

Measurable changes in piano performance following a Body Mapping workshop

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Abstract

Body Mapping has emerged among movement education techniques as one of the only somatic methods to focus specifically on musicians. Little research has been conducted to determine what changes, if any, participants in Body Mapping workshops experience. This study used MIDI to examine pitch, tone, tempo, and articulation of scale and arpeggio piano performance one day before and after a Body Mapping workshop. Participants were found to exhibit few measurable changes in these aspects of scale and arpeggio. A series of exploratory analyses were then conducted, which found greater changes in the visually observable aspects of piano performance than in aurally perceptible ones. The results suggest that immediately following a Body Mapping workshop, piano performance may improve in visually observable measures, but not in the aurally perceptible measures of scale and arpeggio performance.

Keywords: Body Mapping, somatic, piano, piano pedagogy, piano performance, MIDI

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GLOSSARY OF MUSICAL TERMS

Arpeggio – a series of musical notes which comprise a chord. In the context of this study, the arpeggios used require the pianist participants to play notes which are spaced further apart than the scale tasks, and the thumb crossing traverses three or four keys, which is larger than the one key which a pianist must traverse in the thumb crossings of the scale task.

Articulation – the amount of overlap or gap between notes of a passage.

Dynamics – the use of relative loudness in music. In piano performance, loudness is primarily controlled by key velocity.

Pitch accuracy – the degree to which the notes produced in a performance of an excerpt or task matches the intended notes.

Scale – a series of musical notes ordered by fundamental frequency. In the context of this study, the scales used require the pianist participants to play a series of consecutive white keys on the piano, such that each note of the scale is evenly spaced.

Tempo – the speed of a musical excerpt or task.

Thumb crossing – in the context of piano performance, a task which requires the thumb to pass under the other fingers, or the fingers to pass over the thumb.

Tone – the perceived sound quality of a musical note or series of notes.

Introduction

Body Mapping

Body Mapping is a somatic¹ method which focuses on equipping musicians and music educators with accurate knowledge of the body in movement, a process which is said to improve music performance and reduce the risk of injury. Music-making is a product of body movement, yet accurate information about the human body and its movements are rarely addressed in music pedagogy. Authors on Body Mapping write that this dilemma, which is said to be the origin of many musicians' limitations and injuries (Conable et al., 2015), may be resolved by learning how the body is designed, in size, structure, and function, alongside of training senses and awareness (Johnson, 2009; Mark 2003). In the mid-1970s, while teaching the Alexander Technique, a "simple and practical method for improving ease and freedom of movement, balance, support, flexibility, and coordination" (Conable, 1991, p. 5), William Conable conceived of Body Mapping as a means to support the learning of the Alexander Technique. Conable observed that his students' perceptions of their bodies were directly impacting their movement, and thereby affecting their progress with the Alexander Technique and with their music performance (Conable, 1991). He termed one's internal representation of the body as one's "body map," and the process of refining one's map of the body came to be known as "Body Mapping" (Conable & Conable, 1995). Although Body Mapping pedagogy today still reflects its roots in the Alexander Technique, Body Mapping has developed into its own distinct method which may be used in conjunction with other somatic methods or on its own (Johnson, 2009). Barbara Conable, one of the most influential authors on Body Mapping, writes that a refined body map is a valuable asset in any somatic work (Conable & Conable, 1995). Teachers

¹ Thomas Hanna (1988), who brought the term "somatics" into common use among movement therapists, defined somatic work as that which addresses both the self-awareness of the student, patient, or client, and the observations made by the educator or therapist in the design and execution of the therapy.

of Body Mapping are trained, licensed, and regulated through an organization called Andover Educators, which was founded by Barbara Conable. As such, a teacher of Body Mapping may be referred to as an Andover Educator (Andover Educators: Teachers, 2016).

The process of Body Mapping involves anatomical information in the training of movement, senses, and awareness, typically in the context of music performance. Some authors describe the body map as the bodily self-representation in the motor and somatosensory cortices (Johnson, 2009; Nichols, 2004; Marsh, 2012), while some suggest that the body map is a construct of consciousness (Conable, 1991), and others offer a less definitive definition (Mark, 2003; Malde, Allen, & Zeller, 2013). Authors generally agree, however, that the body map is a representation of the body in the brain and that its accuracy is a determining factor in the quality of the body movement produced. Differences between the body map and the anatomical structure of the body are termed “mismappings.” Such mismappings are associated with awkward, uncoordinated, and strained movements that result in technical problems in music-making and are said to lead to injury (Conable & Conable, 1995). Andover Educators agree that a body map may be correct or incorrect whether or not it has been consciously trained, and that an inaccurate body map may be corrected through Body Mapping (Malde et al, 2013). This process of body map correction typically includes three steps: (1) self-inquiry, evaluating one’s current body map through methods such as the drawing of anatomical structure(s), (2) consulting of the anatomy with textbooks and models, and (3) finding the kinesthetic experience of the structure(s) in the context of whole body (Johnson, 2009; Malde et al, 2013, Copeland, 2007). Body Mapping classes differ from anatomy classes in that participants are expected to gain an awareness of the anatomical structures and functions within the context of their whole body movement and self-awareness (Malde, 2009).

Anecdotal evidence of improvements to music performance following Body Mapping study

Videos of workshops, websites of individual Andover Educators, and instructional literature indicate that students of Body Mapping experience improvements to their music performance. What Every Musician Needs to Know About the Body (WEM) is a course, typically six hours in length, devised by Barbara Conable to provide essential information on the body in movement to musicians. Taught by licensed Andover Educators, this course is said to, “improve [musicians’] singing and playing by optimizing movement, breath support, and coordination” (Allen, n.d.). Body Mapping is also taught in private lessons, which are believed to be able to increase musicians’ technical and musical abilities (Blumer, 2016). The refining of one’s own body map is asserted to refine movement, thereby allowing the musician to play with greater fluidity (“Body Mapping for Musicians”, n.d.; Breault Mulvey, n.d.; Urso-Trapani, n.d.; Pearson, 2016), better dynamic control (Harscher, 2010; Murray, n.d.), a reduced prevalence of errors (Conable et al, 2015; Mark 2003), and overall greater skill (Sever, n.d.; Roberts, n.d.; Caplan, n.d.). Videos of workshops in Body Mapping show a change in sound quality following instruction (Pearson, 2011) most clearly observable in the reactions of audiences, who comment that the tone has become fuller, richer and more beautiful (Breault Mulvey, 2016; Blumer, 2014). This phenomenon of improved tone quality is echoed in instructional literature (Conable, 2000a; Johnson, 2009), which also asserts that Body Mapping helps promote consistency between performances (Pearson, 2006; Conable, 2000a; Malde et al., 2013). Various authors write that Body Mapping assists in playing for longer periods of time (Buchanan, 2014a; Johnson, 2009) and playing at faster tempi (Harscher, 2010). Singers and instrumentalists alike are said to improve in their technical facility (“Iowa State University Music: Body Mapping”, n.d.; Krayer-Luke, 2014; Harscher, n.d.; Rennie Salonen, n.d.) and are able to practice and perform with

greater expressivity (Conable, 2000a; Mark 2003; Kraye-Luke & Breault Mulvey, 2014). While there are a large number of sources describing the reputed effects of Body Mapping, the pertinent research literature is currently limited to two qualitative and one quantitative study.

Research on the effects of Body Mapping among musician participants

Knaub (2002) conducted a qualitative study to explore the experiences of music students who studied the Alexander Technique and Body Mapping with William Conable from 1973 to 1998. Participants, all of whom had taken these classes for at least one semester, reported that studying the Alexander Technique and Body Mapping allowed them to have greater facility, noting benefits such as better breath control and an ability to sing longer phrases. They reported perceiving that they were able to sing or play with less effort. Many of the participants reported an improvement to their musical sound, describing an increase in consistency of tone, as well as “more ping, overtones and resonance” (p. 77). Others observed that they had greater stamina, deeper breathing, improved intonation in violin playing, and increased dynamic control. Students reported that sometimes their playing improved dramatically in a short period, while at other times improvements happened over the course of longer periods of study. Knaub also found that students experienced greater self-awareness, greater environmental awareness, less tension, and an increase in perceived ease. Although Knaub’s research used data collected from journals of those studying Alexander Technique and Body Mapping simultaneously, journal entries reported perceived benefits of specifically Body Mapping principles. Evidence of this can be seen in quotations that mention specific mapping issues, such as instrumentalists who particularly noted the mapping of the upper limb as directly applicable to performance and pianists who expressed that mapping of the ulna was especially helpful. Though drawn from subjective experience, these

findings support the anecdotal evidence of changes in music performance associated with Body Mapping.

Buchanan (2014b) explored students' perceptions of performance experiences throughout one semester of Body Mapping study at an American university. Participants comprised of 12 undergraduate students and 10 faculty members who were asked to provide comments on the student participants' musical development and performance during the semester. In self-reflective journals and in-depth interviews, student participants expressed that they felt more capable of musical expressivity. Student participants gave credit to Body Mapping for their improved understanding of technical elements such as tone quality, even vibrato, breath support, and articulation. Students described enhanced ability to handle fast tempi, loud dynamics, and intonation, and in many cases, an increased ease of body movement as well. Nine of the 12 students additionally reported improvement in their focus during performance. While three of the students perceived only minimal results, all 12 students asserted a view that Body Mapping "was of significant value as a discipline and tool for musicians" (Buchanan, 2014b, p. 12). Faculty member participants were noted as being in agreement with the changes their student participants subjectively expressed. While data were collected from students in an undergraduate course for credit, potentially contributing to bias in the results, the presence of data from studio teachers supports the student participants' perceptions. The result of the studies by Buchanan and Knaub are in line with the anecdotal evidence of improvements in music performance associated with Body Mapping, but are, to the author's knowledge, the only qualitative research studies to date in Body Mapping.

The single quantitative study to explore Body Mapping suggests that the effects on pianists following a 50 minute private lesson are not as clearly observable by a panel of experts

as anecdotal evidence indicates. Wong (2015) investigated the immediate observable effects of a single private lesson in one of three somatic methods: Alexander Technique, Feldenkrais or Body Mapping. A panel of experts, blind to condition, rated silent video recordings and audio recordings of participants before and after their somatic session. Four of ten pianists received a 50 minute online Body Mapping lesson from a licensed Andover Educator. The study found that while judges' evaluations of musical quality were higher for post-test audio recordings on all factors except consistency of tempo, and on average, the scores increased by a mean of 4%, none of the changes to perceived musical quality were found to be statistically significant. This study was novel in its quantitative investigation of performance outcomes. However, much more remains to be explored in this area. To the author's knowledge, the work of Knaub, Buchanan, and Wong comprise the entirety of the research conducted to date into the effects of Body Mapping on music performance. This available evidence suggests that students report improvements to their performance and pain levels when studying Body Mapping with a teacher in person for one semester, but the changes after only 50 minutes of instruction through an online interface are minimal and not easily detected by observers. Thus, there is not yet enough evidence to draw conclusions about the effects of Body Mapping for musicians.

Need for research

Considering the increased role of Body Mapping in music education today, there is now a need to address the lack of research evidence concerning the effects of Body Mapping. Having grown in popularity since its conception in the 1970s, Body Mapping is now present in curricula at 18 post-secondary music institutions in Canada, the United States and Finland (Mollnow-Wilson, personal communication, 2015). Outside of post-secondary institutes, Andover Educators provide workshops and private lessons in the United States, Canada, the Netherlands,

Finland, Belgium, Turkey, Japan, the United Kingdom, Mexico, and South Africa (http://bodymap.org/main/?page_id=25). Instructional literature on Body Mapping is available for many instruments, including piano, organ, violin, flute, clarinet, oboe, trumpet, trombone, horn, euphonium, tuba, and voice (Conable & Conable, 1991; Conable, 2000a; Mark, 2003; Marsh, 2012; Malde et al., 2013; Likar & Conable, 2009a; Johnson, 2009; Vining, 2009; Pearson, 2006; Caplan, 2009; Vining 2010; Gilmore, 2005) and Body Mapping resources can be accessed in an increasing number of languages, including English, French, Spanish, and Japanese (Likar & Conable, 2009b; Likar & Conable, 2009c; Sanchez Diaz, 2017). Yet, to the author's knowledge, only three research studies have been conducted to evaluate the effects of Body Mapping on music performance.

Previous research in Body Mapping has had some limitations. While the qualitative work that has been done is valuable, both qualitative studies have been based on reports from students who were taking a course for credit at a post-secondary institution, which puts into question the fidelity of positive reports. Buchanan's (2014b) study involved faculty members reports, which strengthens this design, however disagreement between the faculty and student reports were not discussed. The one quantitative study had only four participants take a Body Mapping session, and this session was only 50 minutes in length and was not given in person. While there are Body Mapping teachers who instruct through online interfaces, this is not the recommended way to learn Body Mapping. Johnson (2009; personal communication, 2016) writes that although Body Mapping lends itself better to distance learning than other somatic methods, that lessons through an online interface are not an accurate representation of the progress that can be made when an instructor is with the student in person. The limitations of the previous research paired with the overall lack of research evidence highlights the need for further investigation. There is a

particular need in this field for empirical research. Therefore, in this study, we will empirically investigate whether there are measurable improvements to piano performance following a Body Mapping workshop.

Chapter 1: Review of Literature

Analysis of performance

Body Mapping literature and anecdotal evidence indicate that musicians experience improvements to performance which can be attributed to Body Mapping. These include increased technical abilities (Conable, 2000a; Johnson, 2009; Conable, 1995; Conable et al., 2015; Alcorn, n.d.; Harscher, n.d.; Krayler-Luke, 2014; Breault Mulvey, n.d.; Rennie Salonen, n.d.; Urso-Trapani, n.d.; Blumer, 2016), greater expressivity (Breault Mulvey, n.d; Pearson, 2006; Conable, 2000; Krayler-Luke & Breault Mulvey, 2014; Harscher, n.d.; Buchanan, 2014b; Mark, 2003), improved pitch accuracy (Mark, 2003), increased dynamic control (Buchanan, 2014b), improvements to tone (Breault Mulvey, n.d.; Pearson, 2016; Johnson, 2009; Blumer, 2014; Johnson, 2013; Conable, 2000), ability to handle louder dynamics (Buchanan 2014b), ability to handle fast tempi (Harscher, n.d.; Buchanan 2014b) and ability to play in greater legato (Breault Mulvey, 2016). Among these reputed improvements, for the context of this study, we will focus on four specific aspects of piano performance: pitch, tone, tempo, and articulation. Improvements to music performance which have been associated with Body Mapping are categorized according to these four aspects in Table 1.1.

Table 1.1
Improvements to music performance which have been associated with Body Mapping

Category	Body Mapping Literature
Pitch	Increase in pitch accuracy, particularly in thumb crossings (Mark, 2003)
Tone	-Increased control of dynamic/tone (Murray, n.d.; Breault Mulvey, n.d.; Buchanan, 2014b; Harscher, n.d.) -Improvement in tone (Breault Mulvey, n.d.; Pearson, 2016; Johnson, 2009; Blumer, 2014; Johnson, 2013; Conable, 2000) -Ability to handle louder dynamics (Buchanan, 2014b)
Tempo	Greater ability to handle tempo (Harscher, n.d.; Buchanan, 2014b)
Articulation	Ability to play with greater legato (Breault Mulvey, 2016)

The improvements to music performance that have been associated with Body Mapping are often described in a nonspecific manner, and many refer to an instrument other than piano. For this reason, it is necessary to first define what an improvement to piano performance may be. Piano pedagogy and performance literature were consulted in order to clarify the kinds of changes that would be considered an improvement to piano performance. For the context of this thesis, it was necessary to focus on a small number of specific aspects of piano performance. Goebel and Palmer (2013) recommended that researchers examine skills such as scales and arpeggios. These are common activities for pianists and thus are well automatized in experienced pianists. Many researchers include C major scales in the playing tasks in their studies (Jabusch, Vauth, & Altenmüller, 2004; Wong, 2015; Beacon, 2015) and likewise arpeggios have been used to examine quality of performance in pianists under a variety of conditions (Yoshie, Kudo, & Ohtsuki, 2008). For this reason, among the contexts in which improvements to performance could be observed, we will focus here on the context of scales and arpeggios. The following review of literature places a particular emphasis on concepts of good piano performance as they relate to scales and arpeggios. Once we have defined what changes in pitch, tone, tempo, and

articulation constitute improvement to piano performance, we will explore how these aspects can be measured.

1.1 Defining improvements to piano performance

The piano pedagogy and performance literature reviewed below was selected based upon the recommendations of three respected piano instructors who teach piano pedagogy to undergraduate and graduate students at two Canadian universities (Volk, personal communication, 2016; Szutor, personal communication, 2016; Comeau, personal communication, 2016). These resources are understood to be those which piano teachers of Canada consult for concepts of good piano performance. When a text or chapter did not refer to specific features that are considered desirable for good piano performance, such as those which review the historical development of piano pedagogy, the text or chapter was not included in this review. Because of the focus of this study, only those concepts of good piano performance which relate to pitch, tone, tempo, and articulation will be discussed here. Other aspects, such as expressivity and voicing, will not be addressed. A list of the texts included in this review of literature can be found in Appendix A.

1.1.1 Pitch. Where the pitch component of piano performance is discussed in piano pedagogical and performance literature, authors commonly state the importance of accuracy. Holmberg (2012) asserts that “the biggest favour you can give yourself is note security” (p. 59), and this is reiterated in Brower (2003), where Hans von Bülow is quoted as saying, “to play correctly is of the first importance” (p. 25). Some authors make recommendations to improve pitch accuracy, such as Chang (2009), who recommends an extensive practice regime, designed such that the performer has confidence that they may “never miss a note” (p. 59). The same author later discusses the coordination which is needed to dependably reach any destination on

the keyboard. The need for these reliable movements is echoed by Fink (1992), who provides a series of physical exercises with a goal of promoting “strong positioning instincts of the hands and fingers” (p. 137). Whiteside (1997) states that fluency and accuracy in scales and arpeggios are needed for good piano performance. Agay (2004) discusses that this is particularly important and more difficult in the execution of thumb crossings. Good piano performance, therefore, has accuracy of pitch.

1.1.2 Tone. Tone is an aspect of good piano performance discussed by piano pedagogues and performers. When referring to the type of tone desired, authors use descriptors such as full and clear (Szumowska in Brower, 2003), and strong (Brower, 2003; Ahrens & Atkinson, 1955; Belaubre, 2004), but without sacrificing the dynamic nuances (Whiteside, 1997). One of the most commonly discussed aspects of tone, evenness, is said to require notes which are even in both strength and length (Ahrens & Atkinson, 1955). Evenness of tone in terms of note strength includes the sounding of every note (Fraser, 2011) and an evenness in sound intensity between consecutive notes, something which is considered particularly challenging in notes played with the thumb (Hofmann, 1976), and in the notes surrounding a thumb crossing (Whiteside, 1997; Bernstein, 1981). Even notes lengths are similarly said to be most difficult to achieve in the notes surrounding a thumb crossing (Hofmann, 1976; Bastien, 1988; Whiteside, 1997; Agay, 2004). Authors acknowledge that in the context of arpeggios, the thumb crossing poses a particular challenge, but notes still should be played evenly (Agay, 2004; Bastien, 1988). Even in rapid passages, the note lengths should remain even (Fraser, 2011; Schneiderman, 1991; Fink, 1992). Good piano performance, therefore, has tone which is strong and is even in both strength and length of notes, particularly surrounding a thumb crossing.

1.1.3 Tempo. Piano performance, except in cases of rubato, is described as good when the tempo is consistent. An even tempo requires the performer to play a technical exercise or piece of music at a speed which remains constant throughout, unless the composer indicates otherwise (Chang, 2009; Bernstein, 1981). Discussions of tempo sometimes use the word “accuracy” to describe good performance. An accurate tempo may refer to a performance which follows a tempo marking in the musical score or a performance which maintains a consistent tempo throughout (Kullak, 1973; Holmberg, 2012; Godowsky in Brower, 2003). Pianists are warned that ascending lines may encourage an increase in tempo and descending lines a decrease in tempo, and that they should compensate for such tendencies so that the tempo may remain consistent throughout (Bernstein, 1981). This strict observance of tempo is not uniformly advocated among pedagogues, however, as some say that this makes for a monotonous and even lifeless sound (Bauer in Brower, 2003). Good piano performance, therefore, is generally considered to have evenness of tempo, unless otherwise indicated by a composer.

1.1.4 Articulation. Piano pedagogy literature advocates evenness of articulation. Articulation may be described as the degree of separation between notes. By comparing the time at which the key is released to the time at which the following key is depressed, we may observe whether there is a gap or an overlap (Hofmann, 1976; Whiteside, 1997; Fraser, 2011; Rosenthal in Brower, 2003; Agay, 2004; Bastien, 1988). A piano performance which has even articulation would have the same amount of gap or overlap between all of the successive notes in a passage. This evenness of articulation is discussed as an element of good piano performance, a task which is particularly difficult in the context of thumb crossings (Bastien, 1988; Hofmann, 1976; Whiteside, 1997). Many authors discuss in detail what the preferred amount of overlap or gap should be in technical exercises and in repertoire, however, articulation preferences vary from

author to author and may be considered stylistic choices (Hofmann, 1976; Fraser, 2011; Szumowska in Brower, 2003; Bachaus in Brower, 2003; Rosenthal in Brower, 2003; Chang, 2009; Whiteside, 1997; Bernstein, 1981; Agay, 2004; Bernstein, 1981). The use of a particular amount of overlap or gap may depend on many factors, including time period of the repertoire (Agay, 2004), purpose of the technical exercise (Bachaus in Brower, 2003), and personal preference (Rosenthal in Brower, 2003; Paderewski in Brower, 2003), but no particular type of articulation is commonly considered to contribute to good piano performance. Good piano performance, therefore, has evenness of articulation.

1.1.5 Summary. Piano pedagogy and performance authors advocate accuracy of pitch, strength and evenness of tone, evenness of tempo, and evenness of articulation. Pitch should be accurate, particularly in thumb crossings. Authors advocate a strong tone which should be even in both strength and length of consecutive notes. Tempo should remain consistent throughout a performance unless rubato is indicated. Articulation is even when the amount of overlap or gap between notes is consistent. These concepts of good piano performance are summarized in Table 1.2. The concepts are presented in parallel with the reputed improvements of Body Mapping, demonstrating specifically how improvements to pitch, tone, tempo, and articulation of piano performance as a result of Body Mapping may be defined.

Table 1.2
Improvements to piano performance in Body Mapping and piano pedagogy literature

Category	Body Mapping Literature	Piano Pedagogy Literature
Pitch	Increase in pitch accuracy, particularly in thumb crossings (Mark, 2003)	Pitch accuracy (Holmberg, 2012; Bülow in Brower, 2003; Chang, 2009; Fink, 1992; Whiteside, 1997; Fraser, 2011; Ahrens & Atkinson, 1955) -especially at thumb crossing (Agay, 2004)
Tone	-Increased control of dynamic/tone (Murray, n.d.; Breault Mulvey, n.d.; Buchanan, 2014b; Harscher, n.d.) -Improvement in tone (Breault Mulvey, n.d.; Pearson, 2016; Johnson, 2009; Blumer, 2014; Johnson, 2013; Conable, 2000) -Ability to handle louder dynamics (Buchanan, 2014b)	Strength of tone (Szumowska in Brower, 2003; Brower, 2003; Ahrens & Atkinson, 1955; Belaubre, 2004) Evenness of tone by note strength (Bernstein, 1981; Ahrens & Atkinson, 1955; Whiteside, 1997; Uszler, 2000; Panderewski in Brower, 2003; Fraser, 2011) -in thumb (Hofmann, 1976) -in thumb crossing (Whiteside, 1997; Bernstein, 1981) Evenness of tone by note length (Ahrens & Atkinson, 1955; Bastien, 1988; Holmberg, 2012; Buxner, 1972) -in thumb crossing (Hofmann, 1976; Bastien, 1988; Whiteside, 1997; Agay, 2004)
Tempo	Greater ability to handle tempo (Harscher, n.d.; Buchanan, 2014b)	Avoid tempo drift (Kullak, 1973; Holmberg, 2012; Chang, 2009; Bernstein, 1981)
Articulation	Ability to play in greater legato (Breault Mulvey, 2016)	Evenness of articulation, particularly across thumb crossing (Bastien, 1988; Hofmann, 1976; Whiteside, 1997)

Having examined what constitutes good piano performance and having identified the types of changes which constitute improvements to performance, we now need to explore the ways in which these changes may be measured quantitatively. The following section will review research literature which uses empirical data for analyzing piano performance.

1.2 Measuring improvements to piano performance with MIDI

Objective measurements of certain aspects of piano performance can be collected with Musical Instrument Digital Interface (MIDI) technology. MIDI has been defined as “a communications protocol that comprises both a set of instructions and the physical connections between compatible devices” (Yelton, 2015, p. 36). The set of instructions in this definition

refers to the data communicated by MIDI which, in the case of piano performance, includes the notes that are played (pitch), the velocity at which the key moves (velocity), and when the keys are depressed and released (timing)². The physical connections, which typically involve 5-pin MIDI connectors or USB connections, allow appropriately equipped musical instruments to communicate pitch, velocity, and timing with computer software (Yelton, 2015). Digital keyboard instruments equipped to communicate MIDI data are widely available, and computer-controlled grand pianos, such as Bösendorfer SE and Yamaha Disklavier have been developed to provide the “natural” playing environment of an acoustic piano, with a complex sensor mechanism which allows MIDI data collection and communication (Goebel & Bresin, 2003). To analyze the data, certain computer programs can generate visual representations of the data for descriptive analysis (Beckman, 1994), or MIDI files may be converted to .csv (comma separated values) format which may be viewed and analyzed in a spreadsheet program (Bresin & Battel, 2000; Johnson, 2000; Andison, 2011; Maidhof, Pitkaniemi, & Tervaniemi, 2013). MIDI technology is a well-established tool to collect and transmit data for piano performance research.

The following sections will address how improvements to pitch, tone, tempo, and articulation may be analyzed using the pitch, velocity, and timing of MIDI data.

1.2.1 Pitch. *Midi pitch data.* Pitch content of MIDI data may be examined to provide a quantitative measurement of pitch accuracy. Pitch errors can be identified by comparing a written score, which shows the intended pitches, to a printout of the MIDI pitch content, which shows the notes played (Gudmundsdottir, 2002; Mito, 2003). Although algorithms may be used for identifying pitch errors in relatively simple music, the task of identifying pitch errors in complex repertoire requires more advanced algorithms (Large, 1993; Finney, 1997), and

² MIDI data also includes other information, such as pitch bend and pedal events, but such data will not be relevant for this study and therefore will not be addressed in this review of literature.

researchers may choose instead to do this analysis by hand (Andison, 2011). Once pitch errors have been identified, codification allows a more nuanced understanding of the errors. Errors are most commonly coded into three categories: added notes, called additions, omitted notes, called deletions, and incorrectly played notes, called substitutions (Andison, 2011; Palmer & van de Sande, 1993; Finney, 1997; Yoshie et al., 2008), with more detailed coding options chosen based on the context of the study. Some examples of detailed coding options include studies of sight reading which may code pitch errors into corrected and uncorrected errors (Mito, 2003; Gunsmundottir, 2002), and studies of rehearsed performance which may code pitch errors in terms of harmonic or diatonic similarity (Palmer & van de Sande, 1993). In a study of children's music reading, analysis may be based on correct notes rather than errors (Frewen, 2010). Pitch accuracy can be expressed by the number of pitch errors (Palmer & van de Sande, 1993; Yoshie et al., 2008; Mito, 2003) or percentage of errors per unit of music, such as per pitch in the score or per bar of music (Finney, 1997; Gudmundsdottir, 2002). As the number of pitch errors decreases, pitch accuracy would be considered to increase, providing a quantitative measure of pitch accuracy which may be nuanced by codification of pitch errors into categories such as addition, deletion, and substitution.

1.2.2 Tone. In piano pedagogy and performance literature, authors write that good piano performance includes notes which are even in both strength and length. Since strength and loudness are often synonymous in piano pedagogy literature, we will consider that the term strength refers to sound intensity. We will first examine how MIDI velocity can be used to measure tone in terms of strength, or sound intensity, and then how MIDI timing can be used to measure tone in terms of note length.

MIDI velocity data. MIDI velocity data can be used to analyze tone of piano performance. MIDI data provides a number from 0 to 127 which represents velocity. The numbers 0 to 127 do not directly represent a conventional unit of measure, such as metres per second, but rather are referred to as arbitrary units (a.u.). Research with computer-controlled grand pianos, such as the Yamaha Disklavier and Bösendorfer SE, has shown that these key velocity values are consistently related to peak sound level (dB), providing a robust measure of sound intensity (Repp, 1997; Goebel & Bresin, 2003). Descriptive analysis of sound intensity may be done by using a computer generated visual representation of the velocity values which are then visually inspected by the researcher (Beckman, 1994). Comparison of various recordings can be conducted in this way, but more often, statistics are used to conduct the analyses. Among these statistical calculations, standard deviation is frequently used to describe evenness. As standard deviation decreases, evenness of tone increases (Johnson, 2000; Yoshie et al., 2008). Standard deviation of velocity has also been used as a measure of motor control (Salmon & Newmark, 1989). Mean key velocity is a calculation which describes the overall sound intensity level or dynamic (Andison, 2011; Finney, 1997; Flowers, Wapnick, & Ramsey, 1997). A performance which has an increase in mean key velocity would be considered to have greater sound intensity, and a decrease in standard deviation of key velocity would be considered to have greater evenness of tone.

MIDI timing data. MIDI timing data provide onset and offset times for each note, which can be used to analyze the temporal aspects of piano playing. The time between the onset of one note and the onset of the following note is called the interonset interval (IOI). In examination of timing, IOI is one of the most common measures. The standard deviation of IOI in consecutive notes of the same value, such as in a passage of eighth notes, can provide a quantitative measure

of evenness (Duke, Cash, & Allen, 2011; Finney, 1997; Ruiz, Hong, Hennig, Altenmüller, & Kühn, 2014). The IOI is inclusive of both duration of the note and the time between the offset of one note and onset of the next, providing a measure of temporal relationships between note onsets (Parncutt & McPherson, 2002). Evenness of tone by note length, therefore, can be quantitatively analyzed by the standard deviation of IOI. As the standard deviation of IOI decreases, the evenness of tone increases. It is common in analysis to delete the last note of a trial due to the common tendency of performers to elongate the final note of an excerpt (Finney, 1997; Loehr & Palmer, 2009; Jabusch et al., 2004). Notes which surround a pitch error are also often omitted from the data before performing analysis because such notes are likely to have IOIs which would be considered outliers in the data set (Finney, 1997; Loehr & Palmer, 2009; Jabusch et al., 2004). Researchers have found that the recording of MIDI timing with a computer controlled grand piano from the Yamaha Disklavier Mark II series was accurate within 10 milliseconds (Goebel & Bresin, 2003), whereas listeners who are experienced musicians are able to hear variations in timing as small as 20 milliseconds (Repp, 1999a). This supports that the accuracy of MIDI timing data is adequate to capture changes in the piano performance which would be audible to the experienced musician listener.

1.2.3 Tempo. *MIDI timing data.* Quantitative measures of tempo can be extracted from MIDI timing data. Tempo may be measured simply by calculating the elapsed time during a trial (Salmon & Newmark, 1989), or by calculating the mean IOI in sections where all rhythmic values are equal, such as in a series of eighth notes (Andison, 2011; Maidhof et al., 2013). To determine if a tempo drift has occurred, mean IOI between first and last repetitions of a sequence may be compared (Loehr & Palmer, 2009). Researchers may also choose to compare IOI in a MIDI recording to a computer-generated ideal in order to describe how the recording deviates

from the markings on the score (Andison, 2011). A performance which has a smaller difference between mean IOI of the first and last repetitions of a sequence would be considered to have greater evenness of tempo.

1.2.4 Articulation. *MIDI timing data.* The difference between the onset time of one note and the offset time of the previous notes is referred to as key overlap time (KOT), when there is an overlap, or key detach time (KDT), when there is a gap. While computer generated visual displays can be used for descriptive analysis of visually observed patterns (Beckman, 1994; Moore, 1992; Wilson, 1992), more frequently, mean KOT or KDT is used to describe overall articulation, and standard deviation of KOT or KDT is used to describe the evenness of articulation (Beckman, 1994; Bresin & Battel, 2000; Palmer, 1988; Repp, 1994; Repp, 1999b). Mean and standard deviation of KOT or KDT can then be compared between participants or between conditions. An increase in mean KOT would indicate an increase in the amount of overlap, and a decrease in the standard deviation of KOT or KDT would be considered an increase in the evenness of articulation.

1.2.5 Summary. Table 1.3 summarizes the improvements to piano performance aspects of pitch, tone, tempo, and articulation discussed in Body Mapping literature, in parallel with the concepts of good piano performance discussed in piano pedagogy and performance literature, and how these aspects may be measured using MIDI data.

Table 1.3

Improvements to piano performance in Body Mapping and piano pedagogy literature, and how they can be measured with MIDI data

Category	Body Mapping Literature	Piano Pedagogy Literature	Analysis by MIDI
Pitch	Increase in pitch accuracy, particularly in thumb crossings (Mark, 2003)	Pitch accuracy (Holmberg, 2012; Bülow in Brower, 2003; Chang, 2009; Fink, 1992; Whiteside, 1997; Fraser, 2011; Ahrens & Atkinson, 1955) -especially at thumb crossing (Agay, 2004)	Pitch errors counted and codified as additions, deletions and substitutions (Gudmundsdottir, 2002; Mito, 2003; Andison, 2011; Finney, 1997; Palmer & van de Sande, 1993; Yoshie et al., 2008)
Tone	-Increased control of dynamic/tone (Murray, n.d.; Breault Mulvey, n.d.; Buchanan, 2014b; Harscher, n.d.) -Improvement in tone (Breault Mulvey, n.d.; Pearson, 2016; Johnson, 2009; Blumer, 2014; Johnson, 2013; Conable, 2000) -Ability to handle louder dynamics (Buchanan, 2014b)	Strength of tone (Szumowska in Brower, 2003; Brower, 2003; Ahrens & Atkinson, 1955; Belaubre, 2004) Evenness of tone by note strength (Bernstein, 1981; Ahrens & Atkinson, 1955; Whiteside, 1997; Uszler, 2000; Panderewski in Brower, 2003; Fraser, 2011) -in thumb (Hofmann, 1976) -in thumb crossing (Whiteside, 1997; Bernstein, 1981) Evenness of tone by note lengths (Ahrens & Atkinson, 1955; Bastien, 1988; Holmberg, 2012; Buxner, 1972) -in thumb crossing (Hofmann, 1976; Bastien, 1988; Whiteside, 1997; Agay, 2004)	Overall sound intensity quantified by mean velocity (Andison, 2011; Finney, 1997; Flowers et al., 1997) Evenness of tone quantified by standard deviation of key velocity (Salmon & Newmark, 1989; Repp, 1996; Jabusch et al., 2004) Evenness of tone by note length quantified by standard deviation of IOI (Duke et al., 2011; Finney, 1997; Ruiz et al., 2014)
Tempo	Greater ability to handle tempo (Harscher, n.d.; Buchanan, 2014b)	Avoid tempo drift (Kullak, 1973; Holmberg, 2012; Chang, 2009; Bernstein, 1981)	Tempo drift quantified by change in IOI between first and last repetitions of a sequence (Loehr & Palmer, 2009)
Articulation	Ability to play in greater legato (Breault Mulvey, 2016)	Evenness of articulation, particularly across thumb crossing (Bastien, 1988; Hofmann, 1976; Whiteside, 1997)	Evenness of articulation quantified by standard deviation of KOT or KDT (Beckman, 1994; Bresin & Battel, 2000; Palmer, 1988; Repp, 1994; Repp, 1999b)

1.3 Research problem. A large body of anecdotal evidence asserts that pianists experience improvements to their music performance following the study of Body Mapping, yet there exists minimal research evidence to support this perception. There is a particular lack of empirical data, and to date, there have been no studies to examine any aspect of participants' performance before and after attending the course, "What Every Musician Needs to Know About the Body" (WEM) which Andover Educators are licensed to teach. Six hour WEM-style workshops are such a common method of Body Mapping instruction, that Body Mapping literature frequently refers to WEM as simply "the course" (Andover Educators: The Course, 2017) and teaching of the course is one of the most central components in the Andover Educators training process (Bindel, 2013). Research is needed to explore the effects of this common method of Body Mapping instruction. There is a particular need for research using empirical data, such as that which can be collected using MIDI. By collecting and analyzing MIDI data from the day before and the day after an instrument-specific version of WEM taught by a licensed Andover Educator, this study can empirically investigate whether there are changes to the pitch, tone, tempo, and articulation of piano performance.

The research question for this study is:

- Does the standard six hour Body Mapping workshop improve the pitch, tone, tempo, and articulation of piano performance of scales and arpeggios as measured by MIDI data?

Given the literature reviewed above, we hypothesize that after the Body Mapping workshop, pitch will be more accurate, tone will be stronger, and tone, tempo, and articulation will be more even. We will ask participants to play the scales and arpeggios legato, and therefore an increase in the amount of key overlap will also be considered an improvement to piano performance. We hypothesize that these improvements will be measurable in the MIDI data.

Chapter 2: Method

2.1 Participants

2.1.1 Population sampling. 38 participants (29 female, $M = 26.35$ years, age range = 18-56 years) were recruited for this study from four Canadian centres. Participants were recruited among those who were currently studying and majoring in piano at an undergraduate or graduate level, or who had previously studied at such a level. One volunteer who held a master's degree in organ performance but who regularly performs on piano was allowed to participate. Another volunteer who works professionally as a pianist and holds an ARCT (Associate of the Royal Conservatory of Toronto) certificate in piano but did not major in piano at a university was also allowed to participate. One volunteer who had neither majored in piano at a university nor held certificates from the Royal Conservatory of Music was permitted to participate in the study because the participant demonstrated similar piano performance abilities to the rest of the sample. The data collected from the intake questionnaires confirmed that all participants were currently active in playing, performing and/or practicing piano. No participant had received more than one group workshop or one private lesson in Body Mapping. Some participants had previous experience with other somatic methods including Alexander Technique and Feldenkrais. Two participants reported owning a book about Body Mapping. Independent samples *t*-tests were conducted to determine whether previous experience with somatic methods had an impact on results, showing little difference in results between those who had had experience with somatic methods and those who had not.

2.1.2 Participant preparation. Participants volunteered for one of eight Body Mapping workshops, scheduled in the four Canadian centres involved in this study. Participants confirmed their availability for one of the full day workshops, a 40 minute pre-test session the day before

the workshop, and a 30 minute post-test session the day after the workshop. Participants were informed of the playing tasks (detailed in Section 2.2.4 below) prior to their intake session. All participants confirmed that they had received the information and agreed to prepare the playing tasks prior to their arrival to the intake and pre-test session.

2.2 Experimental Design

2.2.1 Timeline of data collection. Participation in this experiment involved components on three consecutive days. On the first day, informed consent was established with participants through consent forms which were approved by the University of Ottawa Office of Research Ethics and Integrity. Participants were provided with opportunities to ask questions about their participation in the study and were informed of their right to withdraw at any time. Participants then completed an intake questionnaire, and a pre-test to examine the participants' piano performance. On the second day, participants took part in a Body Mapping workshop called, "What Every Pianist Needs to Know About the Body" taught by the researcher, a licensed Andover Educator. This was a WEM-style workshop which was tailored specifically for pianists. A maximum of six participants were allowed in any one workshop to control for the amount of individual attention given to each participant. A post-test which mirrors the pre-test was administered on the third day. To control for experience accumulated between pre-test and post-test, participants were asked to not practice between their initial pre-test and the final post-test. Participants were encouraged to play piano during the workshop as an integral part of the learning process. MIDI, audio, video, and bench height and distance data were recorded during pre-test and post-tests.

2.2.2 Intake questionnaire. Participants were asked to arrive individually at the designated location for an intake session of approximately 40 minutes on the first day of their

participation in the study. After becoming acquainted with their test environment, the participant was given thorough information on the research study both verbally and in written format. After reading the consent form and asking any questions, the participant was given the opportunity to sign the consent form (see Appendix B). Once informed consent had been established, a brief questionnaire was administered, comprising demographic information and past experience with music and Body Mapping (See Appendix C to view the questionnaire).

2.2.3 Pre-test. The pre-test occurred on the first day of the study immediately following the questionnaire. The participant was asked to be seated comfortably at the instrument on an adjustable padded bench and was invited to change the height of the bench as needed. Before each participant had entered the room, the bench was returned to its lowest height and pushed under the keyboard such that adjusting the bench was necessary for most participants. Bench height and distance were recorded after the participant had completed the testing session. In the case of two participants, bench distance data could not be collected because the participant returned the bench to its original position before distances could be measured. Participants were given at least two minutes to become familiar with the instrument before trials and recordings were conducted. In piano performance research, where participants are required to play at a particular tempo, it is common practice to provide a metronome stimulus at the desired speed before the participant begins to play which is silenced when the participant begins to play (Ruiz et al., 2014; Goebel & Palmer, 2008; Andison, 2011; Wong, 2015). As such, for each playing task, the metronome speed was given audibly and the participant was asked to perform a trial run of the playing task. As soon as the participant began to play, the metronome was stopped. Participants were given at least one trial run of each playing task before the task was recorded, which helped them become accustomed to both the metronome speed and the sequence of

events. In some instances, the participant stopped prematurely or requested to re-record a task due to pitch errors or distraction. When the participant requested to re-record, the request was granted and the second recording was later used in analysis.

2.2.4 Playing tasks. Participants were informed of the playing tasks prior to the first day of the study. For the pre-test and post-tests, participants were required to play four octave C major scale and C major arpeggio hands separately³.

C major scale. Participants in the present study were asked to play four octave scales, ascending and descending. Similarly to the data collection procedure of Cheng and colleagues (2013), participants were asked to repeat the scales ascending and descending continuously without pauses until they were asked to stop. This allowed us to gather multiple repetitions of each fingering sequence and to measure tempo drift. Asking the participant to repeat the scale continuously allowed the participant's attention to be devoted to the playing task and not to counting repetitions. The primary researcher ensured that 5 repetitions of the scale were recorded before stopping the participant. Participants performed the scale with the right hand first, repeating continuously until asked to stop, and then the same was recorded with the left hand only. Participants were given a metronome stimulus at 120 beats per minute and were asked to play the scale in eighth notes to the metronome's quarter beat pulse. As with all playing tasks, during both trial runs and recordings, the metronome was stopped as soon as the participant began to play. The use of a standardized tempo recommendation gave some uniformity across participants and allowed us to analyze the pianists' ability to maintain tempo without external timekeeping stimuli. For consistency across performances, participants were asked in the pre-test and in the post-test to play the scales legato and without accent.

³ Participants were also asked to prepare the first 28 bars of Mozart Sonata in C major, K545, 1st movement (Appendix E), however, the MIDI data from this playing task were not analyzed in this thesis.

C major arpeggio. Participants were asked to play a four octave C major arpeggio ascending and descending continuously with repetitions collected in the same manner as scales. Participants played the arpeggio with the right hand and then the left. An audible metronome stimulus of 84 beats per minute was given, in accordance with the tasks of the Royal Conservatory of Music regulations for Grade 9 (Royal Conservatory, 2015) and again, the metronome stimulus was silenced before participants began to play in sixteenth note subdivisions of the metronome beat. As with the scale, participants were asked to complete at least one trial run of the arpeggios before they were recorded. Participants were asked to play the arpeggios legato and without accent.

2.2.5 Intervention. The day after their pre-test, participants received a typical six hour WEM-style Body Mapping workshop that had been tailored for pianists, called, “What Every Pianist Needs to Know About the Body”. This course is standard among teachers of Body Mapping, as trainees in this method are required to prepare the six hour curriculum as a requirement for licensing (Bindel, 2013). WEM-style Body Mapping workshops typically address the following topics in order: general concepts, training of senses, attention, movement, balance of the body, arms, breathing, legs, and constructive rest. This is often followed by a masterclass in which each participant can work individually with the instructor (Conable, 2000a). Accordingly, our intervention was designed to follow the same order of events. On the day of the intervention, participants were allowed short breaks between each of the hours and one hour-long break. Each participant received 15-20 minutes of the masterclass time. For reference purposes, MIDI, video, and audio recordings were taken during the masterclass.

2.2.6 Post-test. The post-test occurred the day after the intervention and followed the same sequence of events as the pre-test. As with the pre-test, the session was recorded with audio, video, and MIDI, as well as bench height and distance.

2.3 Measurements

2.3.1 Questionnaire. A questionnaire tool, which can be found in Appendix C, was used to collect demographic information and music and somatic training history of participants. Participants' age, gender, left- or right-handedness, number of years playing piano, first year of piano lessons, post-secondary piano training, and their experience, if any, with somatic techniques such as Body Mapping was requested. Space was included for participants to disclose and describe any musculoskeletal conditions that may be related to or affect their piano performance. The questionnaire was modelled after one used by Beacon (2015) because it was designed for a research study on the effects of a somatic method, and covered all of the relevant information.

2.3.2 Audio and video recording. An audio/video recorder was used to document testing sessions and the masterclass. For sessions conducted at the University of Ottawa, the audio and video recording setup of the Piano Pedagogy Research Laboratory was used. For sessions conducted in other Canadian centres, a Zoom q2n was selected for its quality of audio recording and portability. Video was recorded from a single camera, positioned at the right or left side of the piano.

2.3.3 Musical instrument digital interface (MIDI). At the Piano Pedagogy Research Laboratory, a Yamaha Disklavier from the Mark III series was used to record the pitch, velocity, and timing of key presses. In centres where a MIDI-equipped acoustic piano was not available, a comparable electric MIDI-equipped instrument was used. These included a Yamaha CP4,

Clavinova CLP-130 and a Yamaha Electric Grand. MIDI data collected from the Yamaha Disklavier were recorded onto a disk and later saved to a computer for analysis. The other MIDI-equipped instruments were connected directly to a Macintosh computer and the MIDI data recorded using the program Alchemusica Version 0.6.4. All MIDI files were later converted to .csv format for analysis.

2.3.4 Bench height and distance. Mark (2003) describes that pianists learning Body Mapping may discover that their habituated bench height or distance from the piano is ill-suited to their body size and shape. To explore whether pianists change their bench height or distance from the piano after a Body Mapping workshop, we measured the bench height and the distance of the bench to the piano during pre-test and post-test. The height of the bench was measured in centimetres from the top of the bench to the floor using a standard measuring tape. Using the same measuring tape, the distance of the bench to the piano was measured from the middle of the piano bench to a landmark on the keyboard instrument. Since a different instrument was used in each data collection centre, the landmark differed from centre to centre, however, the same landmark was used consistently in each data collection centre.

2.4 Data analysis

Data collected in this study were first processed in Excel and the final statistical analyses were conducted using Statistical Package for the Social Science (SPSS). For certain statistical tests, it was necessary to determine whether or not the data were normally distributed, as this has an impact on the choice of parametric or nonparametric statistical tests. In order to assess normality of distribution, descriptive statistics for kurtosis and skewness were examined, and any value over 1.5 was flagged. Shapiro-Wilk tests were conducted on the flagged data sets, and for values which were statistically significant (significantly different than a normally distributed data

set of the same mean and standard deviation, $p < .05$) were examined for QQ graphs, histograms and box plots. In measures that demonstrated non-normal distribution among all of the above tests, z -scores were calculated. Following a standard deviation based method of trimming data described by Field (2014), any participants' datum which yielded a z -score of more than 2.58 standard deviations from the mean was identified as an outlier and eliminated. In data sets where outliers were eliminated, these eliminated values constituted about 1%-3% of the data set. Once these outliers were removed, normality tests were conducted again, and in all cases except for measures of pitch accuracy, normal distribution was noted. Eliminated outlier values were excluded pairwise, so that if a participant's datum was considered an outlier in the pre-test, the same datum was ignored in the post-test. In the case of pitch accuracy, where normal distribution could not be achieved, no outliers were removed, and nonparametric statistical tests were used.

2.4.1 MIDI

File processing. For analyzing pitch and for general reference purposes, music scores of the performances were generated using the application MuseScore 2.0.2. Windows Media Player was used to render synthesized audio of the MIDI files, which was referenced throughout the analysis process, particularly during pitch error identification.

For analysis of key velocity and timing, MIDI data files were first converted to the file format comma separated values (.csv). For each scale and arpeggio, a series of commands was designed in the spreadsheet program Excel to extract the relevant velocity and timing information. The .csv files could then be inserted into the corresponding Excel template and the program would execute a series of tasks. Firstly, the program would separate the repetitions of the scale and arpeggio and compare each repetition to a list of correct note events for the relevant scale or arpeggio. Where mismatches between the recorded repetition and the correct sequence

of note events were identified, the entire repetition was discarded. In two of the arpeggio recordings, the abundance of errors rendered all but one or two repetitions unusable by the series of commands. These recordings were divided into ascent and descent of the arpeggio, and error free ascents and descents were used to compile error free repetitions. Depending on the number of errors in the recording, between three and six error-free repetitions were then carried forward into a sheet which addressed velocity and a sheet which addressed timing. In both the velocity and timing sheets, note onsets and offsets were coded with a note order (first note, second note, third note, etc.) and with the finger which most likely played it according to conventional scale and arpeggio fingerings. In left hand arpeggios, where it is conventional to use either third or fourth finger, the finger number was coded as “3or4” to allow that participants could have used either finger.

MIDI pitch data. Using the MIDI-rendered printout of scale and arpeggio recordings, pitch errors were identified by hand (Gudmundsdottir, 2002; Mito, 2003; Andison, 2011) and classified as additions, deletions, and substitutions (Palmer & van de Sande, 1993; Andison, 2011; Finney, 1997; Yoshie et al., 2008). The primary researcher and two research assistants performed these evaluations to reduce the bias of human error. Where differences between analysts were found, the researcher and research assistants consulted to conclude the correct number of additions, deletions, and substitutions. In all cases of initial disagreement, the correct numbers were easily determined and concluded. The quantity of errors and the types of errors present were compared between pre-test and post-test. Since the recordings often included more than 5 repetitions of the scales and arpeggios, the researcher and research assistants took care to count errors in the same number of repetitions between pre-test and post-test (i.e. if the pre-test

included 5 repetitions, but the post-test included 6, only the first 5 repetitions of both files were inspected for pitch error).

MIDI velocity data. In the scale and arpeggio recordings, velocity was analyzed using the Excel series of commands designed for this project, yielding quantitative measures of tone. Once the series of commands had deleted all repetitions that included errors, the error-free repetitions were carried into a spreadsheet which analyzed velocity. Some of the MIDI-equipped keyboard instruments used in this study do not measure velocity of note offsets. Only note onsets were used for velocity analysis. Note onsets from error-free trials were coded for finger number given conventional scale and arpeggio fingerings. Mean and standard deviation were calculated for each individual repetition, across all repetitions, and for all occurrences of each finger across repetitions. When all pre-test and post-test scale and arpeggio recordings had been entered into the program, another spreadsheet was used to extract the resulting values for each recording: mean velocity, standard deviation of velocity, mean velocity of each finger, and standard deviation of the velocity of each finger. These results were then exported into the software program SPSS, where statistical tests were conducted.

MIDI timing data. Scale and arpeggio recordings were entered into the Excel program discussed above. These data yielded measures of evenness of tone by note length, evenness of tempo, and evenness of articulation. In the timing analysis sheet, note onsets and offsets were coded for finger number and ascent or descent. Ascent and descent coding was used to identify the location and type of thumb crossings (ie: thumb travelling under, or other fingers travelling over the thumb). Type and location of thumb crossings were coded using conventional scale and arpeggio fingerings.

Evenness of tone by note length. IOI was calculated by subtracting the onset time of one note from the onset time of the previous note. Standard deviation of IOI was calculated to provide a measure of evenness of tone by note length. To further explore changes in each finger, mean and standard deviation of IOI were also calculated for each finger.

Evenness of tempo. For scale performance, mean IOI of the first repetition was subtracted from mean IOI of the last repetition, yielding a measure of tempo drift. Due to the high prevalence of pitch errors in the arpeggio recordings, tempo drift could not reliably be extracted from the MIDI data.

Evenness or articulation. KOT was calculated by subtracting the offset time of one note from the onset time of the following note. This yielded a KOT which was positive when there was an overlap between the two notes, and a KOT which was negative when there was a gap between the two notes. Although a gap between notes is usually referred to as key detach time (KDT), for consistency of terminology in this study, the term KOT was used consistently in cases of both overlap and gap. Once KOT had been calculated for each pair of consecutive notes in error-free repetitions, the next command in the sequence calculated mean and standard deviation, providing measures of amount of overlap and consistency of articulation. To explore individual fingers, mean and standard deviation of KOT were also calculated for each finger number in ascent and descent.

When all scale and arpeggio recordings were processed, another spreadsheet was used to extract the resulting data: mean and standard deviation of IOI and KOT, amount of tempo drift, and mean and standard deviation of IOI and KOT across the entire scale or arpeggio and for each finger number. These results were then exported to SPSS where statistical tests were conducted.

Chapter 3: Article

The Measurable Effects of Body Mapping on Piano Performance

Body Mapping is a somatic⁴ method which has developed to equip musicians and music teachers with accurate knowledge of the body in movement, and this process is said to both improve music performance and reduce the risk of injury. Anecdotal evidence indicates that musicians studying Body Mapping experience improvements to their music performance, including greater pitch accuracy (Mark, 2003), greater expressivity (Pearson, 2006), and increased ability to handle fast tempi (Harscher, n.d.). Videos of workshops in Body Mapping show a change in sound quality following instruction (Pearson, 2011) most clearly observable in the reactions of audiences who assert that the tone has become fuller, richer and more beautiful (Breault Mulvey, 2016; Blumer, 2014). This phenomenon of improved tone quality is echoed in instructional literature (Conable, 2000a; Johnson, 2009), which also asserts that Body Mapping helps promote consistency between performances (Pearson, 2006; Conable, 2000a; Malde, Allen, & Zeller, 2013). Singers and instrumentalists alike are said to improve in their technical facility (“Iowa State University Music: Body Mapping”, n.d.; Kraye-Luke, 2014; Harscher, n.d.; Rennie Salonen, n.d.) and are able to practice and perform with greater expressivity (Conable, 2000a; Mark 2003; Kraye-Luke & Breault Mulvey, 2014). While there are many sources describing the reputed effects of Body Mapping, the body of research literature on the effects of Body Mapping is currently limited to two qualitative and one quantitative study.

Research suggests that when studying Body Mapping with a teacher in person for the length of at least one semester, students report improvements in their performance and pain levels (Knaub, 2002; Buchanan, 2014b), but the changes after a single hour of instruction

⁴ Thomas Hanna (1988), who brought the term “somatics” into common use among movement therapists, defined somatic work as that which addresses both the self-awareness of the student, patient, or client, and the observations made by the educator or therapist in the design and execution of the therapy.

through an online interface are minimal and not easily detected by observers (Wong, 2015). Student participants in the two qualitative studies expressed through reflective journals that Body Mapping allowed them to have greater facility and, for singers and wind instrumentalists, greater breath control (Knaub, 2002), as well as greater expressivity and focus during performance (Buchanan, 2014b). In the single quantitative study to explore Body Mapping, a panel of experts, blind to condition, rated video and audio recordings of pianist participants before and after a private lesson in a somatic method. Four of ten pianists received a 50 minute online Body Mapping lesson from a licensed Andover Educator. The study found that while judges' evaluations of audio recordings were on average 4% higher for post-test recordings on all factors except consistency of tempo, none of the changes to perceived musical quality were statistically significant. This suggests that the effects on pianists following a 50 minute private lesson online are not as clearly observable by a panel of experts as anecdotal evidence indicates (Wong, 2015). More research is needed to determine whether the reputed improvements to performance are present and empirically measurable.

When considering that Body Mapping is one of the only somatic methods intended specifically for musicians, which has a large body of instructional literature and countless testimonies of its effectiveness, the presence of only three research studies is insufficient. In light of the increased role of Body Mapping in music education today, its presence in 18 post-secondary institutions (Mollnow Wilson, personal communication 2015), and availability of instructional literature (Andover Educators: Recommended reading, 2017), there is a need to investigate whether the music performance of students studying Body Mapping actually improves in an empirically measurable way. Among the reputed improvements to music performance associated with Body Mapping, in this study we will investigate whether Body

Mapping can have a measurable impact on the pitch, tone, tempo, and articulation of piano performance.

Literature review

In the section which follows, we will first consult piano pedagogy and performance literature to determine how an improvement to piano performance maybe defined, and then we will explore ways in which researchers can measure such changes. Since there are many contexts in which improvements to performance could be observed, here, we choose to focus specifically on the piano performance of scales and arpeggios. These are common activities for pianists and thus are well automatized in experienced pianists. Many researchers include C major scales in the playing tasks in their studies (Jabusch, et al., 2004; Wong, 2015; Beacon, 2015) and likewise arpeggios have been used to examine quality of performance in pianists under a variety of conditions (Yoshie, Kudo, & Ohtsuki, 2008). Goebel and Palmer (2013) recommended that researchers examine skills such as scales and arpeggios. For this reason, the review of literature below places a particular emphasis on concepts of good piano performance as they relate to scales and arpeggios.

Since many of the improvements to music performance associated with Body Mapping are described in a nonspecific manner, or refer to an instrument other than piano, it is necessary to first define what an improvement in piano performance may be. Piano pedagogy and performance literature were consulted to define improvement to pitch, tone, tempo, and articulation of piano performance. Authors emphasize the importance of pitch accuracy (Holmberg, 2012; Bülow in Brower, 2003; Chang, 2009; Fink, 1992; Whiteside, 1997; Fraser, 2011; Ahrens & Atkinson, 1955), a strong tone (Brower, 2003; Ahrens & Atkinson, 1955; Belaubre, 2004), which is even in both strength (Bernstein, 1981; Ahrens & Atkinson, 1955;

Whiteside, 1997; Uszler, 2000; Panderewski in Brower, 2003) and in length of consecutive notes (Ahrens & Atkinson, 1955; Bastien, 1988; Holmberg, 2012; Buxner, 1972). This is said to be important and more difficult in the case of thumb crossings (Hofmann, 1976; Bastien, 1988; Whiteside, 1997; Agay, 2004; Bernstein, 1981). Authors advocate an even tempo unless rubato is indicated, particularly in avoiding tempo drift (Kullak, 1973; Holmberg, 2012; Chang, 2009; Bernstein, 1981), as well as evenness of articulation, where amount of gap or overlap is consistent among consecutive notes (Bastien, 1988; Hofmann, 1976; Whiteside, 1997). Based on piano pedagogy and performance literature, an improvement to the pitch, tone, tempo, and articulation of piano performance would have greater pitch accuracy, strength and evenness of tone, evenness of tempo, and evenness of articulation.

MIDI data can be used to quantitatively measure the pitch, tone, tempo, and articulation of piano performance, allowing researchers to determine differences among recordings of performances. MIDI technology yields data on pitch, velocity, and timing. MIDI pitch data can be used to examine pitch accuracy. Pitch errors can be identified by comparing a written score, which shows the intended pitches, to a printout of the MIDI pitch content, which shows the notes played (Gudmundsdottir, 2002; Mito, 2003). Pitch accuracy can be further explored by classifying pitch errors into added notes, called additions, missed notes, called deletions, and incorrectly played notes, called substitutions (Palmer & van de Sande, 1993; Finney, 1997; Yoshie et al., 2008). MIDI velocity data, which is a measure of sound intensity (Repp, 1997), may be used to quantify evenness of tone by note strength of consecutive notes (Salmon & Newmark, 1989; Repp, 1996), while the evenness of tone by note length may be examined using MIDI timing data. The time between the onset of one note and the onset of the following note is called the interonset interval (IOI) and standard deviation of IOI provides a quantitative measure

of evenness of tone by note length (Duke, Cash, & Allen, 2011; Finney, 1997; Ruiz, Hong, Hennig, Altenmüller, & Kühn, 2014). As the standard deviation of IOI decreases, the evenness of tone increases. MIDI timing data can also provide a measure of evenness of tempo and articulation. The difference between the mean IOI in the first and last repetitions of a sequence with notes of the same value, such as sequences of eighth notes, can be used to quantify tempo drift (Loehr & Palmer, 2009). Articulation is measured by key overlap time (KOT), defined as the difference in time between the onset of a note and the offset of the previous note. Mean KOT can be used to describe the articulation, with positive KOT describing an overlap and negative KOT describing a gap. Standard deviation of KOT is a quantitative measure of evenness of articulation (Beckman, 1994; Bresin & Battel, 2000; Palmer, 1988; Repp, 1994; Repp, 1999b).

The claims made about improvements to music performance associated with Body Mapping, how these improvements may be clarified for the context of piano performance by piano pedagogy literature, and how these improvements may be measured using MIDI data are summarized in Table 1.

Table 1

Improvements to piano performance in Body Mapping and piano pedagogy literature, and how they can be measured with MIDI data

Category	Body Mapping Literature	Piano Pedagogy Literature	Analysis by MIDI
Pitch	Increase in pitch accuracy, particularly in thumb crossings (Mark, 2003)	Pitch accuracy (Holmberg, 2012; Bülow in Brower, 2003; Chang, 2009; Fink, 1992; Whiteside, 1997; Fraser, 2011; Ahrens & Atkinson, 1955) -especially at thumb crossing (Agay, 2004)	Pitch errors counted and codified as additions, deletions and substitutions (Gudmundsdottir, 2002; Mito, 2003; Andison, 2011; Finney, 1997; Palmer & van de Sande, 1993; Yoshie et al., 2008)
Tone	-Increased control of dynamic/tone (Murray, n.d.; Breault Mulvey, n.d.; Buchanan, 2014b; Harscher, n.d.) -Improvement in tone (Breault Mulvey, n.d.; Pearson, 2016; Johnson, 2009; Blumer, 2014; Johnson, 2013; Conable, 2000) -Ability to handle louder dynamics (Buchanan, 2014b)	Strength of tone (Szumowska in Brower, 2003; Brower, 2003; Ahrens & Atkinson, 1955; Belaubre, 2004) Evenness of tone by note strength (Bernstein, 1981; Ahrens & Atkinson, 1955; Whiteside, 1997; Uszler, 2000; Panderewski in Brower, 2003; Fraser, 2011) -in thumb (Hofmann, 1976) -in thumb crossing (Whiteside, 1997; Bernstein, 1981) Evenness of tone by note lengths (Ahrens & Atkinson, 1955; Bastien, 1988; Holmberg, 2012; Buxner, 1972) -in thumb crossing (Hofmann, 1976; Bastien, 1988; Whiteside, 1997; Agay, 2004)	Overall sound intensity quantified by mean velocity (Andison, 2011; Finney, 1997; Flowers et al., 1997) Evenness of tone quantified by standard deviation of key velocity (Salmon & Newmark, 1989; Repp, 1996; Jabusch et al., 2004) Evenness of tone by note length quantified by standard deviation of IOI (Duke et al., 2011; Finney, 1997; Ruiz et al., 2014)
Tempo	Greater ability to handle tempo (Harscher, n.d.; Buchanan, 2014b)	Avoid tempo drift (Kullak, 1973; Holmberg, 2012; Chang, 2009; Bernstein, 1981)	Tempo drift quantified by change in IOI between first and last repetitions of a sequence (Loehr & Palmer, 2009)
Articulation	Ability to play in greater legato (Breault Mulvey, 2016)	Evenness of articulation, particularly across thumb crossing (Bastien, 1988; Hofmann, 1976; Whiteside, 1997)	Evenness of articulation quantified by standard deviation of KOT or KDT (Beckman, 1994; Bresin & Battel, 2000; Palmer, 1988; Repp, 1994; Repp, 1999b)

Research question

A large body of anecdotal evidence indicates that pianists' music performance improves following the study of Body Mapping, yet there exists minimal research evidence to support this perception. There is a particular lack of empirical data, and to date, there have been no studies to examine any aspect of participants' performance before and after attending the course, "What Every Musician Needs to Know About the Body" (WEM) which Andover Educators are licensed to teach. Six hour WEM-style workshops are such a common method of Body Mapping instruction, that Body Mapping literature frequently refers to WEM as simply "the course" (Andover Educators: The Course, 2017) and teaching of the course is one of the most central components in the Andover Educators training process (Bindel, 2013). Research is needed to explore the effects of this common method of Body Mapping instruction.

The purpose of this study is to empirically investigate whether there are improvements to the pitch, tone, tempo, and articulation of piano performance following a Body Mapping workshop which are measurable by MIDI data. In this study we address the following question:

- Does the standard six hour Body Mapping workshop improve the pitch, tone, tempo, and articulation of piano performance of scales and arpeggios as measured by MIDI data?

Given the literature reviewed above, we hypothesize that after the Body Mapping workshop, pitch will be more accurate, tone will be stronger, and tone, tempo and articulation will be more even. We will ask participants to play the scales and arpeggios legato, and therefore an increase in the amount of key overlap will also be considered an improvement to piano performance. We hypothesize that these changes will be quantitatively evident in the MIDI data.

Method

Participants. 38 participants (29 female, $M = 26.35$ years, age range = 18-56 years) were recruited for this study from four Canadian centres. Participants were recruited among those who were currently studying and majoring in piano at an undergraduate or graduate level, or who had previously studied at such a level. One volunteer who held a master's degree in organ performance but who regularly performs on piano was allowed to participate. Another volunteer who works professionally as a pianist and holds an ARCT (Associate of the Royal Conservatory of Toronto) certificate in piano but did not major in piano at a university was also allowed to participate. One volunteer who had neither majored in piano at a university nor held certificates from the Royal Conservatory of Music was permitted to participate in the study because the participant demonstrated similar piano performance abilities to the rest of the sample. The data collected from the intake questionnaires confirmed that all participants were currently active in playing, performing and/or practicing piano. No participant had received more than one group workshop or one private lesson in Body Mapping. Some participants had previous experience with other somatic methods including Alexander Technique and Feldenkrais. Two participants reported owning a book about Body Mapping. Independent samples t -tests were conducted to determine whether previous experience with somatic methods had an impact on results, showing little difference in results between those who had had experience with somatic methods and those who had not.

Procedures. All participants were informed of the playing tasks (see section below) prior to their participation in the study and agreed to prepare adequately for fluent performance of each task. The day before and the day after their participation in the group intervention activity,

participants arrived to the data collection centre individually for testing. During each testing session, the participant was asked to be seated at the instrument on an adjustable bench and then was given at least two minutes to become familiar with the instrument before any recording was conducted. For each playing task, the metronome speed was given audibly and then silenced when the participant began to play. Participants were given at least one trial run of each playing task before recording. During performance of the playing tasks, audio, video, and MIDI data were collected. Mark (2003) describes that pianists learning Body Mapping may discover that their habituated bench height or distance from the piano is ill-suited to their body size and shape. To explore whether pianists change their bench height or distance from the piano after a Body Mapping workshop, participants' chosen bench height and distance were recorded after each the testing session was completed. A questionnaire was administered comprising information on participant age, gender, left- or right-handedness, number of years of piano lessons, first year of piano lessons, post-secondary piano training, their experience, if any, with somatic methods such as Body Mapping, and their experience, if any, with musculoskeletal injuries.

Playing tasks. Participants were asked to play four octave C major scales and arpeggios, ascending and descending, repeating without pauses until they were asked to stop. The primary researcher ensured that 5 repetitions of the scale or arpeggio were recorded before stopping the participant. Asking the participant to repeat the task continuously allowed the participant's attention to be devoted to the playing task and not to counting repetitions. Participants performed the scale with right hand only first, followed by scale with left hand only, followed by four octave C major arpeggios with the right hand only and then with the left hand only. Participants were given an auditory metronome stimulus at 120 beats per minute for the scale and were asked to play in eighth notes, and 84 beats per minute for the arpeggio and were asked to play in

sixteenth notes. As soon as the participant began to play, the metronome was stopped.

Participants were given one trial run of the scale and arpeggio before recording⁵.

Intervention. Participants received a six hour WEM-style Body Mapping workshop that had been tailored for pianists. The workshop was designed to be similar to other Body Mapping workshops taught by licensed Andover Educators, including group instruction and a masterclass in which each participant worked individually with the instructor. To control for the amount of individual attention given to each participant by the instructor, a maximum of six participants were allowed in each workshop, and 15-20 minutes of the masterclass time was allotted for each participant.

Measurements. To examine pitch, tone, tempo, and articulation of pre-test and post-test scale and arpeggio recordings, MIDI data were collected during testing and then analyzed using a program designed for this study. At the Piano Pedagogy Research Laboratory, a Yamaha Disklavier from the Mark III series was used to record the MIDI data, while in other centres a comparable electric MIDI-equipped instrument was used. The collected MIDI files were converted to .csv format and were processed using a program designed specifically for this project. The program first separated the repetitions of scale or arpeggio, and detected whether any pitch errors were present. Repetitions with pitch errors were discarded, and error-free repetitions were analyzed for key velocity and timing data, which provide measurements of tone, tempo, and articulation. The resultant data were exported for comparison between pre-test and post-test. Timing data in .csv files are given in clockpulses. However, the results of the timing analysis were later converted to milliseconds for presentation. While the program described above was capable of identifying the presence of errors in each repetition, it was not able to

⁵ Participants were also asked to prepare the first 28 bars of Mozart Sonata in C major, K545, 1st movement (Appendix E), however, the MIDI data from this playing task were not analyzed in this thesis.

classify them into the categories of addition, deletion, and substitution. Analysis of pitch was conducted by the primary researcher and two research assistants who manually counted pitch errors using music scores generated from the MIDI files with audio. Errors were coded as addition, deletion, or substitution. Where differences between analysts were found, the researcher and research assistants consulted to conclude the correct number of additions, deletions and substitutions. In all cases of initial disagreement, the correct numbers were easily agreed upon. Audio and video data were also collected during pre-test and post-test sessions.

Results

Data collected in this study were analyzed using Statistical Package for the Social Science (SPSS). Each of the data sets were assessed for normality of distribution by use of kurtosis and skewness descriptive statistics, Shapiro-Wilk tests and visual examination of QQ graphs, histograms and box plots. Following a standard deviation based method of trimming data described by Field (2014), any participant's datum which yielded a z-score of more than 2.58 standard deviations from the mean was identified as an outlier and eliminated. In data sets where outliers were eliminated, these eliminated values constituted 1%-3% of the data set. Eliminated outlier values were excluded pairwise, so that if a participant's datum was considered an outlier in the pre-test, the same datum was ignored in the post-test. Where the data were normally distributed, parametric tests were used, and where normality could not be achieved, no outliers were removed and nonparametric tests were used.

Pitch. Once pitch errors were counted and coded, the total number of pitch errors was divided by the number of repetitions recorded, yielding an error rate for each scale and arpeggio. Error rates varied widely among participants, and as such, normal distribution of data could not be obtained by removing outliers. For this reason, no outliers were removed and Wilcoxon

signed ranks test, a nonparametric test, was conducted to determine whether the differences between pre-test and post-test error rates were statistically significant. Wilcoxon signed ranks test uses median rather than mean as the measure of average. Median error rate was 0 pitch errors per repetition in both the pre-test and the post-test in right hand ($Z = -2.03, p = 0.04$) and left hand scales ($Z = -.77, p = 0.44$). Right hand arpeggio pitch error rate decreased from a median 0.50 pitch errors per repetition in pre-test to 0.44 pitch errors per repetition in the post-test ($Z = -.11, p = 0.91$). Left hand arpeggio recordings had a median of 0.38 pitch errors per repetition in both pre-test and post-test ($Z = -1.32, p = 0.19$). Pitch accuracy was also examined in terms of the rate of additions, deletions, and substitutions. The rate of additions per repetition increased slightly from 0.71 in the pre-test to 0.76 in the post-test ($Z = -.86, p = .39$), while the median deletions per repetition remained 0 in pre-test and post-test ($Z = -.20, p = .84$). Substitutions decreased slightly from 0.13 substitutions per repetition in pre-test to 0.11 substitutions per repetition in the post-test ($Z = -1.60, p = .11$). While there were some small changes in pitch accuracy between pre-test and post-test, none of these differences reached statistical significance, and therefore cannot be attributed to the Body Mapping workshop.

Tone. *Strength of tone.* Strength of tone is here quantified by mean key velocity of the MIDI data, with an increase in mean key velocity indicating an improvement to performance. Key velocity values are presented in the arbitrary units (a.u.) assigned by MIDI data which range from 0-127 and are closely related to peak sound level measured in decibels (Repp, 1997; Goebel & Bresin, 2003). Unlike pitch data, velocity data were normally distributed. Less than one percent of values were considered outliers and removed, and parametric tests were used. Mean velocity in right hand and left hand scales and arpeggios are presented in Table 2 with results of the paired samples *t*-test which was conducted on the results. While mean velocity increased in

the right hand scale, it decreased in the left hand scale and both arpeggios. These changes, however, were all generally less than one unit of key velocity. Based on preliminary results from a study currently being conducted at the University of Ottawa Piano Pedagogy Research Laboratory, a difference in key velocity of less than 2%, which in this case would be just over one unit of key velocity, is not a change that would be perceptible to listeners. Collected data were also coded by finger number, given conventions of scale and arpeggio fingering laid out by the Royal Conservatory of Music. The findings pertaining to individual fingers are not presented in detail here because the changes were consistently lower than one unit of key velocity and no strong trend of increases or decreases could be found for any of the finger numbers or any of the playing tasks.

Table 2
Mean velocity

	<u>Pre-test (a.u.)</u>	<u>Post-test (a.u.)</u>	<u>Difference</u>	<u><i>t</i></u>	<u><i>df</i></u>	<u>Sig (2-tailed)</u>
RH scale	57.17	57.85	0.67	-1.49	37	0.15
LH scale	55.29	54.82	-0.47	0.96	37	0.34
RH arpeggio	61.12	60.94	-0.19	0.48	37	0.63
LH arpeggio	58.45	58.17	-0.29	0.74	37	0.46

Evenness of tone by note strength. Standard deviation of key velocity is a measure of evenness of tone by note strength, or sound intensity. With a decrease in standard deviation indicating greater evenness which is considered an improvement to performance. Pre-test and post-test standard deviation of velocity were calculated and compared. Group means are presented in Table 3, showing no clear trend in key velocity between pre-test and post-test of any scale or arpeggio. Standard deviation of velocity increased slightly in each of the scales and arpeggios, but none of these changes were greater than one unit of MIDI velocity. Paired

samples t -tests were conducted on these data and the resultant t and p values and df are also reported in Table 3, showing that none of the differences between pre-test and post-test data were statistically significant.

Table 3
Standard deviation of velocity

	Pre-test (a.u.)	Post-test (a.u.)	Difference	t	df	Sig (2-tailed)
RH scale	5.58	5.62	0.03	-0.27	37	0.79
LH scale	5.13	5.23	0.10	-0.82	37	0.42
RH arpeggio	7.14	7.25	0.11	-0.41	37	0.68
LH arpeggio	7.15	7.16	0.02	-0.09	37	0.93

Evenness of tone by note length. Interonset interval (IOI), defined as the time between the beginning of one note and the beginning of the following note, was calculated for each successive note of the scales and arpeggios. Standard deviation of IOI provides a measure of evenness of tone by note length, with a decrease in standard deviation indicating greater evenness of tone by timing, and therefore an improvement to performance. Like velocity data, timing data were normally distributed and less than one percent of values were flagged as outliers and therefore removed. Parametric statistical tests were used. Standard deviation of IOI values of right hand scale, left hand scale, right hand arpeggio and left hand arpeggio are presented in Table 4. Differences between standard deviation of IOI in pre-test and post-test were consistently less than one millisecond (ms). Research has shown that musicians are capable of hearing changes in IOI of 20 ms and greater (Repp, 1999a). It is therefore unlikely that reductions in the standard deviation of IOI that were less than 1 ms could be audible to observers. Paired samples t -tests revealed no statistically significant differences between pre-test and post-test standard deviation of IOI.

Table 4
Standard deviation of IOI

	Pre-test (ms)	Post-test (ms)	Difference	<i>t</i>	<i>df</i>	Sig (2-tailed)
RH scale	12.98	12.99	0.01	-0.01	37	0.99
LH scale	14.24	14.10	-0.15	0.31	37	0.75
RH arpeggio	12.69	13.17	0.47	-1.06	37	0.29
LH arpeggio	14.92	14.60	-0.32	0.61	36	0.55

Tempo. In each pre-test and post-test recording of scales, tempo drift was quantified by subtracting the mean IOI of the sixth repetition from the mean IOI of the first repetition. A decrease in amount of tempo drift would be considered an improvement to performance. Tempo drift could not be calculated in recordings of arpeggios due to the high prevalence of errors in the first and sixth repetitions. For right hand scales, the mean tempo of pre-test recordings slowed by 10.38 ms from first to sixth repetition and in the post-test the mean tempo slowed by 10.59 ms. This yielded a difference of 0.20 ms ($t(37) = 0.249, p = 0.99$). For left hand scales, the tempo of the pre-test recording slowed by 9.71 ms from the first to sixth repetition, and in the post-test the tempo slowed by 9.48 ms. This yielded a difference of mean IOI of 0.22 ms ($t(37) = -0.184, p = 0.86$). Neither of these differences between pre-test and post-test were found to be statistically significant. Therefore, the small changes noted cannot be attributed to the Body Mapping workshop. Regardless of statistical significance, changes of this magnitude are unlikely to be audible to listeners. Considering that the metronome stimulus was given at a tempo of 120 beats per minute with the scale played in eighth notes, the expected IOI would be 250 ms. In this context, we can see that a mean tempo drift of 10 ms of IOI would be considered quite small, and that a reduction in this tempo drift of less than 1 ms is negligible.

Articulation. Amount of overlap. Key overlap time (KOT), defined as the time between the beginning of one note and the end of the previous note, is a measure of articulation. Where there is a detachment between notes, KOT is negative, and where there is an overlap between notes, KOT is positive. Since participants were asked to play the scales and arpeggios legato, we would consider an increase in KOT to be an improvement in performance. Mean KOT of all playing tasks is presented in Table 5. KOT increased in each of the playing tasks. A paired samples *t*-test indicated that only the increase in KOT of the right hand scale was statistically significant and therefore attributable to the Body Mapping workshop. Cohen’s *d*, a measure of effect size, was calculated to be 0.30, which indicates a small effect of the Body Mapping workshop on mean KOT.

Table 5
Mean KOT

	Pre-test (ms)	Post-test (ms)	Difference	<i>t</i>	<i>df</i>	Sig (2-tailed)
RH scale	9.01	13.39	4.38	-2.47	36	0.018
LH scale	3.93	4.96	1.03	-1.27	37	0.21
RH arpeggio	-20.33	-18.35	1.98	-1.59	37	0.12
LH arpeggio	-16.55	-16.23	0.32	0.65	34	0.52

Evenness of articulation. Standard deviation of KOT is a measure of evenness of articulation, with a decrease in standard deviation indicating greater evenness of articulation which would be considered an improvement to performance. Standard deviation of KOT of each scale and arpeggio are presented in Table 6, showing that standard deviation of KOT increased in each of the scales and arpeggios. This indicates that there was less evenness of articulation in the post-test. Only the difference between pre-test and post-test values of the right hand scale was

found to be statistically significant. Cohen's d for this measure was calculated to be 0.45, which indicates a small effect size. These changes were less than 4 ms, which is unlikely to be audible to listeners.

Table 6
Standard deviation KOT

	Pre-test (ms)	Post-test (ms)	Difference	t	df	Sig (2-tailed)
RH scale	24.43	27.95	3.52	-3.655	34	0.001
LH scale	24.24	25.34	1.09	-1.602	37	0.12
RH arpeggio	42.60	43.03	0.43	-0.301	37	0.76
LH arpeggio	37.86	38.31	0.44	0.688	36	0.50

Bench height and distance

No significant differences were found between pre-test and post-test bench height, as the mean bench height across all participants in the pre-test was 49.34cm and in the post-test was 49.24cm ($t(35) = 0.30, p = .77$). Mean bench distance from the piano increased slightly from 58.81cm to 60.14cm, but this was not found to be statistically significant ($t(34) = -2.0, p = 0.052$).

Discussion

The results of this study indicate that although there were some differences in pitch, tone, tempo and articulation of scale and arpeggio performance between MIDI recordings taken before and after the Body Mapping workshop, these differences were generally not found to be statistically significant, all of the changes were too small to be aurally perceptible to listeners and there was no clear trend of improvements. We hypothesized that pitch would become more accurate after the Body Mapping workshop, but we found little change in pitch accuracy, with median error rate changing no more than one tenth of one error per repetition of scale and arpeggio. We hypothesized that tone would become stronger and more even, quantified by

increased key velocity mean, decreased standard deviation of key velocity, and decreased standard deviation of IOI. Contrary to our hypothesis, we found that tone changed little from pre-test to post-test with mean key velocity changing less than one unit, standard deviation of key velocity changing less than one unit, and standard deviation of IOI changing less than one millisecond. Changes this small would likely not be aurally perceptible to listeners and none of these changes were found to be statistically significant. We hypothesized that tempo would be more even, and we quantified this by the difference in mean IOI between the first and sixth repetition of the scales. The amount of tempo drift changed less than one millisecond of IOI between pre-test and post-test.

There were some small changes in articulation which were found to be statistically significant, however, these changes were all below a level which would be audible to listeners and demonstrate no clear trend of improvements. Since we asked participants to play the scales and arpeggios legato, an increase in key overlap time would be considered more legato and therefore an improvement to performance. We hypothesized that articulation would become more legato, with greater mean key overlap time, and that the articulation would become more even, which would be demonstrated by reduced standard deviation of key overlap time. Articulation became slightly more legato, with mean KOT increasing as much as four milliseconds. This would be considered an improvement to performance, however, 4 ms is far below the perceptible level of 20 ms. This increased legato articulation was not always more even, however, with standard deviation of KOT increasing by 0.43-3.52 ms among each scale and arpeggio. Changes in articulation were found to be statistically significant in only the right hand scale of both mean and standard deviation of KOT. Since these changes were far less than the perceptible level of 20 ms, however, we can assume that these changes were not audible.

That the changes measured were below the perceptible level indicates that the Body Mapping workshop did not result in any improvements in pitch, tone, tempo, and articulation of the piano performance of scales and arpeggios.

While there is an abundance of anecdotal evidence and some research evidence that musicians perceive improvements to the pitch, tone, tempo, and articulation of music performance, the results of this study do not support that such improvements are evident in pianists following a WEM-style Body Mapping workshop. The two previous qualitative studies conducted on Body Mapping found that students reported improvements to their performance (Buchanan, 2014b; Knaub, 2002) and instructional and promotional literature give examples of cases wherein participants experienced improvements to their performance, including to specifically technical elements (Conable, 2000a), to pitch accuracy (Mark, 2003), to tone (Johnson, 2009), to tempo (Harscher, n.d.), and to articulation (Breault Mulvey, 2016). Despite these well documented perceptions, we did not find such improvements in pianists following a Body Mapping workshop. Videos of masterclasses show students, instructors, and audience members alike stating that they perceive a change to the musical sound (Blumer, 2014; Breault Mulvey, 2016, Johnson, 2013), but the small changes we measured were not at a level which would be aurally perceptible to listeners. This puts into question the perception of improvements at such workshops.

Wong (2015) had similar findings of little change in perceptible musical sound following a Body Mapping lesson. In Wong's study, a panel of judges listened to audio excerpts of piano performance which had been recorded immediately before and after a 50 minute online lesson in a somatic method. While only four of the ten participants received a Body Mapping lesson, the findings are supported by the present study. Wong found that judges were able to correctly

identify the post-test audio recording 56% of the time, which was not found to be statistically significant in its difference to chance. When asked to evaluate the recordings on a number of factors, such as consistency of tone and expressivity, the ratings improved a mean of only 4% from pre-test to post-test evaluations. Wong found a trend, that generally the post-test recordings were rated higher, with the exception of consistent tempo, but in none of these factors was the difference between pre-test and post-test evaluations statistically significant. Similarly, we found that MIDI data of piano performances recorded the day before and the day after a Body Mapping workshop were not significantly different, and even those changes that were statistically significant were not large enough to be aurally perceptible. This supports the findings of Wong that while there are some small changes, a single Body Mapping lesson or workshop cannot be said to elicit improvements to piano performance. While the body of research which has been conducted on the effects of Body Mapping is yet small, the findings of these two quantitative studies do not support the anecdotal evidence and participant reports of improvements to performance.

A comparison of the present findings with the anecdotal and qualitative research evidence invites a number of questions. According to the anecdotal evidence, observers perceive improvements to the sound of music performance during a Body Mapping lesson, workshop, or masterclass. The results of this study and the results of Wong (2015) suggest that this common perception may have its origin in aspects other than the pitch, tone, tempo, and articulation. It could be that changes are observed visually and this is perceived as being a change to musical sound. Researchers have found that visual information is dominant in perceptual reports (Posner, Nissen, & Klein, 1976) and that evaluations of musical quality are influenced by visual aspects, such as the body movements of the performer (Tsay, 2013; Siddell-Strebel, 2007). Since Body

Mapping is a method that trains movements of the body (Johnson, 2009), it is possible that in masterclass and workshop settings, audience members visually observe a change in the body movements of the performer and this perception of improvements to visually observed aspects dominates the observers' perception and causes them to perceive that the sound has changed as well. Wong (2015) found that judges were more frequently able to correctly identify the post-test recordings by video than by audio, supporting that perceptions of improvements to music performance immediately following a Body Mapping workshop may be more strongly related to visual aspects than to audible ones.

Conclusion

The results of this study provide important insight for musicians, music teachers, and Body Mapping instructors. We found that one day after a standard six hour WEM-style Body Mapping workshop, pianists demonstrated little measurable change in pitch, tone, tempo, and articulation of scale and arpeggio performance. Only two measures, amount of legato in the right hand scale, quantified by mean KOT, and evenness of articulation in the right hand scale, quantified by standard deviation of KOT, were found to have a statistically significant difference between pre-test and post-test measures. Neither of these changes were at a level which would be audible to listeners. The results of this study cannot support any claims that Body Mapping can immediately improve piano performance. While pianists and audience members may perceive that a Body Mapping workshop has improved the pitch, tone, tempo, or articulation of their playing, organizers and educators should refrain from claiming that WEM workshops have such outcomes.

The limitations of this study highlight directions for future research. The playing tasks studied here are limited to scales and arpeggios, and it may be possible that we would see some

improvements in repertoire performance. In this study, we looked at specifically pitch, tone, tempo, and articulation, and it is possible that there may be some other measurable improvements to music performance following a Body Mapping workshop, such as expressivity. Future research should consider using playing tasks that are repertoire based, and use methods to examine expressivity of the performances. In this way, we can examine whether Body Mapping has an impact on the expressivity of music performance, as is claimed in some Body Mapping pedagogical literature (Pearson, 2006) and participant reports (Buchanan, 2014b). This study and the study of Wong (2015) were limited to a short term intervention, with participants receiving Body Mapping instruction on only one day. It is possible that Body Mapping studied over a longer period of time may have a measurable impact on pitch, tone, tempo, and articulation of music performance, whereas one day of instruction does not. Finally, this study was limited to pianists. Many of the claims associated with Body Mapping relate to other instruments, and it is possible that while pianists do not experience improvements to their pitch, tone, tempo, and articulation immediately following a WEM workshop, that other instrumentalists and singers do. Further research is required to fully understand the impact that Body Mapping has on music performance.

Chapter 4: Discussion and Conclusion

The results of this study indicate that there are no measurable improvements in pitch, tone, tempo, or articulation of scale and arpeggio piano performance the day after a six hour WEM-style Body Mapping workshop, as measured with MIDI data. Given the extensive anecdotal literature which asserts that musicians experience improvements to performance following Body Mapping workshops, we hypothesized that we would see improvements in the post-test recordings. However, the results do not support the hypothesis. Although we did find some small changes, there was no strong trend of improvements in the MIDI data. Only the changes to right hand scale articulation were found to be statistically significant, but these changes were not consistently indicative of improvements to piano performance, nor were the magnitude of the changes large enough to be audible to listeners. The dissimilarity between the present results and anecdotal evidence suggests that the common audience perception of improvements to piano performance in Body Mapping workshops may be related to aspects of performance other than pitch, tone, tempo, and articulation. In order to further investigate the question of whether there may be some improvements that our study did not capture, we conducted four exploratory analyses using the audio and video data that were collected during pre-test and post-test sessions.

4.1 Exploratory analyses

4.1.1 Exploratory analysis 1: Identification task by audio, arpeggio. An identification task, wherein judges are asked to identify which of two audio recordings they believe to have been taken after an intervention, has been used by Wong (2015) to determine whether changes in music performance following a somatic session were aurally perceptible to listeners. In the present exploratory analysis, eight judges were recruited from Andover Educators using the organization's internal communication system. Judges signed consent forms approved by the

University of Ottawa Office of Research Ethics and Integrity (see Appendix D). All of the judges were professional musicians and music educators (piano [$n = 6$], flute [$n = 1$], oboe [$n = 1$]), fully licensed in Body Mapping and in good standing with the organization. The judges were provided with a link to a webpage which presented pairs of pre-test and post-test audio clips of each participant playing the left hand arpeggio, and were asked to indicate which they thought was taken after the Body Mapping workshop⁶. Since Geringer and Johnson (2007) found no measurable effect of audio clip duration on panel evaluation scores of music performances. For this reason, we used clips which were 10 seconds in length, encompassing two full repetitions of the arpeggio. The order of pairs of recordings and the order of correct responses were randomized. Once answers were submitted, the responses were analyzed using SPSS.

Judges correctly identified the post-test audio arpeggio recordings 51% of the time ($N = 360$). A binomial test was conducted on the response data and revealed that the difference between the judges' average accuracy rate and chance level (50%) was not statistically significant ($p = .87$). The findings of this exploratory analysis indicate that a panel of judges, blind to condition, was not able to detect which of two arpeggio recordings was taken after the Body Mapping workshop, which supports the findings of our MIDI analysis. Through the analysis of the MIDI data, we found that there were no measurable improvements to piano performance of arpeggios, and likewise judges were unable to aurally perceive a change. This also supports the findings of Wong (2015) who likewise found that judges were unable to identify the post-test recording at a rate statistically significant in its difference to chance level. This supports the findings of our study that the Body Mapping workshop did not elicit immediate

⁶ For this analysis and exploratory analyses 2 and 3, judges were also asked which of the recordings they believed was better. Judges gave the same response to both questions in 93% of cases ($N = 1440$). For this reason, results here are presented for answers to the question, "Which was taken after?"

measurable improvements to the pitch, tone, tempo, or articulation of piano performance of arpeggios at a level which was audible to listeners.

4.1.2 Exploratory analysis 2: Identification task by audio, Mozart. Given the findings of no measurable improvements to arpeggio performance, which was supported by both MIDI and exploratory panel analysis, we explored whether there were some perceptible improvements to piano performance which could be perceived in repertoire performance but not in the arpeggio. We had recorded bars 1-28 of Mozart Sonata in C major, K545, 1st movement during data collection, and audio from these recordings was used to conduct the exploratory analysis. The same eight judges who completed the identification task in exploratory analysis 1 were given access to a webpage which presented pairs of pre-test and post-test audio recordings of each participant playing the Mozart excerpt and were asked to indicate which one they believed was taken after the Body Mapping workshop. We used audio clips which were 15 seconds in length, encompassing the initial thematic material of the sonata. The order of pairs of recordings and the order of correct responses were randomized.

Judges correctly identified the post-test recording 59% of the time. A binomial test revealed that the difference between the judges' accuracy rate and chance level (50%) was statistically significant ($N = 360, p = .001$). These findings indicate that a panel of judges, blind to condition, were able to detect which of two Mozart recordings was taken after the Body Mapping workshop at a rate better than chance. While 59% does not immediately appear to be much higher than chance level, that this score was achieved across 360 identification tasks contributes to statistical significance of this score, providing an interesting direction for future research. The difference between the findings of exploratory analyses 1 and 2 suggests that there were some aurally perceptible changes in performance of Mozart but not in the performance of

arpeggios. This suggests that a Body Mapping workshop may have an impact on an aspect of piano performance which can be found in repertoire, but not in scales and arpeggios. Future research should consider investigating whether this is the case, and if so, what aspects these are. Without knowing the judges' evaluation criteria, it is impossible to say exactly what changes in the piano performance were perceived in the present exploratory analysis.

4.1.3 Exploratory analysis 3: Identification task by silent video. Knowing that evaluators of music performance typically use both visual and auditory information, and having found that judges were not able to identify the post-test arpeggio recording by auditory information, we wondered whether the anecdotal evidence of immediate improvements to piano performance following a Body Mapping workshop were related to visual information. The eight judges who completed exploratory analyses 1 and 2 were given access to a webpage which presented the same recordings of arpeggio and Mozart that they had previously heard in audio format, except in this analysis, they were presented with silent video clips. The order of pairs of recordings and the order of correct responses were randomized. The results were collected and analyzed in the same manner as exploratory analyses 1 and 2.

The judges were able to correctly identify the post-test video 64% of the time for both the arpeggio clips ($N = 360$) and the Mozart excerpt clips ($N = 360$). A binomial test revealed that the difference between these scores and chance level (50%) was statistically significant in both arpeggio ($p < .001$) and Mozart ($p < .001$) silent video clips. These results indicate that a panel of judges was able to correctly identify the post-test recording from 10-15 seconds of silent video in both arpeggios and Mozart at a rate greater than chance level. This suggests that there were some visually observable changes to piano performance following the Body Mapping workshop. This supports the theory that anecdotal evidence of immediate improvements to piano performance

following a Body Mapping workshop may be more strongly related to visual information than to sound.

4.1.4 Exploratory analysis 4: Panel factor analysis task, silent video. To further investigate visually observable changes, we conducted an analysis similar to Wong (2015) and Valentine and colleagues (1995), which used a Likert-style scale to evaluate a series of factors describing quality of movement and posture, termed “body use” or “body usage”, through video footage. Five judges who had not participated in the exploratory analyses 1, 2, and 3 were recruited from Andover Educators, all of whom were professional musicians (piano [$n = 1$], flute [$n = 1$], violin [$n = 3$]), fully licensed in Body Mapping and in good standing with the organization. Judges were given access to a webpage which presented 38 folders, one for each pianist participant. Each folder contained ten silent video clips, five of which were from the pre-test, marked “X” or “Y”, and five were from the post-test, marked with the remaining letter. Judges were asked to evaluate “X” and “Y” videos using an evaluation form (see Appendix D) which was modelled after forms used by Valentine (1995) and Wong (2015). The form uses a 7-point Likert-style scale for the evaluation of body usage in factors of: head/neck, upper back/chest, lower back, shoulder region, arms, hands/wrists, legs/feet, and general impressions. The 7-point scale on the form used the number 1 to indicate “very good usage and coordination” and 7 to indicate “severe misuseage”. Judges, blind to condition, used one form to analyze the “X” videos and another for the “Y” videos. Judges were also asked to identify which of the videos, “X” or “Y”, they believed to have been taken after the Body Mapping workshop. Assignment of the letters “X” and “Y” to pre-test and post-test videos was randomized. Evaluation forms were filled out electronically, or were printed and filled out manually, and then submitted to the primary researcher. As previous researchers have done (Valentine et al., 1995;

Wong, 2015) pre-test and post-test scores assigned by judges were converted during analysis from numbers on the Likert-style scale to percentage scores with 100% indicating very good

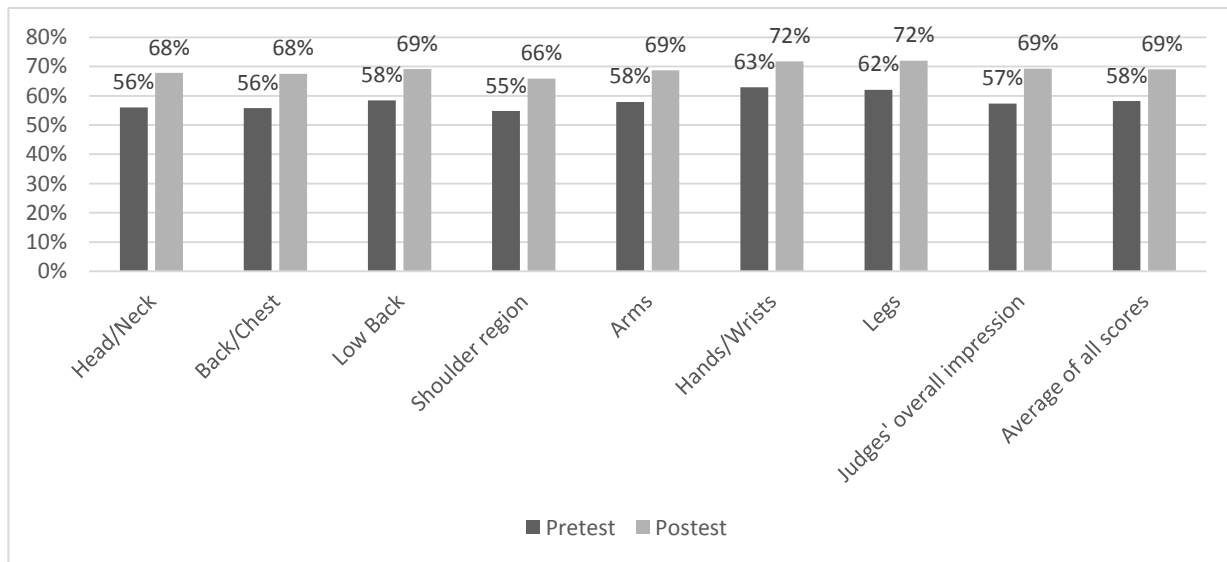


Figure 3.1: Pre-test and post-test scores assigned by panel of judges on 8 factors of body usage

body usage and coordination, or “1” on the Likert-style scale. Data were analyzed using SPSS.

The mean scores of pre-test and post-test videos are reported in Figure 3.1, demonstrating a clear trend of improvement in body usage score from pre-test to post-test. To determine whether these differences are statistically significant, a paired samples *t*-test was conducted. Table 3.1 presents these results with the difference of means between pre-test and post-test. All of the differences were found to be statistically significant ($p < .01$). Cohen’s *d* was then calculated as a measure of effect size. Cohen (1992) writes that a coefficient *d* greater than 0.8 is considered a large effect, and therefore the data in Table 3.1 indicate a large effect.

Table 3.1
Paired t-test results for exploratory analysis 4

Body segment factor	Difference of means	t	df	Sig. (2-tailed)	Cohen's d
Head/Neck	-12%	-5.48	36	0.00	1.14
Back/Chest	-12%	-6.16	34	0.00	1.30
Low Back	-11%	-5.30	37	0.00	1.20
Shoulder region	-11%	-5.75	37	0.00	1.30
Arms	-11%	-5.61	37	0.00	1.25
Hands/Wrists	-9%	-5.08	37	0.00	1.22
Legs	-10%	-4.76	37	0.00	1.19
General impression	-12%	-5.97	37	0.00	1.26

For further examination of the individual judges' scores, see Table 3.2. Each judge gave, on average, better body usage scores to the post-test recordings in every body segment factor. On average, the judges were able to correctly identify the post-test recording 75% of the time. Accuracy rates of individual judges were 87%, 74%, 68%, 71% and 76% respectively. Evaluator 1, whose accuracy rate was the highest, was also the only judge on this panel whose primary instrument was piano. A binomial test determined that the difference between the accuracy rate of the judges and chance level (50%) was statistically significant ($N = 190, p < .001$). The results indicate that the judges were able to correctly identify the post-test recording at a rate better than chance, and that they perceived improvements in the body usage and coordination of participants.

Table 3.2
Scores of individual judges in exploratory analysis 4

Body segment factor	<u>Judge 1</u>		<u>Judge 2</u>		<u>Judge 3</u>		<u>Judge 4</u>		<u>Judge 5</u>	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
Head/Neck	44%	59%	51%	58%	42%	52%	38%	47%	28%	48%
Back/Chest	41%	54%	51%	58%	43%	56%	38%	46%	29%	45%
Low back	42%	55%	56%	63%	45%	57%	39%	47%	39%	53%
Shoulder region	43%	57%	45%	50%	48%	59%	37%	47%	30%	46%
Arms	45%	59%	47%	53%	52%	64%	39%	48%	35%	50%
Hands/Wrists	45%	58%	66%	69%	58%	64%	42%	52%	32%	45%
Legs	45%	57%	56%	62%	56%	65%	43%	52%	39%	53%
Evaluators' perception of overall body usage	44%	60%	52%	59%	51%	59%	38%	46%	31%	50%
Overall change	44%	57%	53%	59%	49%	59%	39%	48%	33%	49%

4.2 Discussion of results of MIDI and exploratory analyses

Our study did not find evidence that the pitch, tone, tempo and articulation of piano performance of scales and arpeggios improved following a standard six hour Body Mapping workshop, and the results of the exploratory analyses 1 support this. With little change in the MIDI data, we concluded that the Body Mapping workshop did not have any effects on the pitch, tone, tempo, and articulation of scales and arpeggios which would be audible to listeners. Exploratory analysis 1 supports this conclusion, as a panel of judges was not able to correctly identify the post-test audio recording of arpeggios at a rate significantly different than chance level. Not only did our quantitative analysis of MIDI data show that the pianists had little change to their scale and arpeggio performance, but this was confirmed by the judges who could not distinguish the pre-test and post-test recordings. This strengthens the findings of our study that pianists do not experience improvements to the pitch, tone, tempo, and articulation of scale and arpeggio performance following a Body Mapping workshop.

Interestingly, in our exploratory analyses, we found that judges were more readily able to identify the post-test audio recording of a Mozart excerpt than they were to identify those recordings of arpeggio. This could be interpreted in a number of ways. Certain musical aspects, like expression, are communicated more prominently in Mozart than in arpeggio performance. The nonscientific literature includes many claims that Body Mapping can improve expressivity (Breault Mulvey, n.d; Pearson, 2006; Conable, 2000; Krayler-Luke & Breault Mulvey, 2014; Harscher, n.d.; Mark, 2003) and qualitative research has found that participants perceive that their expressive abilities have improved (Buchanan, 2014b). It could be that the Body Mapping workshop resulted in improved expressivity, but not pitch, tone, tempo, or articulation. However, since the judges were not specifically asked to evaluate expressivity, we cannot assume from exploratory analysis 2 that pianists improved in this measure. It is also possible that pianist participants in this study did not adequately prepare the Mozart excerpt prior to the beginning of the study. Despite being asked not to practice outside of the workshop between pre-test and post-test, the practice accumulated during the pre-test may have contributed to the improvements observed in the post-test. Participants were also asked to play the Mozart excerpt during the masterclass, which would have contributed to the effect of accumulated practice. It is also plausible that because the participants were coached on applying Body Mapping principles in the specific context of the Mozart excerpt, that improvements to performance were found in this excerpt, but not in the scales and arpeggios. There is not sufficient evidence in the data collected and analyzed in this study to support claims that Body Mapping has an immediate impact on piano performance; however, this provides interest for future research.

Despite our finding of little change to the pitch, tone, tempo, and articulation of piano performance, several participants in this study orally reported a perception that the workshop was

beneficial for their playing. One participant in particular contacted the primary researcher specifically to report that certain passages in their concert repertoire which had previously had pitch errors were now more accurate. Another participant reported that during a performance in the week following the workshop, they were able to gain better control of their right hand which had previously felt unstable. Both participants attributed these improvements to the tactics learned in the Body Mapping workshop. These reports show that participants in the present study perceived improvements congruent with anecdotal evidence, which supports that even when no immediate changes are measurable, participants can still perceive that their playing has changed. The feedback from these participants also suggests that Body Mapping principles may be valuable as a tool for working through specific technical issues, since both participants had a particular issue they were struggling with in their repertoire which they perceived to have improved after they applied Body Mapping principles.

The findings of exploratory analyses 1, 2, and 3 may be compared to the same evaluation method used by Wong (2015). In Wong's study, 10 participants received a 50 minute lesson in either Body Mapping, Alexander Technique, or Feldenkrais. A panel of judges conducted the same identification task as was used here in exploratory analyses 1, 2, and 3. Given pairs of audio or silent video recordings of scales and two repertoire excerpts, judges were asked to identify which of each pair was taken after the somatic session. Wong's study found that judges were able to correctly identify the post-test audio recordings 56% of the time. This is very similar to our findings in the present study of 51% accuracy with arpeggio recordings and 59% accuracy with Mozart recordings. When presented with silent video clips, the judges in Wong's study were able to correctly identify the post-test recording 67% of the time, and in the present exploratory analysis 3, judges were able to correctly identify the post-test recording 64% of the

time, where they were given 10-15 seconds of video, and 75% of the time in exploratory analysis 4, where they were given up to five minutes of video. The findings of the present study confirm the findings of Wong that judges are better able to identify the post-test recording by silent video than by audio.

Exploratory analysis 4 showed a similar trend to the analysis of Wong (2015) but with greater differences between pre-test and post-test. In Wong's study, judges rated post-test silent video recordings 1%-5% higher on body usage and coordination in the eight body segment factors, with only the difference in head/neck relationship yielding statistical significance. The findings of the present study show the same trend as Wong's, with improvement in every body segment factor, but in the present study those changes were larger, 9%-12%, and each of the changes in each of the body segment factors was found to be statistically significant. This difference between the results of the two studies could be attributable to the difference in length of somatic intervention. Participants in Wong's study received a 50 minute lesson, whereas participants in the present study received a six hour workshop. It also could be that the elapsed time between intervention and post-test contributed to this. Wong's participants were tested immediately following the lesson, whereas participants in the present study were tested the next day. The homogeneity of intervention and judges may also play a role. In Wong's study, participants received a lesson in one of three somatic methods, whereas in the present study, all participants received the same type of workshop in Body Mapping. The judges in Wong's study were sampled from various somatic methods, but the judges in the present study were all licensed in Body Mapping.

The results of exploratory analyses 3 and 4 suggest that judges perceive improvements to piano performance in silent video. Exploratory analysis 3 found that judges were able to

accurately identify the post-test recording at a rate significantly different than chance level. Since the judges tended to answer the questions “Which video was taken after the Body Mapping workshop?” and “Which is better?” similarly, we can assume that the changes they visually observed were also perceived as improvements. In exploratory analysis 4, judges on average rated post-test videos 9%-12% closer to “very good usage and coordination” than pre-test videos in every body segment factor of the evaluation form, likewise signifying that they visually observed improvements. The judges’ visual observation of improvements, compared with the relative lack of evidence of aurally perceptible improvements, raises an interesting hypothesis. Reports of improvements to piano performance immediately following a Body Mapping workshop might be more closely related to visual observation than aural perception.

Researchers have found that when presented with audio and video information, observers depend highly on the visual aspects. Posner and colleagues (1976) proposed through their research that in processing incoming information and in memory recall, visual input tends to dominate other perceptual mechanisms. In the context of a Body Mapping masterclass, this would mean that visual information could dominate auditory information in the processing of perceived improvements to performance. Tsay (2013) examined musical contexts and found that, in spite of their reports that sound is the most important factor in determining the winner of a music competition, judges were more reliably able to select the winner of a competition by silent video than by audio recordings. This may mean that when an audience visually observes an improvement, even if the audible aspects have not changed, they may perceive an improvement in the musical sound. Audiences of Body Mapping workshops and masterclasses are able to both see and hear the performance, whereas judges in our study evaluated visual and audio information from performances separately. The judges’ perception of improvements in the silent

video, compared to the relative lack of perceived improvements measured in audio data, suggests that some of the perceptions of immediate improvement to musical quality may have their origin in visual observation. In other words, it is possible that audiences in Body Mapping workshops visually observe improvements in body movement and coordination and as a result of this observation, they perceive audible improvements as well, even if the sound has changed very little in the context of the workshop.

4.3 Conclusion

In this study, we investigated the effect of a six hour Body Mapping workshop on the performance of pianists, measured the day before and the day after the workshop. As table 4.1 summarizes, no clear trend of improvements to scale and arpeggio performance were found in collected MIDI data in the aspects of pitch, tone, tempo, or articulation. While there were some statistically significant differences between pre-test and post-test articulation data in the right hand scale, these changes were not consistently indicative of improvements and none of these changes were at a level which would be audible to listeners. Four exploratory analyses expanded upon the investigation, finding that judges, were not able to correctly identify the post-test arpeggio audio recordings at a rate significantly greater than chance, supporting the findings of the study that the pianists did not experience improvements to their performance of arpeggios following the Body Mapping workshop. The judges were more readily able to identify the post-test recordings of Mozart, which provides an interesting direction for future research. Our exploratory analyses also found that judges were able to identify post-test silent video recordings at a rate significantly greater than chance level, and when asked to evaluate the quality of body usage and coordination of various body segments, they visually observed improvements in the post-test videos on all of the body segment factors. The strength of the trend of visually observed

Table 4.1
Summary of MIDI analysis results and audibility

Category	Quantification of improvement to piano performance	Amount of change from pre-test to post-test	Would this be audible?
Pitch accuracy	Decrease in median pitch error	RH scale: no change LH scale: no change RH arpeggio: -0.06 pitch errors LH arpeggio: no change	No
Strength of tone	Increase in mean key velocity	RH scale: +0.67 a.u. LH scale: -0.47 a.u. RH arpeggio: -0.19 a.u. LH arpeggio: -0.29 a.u.	No ¹
Evenness of tone	Decrease in standard deviation of key velocity	RH scale: +0.03 a.u. LH scale: +0.10 a.u. RH arpeggio: +0.11 a.u. LH arpeggio: +0.02 a.u.	No
	Decrease in standard deviation of IOI	RH scale: +0.01 ms LH scale: -0.15ms RH arpeggio: +0.47ms LH arpeggio: -0.32ms	No ²
Evenness of tempo	Decrease in tempo drift, quantified by difference in mean IOI of first and last repetition of scale or arpeggio	RH scale: +0.20ms LH scale: -0.22ms RH arpeggio: N/A LH arpeggio: N/A	No
Amount of legato	Increase in mean KOT	RH scale: +4.38ms* LH scale: +1.03ms RH arpeggio: +1.98ms LH arpeggio: +0.32ms	No
Evenness of legato	Decrease in standard deviation of KOT	RH scale: +3.52ms* LH scale: +1.09ms RH arpeggio: +0.43ms LH arpeggio: +0.44ms	No

Notes:

*indicates statistical significance

¹ While intensity discrimination is not well studied, a project currently being conducted at the Piano Pedagogy Research Laboratory at University of Ottawa is finding that changes smaller than 2 a.u. are inaudible to the majority of human listeners.

² Researchers have found that musician listeners can hear changes in IOI as small as 20ms. For this reason, the changes documented in this chart are unlikely to be audible.

improvements compared with the lack of aurally perceptible improvements and clear trends in the MIDI data suggest that the common perception that Body Mapping workshops can elicit improvements to piano performance may be more strongly related to visual information rather than auditory information.

The findings of this study put into question some of the claims made about Body Mapping. Videos of WEM workshops show teachers, participants, and audience members expressing a perception that the sound has changed (Blumer, 2014; Johnson, 2013; Breault Mulvey, 2015), but we did not find sufficient evidence to support that there are aurally perceptible improvements to piano performance, challenging this commonly held perspective. Given the findings of this study, organizers of WEM workshops should refrain from claiming that these workshops can elicit improvements to the playing abilities of pianists. Body Mapping literature often relates sound quality to movement quality. Mark (2003) writes, “As quality of movement improves, the playing becomes freer, more expressive, more secure...” (p.5) While it is possible that in the long term, quality of movement and quality of sound are associated, in this study such a connection was not evident one day after a Body Mapping workshop. We found negligible change to sound quality, but judges visually observed improvements in quality of body usage and coordination. This suggests that, at least in the short term, it is possible for body usage and coordination to change in pianists without a detectable change in the musical quality. While this may challenge those Andover Educators who teach that movement quality and sound quality are closely related, it could also be understood as beneficial for those musicians and music educators who wish to study Body Mapping but do not want the somatic work to interfere with their music performance.

There were some limitations to this study, however. Our study used a six hour Body Mapping workshop as the intervention. Although this is a standard way that Body Mapping is taught, it may be that some changes to piano performance occur after pianists have had time to practice their instrument while applying the principles of Body Mapping. This study was limited to pianists, and it is possible that there would be some changes to music performance in other instrumental or vocal populations. While the exploratory analyses provide interesting insight, these findings are more limited. Although exploratory analysis 2 found that judges were able to identify the post-test audio recording of Mozart at a rate greater than chance level, this analysis was limited to judges' perceptions of 15 second clips without any breakdown of evaluation criteria. That the judges were able to correctly identify the post-test audio recording by Mozart, but not of arpeggio, invites us to consider what aspect of the repertoire performance had changed. Without knowing the evaluation criteria, we cannot make any conclusions about the effect of Body Mapping on repertoire performance, but future research could investigate this question. Since this study lacked a control group, it is likewise impossible to know whether the changes in the Mozart excerpt perceived by the judges were due to the Body Mapping workshop or to practice accumulated during the pre-test.

There are many avenues for further research in this area. In this thesis, we have raised the hypothesis that perceptions of immediate improvements to piano performance could be more strongly related to physical movements than to changes in musical sound. Given this hypothesis, it will be important for future research to address the effect that Body Mapping may have on visually observable aspects of piano performance. This research could be done using a panel analysis that asks judges to describe more specifically what they observe to have changed, such as body movement, coordination, or postural patterns, or using motion capture technology to

measure which movement parameters are changing. Research could also be conducted to determine whether changes to piano performance occur following a longer period of Body Mapping lessons or workshops, or a comparison between short term and long term outcomes of pianists. Anecdotal evidence, pedagogical literature and qualitative study participant reports include assertions that Body Mapping has an impact on aspects of music performance which do not relate to the piano, such as breath control. Since all of the quantitative research conducted on the effects of Body Mapping thus far has examined pianists exclusively, future research should consider investigating aspects of music performance which are specific to other instruments and voice. Given the findings of our exploratory analyses, future research which focuses on the analysis of repertoire would provide greater insight into the effect of Body Mapping on piano performance. Researchers could use MIDI data analysis similar to what was used in this study to analyze whether changes to repertoire performance occurs following a Body Mapping workshop whereas performance of scales and arpeggios does not. The present study provides an important contribution to this field of research; however, considering this is only the fourth study conducted on the effects of Body Mapping on music performance, much more research is needed to understand the effect of this musician-centred somatic method.

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Appendix A

List of piano pedagogy and performance literature

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Appendix B

Pianists – Letter of information and consent form

Letter of Information
(for pianist participants)

Dear piano teacher/piano student:

We are conducting a ground-breaking research study to investigate the impact of participation in a Body Mapping workshop on the performance of pianists. Body Mapping has become popular among pianists as a way to prevent and rehabilitate from injury. Many pianists also claim that their ability to perform is enhanced when they engage in Body Mapping sessions. Unfortunately, little research has been conducted in this area. Musicians and music teachers have no quantitative empirical research to help them decide whether or not to use Body Mapping as a method of performance enhancement for themselves or their students. This study aims to help musicians and music educators by analyzing aspects of piano performance before and after a session in Body Mapping.

We are currently recruiting participants to take part in the study and receive a one day workshop in Body Mapping (a \$150 value), free of charge. Below is a description of the study and the tasks involved. Should you wish to volunteer to take part in the study, or if you would like more information, please do not hesitate to contact Teri Slade.

Title of the study: The Measurable Effects of Body Mapping on Piano Performance

Objective: The purpose of this study is to test the claims of performance enhancement in pianists following Body Mapping study. Our study will investigate any changes in pianists' use of pitch, velocity, timing and tone before and after an instrument-specific version of the most common Body Mapping workshop format, called, "What Every Pianist Needs to Know About the Body" taught by a licensed Andover Educator.

Criteria for Participation:

You are eligible to participate if you:

- Are 18 year of age or older.
- Are currently studying and majoring in piano at the university level OR have studied and majored in piano at the university level.
- Have had no more than one private lesson and one group workshop in Body Mapping.
- Have no medical issues which inhibit the ability to play piano.

What participants will be asked to do:

Participants will be asked to perform a short collection of playing tests before and after a Body Mapping workshop. Components of this study will take place on 3 consecutive days. On day 1, participants will arrive individually for a testing session where they will complete a short intake questionnaire and perform the playing requirements which will be recorded with audio, video

and MIDI data. Participation on day 1 will take approximately 40 minutes and will be scheduled based on participant availability. On day 2, a maximum of six participants will arrive together to receive a Body Mapping workshop specifically designed for pianists. This workshop, called, “What Every Pianist Needs to Know About the Body” will take place between 9am and 5pm on the second day of testing. On day 3, participants will arrive individually to repeat the playing requirements with the same protocol as day 1. Participants will then complete a short auditory perception test. Participation on day 3 will take approximately 30 minutes.

Playing requirements:

- C major scale, hands separately, played legato without accent, in eighth notes at 120 beats per minute, continuously ascending and descending until asked to stop.
- *C major arpeggio, hands separately, played legato without accent, in sixteenth notes at 84 beats per minute, continuously ascending and descending until asked to stop.*
- *Mozart Sonata in C major, K545, 1st movement, bars 1-28, at 132 beats per minute.*

Risks: Since Body Mapping sessions require slow and gentle movements, participation in this study carries a low risk of physical discomfort due to potential muscle fatigue, strain or the aggravation of a preexisting injury. Since movement is done slowly, and stretching or rapid moving are NOT part of somatic training methods, the inherent risk is very low.

Benefits of project: Participants will directly benefit by receiving a Body Mapping workshop (valued at \$150) free of charge. Research on the outcomes of Body Mapping is scarce, and this project will help shed light on the specific outcomes of Body Mapping on piano performance. Armed with greater knowledge about somatic training outcomes, future research can help to further refine the role of somatic training in music pedagogy and injury prevention/intervention.

Confidentiality and anonymity: All information provided on intake questionnaire, consent forms, auditory perception tests, and all video/audio and MIDI data obtained during the study will remain strictly anonymous and confidential and are used for research purposes only. Only the primary researcher, Teri Slade, and her supervisor, Dr. Gilles Comeau, and authorized research members at the Piano Pedagogy Research Laboratory will have access to this data. Participants will be assigned an alphanumeric code that will be used in the place of a name during analysis and publication. When the results are published, no information about individuals or photographic identities will be made public, unless participants indicate that they would like still images and/or audio-video footage of them to be used in publication or conference presentation. If participants consent to the use of their likeness in publication, participant information will not in any way be linked to any electronic data or printed publication. All collected data will be kept on secure servers under password protection inside the Piano Pedagogy Research Laboratory, which is locked and armed with security alarms when unoccupied. Access to all computers is strictly monitored by lab administration. All data will be kept in hard copy for 5 years, after which it will be destroyed.

Funding: *No cost will be transferred to the participants. Participants will not be compensated.*

Voluntary participation: Participation in this project is completely voluntary and participants reserve the right to withdraw from the study at any time, for any reason and do not need to provide justification for withdrawal.

If you have any questions with regards to the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON, K1B 6N5. tel: 613-562-5387 or ethics@uottawa.ca.

If you have any questions or require more information about the study itself, you may contact the researcher or her supervisor.

Teri Slade, MA Candidate

Dr. Gilles Comeau, PhD

Consent Form
(for pianist participants)

Title of the study: The Measurable Effects of Body Mapping on Piano Performance

Principal Investigator: Teri Slade
Department of Music

Project Supervisor: Dr. Gilles Comeau
Department of Music

Invitation to participate: I am invited to participate in the abovementioned research study conducted by Teri Slade, supervised by Dr. Gilles Comeau.

Purpose of the study: The purpose of this study is to determine whether performance enhancement may be measured in pianists' use of pitch, velocity, timing and tone following the study of Body Mapping.

Participation: I confirm that:

- I am 18 years of age or older.
- I am currently studying piano as my major instrument at the university level OR have studied piano as my major instrument at the university level.
- I have had no more than one private lesson and one group workshop in Body Mapping.
- I have no medical issues which inhibit my ability to play piano

My participation will consist of:

Day 1:

- Completing a few general questions regarding myself and my history with piano playing and somatic methods.
- Playing a C major scale, hands separately, in eighth notes at 120 beats per minute, continuously ascending and descending until I am asked to stop.
- *Playing a C major arpeggio, hands separately, in sixteenth notes at 84 beats per minute, continuously ascending and descending until I am asked to stop.*
- *Playing bars 1-28 of Mozart Sonata in C major, K545, 1st movement at 132 beats per minute. Video, audio and MIDI recordings will be taken during the testing session.*

- *My participation on Day 1 will take approximately 40 minutes. My chosen bench height and distance will be recorded.*

Day 2:

- *Attending a six-hour workshop called, “What Every Pianist Needs to Know About the Body” in which I will learn about Body Mapping. I understand that video, audio, and MIDI recordings will be taken during the masterclass portion of this course.*
- *I will be available between 9am and 5pm on Day 2 for participation in this six hour course, plus breaks and rest times.*

Day 3

- *Repeating the playing requirements of Day 1 while video, audio and MIDI recordings are taken.*
- *Completing a short key velocity perception test in which I will listen to pairs of notes and discern which of the two notes is louder.*
- *My participation on Day 3 will take approximately 30 minutes.*

Risks:

My participation may entail feelings of tiredness during or after the Body Mapping course. I have received assurance from the researcher that every effort will be made to minimize these risks (i.e. I may take a break if I need to.).

Benefits:

I will receive the Body Mapping workshop for free, which would typically cost me \$150. My participation in this study will benefit the piano playing community and the music community in general. Many musicians claim that Body Mapping has enhanced the way in which they play piano, but there is little research to support or refute this. Should this project demonstrate that there are positive outcomes to piano performance, the music community would be better informed about the effects of a Body Mapping workshop on piano performance.

Confidentiality and anonymity:

I have received assurance from the researcher that the information I will share will remain strictly confidential. I understand that the contents will be used only for the purposes of this study and that my confidentiality will be protected. Anonymity will be protected through alphanumerical identification. Any personal information collected (name, gender, email) will only be used in the context of this study and the consent form and intake questionnaire containing this information will be kept securely and removed from the laboratory at the end of testing sessions so that it will not be possible to link participants to the data collected. Audio, video, and MIDI data collected will only be associated with the alphanumerical identification of the participant and will be securely stored. Only selected people directly involved with the research project will have access to the data during this time.

Any data collected for this project will be used for this project only.

Conservation of data: The data collected (personal information, consent form, answers to general questions, video and audio recordings, MIDI data, and key velocity perception test sheet) will be kept in a secure manner (kept under lock and key, password protected on laptop). Only selected people directly involved with the research project will have access to the data during this time. All data will be destroyed five years after the completion of this study.

Compensation: Participation in this study is strictly on a voluntary basis. I will not receive any form of compensation for participating in this study.

Voluntary participation: Participation in this study is strictly voluntary and *I have the right to refuse to answer any questions during this session without fear of reprisal or ill treatment*. I can choose to withdraw from the study at any time while the experimental session is being conducted. After the testing session, I will not be able to withdraw from the study since it will not be possible to identify the data associated with me. I do not have to provide any reason or justification to withdraw.

If I have any questions about the study, I may contact the researcher or supervisor.

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON, K1N 6N5

Tel.: (613) 562-5387

Email: ethics@uottawa.ca

There are two copies of the consent form, one of which is mine to keep.

I, _____, confirm that I have read and understood the information presented in the consent form above, and acknowledge the risks of participation as they have been described. I understand that I am under no obligation to participate, and that I have the right to withdraw from the study at any point, for any reason. By signing this form I confirm that I meet the criteria for participation as described and that I participate at my own risk.

- By checking this box, I consent that still images and/or audio-video recordings of me may be used for conference presentation or printed publications, with the understanding that my identity will in no way be linked to any of the electronic data and my personal information will in no way be revealed in connection with any images or audio-video recordings used. *(Note: It is possible to participate in the study without checking this box)*
- Please contact me by email with information about the results of this study when it is published. *(Note: It is possible to participate in the study without checking this box)*

Signature of participant

Date

Signature of researcher

Date

Appendix C

Pianists – Intake questionnaire

Participant Intake Questionnaire

Identifiers	
Name	
Email address	
Phone number	
Current City/town	
Alpha-Numeric Codes (for office use only)	
Physical characteristics	
Age/year of birth	
Gender	
Height	
Left handed or right handed	
Participant history	
1. How many years of piano lessons have you had?	
2. Age that study of piano commenced:	
3. Are you currently studying piano? Y/N Location/teacher	
4. Highest degree of music training attained (degree/RCM certificate/etc.)	
5. Do you play the piano as an aspect of your career? Y/N	
6. Approximately how many hours a week do you spend practicing/playing piano?	
7. Have you had any previous experience with Body Mapping? Y/N a) If so, please describe any group workshops you have participated in. b) Please indicate the number of private lessons, if any, you have had in Body Mapping	
8. Do you have any history with any form of somatic training other than Body Mapping? (ex: Alexander Technique, Feldenkrais, Eutony, Rolfing, etc.) a) If so, please indicate which method(s) b) Please indicate the number of private lessons and/or group workshops you have experienced in these method(s).	

<p>9. Do you participate in any fitness/physical conditioning activities such as sports, yoga, dance, swimming, etc.? Y/N</p> <ul style="list-style-type: none"> a) If so, please describe activity(ies) briefly b) Please estimate the total number of hours per week spend on physical fitness/conditioning activities. 	
<p>11. Do you have any history/experience with playing-related musculoskeletal pain or injury? If so, please described briefly, including</p> <ul style="list-style-type: none"> a) whether you have seen received a medical diagnosis b) what the diagnosis is, if known c) location of pain d) approximate time of onset e) whether it is resolved or ongoing f) whether you sought or are seeking treatment g) Does this condition prevent you from being able to play the piano? 	
<p>12. Do you have any other health concerns or medical diagnoses which would affect your movement and/or ability to play the piano?</p>	
<p>13. Why are you interested in participating in this study? (optional)</p>	

Appendix D

Judges – Letter of information, consent form, and data collection tool

Letter of Information
(for panel evaluators)

Dear piano teacher/Body Mapping instructor:

We are conducting a ground-breaking research study to investigate the impact of participation in a Body Mapping workshop on the performance of pianists. Body Mapping has become popular among pianists as a way to prevent and rehabilitate from injury. Many pianists also claim that their ability to perform is enhanced when they engage in Body Mapping sessions. Unfortunately, little research has been conducted in this area. Musicians and music teachers have no quantitative empirical research to help them decide whether or not to use Body Mapping as a method of performance enhancement for themselves or their students. This study aims to help musicians and music educators by analyzing aspects of piano performance before and after a session in Body Mapping.

We are currently recruiting piano instructors and Body Mapping teachers to participate as a blind panel. Below is a description of the study and the tasks involved. Should you wish to volunteer to take part in the study, or if you would like more information, please do not hesitate to contact Teri Slade.

Title of the study: The Measurable Effects of Body Mapping on Piano Performance

Objective: The purpose of this study is to test the claims of performance enhancement in pianists following Body Mapping study. Our study will investigate any changes in pianists' use of pitch, velocity, timing and tone before and after an instrument-specific version of the most common Body Mapping workshop format, called, "What Every Pianist Needs to Know About the Body" taught by a licensed Andover Educator.

Criteria for Participation:

You are eligible to participate if you:

- Are 18 year of age or older.
- Are an actively teaching piano instructor OR a Body Mapping instructor

What participants will be asked to do:

Panel evaluators will be asked to listen to and/or watch a series of video clips from testing sessions. Performances will be sent to all members of the blind panel. Members of the panel will then be required to answer questions on a rating scale provided by the principal investigator concerning the performances in the areas of either posture and body usage, or tone quality and expressiveness. After completing the viewing or listening process and answering the questions, members of the panel will send their responses along with recordings (for the protection of privacy of the pianists) back to Teri Slade.

Benefits of project: Research on the outcomes of Body Mapping is scarce, and this project will help shed light on the specific outcomes of Body Mapping on piano performance. Armed with greater knowledge about somatic training outcomes, future research can help to further refine the role of somatic training in music pedagogy and injury prevention/intervention.

Confidentiality and anonymity: Data collected from the blind panel will only be identified through alphanumerical identification. Any personal information collected (name, mailing and email addresses) will only be used in the context of this study (ie: communication with panel member) and the consent form containing this information will be kept securely so that it will not be possible to link participants to the data collected.

Conservation of data: All audio and video data will be destroyed five years after the completion of this study.

Funding: No cost will be transferred to the participants. Participants will not be compensated.

Voluntary participation: Participation in this project is completely voluntary and participants reserve the right to withdraw from the study at any time, for any reason and do not need to provide justification for withdrawal.

If you have any questions with regards to the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON, K1B 6N5. tel: 613-562-5387 or ethics@uottawa.ca.

If you have any questions or require more information about the study itself, you may contact the researcher or her supervisor.

Teri Slade, MA Candidate
Dr. Gilles Comeau, PhD

Consent form for panel evaluators

I, _____, confirm that I have read and understood the information presented in the letter for information for the study “The Measurable Effects of Body Mapping on Piano Performance” conducted by Teri Slade and supervised by Dr. Gilles Comeau. I understand that I am under no obligation to participate, and that I have the right to withdraw from the study at any point, for any reason. By signing this form I confirm that I meet the criteria for participation as described and that I participate at my own risk.

- Please contact me by email with information about the results of this study when it is published. (*Note: It is possible to participate in the study without checking this box*)

Signature of participant

Date

Signature of researcher

Date

Evaluation Chart

Complete the following rating chart for each pianist's video clips. **Rate the performance on the use or misuse of the following parts of the body.** Circle or highlight the number that best reflects what you perceive. Remember to answer the question at the very end of the chart. **Do not forget** to indicate the file name in the appropriate space.

Rating Scale

1 = very good usage and coordination	2 = good usage and coordination	3 = slight misusage	4 = slight misusage likely to cause impairment to performance	5 = misusage likely to cause impairment to performance	6 = serious misusage	7 = severe misusage
--	---------------------------------------	------------------------	---	---	-------------------------	------------------------

Pianist number:							
Files marked: X or Y							
Head/Neck	1	2	3	4	5	6	7
Upper Back/Chest	1	2	3	4	5	6	7
Lower Back	1	2	3	4	5	6	7
Shoulder region	1	2	3	4	5	6	7
Arms	1	2	3	4	5	6	7
Hands/Wrists	1	2	3	4	5	6	7
Legs/Feet	1	2	3	4	5	6	7
General impression of overall body usage	1	2	3	4	5	6	7

Do you think that this clip was recorded BEFORE the somatic session or AFTER? Please circle or highlight your answer:

Before

After

Appendix E

Mozart Sonata, K545, 1st movement, bars 1-28 (Mozart, n.d.).

Sonate 16 in C major

Sonata facile

W. A. Mozart
K 545

Allegro

The musical score is presented in two systems of staves. The first system (measures 1-3) begins with a treble clef and a bass clef. The treble staff starts with a half note chord (C4, E4, G4) and a half note chord (F4, A4, C5). The bass staff plays a steady eighth-note accompaniment. Dynamic markings include *mp* and *p*. The second system (measures 4-6) continues the accompaniment with more complex rhythmic patterns in the treble. The third system (measures 7-9) features a more active treble line with sixteenth-note runs. The fourth system (measures 10-12) includes a forte (*f*) dynamic marking and a trill (*tr*) in the treble. The fifth system (measures 13-14) shows a change in the bass line with a *p* dynamic. The sixth system (measures 15-16) concludes the piece with a *mp* dynamic and a trill in the treble.

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2

17

19

21

24

26

29

The image shows a page of musical notation for piano, consisting of six systems of two staves each. The music is in 3/4 time and features complex fingerings and dynamics. The first system (measures 17-18) includes a trill in the right hand and a steady eighth-note accompaniment in the left hand. The second system (measures 19-20) continues the accompaniment with various fingerings. The third system (measures 21-22) introduces a piano (*p*) dynamic and features a more active right hand with slurs and ties. The fourth system (measures 24-25) is marked forte (*f*) and includes a trill in the right hand. The fifth system (measures 26-27) features a complex right-hand melody with many slurs and ties, while the left hand provides a simple harmonic accompaniment. The sixth system (measures 29-30) continues the complex right-hand melody and includes a triplet in the left hand.