interactive systems (Volpe, 2005, 3).

The Multisensory Expressive Gesture Applications project (MEGA) was a multi-disciplinary program with the objective to design and develop multimodal mixed reality environments 'for the performing arts that could be populated by real and virtual subjects' (Camurri et al., 2005, 5). In order to develop an environment as realistic as possible, the 'real' subject should be able to interact with the 'virtual' subject as naturally as possible. Through environments such as MEGA, research concerning music cognition can be used to provide valuable new insight for the field of music cognition.

2.7 RESEARCH TOOLS

This section briefly outlines the technology (hardware and software) used in the research project detailed in **Part 3.**

2.7.1 Motion Capture Technology

Motion Capture (MoCap) is a technique for recording and observing movement. The modern digital MoCap system was originally used for studies in biomechanics (e.g. gait perception) and more recently in industries such as surveillance, computer animation, video game design and applied research studies (Moeslund & Granum, 2000). There are several MoCap technologies but all are similar in the way that a subject is recorded using high resolution cameras in the goal of measuring movement parameters, such as velocity, angles, acceleration, etc. The data is stored in a file (e.g. text file) and can be analyzed and processed as a time series of events. In music perception and musical movement analysis, these systems can be useful for calculating and interpreting expressive movement over time.

The modern MoCap system is a descendent of a technique developed in the late 1800's in which human and animal motion was captured by taking quick consecutive pictures within a small time frame (Perales, 2001). In the 1970's, Johansson (1973) developed a point-light technique where the contrast of a video was altered so that only reflective markers could be seen in the image. This took away all of the visual detail of a moving picture while still being able to indicate movements. Davidson (1993, 1995) applied the same method in her forerunning research into expressive content perceived in the visual channel of a musical performance. In the last decade, as the costs of technology have gone down and since there has been a growing interest in conducting inter-disciplinary research, a growing number of music and fine arts departments have taken advantage of digital systems for motion capture. Examples of departments that have integrated motion capture systems in their research include the University of Ghent, the Input Devices and Music Interaction Laboratory at McGill University, University of Oslo, University of California, etc.

Currently, the University of Jyväskylä's Music department is host to the Qualisys motion capture system[6]. The ProReflex system by Qualisys is a motion capture system that can use up to 32 precision cameras. The music department's motion capture system has 8 cameras that can measure movement at up to 120 frames per second. The cameras function by emitting infrared light onto reflective markers placed on a subject. The image of each camera is interpolated together in order to achieve a 3-D point-light representation of the subject, which moves in relation to a stable axis.

The technique of using a MoCap system to derive information about musical movements seems to be coming of age. A growing number of facilities mean that there can be more partnerships between different research centers. However, it was found that each institution used their own file formats and their own analytic tools for analysis, making them incompatible with the tools developed in other faculties. Currently, researchers from different faculties are working together to develop a standard way in which MoCap data can be shared for analysis throughout different institutions. Researchers at the University of Oslo are developing a Gesture Description Interchange Format (GDIF), whose goal is to develop a specification dedicated to storing gesture-related data and analysis in a universal format that can be shared among different research teams (Jensenius et al., 2006b). Closely related to this, the Canadian multi-disciplinary research group CIRMMT (Centre for Interdisciplinary Research in Music Media and Technology) has begun a series of workshops (Cossette & Wanderley, 2007), which are organized so that different groups can come together and collectively discuss what standards should be placed in musical gesture research (e.g. easily interchangeable files, placement and number of markers on subjects).

2.7.2 Video/Audio (QuickTime, ProTools)

QuickTime is a video authoring software. It was with this software that preliminary video analysis was made. It was also used to author clips of point light displays with

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[6] www.qualisys.com

images derived from the Qualisys software. ProTools was used to record audio and MIDI data. The data was then annotated and exported as .wav files.

2.7.3 MIR Toolbox

The MIRToolbox (Lartillot & Toiviainen, 2007) developed at the University of Jyväskylä is a set of functions in MATLAB that serve to compute audio and retrieve information related to timbre, spectrum, pitch, tonality etc. Each function is based on models of music perception and cognition in pre-existing literature.

Part of the analysis made use of the MIRToolbox function that computes the spectral flux in a sound file. Spectral flux is the measure of how quickly the amplitude spectrum of a signal is changing. It calculates the distance between the amplitude spectra of one frame of audio with the previous frame. Most commonly, the Euclidean distance represents the distance between the two successive frames. This is the default value used by MIRToolbox in the spectral flux function. It returns a value related to the 2-norm or Euclidean distance. MIRToolbox returns an array of values representing the distance between amplitude spectra of subsequent audio frames.

2.7.4 Qualisys Toolbox

The Qualisys toolbox[7] is a set of MATLAB functions specifically designed to work with files exported from the Qualisys MoCap software. The toolbox was used to load the Qualisys files into MATLAB and operations such as a gap filling function, which uses an interpolation algorithm to fill gaps in the movement data. Also, the toolbox was used to create JPEG files of the point light displays, which were later made into QuickTime movies. More information about how the Qualisys Toolbox was used during the analysis can be found in **Section 3.2.1.2** and **Section 3.2.2.2**.

[7] The Qualisys Toolbox was developed at the Department of Music, University of Jyväskylä

3 RESEARCH PROJECT

The research project's schedule spanned several months from October 2006 to March 2007. In total, there were 11 Motion Capture (MoCap) sessions with three different pianists. The time period between sessions varied depending on the availability of the participants.

3.1 EXPERIMENTAL DESIGN

The methodology of the empirical portion of this thesis followed the tradition of past studies in which musical performances were played in three expressive intentions (e.g. Kendall & Carterette, 1990; Davidson, 1993 & 1995; Wanderley et al., 2005) or had the musician perform with specific emotional qualities (Dahl & Friberg, 2003). Studies have shown that it is the expressive intention of the performer and not necessarily the musical piece that elicits emotions in the listeners. In fact, it is the performer the influences the listener's understanding of the music (Juslin, 2003). Following this idea, the intention was to study how individual pianists used musical gestures for the sake of expression in music performance.

The novel attributes of this study were:

a) The focus was on the performance gestures of pianists.
b) There was emphasis on how musical gestures evolved throughout the course of learning a piece of music. By the time the player had the piece memorized, there should have been a significant difference in expressivity observed in the performance gestures.
c) To see if movement patterns evolved from the note-learning stage until the piece is known by memory and ready for public performance.
d) Because each pianist played the same piece, there might have been performance gesture correlations between pianists.

Despite the objectives listed above, the design remained exploratory in nature. The study did not seek to prove a specific hypothesis, however, it was expected that the results would confirm the work of past studies. Examples of these confirmations would include:

a) The levels of expression have an effect on the amount of musical gestures used in the performance.
b) Motor memory is responsible for an accurate rendition of a piece
c) It is possible to play a note perfect rendition of a piece of music with no expression, although the absence of expression may affect musical elements such as timing and phrasing.

The implications of this and subsequent research can serve a purpose in the areas mentioned in **Section 2.6**, most notably the area of Music Education and Music Technology. All musicians move their body in an expressive manner to a certain extent when they play. However, the control and activation of these gestures represents an implicit knowledge. A formal understanding of performance gestures can help music educators and performers form an explicit knowledge of their own movement patterns so they may move more effectively.

Characteristics of performance were studied qualitatively and quantitatively. The quantitative performance features include timings of each performance, range of motion, evolution of movement between sessions, difference in movement patterns between pianists, and finally, difference in movement patterns between expressive performance manners.

3.1.1 Media and data collecting hardware

Qualisys ProReflex Motion Capture System: see ***Section 2.7.1***

Piano: The piano used throughout the sessions was a Yamaha Disklavier Pro Mark IV. The Disklavier has a technologically sophisticated design that combines a traditional grand piano with hammer sensors that can record elements such as note onset and offset times and velocity. The data can be stored in MIDI format and transmitted to MIDI devices or computers. The piano lid was kept closed throughout the sessions so as not to obstruct the cameras from getting a clear view of the instrument. To alleviate the risk of unwanted infrared reflections from the piano's glossy surface, the piano was draped with a bed sheet and the control box beneath the left side of the keyboard was also covered up.

Audio: An AKG condenser model C414 microphone was placed near the cut away of the piano and patched via XLR cable to one of the inputs in the Digidesign Mbox. Because of the noise coming from the MoCap cameras' fans, the audio signal has a small amount of background noise. However, it was decided that the amount of audible noise would not affect the analysis.

Digidesign Mbox2 & ProTools LE 7.0: The audio and MIDI signals were recorded in the ProTools software via the Mbox. ProTools was also used to annotate audio footage, synch video footage with MoCap data and create multimedia video clips used for presentations (Thompson, 2007).

Video Camera: The sessions were videotaped using a Sony DCR (mini DV) camcorder with Maxell mini digital videocassettes.

3.1.2 Set –up and Procedure

The standard procedure for each session involved a 90-minute set-up period where the room was organized. The Disklavier was moved to the centre of the room and the cameras were placed in the correct formation. The MoCap system was calibrated and finally, some tests were run on the system to make sure the cameras were well placed. If needed, the system would get re-calibrated. The floor plan of the studio in which the sessions were held can be seen in **Figure 2**. Note that this figure is not to scale but shows the general location of objects in the room.

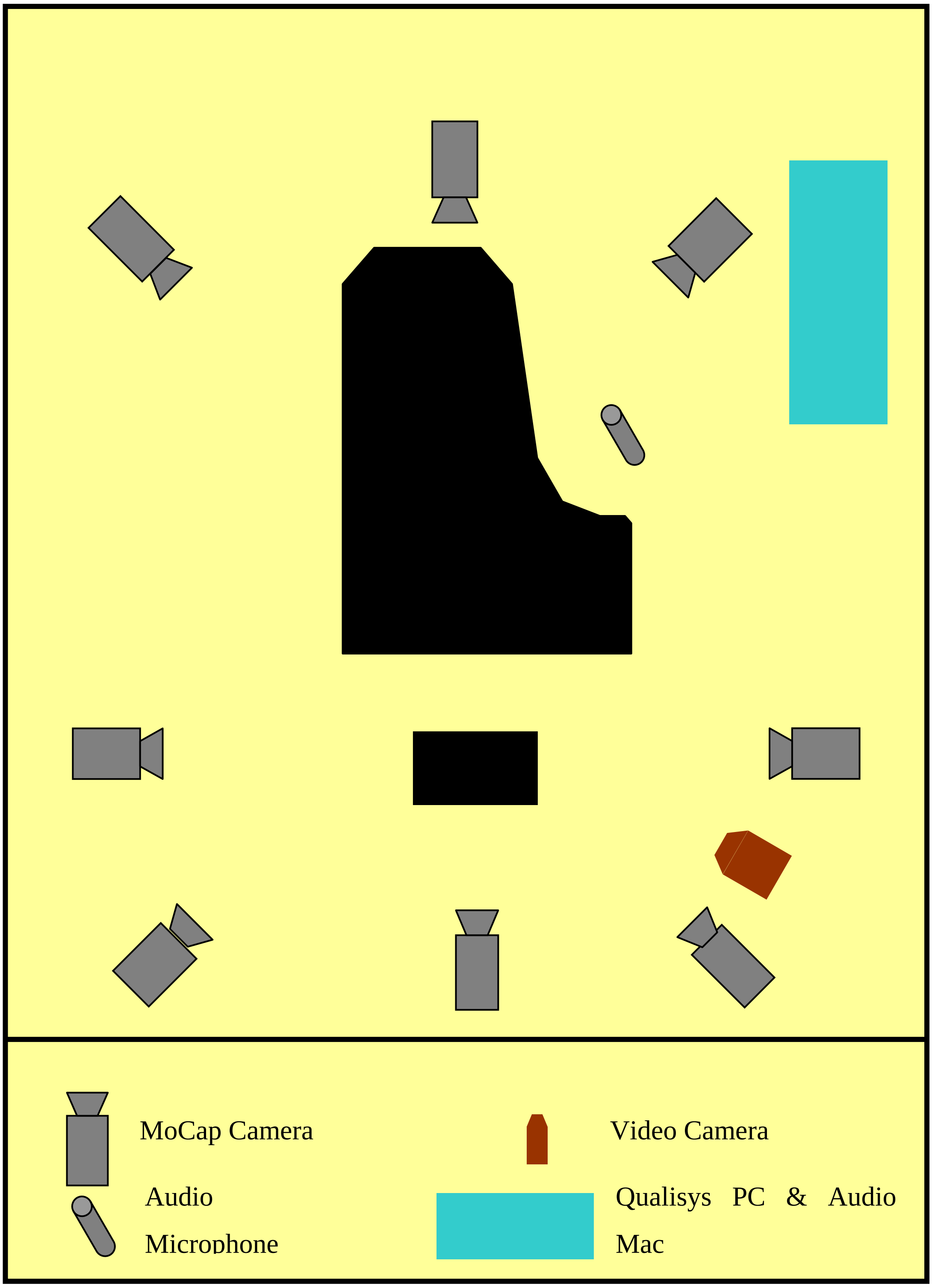

FIGURE 2. Floor plan of motion capture studio

Once the participant came to the session, fifteen markers were placed on them (four on the head, two on shoulders, one at the centre of the back, two on the lower back, two on the elbows, two on the wrists and additionally, two markers were placed at each end of the keyboard. They were asked to practice the piece they would be playing during the experiment. These practice sessions (average of 10 minutes) were captured with the MoCap system (usually unbeknownst to the participant). Originally, the practicing data was to be used in the analysis but was not because of time constraints and the logistical problem of annotating a warm-up session.

Once the pianist was comfortable with the laboratory environment and any problems involving marker placement were solved, it was explained that they should play a short excerpt of their piece in three different performance manners with different levels of expression: *Minimum expression, normal expression* and *maximum expression*. For the most part, the words *movement* and *gesture* were avoided. The goal was to let each pianist interpret for him or herself what was meant by different levels of expression. However, with all the cameras and markers on their body, it might have assumed that their movements were being analyzed, but this was never stressed.

3.1.3 Participants

Three pianists volunteered to take part in the study. All three were competent pianists, having each had at least 10 years of playing experience. Player 1 (b. 1982) had played piano for 15 years and currently in her fourth year of studying piano pedagogy at the Jyväskylä University of Applied Sciences (Jyväskylän ammattikorkeakoulu) and participated in four sessions. Player 2 (b. 1978) had been playing piano for 22 years. She had received her Bachelors of music from the same university and participated in four sessions. Player 3 (b. 1977) was a visiting researcher at the University of Jyväskylä's music department with 17 years of piano experience. He had studied piano performance until 2003 as part of his musicology studies at the Liszt Academy at Budapest and participated in three sessions. Both Players 1 and 2 were Finnish females and Player 3 was a Hungarian male. The participants were given an honorarium for participating in the experiment in the form of gift vouchers for the music store ‘Free Record Shop’.

Throughout the four sessions, Player 1 performed the Beethoven Sonata Opus 26, number 12; 1st movement, the piano part for Poulenc’s Sonata for Violin and Piano, 1st movement and the Brahms Intermezzo in A major Opus 118 #2. Both Player 2 and Player 3 played the Brahms Intermezzo in A major Opus 118 #2. However, they played works by different composers while warming up for the experiment.

To reduce the scope of data, the analysis for this thesis focuses solely on an excerpt from the Brahms Intermezzo. The number of times the excerpt was played differed from session to session and from player to player depending on how much time the participant could devote to the session, etc.

3.2 Analysis

3.2.1 Quantitative approach: a search for similarities and differences

When it was realized that all three pianists were playing the same Brahms Intermezzo, the focus of the analysis switched to this piece in order to search for trends, similarities and differences between each pianist. The comparative aspects between performers that were investigated were length of performance and range of motion. Individually, there was also some information gathered concerning how the pianists changed their movement patterns throughout the course of the experiment. The results of these sections are not to be generalized to the entire community of pianists. However, the observations and inferences made can be used as good starting points for further research.

3.2.1.1 Performance Length

It has been suggested by the literature (Wanderley et al., 2005) that the lack of musical gestures in an *immobilized* performance can have an effect on the timing of the piece, both locally and globally. It would seem that a deficiency in gestural movement might throw-off the performer’s perception of the piece’s rhythmic structure. Some tests were made to observe if the lengths of the performances were influenced by the lack or amplification of expression.

Table 1 shows the performance manner and the total number of times it was played (all players put together), the average length of their performance manner and the standard deviation for each. The data represents the time at which they started to play the Brahms Intermezzo (1^{st} measure) until the end of the 16^{th} measure. Natural deviations from the main tempo made it difficult to find the exact tempo of the piece. However, it can be taken for granted that the performances with longer lengths were performed slower than those with short times. From this table, it can already be seen that the performances that had the *normal* level of expression were more uniform in length than the *minimum* or *maximum* levels of expression. There are several reasons why this might occur. The most obvious one might be that the *normal* rendition was performed more times than the other two, however not by much, but perhaps enough to make the deviations from the average higher in the *minimum* and *maximum* renditions. It could also be that the performances with *normal expression* would be the closest to what the participants would play if they were rehearsing or performing in a recital or making an audio recording. It was this level of expression in which they felt more natural playing.

TABLE 1. Average length of the 3 different performance manners and their standard deviations.

Performance Manner (Total number of times played)	Average length (sec)	Standard Deviation (sec)
Normal expression (16)	49.6	6.4
Minimum expression (13)	45.9	13.3
Maximum expression (12)	51.7	11.5

While **Table 1** presents global information about length, it is worthwhile to have a closer look at the participants individually. The *minimum and maximum* levels of expression were compared in length to the *normal* level of expression. An analysis of variance was conducted to see if the lengths between performance manners varied significantly for each pianist. For Player 1 and Player 2, it was found there was no significant difference in the length of the performances.

Table 2 shows performance length details for Player 1. In her session 3, Player 1's lengths for each performance varied drastically. In the fourth session, the length throughout all the performances manners was much closer. An explanation for this would be that the player was more comfortable with the score in the fourth session. However, in a subsequent interview, the pianist noted that she was trying to play with *minimum* or *maximum* expression while still adhering to the basic instructions in the score. The tempo is intended to be *Andante teneramente* (slow and warm). This would indicate that for Player 1, to play with *minimum* expression might mean to play the score as plainly as possible (paying close attention to what is on the score with no expressive input from the player) while the *maximum* expression might mean to play the score as exaggerated as possible, which is why the *maximum* performance was so slow.

TABLE 2. Player 1: two sessions in which Brahms Intermezzo was played.

Session	Performance Manner	Performance Length (sec)	% Difference between with normal
Session 3/4	Minimum	71.8	+13.0 %
	Normal	63.5	
	Maximum	82.8	+30.4
Session 4/4	Minimum	61.2	+0.8
	Normal	60.7	
	Maximum	63.0	+3.7

Player 2 was able to play the Brahms Intermezzo throughout four sessions. **Table 3** shows Player 2 had the least amount of varied lengths in time between sessions and across the three performance manners.

Player 3, however, did show significance in the length of performance between performance manners (F = 69.6, p <0.0002). The discrepancy between Player 1 and

Player 2 with Player 3 is a result of their individual understanding of what it means to play in different levels of expression. For Player 3 especially, there was an implicit link between playing with expression and length (see **Table 4**). The *normal* and *maximum* renditions are much closer in length compared to the *minimum*. Player 1 decided to play the *minimum expressive* rendition with no creative input (such as strictly following the directions of the score) while Player 3 decided to play the excerpt as unmusically as possible and ignored the score's instructions.

TABLE 3. Player 2: four sessions in which Brahms excerpt was performed

Session	**Performance Manner**	**Performance Length (sec)**	**% Difference between with normal**
Session 1/4	Minimum	52.7	+0.8 %
	Normal	52.3	
	Maximum	49.5	-5.2 %
Session 2/4	Minimum	56.4	+0.9 %
	Normal	55.9	
	Maximum	54.4	-2.6 %
Session 3/4	Minimum	55.1	+1.3 %
	Normal	54.4	
	Maximum	52.5	-3.5 %
Session 4/4	Minimum	55.0	+3.6 %
	Normal	53.1	
	Maximum	52.9	-0.3 %

TABLE 4. Player 3: three sessions in which Brahms excerpt was played.

Session	**Performance Manner (number of times played)**	**Performance Length average (seconds)**	**% Difference between with normal**
Session 1/3	Minimum (4)	36.5	-20.9 %
	Normal (6)	46.1	
	Maximum (3)	46.0	-0.3 %
Session 2/3	Minimum (1)	35.8	-22.6 %
	Normal (2)	46.3	
	Maximum (1)	43.2	-6.8 %
Session 3/3	Minimum (2)	31.5	-25.6 %
	Normal (2)	42.3	
	Maximum (2)	42.2	-0.1 %

3.2.1.2 Range of motion

The next step was to see how the *range of movement* changed throughout the different performance manners. The movement data was imported into MATLAB using the Qualisys Toolbox where the range of motion for three body parts was measured. The Qualisys movement data was stored in a matrix. Each marker was designated three columns, *x*, *y* and *z*, to represent a 3-dimensional coordinate plane. The range of a marker was determined by extracting a single column from the matrix. If the horizontal trajectory of a marker was required, the *x* column was extracted, for the vertical, the *y*, and so on. The next step was to apply MATLAB's *range* function, which subtracts the lowest number in the column from the highest number.

Figure 3 shows the movement range of three markers:

> *Figure 2A:* The horizontal movement of the head markers from the *x-axis* (mean was taken of four head markers).
>
> *Figure 2B:* The horizontal movement of the shoulder markers from the *x-axis* (mean was taken of two shoulder markers).
>
> *Figure 2C:* The vertical movement of the wrist markers from the *y-axis* (mean was taken of two wrist markers).

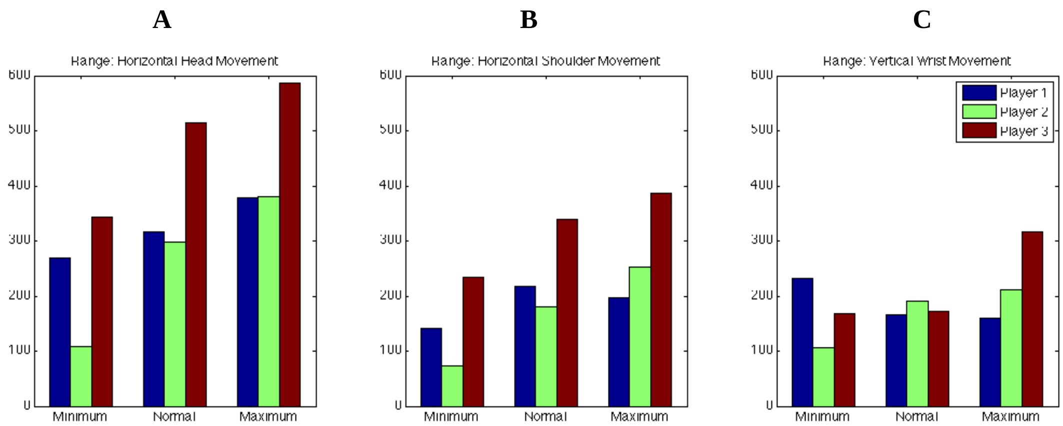

FIGURE 3: The range of movement of the head, shoulders and wrists.

Each color represents a pianist and the bars are grouped by performance manner. This data was taken from the last session (for Player 1 (blue) & Player 2 (green): session 4; for Player 3 (red): sessions 3). The range of motion increases as the level of expressivity rises for every pianist in every marker except for Player 1 in the wrist markers **(Figure 2C, blue).** Despite this, the bar chart might still indicate that heightened expressivity is associated with a wider range of motion. The head had a substantially larger range than the shoulders and wrists. This is due to the fact that the head has a higher degree of freedom than the other two markers. As a pianist's main contributor to ancillary gestures, the head is freer to move when the player wants to play with maximum expression. Wrists, which are needed to play the piece accurately, have the least degrees of freedom when it comes to playing expressively. For this reason, it is acceptable to discern that wrists do not play a role in expressive movement for pianists.

3.2.1.3 Movement with respect to score

It was expected that ancillary gesture patterns would have a correlation with the music's score. That is, movement patterns might act as symbols for musical content, be it structural or expressive. By plotting the movement variables acceleration and velocity with the spectral flux, strong relationships between movement and music were revealed (Luck & Toiviainen, 2006).

Throughout the performances of each participant, Player 3 showed the most interesting results in regards to evoking phrasal boundaries and symbolic expressive gestures through his playing. **Figure 4** shows information about Player 3 in his third session. The spectral flux[8], velocity and acceleration for the three performance manners are aligned together. The data represents an extract (first 16 measures) from The Brahms Intermezzo[9]. The first thing to notice is how the excerpt's four phrases are clearly denoted in the spectral flux, represented by dips in energy **(bottom row of Figure 4).** Secondly, the head movement patterns change drastically from the *minimum expression* rendition to the *maximum expression* rendition. As the renditions increased in expression, so did the velocity **(Figure 4; top row)** and acceleration patterns **(Figure 4; middle row)** of the head, as did the spectral flux of each performance **(Figure 4; bottom row).**

[8] Spectral Flux is defined in Section 2.5.1

[9] The first page of the score for Brahms Intermezzo, Opus 118 # 2 is located in Appendix 3.

Minimum Performance

Upon comparison with the video footage, the minimum performance **(Figure 4A)** shows a limited amount of head movement that is not expressive but purely functional (instrumental gestures needed to perform the piece adequately). From the video, it is seen that the head stays focused in the mid-section of the keyboard. The spikes in the velocity graph show that he is turning his head quickly to play a leaped note in measure two[10]. It could be debated whether this gesture is instrumental or ancillary, as it can still count as a structural gesture needed to play the notes correctly. Also, notice the increase in velocity near the end of the minimum performance, right after a cadence, to signify the end of that section. Additionally, comparing the spectral flux graph with the acceleration and velocity graph, we can see Player 3 moves the head very little at the point where he uses the most volume in his playing.

Normal Performance

The *normal expression* performance contained a significant amount of symbolic head gestures. Through observing the MoCap point light display **(Figure 5),** it can be seen that the head remains low during the melody's antecedent **(measures1-4)** but rises at the melody's consequent **(last four measures of phrase)**. The MoCap data also shows the head *acting-out* the melody. For example, the rising bass line in measure six was perceived in the rising motion of the head. At the end of this phrase, the head points up to the ceiling and remains there until the start of the next phrase. A free-hand representation of the head's movement is seen in **Figure 6**[11]. Notice the slow ramp and the sharp drop of the head, which occurs in measure six when the bass rises. At the phrase's climax, the head is at its highest and remains at that point.

Maximum Performance

The *maximum expression,* displayed in **Figure 4C,** showed the highest correlation between musical gestures and musical content. The graphs show that the head movement is used to complement melodic motives as well as re-enforce them. From the MoCap display, the head can be seen 'answering the melody' by re-acting with a

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[10] The first page of the score for Brahms Intermezzo, Opus 118 # 2 is located in Appendix 3.

[11] This representation could also be made using an algorithm in MATLAB.

nod after a grace note or accented high note occurs. In measure six, Player 3 once again made a rising gesture with his head to symbolize the rising bass arpeggio, which may remind someone of the kinematic imagery found in Glenn Gould's performances.

The red dotted circles in the spectral flux and acceleration graphs show a correlation between the music's spectral flux and the head's acceleration. When the spectral flux is at its lowest (phrase boundaries), the head's acceleration is at its highest, showing that there was more head movement at the end of phrases. Although these movements were exaggerated, the correlation is also visible but to on a smaller scale in the *normal expression* rendition **(Figure 4B).**

The acceleration in head movement at the phrase boundaries may be related, as stated in Wanderley et al. (2005), as cues used to for expressive timing while performing. Whereas clarinetists have more degrees of freedom in their ancillary movements (e.g. knees), pianists' movements are limited to what they can move while sitting down with their arms extended. For this reason, most gestures that could be said to be *symbolic* occur in the head and torso gestures. On the other hand, some pianists have been known to sing along to the piece they are performing. It would be interesting as a future pursuit to investigate the structural or expressive meaning of the grunts, moans and other vocalizations pianists make while performing.

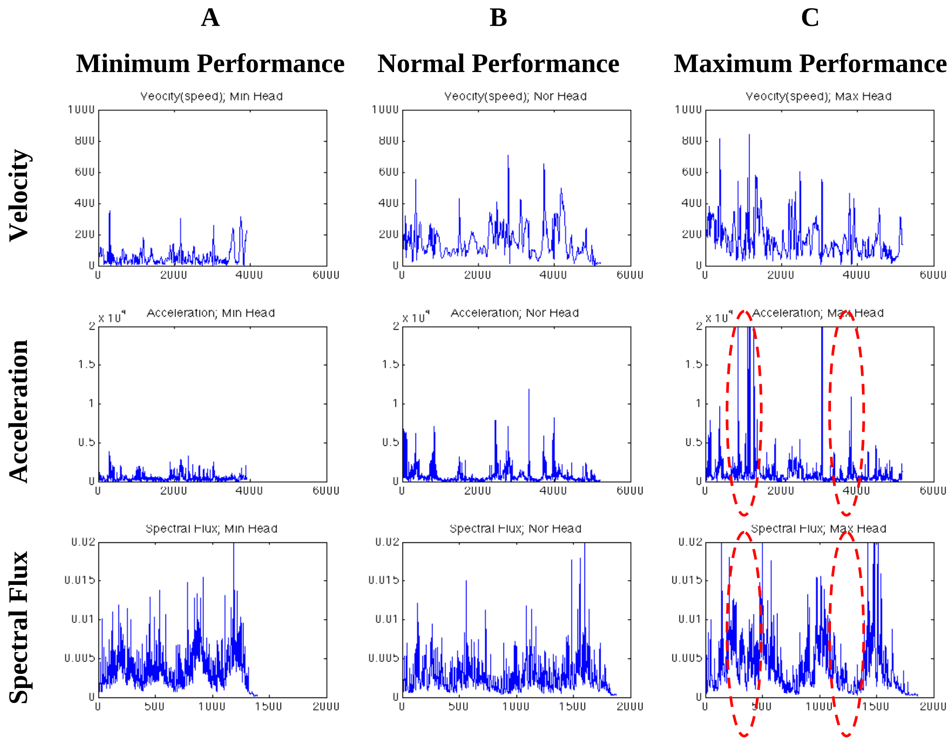


FIGURE 4. Player # 3; Session 3. Head movement features (velocity and acceleration) is aligned with the spectral flux of the first 16 bars of Brahms Intermezzo. The dips in the spectral flux indicate musical phrases.

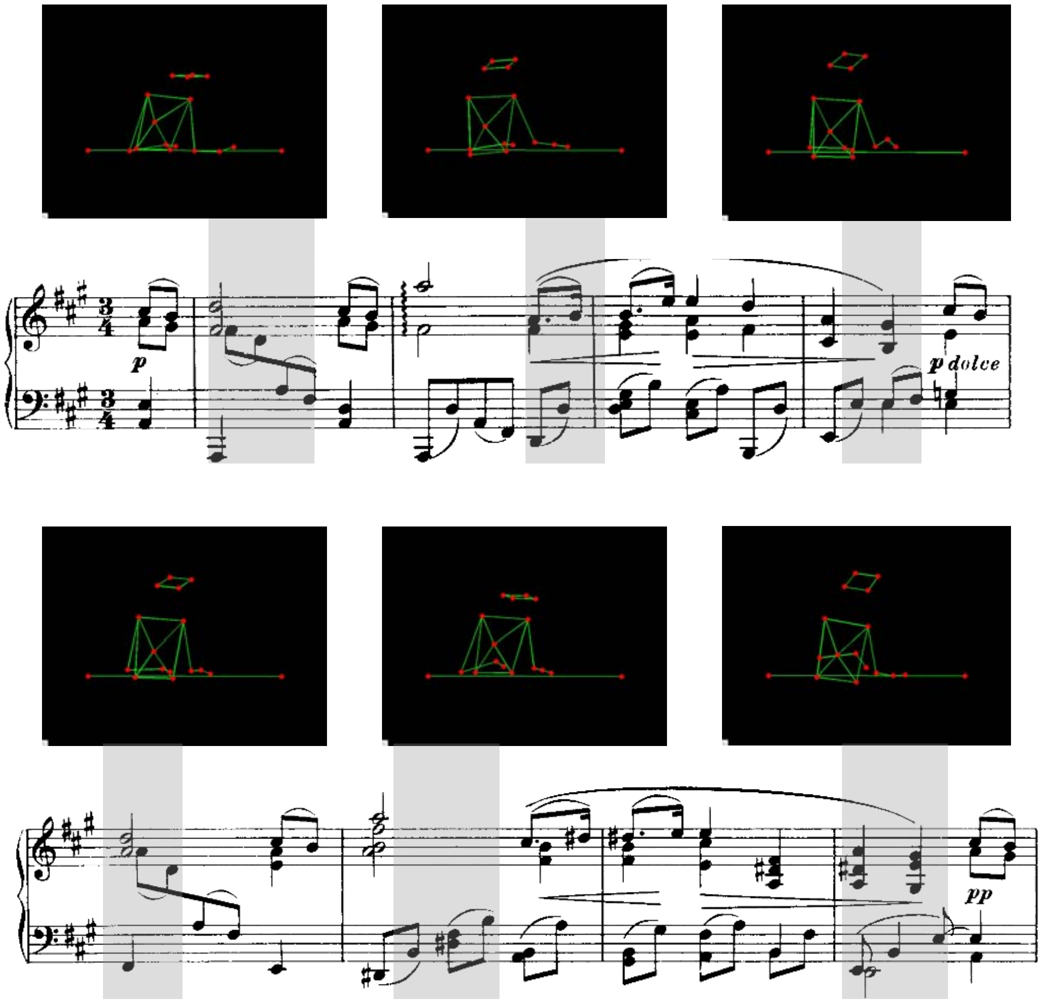


FIGURE 5. Player 3; Session 3; Normal Expression; The position of the head at different points in the 1st 8 measure of Brahms Intermezzo.

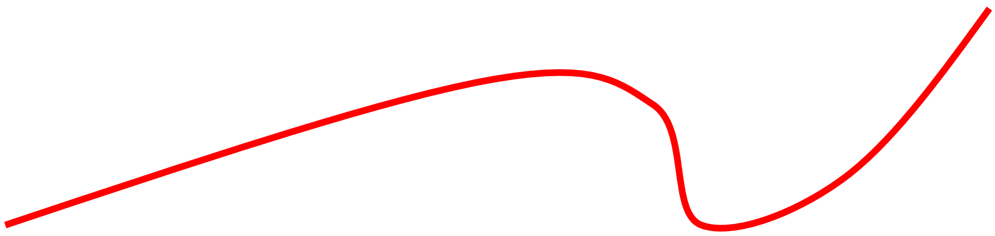


FIGURE 6. A free-hand representation of the head's movement pattern during the first 8 measures of the Normal Performance.

3.2.1.4 Evolution of movement throughout sessions

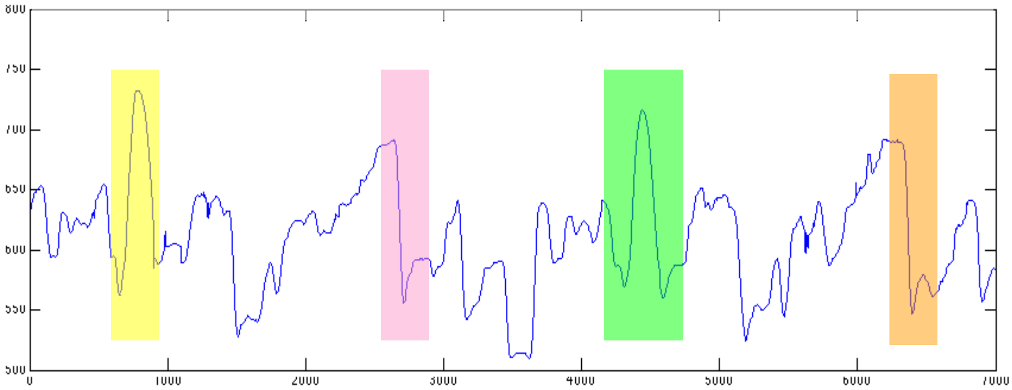
Another aspect of the research study was to investigate the development of movement throughout the course of learning a piece of music. The results of this portion of the research were either inconclusive or not validated by any statistical method, such as Pearson correlations. However, some interesting observations can still be made.

Right elbow movement patterns throughout two sessions

For Player 1, the right elbow's movement pattern in the vertical plane was extracted for two sessions and plotted with fragments from Brahms' Intermezzo. **Figure 7** shows data from Session 3 and Session 4. From the Figure, it can be seen where the score was performed with very similar movement patterns. When the content of the score is analyzed and put into a piano playing context, it becomes evident that this movement pattern was very *functional*. In other words, the movements made were *instrumental gestures* as opposed to *ancillary gestures*. They were needed to perform the piece properly. For example, the yellow and green peaks in the movement pattern are a result of the leaped note in the score. Likewise, the sharp pink and orange attenuations are a result from playing a repeated note and then quickly jumping down.

Interestingly enough, upon observing the MoCap display for clarity, the elbows were, at the stages pointed out, moving very gracefully. The yellow and green peaks, although functional, formed a very equal and round curve. Although not shown here, the head at this point also made an expressive gesture, complimenting what was being done with the arms. This might correspond to what Robert Hatten has argued about musical gestures. They are 'emergent gestalts that convey affective motion, emotion and intentionality be fusing otherwise separate elements into continuities of shape and force' (Gritten & King, 2006, xxi). From looking at the graph, the elbow movement seemed mechanic and purely functional. However, put into context with other expressive gestures in plain view, the elbow appeared very expressive indeed. This is further proof that gestures are only meaningful when put into a specific context.

a) Player 1; Normal Expression; Right Elbow Movement; Session 3



b) Excerpts from Brahms Intermezzo Op. 118/2

c) Player 1; Normal Expression; Right Elbow Movement; Session 4

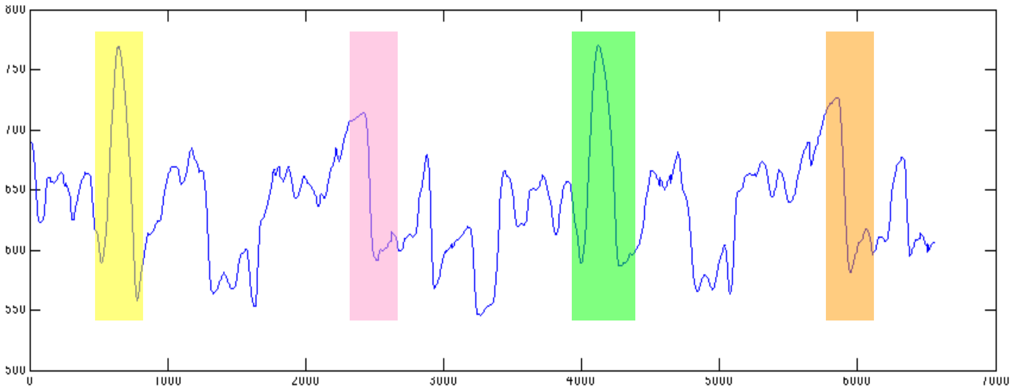


FIGURE 7. The movement pattern in the right elbow seemed very consistent from session 3 to session 4 for Player 1.

Head movement pattern throughout four sessions

As explained above, the head in piano performance is the body part with the highest degree of freedom in terms of expressive movement. **Figure 8** displays information about the head movement pattern in the horizontal plane for Player 2. These represent *normal expression* interpretations throughout four sessions. From the data, it is unclear whether a pattern can be found from one session to the next. To do so would require more robust statistical techniques. However, one could make the claim that in **Figure 8A**, the movement patterns for Sessions 2 & 4 are very similar. The similarities are shown with matching colored oval shapes.

Figure 8B shows the range of motion in each performance of the excerpt over four sessions. Again, there is no discernable pattern in this bar graph. However, upon observation of the point light data, the head exercises more expressive movement than any other body part. The head is indeed an interesting producer of expressive movement. Further analysis uniquely concentrated on expressive head movement should elicit more concrete results than what is presented here.

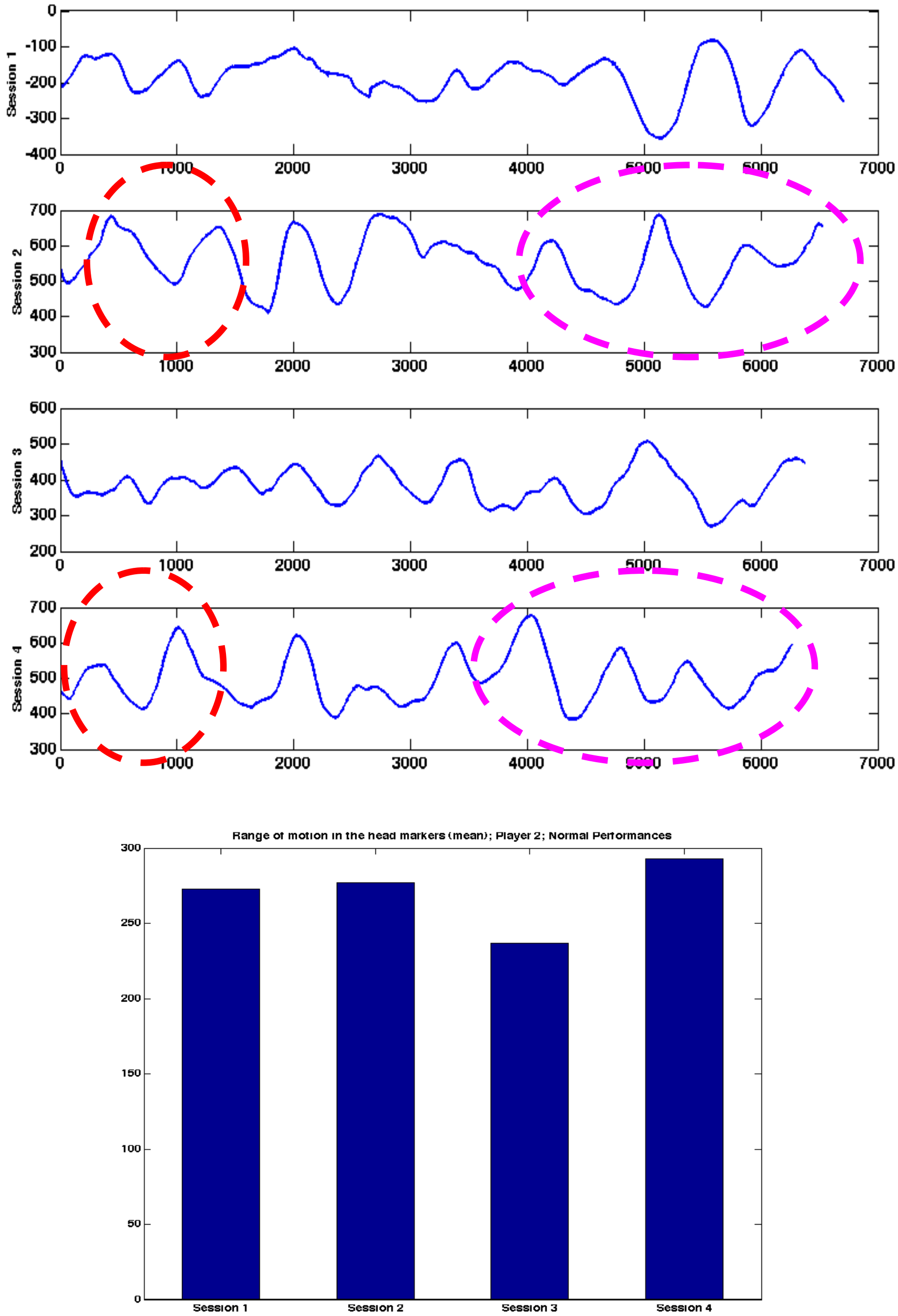


FIGURE 8. A) Player 2; Horizontal Head Movement Patterns; 4 sessions; for Player 2 in normal expression over for sessions 1 to 4 (top to bottom). The matched colored oval shapes indicate similar pattern between Session 2 and Session 4. B) Bar graph showing the range of motion in horizontal head movement within sessions 1 to 4 (left to right).

3.2.2 Qualitative Approach: Participant Comments

The data-collecting process provoked many interesting conversations between the participants and myself before, during and after the sessions. Their comments were very insightful and are presented here as they reveal their mindset when playing for the research project.

Overall, it was revealed that the pianists had a very good *implicit* knowledge of how to move in order to effectively play a certain level of expression. Prior to any performance, they did not have an exact strategy of how they would move. However, after seeing the point light displays, they were able to tell why they moved at certain spots and what the effect of the motion was even though they were not aware of it while performing:

> "I truly believe there is a connection between the musical expression and movement. I don't know what comes first, sometimes you think your doing something in the music, and your body is doing it, but it just does not come out of the piano."
> *-Player 2, Session 3*

Different levels of expression

Practicing a piece with a pre-determined expressive condition is a technique used by some music educators (Davidson, 1993). A minimum amount of expression can be used by a student to focus on playing a note-perfect rendition while a maximum amount of expression can be used to practice expressive features like dynamics, etc. The participants were not familiar with this technique but agreed it could be a good practicing method. For performing with a minimum amount of expression, each showed individual strategies:

> "I used the score for the first time [minimum expression*]*, I was concentrating on the text and making it in a dry way and also the last time, when it was over doing it, I tried to overdo all the dynamics."
> *- Player 1, Session 3*

> "I made phrasing very straight…concentrating on the text and…played it simple without any effort."
> *-Player 1, Session 4, after having played Beethoven Sonata*

> "It is extremely difficult to play with minimum of expression. For example 'jumps' need bigger movements and if you limit yourself too much then it's hard to play them right.
> *-Player 2, post experiment interview*

Despite the unnaturalness of playing the *minimum expression,* the participants seemed most uncomfortable playing with *maximum expression.* After each performance of the *maximum expression,* terms like 'disgusting' and 'awful' were used. Player 2, who recognized the link between expression and movement, thought her *maximum expression* rendition was too heavily focused on moving to play the music correctly. For Player 1, who also played a Beethoven Sonata, said this piece was particularly hard to play with more expression because she felt the heightened expression made it seem more like a Romantic work as opposed to a work from the Classical era.

Player 2 disliked watching performers who move too much and felt it was distracting to the music. She may have been referring to showy performances that take away from the music's humility but admitted a limited amount of 'natural movement' was essential to playing music with accuracy.

> "But of course, there is natural movement. I don't necessarily know that (sic) I'm doing something but I just do it. Because, if there is not movement at all, there's no expression, it's difficult to keep the lines together and the quality of sound 'changes'. You have to play with expression…to make the melodic jump, you need to play rubato."
> *- Player 2, Session 3*

This quote shows that while performing, she was unaware of the movement, yet knew that musical gestures would help her play with more expression. This shows she had *implicit knowledge* about the affect of her movements on the music but no formal conception of how she would move. When observing the MoCap display of her performance, she noticed that her gestures were compliant with musical phrases and were used to herald in new musical textures and ideas. This transformed the awareness and function of her musical gestures from being *implicit knowledge* to *explicit knowledge*.

Finally, it was detected that there was a strong correlation between the performances and character. Player 2 and Player 3 both contested that their playing was usually very expressive. Player 3 went further to say that he played more expressively than other pianists. This expressivity was sensed in his overt behavior in the performance manners. Indeed, his *normal expression* performances showed more expressivity and a larger range of motion than Player 2's *maximum expression*. It would be interesting to follow-up this report with an investigation into the individual interpretation of different levels of expression. It may be that although all different, the range of expressiveness might have been proportionally similar.

To sum up, the interviews revealed that participants, prior to playing, had an *implicit knowledge* about musical gestures and their function in projecting a specific level of expression. After viewing their own performances, the participants were able to interpret the symbolism behind their gestures *explicitly* and in relation to musical structure. It was also found stylistic interpretations of the Brahms Intermezzo varied for each participant with different methods for defining *minimum, normal* and *maximum* levels of expression. The varying interpretations seemed to be dependant on the personality of each participant.

3.3 Overview

The empirical portion of this thesis focused on three pianists and their performances of a sixteen-measure excerpt from the Brahms Intermezzo Op.118 # 2. Each pianist participated in three or four sessions where they were asked to play the excerpt in different levels of expression *minimum, normal, maximum.* The goal was to investigate the differences and similarities between the pianists in terms of performance length and range of bodily movements, the progression of movement patterns within the time span of the sessions and how each individual used movement and musical gestures to play in different levels of expression.

Aspects of performances discussed were length of performance, range of movement between each performance manner and each pianist, an interaction between musical gestures and the score and how gestures were used as symbols for musical structure. Excerpts from interviews conducted during and after the data-collecting process was presented to show that each pianist interpreted the instructions in their own way, which apparently reflected on their personality. The observations made throughout the analysis are highlighted below.

- The *normal* performances were much more uniform in *length* than the other performance manners, signaling perhaps that the pianists were most comfortable to perform in this expressive manner.
- As the level of expression was increased, players had a higher *range* of motion in the shoulders, head and in the exception of Player 1, the wrists. This indicates that more movement is a good predictor for more expression.
- The participating pianists interpreted the performance levels differently, resulting in very varied performances. For example, Player 1 interpreted *minimum expression* as meaning to follow the instructions from the score with no creative input from the performer. Player 3 on the other hand, understood *minimum expression* to mean the absence of all expression, including what is written on the score.
- Acceleration in head movement was observed in between musical phrases for Player 3, indicating a correlation with findings from Wanderley et al. (2005) concerning using movement to indicate phrase boundaries.
- For Player 1, elbow movement pattern between two sessions remained very constant. This movement was at first believed to be functional, but when viewing the point light display and put into context, the elbow rotation, combined with ancillary gesture in the head made the elbow movement seem much more expressive than when seen alone. This indicates that a gesture is more expressive when put into a wider context with other gestures.
- Even with the absence of expression and movement, performances with a minimum amount of expression rendered note perfect renditions but in the case of Player 3, they were played much faster.
- Head gestures in the maximum expression and to a lesser extent, the normal expression correlated with the melodic structure with both complementing movements (answering the melody) and reinforcing movements (moving with the melodic contour).
- Even when playing with minimum amount of expression, players can still play note perfect renditions.

- The head movement pattern for each session for Player 2 showed no overt trace of expressive gesture development. More robust statistical analysis must be made to determine if expressive head gesture change throughout the course of learning a piece of music.
- Through interviews, it was revealed that pianists' style of playing mirrored in their personality. This could relate to how Glen Gould's eccentric personality played such a large role in his performance manner.
- Additionally through the interviews, it was revealed that participants had an implicit knowledge about using movement to convey expression. Upon watching the playback of their performances, they were able to indicate where they moved and why, showing that although the knowledge of musical movement is implicit, it might be possible to construct some movement principles, causing the knowledge to become explicit.

4 CONCLUSION

4.1 Overview of thesis

The thesis presented the topic of expressive body movement in piano performance. The goal of the literature review was to discuss topics related to *musical gestures*, including musical semiotics and music movement perception, eventually culminating in a case study on the performance gestures of a famous pianist.

After detailing how musical gesture research can affiliate with other research disciplines (music education, music technology and music cognition), an empirical study was outlined and presented. The focus of the study was to detail the similarities between three pianists under a framework in which the players had to interpret an excerpt from the Brahms Intermezzo in A major, Opus 118 # 2, in three renditions with each a different pre-determined expressive intention; *minimum expression, normal expression* and *maximum expression.* The study made use of Motion Capture technology and spanned several months with each pianist attending three or four sessions.

The analysis dealt with several elements. The quantitative portion focused on the length of the performances between expressive manner and pianists, range of movement in accordance to expressive manner, correlating expressive gestures with musical structure such as phrasing and melodic direction and development of movement through multiple sessions. Interviews conducted during and after the data collecting process provided insight concerning the implicit and explicit knowledge musicians have of expressive gestures and possibly how the level of expressiveness used in a performance can predict personality.

Although not conclusive, this thesis serves as a starting point for future, more detailed research that will make greater use of advanced statistical techniques, original computational algorithms for measuring kinematic movement features and more precise motion capturing. However, through intelligent observation and inference, a summary of key findings can be offered:

- Implicit linear relationship between amount of expression requested by the exercise and amount of movement performed by musician
- Acceleration in head movement between two adjacent musical phrases.
- For at least one of the participants, there was a direct relation between the tempo of a performance and amount of expression used
- Faster tempos in performances with minimum expression.
- Less variance between normal and maximum expressions.

4.2 Implications and Future directions

While this study has afforded me the opportunity to investigate a large number of issues concerning musical gestures, it is still a starting point. The analysis of this research will persist in numerous ways with more advanced analytical techniques that were not used in the project.

The research project collected much more data than was analyzed in this thesis. Future plans include investigating changes in velocity and note duration and also forming a tempo curve of performances. This can be achieved by analyzing MIDI data in the MIDI Toolbox, developed at the University of Jyväskylä (Eerola & Toiviainen, 2004). There would also be a need to investigate the video footage of the sessions. Analysis of movement in video can be done using the Musical Gestures Toolbox (Jensenius et al., 2005), a collection of Max/MSP/Jitter patches that has gesture analysis and synthesis capabilities.

Most importantly, there still needs to be statistical analysis done. Music perception can make use of general research methods used in other types of perception research (Windsor, 2004) and apply them to specifically to music research. One interesting direction would be to have subjects make continuous rating judgments of perceived expression when viewing the point light displays from the current study. Schubert (2004) developed interesting techniques for analyzing emotion ratings from musical stimuli and it may be interesting to incorporate these methods in a future study about perceiving different levels of expression in a piano performance. Autocorrelation is becoming an important computational technique for music cognition studies

(Toiviainen & Eerola, 2006). It might be possible to apply autocorrelation techniques on the movement data to find periodicity within the head rotations. If for example, periodic motion was found in the head movements, it could then be correlated with musical data to see how the music induced a specific head movement pattern.

Gabrielsson (1988) stated that it is very difficult to find generalities in music performance data. There is greater value in finding relations between the performance and the listener's experience of the performance. To work towards developing a final model of music movement perception, it is detrimental to induct a subjective rating analysis within the framework of study. The thesis concludes with the assertion that it has successfully established a framework for the commencement for future comprehensive and elaborate empirical study.

4.3 Closing thoughts

In the 20th century, the way in which music is perceived changed forever. Before the onset of recording devices, the experience of music was a collectively visual and aural experience. Even if people were not involved in the actual music production process, they participated in the musical experience by perceiving and connecting the sounds, sites and even the cultural context where the music took place (Iazzetta 2000). Recording technology in the 20th century brought along a divide between what we see and what we hear in terms of music. The divide is between the music and the music production, not necessarily an image. For example, classical music is more likely to be experienced by the general population in films where the music can be combined with an image.

In the early days of recorded music, the goal was to produce a recording that had a high fidelity with the original sound it was reproducing. With advances in recording technology and the democratization of sound manipulating software, the situation has changed. The goal no longer involves reproducing real sounds as it tries to re-create live what was done on the recording (Iazzetta, 2000).

During the interview session, Player 3 spoke with me about what it was like for pianists of the early 20th century to, for the first time, be able to *listen* to their own playing on a recording. A well-known piano teacher heard his own recording and was terrified to realize that he made the same mistakes as his students, the very same ones he had been correcting them on. The trend of checking mistakes on a recording of course continued throughout the century. We have become more influenced by sound and music abstracted from its original source and it has changed the way we perceive music.

The continuing study and analysis of expressive bodily gestures is useful because, if anything, it reminds us that expressive movement is not a subordinate to sound, but an integral part of a larger musical experience. Expressive bodily movement is the extra-musical parameter of music that completes the cycle of expression implied by Aristotle's Doctrine on Imitation. Music imitates the states of the performer's soul only to be embodied by her expressive movements.

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APPENDICES

Appendix 1: Score for Brahms Intermezzo, Opus 118 # 2

International Music Score Library Project (2006). 6 Klavierstüke, Op. 118 (Brahms, Johannes). Retrieved June 1, 2007, from http://imslp.org/wiki/Klavierst%c3%bccke_Op.118_(Brahms,_Johannes).

2. Intermezzo, A Major Op. 118/2

Appendix 2: Session Dates

Player 1

Session 1: October 27, 2006

Session 2: December 18, 2006

Session 3: February 7, 2007

Session 4: March 10, 2007

Player 2

Session 1: January 31, 2007

Session 2: February 23, 2007

Session 3: March 2, 2007

Session 4: March 10, 2007

Player 3

Session 1: February 7, 2007

Session 2: March 2, 2007

Session 3: March 10, 2007

Appendix 3: Participant Interviews

Player 1, Session 3

Transcribed from audio, casual conversation during the session and in between takes of Brahms Intermezzo

Before playing Brahms maximum expression

Marc Thompson: Are you ready to play in the max expression?

Player 1: Yes, whatever that means...

M.T.: Exactly.

After Brahms maximum expression

P1: It's hard to figure out what it means *(playing with maximum expression)*, what does it mean?

M.T. That's what is interesting, it is ok, it is just your own interpretation of what it means to play with or without expression

On playing the minimum and maximum expression

P1: I used the score for the first time, I was concentrating on the text and making it (sic) in a dry way and also the last time, when it was over doing it, I tried to overdo all the dynamics. So the first and third time, I just a little bit watched but not all the time....

Player 1, Session 4

Transcribed from audio, conversation in between takes of Beethoven Sonata Opus 26, number 12; 1st movement

Minimum expression performance

Marc Thompson: Was it hard to play without playing any expression?

Player 1: A little bit yeah, but I don't know. It's just in my head, it's because I don't know the text 100 %. It should work out with any kind of expression.

Maximum Expression:

P1: It's very difficult to play this over. It's the most difficult thing. The *(maximum)* one is the most difficult with Beethoven, because it's very simple music.

M.T.: Because there is more range in more modern music?

P1: Yeah.

M.T.: Which one was the hardest to play?

P1: The last one...*(referring to maximum expression)*

M.T.: Do you like the way it came out, the last one?

P1: No, it's awful, awful...Because I played it like a Romanic piece, like if it were Brahms or Strauss or Chopin...

M.T.: So the second one was the one that you preferred?

P1: Yeah, the second one...

M.T.: How did you play for the first one? How did you use minimum expression?

P1: I just didn't give...I made phrasing very straight, kind of, concentrating on the text and play it simple without any effort...

Player 2, Session 3

Transcribed from audio, conversation in between takes of Brahms Intermezzo

After playing Brahms in all 3 expressive manners

Player 2: I feel music is the most important thing and pianists who move too much and it is distracting during a recital, that's why I try to keep myself in control. But of course, there is natural movement. I don't necessarily know that I'm doing something but I just do it. Because, if there is not movement at all, there's no expression, it's difficult to keep the lines together and the quality of sound 'changes'. You have to play with expression for lines. To make the melodic jump, you need to play rubato.

After playing entire Brahms Intermezzo from beginning to end

P2: Feels better to play the whole piece...just bigger...harder to play it as a whole, development so important in the music, there is no climax...

I truly believe there is a connection between the musical expression and movements, I don’t know what comes first, sometimes you think your doing something in the music, and your body is doing it, but it just does not come out of the piano.

Player 2, Session 4

Post-session interview. After viewing the point light displays of her performances, Player 2 was asked to comment on them and questions were asked via e-mail.

1. What is your general impression about the performances?

I look more relaxed than I was expecting. My performances are generally quite shy, I think.

2. Which was your favorite?

I wish I didn't have to choose a favorite, I'm not that happy with any of the performances ;) I guess I have to say the normal of expression – then I am at least trying to be the most honest with the music I'm playing!

3. Do you think there is any symbolism in your movements (in any of them)? Do you see any links in your movements and with the music (cadence, harmony, melody)?

This is a good question. While playing I wasn't thinking there would be any symbolism in my movements. However I can't say there isn't something. Most obvious it would be at the end of the piece, I think. Also in the part were new kind texture of music appears.

4. Do you see any tension in your movements?

Hmmm… I know there is some tension – however it's that kind of tension in my arms that other people might not see it. I can see it because I already know it's there!

5. You said that you tried to move in three different ways (minimum, normal, maximum) but tried to keep the same sound and tone in the piano. Do you think you were successful?

Not as successful as I was hoping. It is extremely difficult to play with minimum of expression. For example "jumps" need bigger movements and if you limit yourself too much then it's hard to play them right. Maximum of movement is terrible in a different kind of way – it's almost embarrassing to play like that. I felt that the focus was totally wrong – I was concentrating more on the movements than the music.

Player 3, Session 3

After playing Brahms with Maximum Expression, transcribed from audio and translated into English from French by the author.

Marc Thompson: If you were at a concert and you saw the performance you just gave, what would you think?

Player 3: It's too much, it is disgusting, certainly too exaggerated, not even the old pianists play like this. The old pianists (early 20th century) play more like the normal version that I played.

M.T.: And if you were performing in front of an audience, this is the performance that you would give?

P3: Certainly.

M.T.: Are you playing like you would play or are you imaging someone else playing?

P3: I am perhaps more romantic in this sense, more romantic than other pianists, you must add. I believe that pianists of today do not play well, simply put. They do not play like we could play. There is a tendency to play in a certain style, *à la mode*. It is in fashion, or it is the trend to play with little expression. It may be a result of the modern era. It is because of modernity. It is because of a modern ethos. It is the age of machine, the machine age. It is because of the evolution of technique

M.T.: So it's a result of modern music that we play without expression?

P3: No, it is because of modernity, because of the ethos of modernity. It is not my idea; there are musicologists who have written it. We have done an interview with pianists, Zoldac Kotisch, who appeared in the film. He edited all the performances of Bartók and Doechany, and he said in an interview that one of my students made with questions that I wrote and she wrote. He told that in his youth in the 1960's, there was a tendency to react to the possibility of the recording. There was a tendency to listen to ourselves in a new way. And we listen to our own recording; you realize your mistakes and the imprecise things. In recordings, these imprecise things come out multiplied! And, pianists worked a lot in 50 and 60's to minimize these imprecise things.

M.T.: Yes, because the old recordings you played at the lecture the other day *(Player 3 had given a lecture on Béla Bartók a few days earlier).* I had the impression that they were from an age when it was not common for pianists to listen to themselves play. And I thought that this was so different from modern pianists.

P3: Yes, certainly, but not just this. It was an age where we did not instantly listen to ourselves. There is an interesting anecdote from the pianist, Max Pauer, a very big pianist from the first half of 20th century. He said that after listening to the very first recordings made in the 1910's of himself, 'Oh my God, I make the same mistakes that I warn more students about, that I forbid my students to make…I had never heard these mistakes before.