MOTION IN MUSICAL SOUND:
THE ROLE OF MUSIC PERFORMER BODILY GESTURE IN CREATING EXPRESSIVE SOUNDING MUSIC

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Tiivistelmä – Abstract

The way that musicians move when they perform is closely linked with their communicative intent and artistic interpretation of the music. While research has shown that musicians' bodily gesture conveys visually expressive information, no previous research has asked if these gestures are important to the musicians' internal process of making the music *sound* expressive. As musicians often perform in situations when they cannot be seen, this question is relevant to issues of performance practice and pedagogy. This study investigated the importance of musicians' use of expressive or ancillary gesture in the process of creating expressive sounding music. Four violinists were instructed to play unaccompanied melodies (intended to convey*sad*, *happy*, *tender* and *scary* emotions) under two movement conditions: *visually expressive* and *immobile*, while their performances were recorded through audio, and motion capture technology. The resulting audio performances were presented to listeners in a perceptual experiment in which listeners were asked to judge the overall expressivity of each performance, and the emotion conveyed by the music.It was hypothesised that: 1) melodies would be perceived as conveying the intended emotions, 2) there would be an effect of performance condition on expressivity ratings, and 3) performers would move more in the *visually expressive* condition than in the *immobile* condition. H1 was supported for six of the eight melodies, showing that those six melodies are suitable for future use in music and emotion research. H2 was supported for the two *sad* melodies and one *happy* melody, but was not supported for the other melodies, indicating that use of body movement can affect a performer's expressivity through sound, but the effect may be influenced by various factors. H3 was supported for all performers, showing that the movement conditions used here were successful in manipulating performers' body movement. In addition, exploring the descriptive statistics of the motion capture data also showed some interesting trends and differences in movement characteristics among the performers. Implications and limitations are discussed.

Asiasanat – Keywords

Music performance, ancillary gesture, expressive gesture, body movement, embodied cognition, musical expressivity, music perception, music pedagogy, performance practice, motion capture.

Säilytyspaikka – Depository	
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CONTENTS

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1 INTRODUCTION

Music and movement are inherently connected concepts. It can even be argued that the ability to derive meaning from, and enjoy music lies in an innate understanding of human body motion (Juslin, 2003; Juslin, Friberg, & Bresin, 2001). When a music teacher coaxes passionate playing from an introverted young performer they often use their hands or their whole bodies to show the story that the music tells, unable to put it into words or specific instructions. The virtuoso violinist JaschaHeifitz was both famously sparing with body movement in his playing, and often criticised for being a ‘cold’ performer (Weschler-Vered, 1986). Was this merely a visual judgement, mistakenly translated into a conclusion about Heifitz’s musicality, or was his immobile body really a reflection of a lack of emotion in his music? More broadly, is expressing musical meaning in bodily gesture, a key aspect of creating expressively shaped musical phrases?

The topic of music performer gesture is a relatively young but growing area of research in music psychology. Most previous research in this field has focused on examining the visual content of performer gesture such as the communicative qualities of gestures, and how movements are related to the performer’s intentions. It has been shown that listeners have a strong, and unconscious visual bias when judging Western classical music performers (Tsay, 2013), and that performers who move more are perceived as being more expressive through visual and audio-visual modes of perception, compared with audio alone (Davidson, 1993). In addition, the Embodied Music Cognition (EMC) approach may suggest that performers’ body movements are important in the cognitive process of creating an expressive music performance (Davidson, 2002; Sloboda, 1996; Juslin, 2003; Juslin, Friberg &Bresin, 2001), and there is evidence that performers’ gestures are related to interpretative elements of musical performance (Thompson & Luck, 2012; Wanderley, Vines, Middleton, McKay, & Hatch, 2005). However, it is not known whether a performer who moves their body more during a performance will produce a more expressive sound than a performer who moves less.

Although in many situations the visual element of a performance is important for an audience, there are contexts in which the music performer cannot be seen, such as screened auditions, recording in a studio, and playing in an orchestra pit or in an off-stage band. In these situations, it would be useful for performers to know if their approach to body movement affects the audience's auditory perception of how their performance sounds. Furthermore, it may be common for music instrumental teachers to neglect the teaching of expressive skills (Juslin, 2001; Lindström et al., 2003), and the use of ancillary and expressive gesture when playing. The current study can therefore inform performance practice and music pedagogy, as well as contributing to the understanding of the role of a musician's body in communicating expression, through the sound of music.

To this purpose, the current study asks the following research question:

Will instructing a musician to either inhibit or freely express their natural body movement during performance affect listener ratings of the audible expressivity of their performance?

This question was addressed by asking violinists to perform eight short melodies under two movement conditions that differed in amount of body movement.The resulting audio was presented to listeners, who rated the expressivity of the music. In addition, listeners rated emotional content, with the aim of validating the emotion labels given to the melodies, and considering how emotional content might mediate the experimental effect. While most previous studies on musicians' gesture have manipulated levels of expressive intent, this study manipulated only the level of movement, as the aim was to explore the effects of movement conditions on the expressive abilities of the performers.

This thesis provides a review of relevant literature on the topics of music performer gesture, expressivity in music performance, the embodied cognition perspective on expressive music making, and the various approaches to rating perceived emotion in music. Then, the aims and hypotheses of the current study are outlined, the methods are described, results are presented and discussed, and a conclusion is provided.

2 LITERATURE REVIEW

2.1 Physical Gestures in Music Performance

In the past 25 years, there has been a growing body of research on the way that musicians move their bodies when they play, investigating the purpose, meaning and communicative ability of musicians' body movements. In this research context, the term 'gesture' refers to physical body movement, and may be defined as "a movement of part of the body… to express an idea or meaning" (Leman, 2010, p.5). These communicative body movements can be found in everyday interactions as well as in musical performance situations (Wanderley et al., 2005), and the question of how the whole body is involved in communication is at the root of the need to study physical gestures. Of course in music, the very nature of creating sound requires movement of some kind, and there is a minimum amount of movement required to carry out the production of a desired sound, but musicians tend to move more than this minimum amount, moving their bodies in a visually expressive way (Broughton & Stevens, 2009). These 'extra' movements may be referred to as 'ancillary' or 'accompanying' gestures (Wanderley, 1999;Wanderley et al., 2005) or 'expressive body movements' (Davidson, 1993).

The term 'ancillary gesture' refers to "movements that do not have a straight link to the generation of sound, but are nevertheless an integral part of musical performance" (Wanderley, 2002, p.241). This may refer to the movement of a clarinet bell (Palmer, Koopmans, Carter, Loehr, & Wanderley, 2009), the shoulder and elbow movements of a pianist (Thompson & Luck, 2012), or a musician's expressive eyebrow movements (Wanderley et al., 2005). Wanderley (2002) defined three different categories of ancillary gesture as 'material/ physiological', 'structural' and 'interperative'. Additionally, Davidson (1993) used the term 'expressive body movements' to refer to musicians' gestures that contained expressive intentions. These two terms may overlap (Jensenius, Wanderley, Godøy, & Leman, 2010), as expressive body movements may be considered ancillary gestures, although not all ancillary gestures are expressive. For the purposes of this study, the focus is on the extra body movements that musicians make when asked to give a visually expressive performance, compared to when they try to keep still while playing. These movements will be referred to as expressive gestures.

Despite the definition of ancillary gesture as ‘integral’ to the performance process, both Wanderley (2002) and Thompson and Luck (2012) showed that it is possible for performers to suppress these gestures to some extent, through use of the *immobile* condition. Under this condition, performers are asked to be as still as possible while they play, and it has been shown that this conditionmay affect performers’ movement patterns (Wanderley, 2002), and use of expressive timing (Thompson & Luck, 2012; Wanderley et al., 2005). A thorough search of the relevant literature revealed no current papers that have investigated the effect of the *immobile* condition on perceptions of expressivity. Furthermore, while it has been shown that asking musicians to play more expressively results in more body movement (Davidson, 1993; Palmer, Koopmans, Carter, Loehr, & Wanderley, 2009; Thompson & Luck, 2012), it is not known if the increased body movement aids the realisation of expressive intentions or is merely a by-product of expressive playing.

The current literature then, has identified that performers move their bodies when they play in ways which produce sounds, support sound production and express musical ideas. To some extent these ‘extra’ movements can be suppressed, and while expressive body gesture has been shown to be visually important for an audience, they may or may not be important to the expressive qualities of the sound of the performance.

2.2 Expressivity in music

It is firmly established that music has the ability to convey emotions to listeners (Hunter &Schellenberg, 2010; Juslin & Laukka, 2004). It follows then, that during this process the musician must ‘convey’ or ‘express’ something through their playing. Indeed, studies have shown that the emotional intentions of music performers can be successfully communicated to listeners when the emotional intent is restricted to one of the basic emotions of *happy, sad, angry* and *fearful* (Gabrielsson & Juslin, 1996; Hailstone et al., 2009; Laukka & Gabrielsson, 2000).However, when more complex emotional intentions are adopted, the accuracy of communication is less effective (Senju & Ohgushi, 1987). In addition, musicians can communicate levels of expression intensity to audiences, such as normal expressivity, exaggerated expressivity and no expressivity, and visual channels of information seem to be important in the audience’s recognition of these different levels (Davidson, 1993). For the purposes of this study, the ‘expressivity’ of a musical performance refers to how clearly or intensely an idea or emotion is conveyed to the audience.

The idea of what constitutes expressive playing, at least in Western classical music, has changed over the course of history. While it is now considered important for a performer to stick precisely to the composer’s notation, before the early twentieth century improvised changes to the written music were considered a normal part of expressive playing. Since the early twentieth centuryclassical music performers have been sticking more diligently to the notation of the composer (Ritterman, 2002), but they are still able to bring the music to life with their own individual interpretations, through the use of ‘expressive playing’. Precisely how musicians do this has been the subject of much research, although it is thought that expressivity is achieved, at least partly, through deviations from the exactitude of the written score (Davidson, 2002; Juslin, 2001; Sloboda, 1996; Woody, 2000). For example, studies have shown that musicians use more variations in timing when aiming to play more expressively, and that these timing variations influence listeners’ judgments of expressivity (Kendall & Carterette, 1990; Palmer, 1989).

The scientific study of expressivity in music is a fairly recent development. In the past, the idea of unpicking the mechanisms of expressive playing has been viewed with distaste (Woody, 2000), possibly because of a desire to maintain an air of mystery around the musician’s creative process. Perhaps as a result of this attitude, pedagogical literature on music playing tends to discuss technical rather than expressive aspects of playing (Ried, 2002), and there is little research on how expressive playing is taught (Lindström, Juslin, Bresin, & Williamon, 2003). Despite this, the importance of expressive playing is mentioned in treatises dating from before the nineteenth century (Ritterman, 2002), highlighting that expressivity in music performance has long been considered an essential performance skill. For example, Leopold Auer brings attention to expressive violin playing in his early 20th century treatise on violin playing. Auer (1960) writes of the importance of “shading” (p.61) in violinists’ playing, and emphasises that violinists should make use of “nuance” (p.62) to avoid monotonous performance. Furthermore, to reinforce the strength of this opinion Auer (1960) also writes that musicians should play with “the fullest amount of expression that music and player can give” (p.69). This opinion that expressivity in performance is important, is reflected in more recent studies on the opinions of music students (Lindström et al., 2003;

Woody, 2000), showing that the idea that a music performer should play expressively has endured over many years.

In reflection of the lack of formally written advice on how to play music expressively, more recent research into teaching methods have shown that instrumental teachers tend to spend more time teaching technique than expressivity (Juslin, 2001), and that the teaching of expressivity is neglected in the early stages of music learning (Lindström et al., 2003).Therefore, further research into the mechanisms of expressive playing is needed, to inform teaching practice.

Precisely how expressive music playing is taught or learned is not known. There is some evidence that listening to others perform is considered an important way to learn expressive playing (Reid, 2002), and was recommended by C.P.E Bach in his 1753 treatise on keyboard playing (as cited in Ritterman, 2002). This idea is perhaps reflected in the more modern concept of 'aural modelling' as a technique for teaching expressive skills, which refers to the way that a teacher will demonstrate expressive playing, encouraging the pupil to mimic their model. Aural modelling has been found to be a popular teaching method (Laukka, 2004; Woody, 2000), and to be more effective in teaching expressivity than verbal instructions alone (Sloboda, 1996). This concept of aural modelling is interesting for the current research question, as through this method of learning it is highly likely that music students not only hear, but also see the performer on whom they are modelling. In this way, the student learns not only from the sound of expressive music, but also from the body movements made by the performer, and use of expressive gesture in shaping sound is implicitly taught.

It is interesting that researchers have often considered expressive teaching and technical teaching to be two separate things. When Van Zijl & Luck (2013a) asked musicians to play in different styles, including 'technical' and 'expressive', some musicians reported that it was difficult to play completely without expression, suggesting that separating expressive playing from technical playing may not be natural, or even possible for some performers. Additionally, Sloboda (1996) considers that technique is needed to bring expressive ideas to life, pointing out that the two cannot be completely separated. This sentiment is further supported by Leopold Auer (1960) who writes "without technical competence even the most gifted interpretative instinct must fail of practical application" (p.72). Given that emotions in music have been shown to be communicated via the manipulation of acoustic features of sound (Gabrielsson & Juslin, 1996;Juslin, 1997; Juslin, 2000) and instrumental technique is required to create those sound manipulations, this makes sense. Therefore, to some extent musical expression and technique can be considered inseparable. However, Lindström et al. (2003) found that students reported spending more time on technical than expressive skills, and that expressive teaching came at a relatively late stage in their education, which suggests that, for some musicians, the two concepts can be separated.

While it may be a matter of opinion whether musical technique can be separated from musical expression, for the purposes of this study it is considered important to remember that expression cannot be realised without technique (Sloboda, 1996). This concept is important to the current research question, as while previous research may suggest that body movement is important in achieving expressive playing, expressive body movement may also interfere with a musician's technical movements, impairing the expressive quality of the produced sound.

In summary, the historical, pedagogical and empirical literature documents that there are such things as expressive and inexpressive musical performances, that expressivity is a desirable quality in a performer, and that ideas of what constitutes expressive playing have changed over the course of history. Performers can communicate specific emotions and expressive intentions in their playing, and this seems to be done partly through small variations from the written score. Very little is known about how expressivity is taught, although the mimicking technique of 'aural modelling' has been documented, and it is suggested here that this technique might make implicit use of body gesture in teaching expressivity. Finally, it is important to remember that expressive playing is achieved partly through mastery of instrumental technique, and that the two concepts are not entirely separate.

2.3 Musician's gesture and expressive playing

Research on musicians' bodily gesture has shown that gesture is linked to expressive intentions. For example, musicians seem to manifest their expressive intention ingesture by moving more when playing expressively and less when playing inexpressively (Davidson, 1993; Palmer, Koopmans, Carter, Loehr, & Wanderley, 2009; Thompson & Luck, 2012). Furthermore, Van Zijl and Luck (2013) found that when performers were asked to focus on expressing the emotion in the music, they moved more than when they focused on feeling the emotions, or on the technical demands of the music. This shows an association between gesture and expressive intention, but does not show how important they are to each other. In other words, we do not know if expressive body movements are an unavoidable consequence of the expressive intention, or just an extra visual manifestation.

Some studies have explored this relationship further, showing thatmusicians' expressive gesturesare intricately involved in expressive and interpretative elements of the music they play. For example, Wanderley (2002) found that expert clarinet players exhibit very similar expressive gesture patterns across different performances of the same piece, and concluded that the expressive gestures were not superflous or random, but were "an integral part of the performance process" (p.252). This conclusion was also drawn by Wanderley, Vines, Middleton, McKay, & Hatch (2005), who compared clarinettists' body movements under various performance conditions. In addition, Davidson, (2007) and Wanderley et al. (2005) observed that piano players are not able to fully inhibit their ancillary gesture, suggesting that the body movements were an important part of the performance process, while Palmer, Koopmans, Carter, Loehr, & Wanderley (2009) showed that clarinettists' movement of the clarinet bell was predicted by use of expressive timing. More recently, Demos, Chaffin, and Logan (2017) also showed that trombonists' body sway reflected the musical structure of their performances. Thus, these findings suggest that expressive movements are integral to the performer's mental conception of the music,but is physical movement required to retrieve expressive ideas, or can a musician still play expressively while suppressing expressive gesture?

Certainly, it seemsthat musicians' bodily gestures are important to visual perceptions of their performance. For example, it has been shown that audiences perceive expressive intent more easily when they can see the musician, compared to when they cannot (Broughton & Stevens, 2009; Davidson, 1993), and that the influence of visual expressive cues may be stronger than audio cues when both are perceived together (Vuoskoski, Thompson, Clarke, & Spence, 2014). Furthermore, Juchiewicz (2008) demonstrated that presenting the same musical audio with visual recordings of different movement manners affected ratings of phrasing, overall performance and use of dynamics and rubato, while perceptual experiments have found that, visually, musicians' gestures can elongate the audience's sense of phrasing, and contribute to perception of tension in the performance (Vines, Wanderley, Krumhansl, Nuzzo, & Levitin, 2004; Wanderley et al., 2005). In addition, it has been shown that musicians' gestures can visually communicate the emotional content of a performance, even when no sound can be heard (Dahl, & Friberg, 2007), although the successful communication was restricted to *happy, sad* and *angry* emotions, while *fear* was not communicated through gesture alone. This tendency to be heavily influenced by visual information when experiencing a musical performance is further highlighted by Tsay (2013) in a study which showed that although people believed that sound was the most important factor in judging classical music competitions, they were better at choosing the winners of past competitions from silent video clips of performances, compared to video with sound, or sound alone. There is plenty of evidence then, that musicians' body movements influence audience perceptions visually, butvery little research exists on the role of these gestures in creating expressive sound.

One way of investigating the importance of expressive performer gesture, is to ask the performer to suppress it. Wanderley et al. (2005) and Thompson and Luck (2012) did this through use of the *immobile* condition, and explored the effects of the condition on performers' use of expressive timing, with somewhat inconsistent results. While Wanderley et al. (2005) found that the *immobile* condition resulted in shorter overall performances, and concluded that the suppression of the performers' movements resulted in a disrupted "sense of global timing" (p.101), Thompson and Luck (2012) found that length of performance was not affected by the *immobile* condition. Thompson and Luck (2012) propose that the contradictory findings could be caused by the difference in studying pianists and clarinettists, or different levels of technical difficulty in the music used, while Wanderley et al. (2005) suggest that the importance of gesture to sense of timing, might be specific to individuals and dependent on the performer's experience of playing without extra movement. Thus, while expressive gesture seems to be involved in how musicians create expression, it could be affected by individual factors, making it possible for some musicians to suppress extra movement without disrupting expressive use of timing.

The research in this field points towards the conclusion that musicians' gesture is involved with the creative process of music making, and visually communicates expressive elements to the audience. However, it is still not known if expressive gesture is merely a visual communicator or if it is an essential element of the cognitive processes underlying the creation of expressive sound.

2.4 The embodiment of expressivity

Providing a theoretical framework to the current research question, is the idea of embodied music cognition (EMC). The embodied cognition approach serves as an alternative to traditional cognitivist models of theory of mind, and places a greater emphasis on our bodily interaction with the environment, sensorimotor representations, and the simulation of action in cognitive processes (Leman, Lesaffre, Nijs & Deweppe, 2010; Matyja, 2010; Thompson & Luck, 2012). EMC applies these principles to the cognition of music, and considers the body to be the mediator between musical intentions or interpretations in the mind, and actualisation or perception of musical ideas in the environment (Leman, 2010). These ideas are important to the current research question, as they suggest that body movements may play an important role in creating expressive sound.

EMC argues that the body is particularly important when engaging with music. Since music making is caused by movement,it is argued that musical sounds are inherently associated with the idea of movementand that the expressive content of music originates in the understanding of motion, gesture and vocal expression (Lindström et al., 2003; Phillips-Silver, 2009; Shove & Repp, 1995). Specifically, musical expression is thought to be closely related to an understanding of ‘biological motion’, meaning the types of motion produced by living things (Juslin, Friberg &Bresin, 2001). Friberg and Sundberg (1999) aimed to test this empirically, in a study that successfully used a kinetic analysis of dancers’ decelerating running to develop a well-fitting model of musical ritardandi (the slowing down of musical tempi). That is to say, the mean deceleration of running plotted against normalised time, was very similar to the mean ritardandi plotted against normalised time. The authors interpreted their findings as support for the notion that decisions on musical ritardandi are based on knowledge of biological motion. In a similar attempt to link auditory perceptions with knowledge of bodily motion, Friberg, Sundberg and Friden (2000), showed that sound stimuli created from recording the various levels of force with which a foot hits the ground when adopting different gates were, to some extent, able to communicate the character of the original gait to listeners, and were easily categorised as relating to motion words. Thus, research rooted in the

EMC approach has aimed to link that which is perceived through sound and music, to that which is experienced through motion of the body, therefore building evidence for the intrinsic connection between motion and music. The current study will contribute to this topic by exploring how important a performer's expressive gestures are in their ability to convey expression through musical sound.

This idea that expressivity in music is closely linked with body movement makes intuitive sense, as expressivity is the communication of emotions, and emotions are inherently experienced through bodily sensation. In addition, the common use of motion related metaphor to describe music, suggests that music and motion are deeply connected concepts (Davidson, 2002). The idea that expressive performance skills are learnt through bodily sensation is also reflected in teaching pedagogy. For example, the acting performance methodology of Jacques Lecoq emphasises learning to feel and express emotion through bodily awareness (Kemp, 2016), and Dalcroze Eurhythmics teaches students to use the body as a tool for engaging with music (Seitz, 2005). Davidson (2002) discusses evidence in the pedagogical literature that bodily movements may be important to expressive playing. She notes that some written works on music teaching advise the use of the body to show expression, and that Balliot's 1834 treatise on violin playing describes how to perform tempi in terms of the player's body movements. In a similar vein, Repp's (1992) translation of Trusslit's 1938 treatise on music performance also discusses the importance of body movement, as well as the general concept of motion, to expression in music. Thus, there is some evidence for an implicit understanding among pedagogues that bodily gesture plays a role in expressive music making.

Delving deeper into this concept, Sloboda (1996) proposes that musicians might use bodily gestures and feelings as a way of storing representations of expressive musical playing. In other words, the feeling of expressivity is embodied and stored in movement representations, rather than memorizing exact details about variations in tempi and dynamics.Furthermore, Juslin (2003) proposes that principles of biological motion are one of five factors that compose musical expressivity, and Juslin, Friberg and Bresin (2001) implement this idea in their computational model of expressive music performance, by using algorithms of timing variation that were derived from human body motion. These ideas are central to the current research question in their implication that body movement is an essential part of musical expression, and could be part of a musician's cognitive process in shaping an expressive musical phrase. The current study takes these ideas a step further, by asking if musicians' use of body gesture at the time of performance is integral to these expressive musical shapings.

This EMC perspective can shape the approach of research on expressive musical playing through encouraging consideration of the role that a musician's body plays in this creative process. Theoretically, the EMC approach proposes that body movement is intrinsic to the communication of musical ideas, which is apparent in the use of movement metaphors as musical descriptors, evidence from pedagogical writing, and empirical evidence that movement information can be derived from sound. By extension, it has been proposed that body movement is central to the way that musicians create expression in music (Juslin, 2003; Juslin, Friberg, & Bresin, 2001; Sloboda, 1996) and the current study sets out to investigate this idea.

2.5 Whole-body movement in violin playing technique

The use of expressive body movement may be particularly interesting in violin playing technique. Due to the complex relationship between the string and the bow, some teachers may advise pupils to try to be still when they play so as not to disrupt the angle of bow to string,which is important for consistency of tone quality. In his treatise on violin playing Galamian (2013) wrote that "exaggerated bodily motions" (p.12) are not desirable in a performance, and suggests that they may cause problems with bowing technique and "add a disturbing factor to the performance" (p.12). However, he also wrote that "suppressing…. every bodily motion" (p.12) could be just as bad as moving too much, pointing out that some movements may aid smoothness of playing and add a naturalness to performance. Furthermore, Leopold Mozart (1985) also writes of the undesirability of excess bodily motion, referring to the importance of the violin remaining in a fixed position, and implying that performers who move too much may appear "ridiculous and unnatural" (p.60) to the audience. On the other hand, Menuhin (1976) wrote of the importance of fluidity in the body while playing, implying freedom of movement as an antidote to stiffness and its effects on sound quality, and gives exercises in using "whole body swing" (p.45) to make bow changes. Menuhin (1976) also writes of the importance of "cultivating sensation" (p.34), and emphasises that a performer should learn through bodily awareness and feeling. It seems then, that there exists a diversity of pedagogical approaches to whole-body movement in violin playing, and through empirical research, this study will make a valuable contribution to the debate.

2.6 Measuring musical expression

So far, this literature review has explored conceptual and theoretical issues relating to expressive movement and music performance, with an emphasis on empirical research which has aimed to tackle these issues. Of course, in order to quantitatively study how performer bodily movement affects the expressive quality of a performance, it is necessary to somehow measure expressivity. The next section will review existing literature on approaches to measuring expressivity and emotion in psychology research, with the purpose of informing the methods of the current study.

2.6.1 Measuring perceived expressivity

The task of measuring listeners' perceptions of expressivity in musical performance is not straightforward. For example, Van Zijl and Luck (2013b) found that musical performances rated as most expressive of sadness were not the highest rated performances in terms of preference, suggesting a complex relationship between expressing musical emotions and delivering an enjoyable performance. In addition, Juslin (1997) found that ratings of musical performance expressivity yielded low consistency among listeners, suggesting that there is a wide range of opinions on what an 'expressive performance' really is. Nonetheless, ratings of musical expressivity have been used in research, both as post-listening measures and continuous ratings.

It has been shown that 'expressivity' as a musical concept is understood between performers and audiences. For example, in Davidson's (1993) seminal study, musicians performed under various expressive intentions, and audiences correctly identified the levels of expressivity. This showed that audiences understood the concepts of 'expressive playing' and 'inexpressive playing', and that the concept of expressivity can be viewed as a scale from inexpressive to very expressive. Indeed, many studies have measured perceptions of expressivity by asking listeners to rate how expressive the performance was on a linear scale (Broughton & Stevens, 2009; Kamenetsky, Hill & Trehub, 1997; Kendall & Carterette, 1990; Sloboda, & Lehmann, 2001; Vuoskoski et al., 2014), while others have used ratings of the strength of a specific emotion, (*e.g.* happy or sad) on a linear scale (Dahl & Friberg, 2007; Gabrielsson & Juslin, 1996; Laukka & Gabrielsson, 2000), or rating the expressiveness of a specific emotion (Van Zijl & Luck, 2013b).

Due to the vagueness of the word "expressivity", it may be useful to give a definition of what the word means when asking listeners to rate expressivity. Kendall and Carterette (1990) used the following definition: "Musical expression can be likened to the expression of an actor in his speaking part: He may speak in a monotone, in a manner appropriate to the idea, or he might exaggerate". This may be useful in giving the listener a non-musical reference to grasp the idea of what is meant by musical 'expressivity'.

In addition, the notion of 'tension'has been used to rate changing perceptions of emotion in music over time. It has been shown that ratings of tension correlate with ratings of the strongest emotion in a music performance (Krumhansl, 1997) and that tension ratings are similar among musicians and non-musicians (Fredrickson, 2000). Musical tension has been used as a continuous measure (Vines, Wanderley, Krumhansl, Nuzzo & Levitin, 2004) and as a single post-listening measure (Nusseck & Wanderley, 2009), and it has been suggested that tension can be used as a substitute for rating the experience of emotion in music (Vines, Krumhansl, Wanderley & Levitin, 2006). Tension may be a useful way to measure the expressivity of a performance, but it may also be influenced by structural elements of the musical score (Krumhansl, 2002), rather than the approach of the musician. Tension then, might be more suited to measuring the expressive potential of the music itself rather than the success of the performer in playing expressively.

Musical expressivity is an elusive concept. However, it seems that measuring expressivity on a linear scale combined with an explanation, to those rating it, of what is meant by 'expressivity' can be used successfully. As ratings of tension might be more influenced by the structural elements of the music, ratings of expressivity would be more suitable for studies wishing to achieve an evaluation of the performer, rather than the written music itself.

2.6.2 Measuring perceptions of specific emotions in music

When studying aspects of the music performer's expressive abilities, it could be useful to determine the emotional content of the music itself as defined by structural features such as harmony, rhythm and melodic shape. One reason for this is that the structural features of the music may affect the listener's ratings of expressivity, so it might be desirable to aim for a balance of different emotions portrayed in the musical stimuli. This would enable the observation of how experimental effects differ depending on the emotional content of the music. However, deciding on the emotional content of a musical excerpt can be difficult due to the subjective nature of emotion in music (Yang, Liu, & Chen, 2006). In addition, it should be considered whether the researcher desires to measure the perceived or induced emotion (Kim et al., 2010), and the listener should be instructed accordingly. The current study focuses on measurements of perceived emotion.

The two main approaches to measuring perceived emotion in music are the discrete approach, and the dimensional approach. Each has a different theoretical basis. The discrete model is based upon the assumption that there are unique cognitive mechanisms for understanding each emotion, while the dimensional model assumes that emotions consist of underlying bipolar dimensions (Lundqvist, Carlsson, Hilmersson, & Juslin, 2009). Studies adopting the discrete approach ask listeners to rate the emotional content of distinct emotions (Eckman, 1992). For example, the Geneva Emotional Music Scale (GEMS) model (Zentner, Grandjean, & Scherer, 2008) is a discrete emotion rating scale, and aims to identify emotions induced specifically by music. Studies adopting the dimensional approach ask listeners to rate 2 or 3 emotion related dimensions; valence (negative to positive), arousal (low to high energy) and tension (low to high). Whether the third dimension is necessary to the construct of emotion experience is unclear, as while Schimmack and Grob (2000) concluded that it was necessary, Eerola and Vuoskoski (2011) concluded that the dimensions could be collapsed to valence and arousal alone without impairing the fit of the statistical model to the data.

The discrete and dimensional approaches have been compared for both music-induced emotions (Vuoskoski & Eerola, 2011) and for perceived emotions in music (Eerola & Vuoskoski, 2011). In both studies the dimensional model was found to outperform the discrete model in discriminating ambiguous emotions, although in terms of perceived emotions the difference between the two models was small. However, one limitation of the dimensional approach is the underlying assumption that the dimensions are bipolar (Schubert, 1999). For example, positive and negative emotions can be perceived or experienced at the same time, so it might make more sense to consider positive and negative valence astwo independent unipolar scales, such asin the Positive and negative affect schedules (PANAS). This limitation may be the reason why the dimensional model of emotion in music has been shown to place music which has been rated as sad or fearful on the positive end of the valence dimension (Eerola & Vuoskoski, 2011; Zentner et al., 2008).

It is unclear which emotion model is the best for measuringmusical emotion.While the dimensional model lacks evidence to back up its theoretical basis of separate neural mechanisms for separate emotions (Eerola & Vuoskoski, 2011), the rating of discrete emotions in music has been found to be reliable across many participants and across cultures (Balkwill & Thompson,1999; Eerola &Vuoskoski, 2013; Kim et al., 2010). However, the discrete model seems to be less effective for identifying mixed or ambiguous emotions. The decision of which model to use, most likely depends on study design and research questions, and some studies have even adopted an approach that conceptualisesmusical emotions as both discrete and dimensional (Christie & Friedman, 2004; Eerola &Vuoskoski, 2013; Nyklíček, Thayer & Doornen, 1997).

3 THE CURRENT STUDY

The literature discussed in this thesis has provided information on the acoustic devices that musicians employ to achieve expressive playing, how performer gesture visually conveys expressivity, and some indication of the effects of the suppression of a musician's natural body movement on their performance. However, very little research on expressive playing has directly addressed the relationship between a performers' approach to, or amount of body movement and the expressivity of the sound of their performance. In other words, if a performer moves more expressively when they play, will they produce more expressive sounding music? Thus, the current study proposed the following research question:

Will instructing a musician to either inhibit or freely express their natural body movement during performance affect listener ratings of the audible expressivity of their performance?

With the aim of answering this question, the current studyasked performers to play under 2 movement conditions, and explored whether listener ratings would be affected by those movement conditions.

While there is some theoretical and empirical evidence to suggest that musicians' body movements are important to the creation of expressive sound (Juslin, 2003; Leman, 2010; Sloboda, 1996; Vines et al., 2004; Wanderley et al., 2005), there is also evidence that ancillary gesture can be suppressed without disrupting expressive intentions (Thompson & Luck, 2012). In addition, the complex nature of violin technique might suggest that too much body movement while performing can be detrimental to sound production (Galamian, 2013), and it may be the case that violinists learn to suppress their expressive gestures without compromising their expressive intention. Therefore, although an effect of movement condition on expressivity ratings was predicted, the direction of the effect was not predicted.

The term 'expressive gesture', was used here to mean any movement which the performer felt was visually expressive and couldbe altered without compromising sound quality. This could include both movements with a physical sound supporting role, and movements with an expressive intention. The precise roles of gestures were not speculated here, but the overall effect of the absence or presence of these gestures on the perceptions of the sound, was the matter of interest.

The independent variable was the amount of expressive gesture, which was manipulated via instructions to the performer. The dependent variable was listener ratings of perceived expressivity. The performances consistedof short melodies which were chosen to each reflect one of the emotions *happy, sad*, *tender*,and *scary*. In addition, the emotional content of the melodies was rated by listeners,with the aim of validating the emotion labels given to the melodies, and exploring how the emotional content of the melodies mediated the experimental effect. The experiment was a between-subjects design.

The experimental manipulation was made by instructing performers to play under 2 conditions; one that asked them to move as little as possible while still playing expressively, and another that asked them to focus on being visually expressive while still taking care of the expressive sound. It was predicted that the former condition would result in less non-essential movement, and the latter would result in more. This was measured using motion capture technology.

The hypotheses were:

H1: Each melody will yield significantly higher emotion ratings for the intended emotion, compared to the other three emotion ratings

H2: There will be an effect of movement condition on listener ratings of audible expressivity. The direction of the effect is not predicted.

H3: The *visually expressive* condition will result in a greater amount of performer bodily movement than the *immobile* condition.

4 METHOD

4.1 Participants

4.1.1 Performers

To create the stimuli for the perceptual task, four violinists, three of whom were female and one of whom was male, were recruited via word of mouth. The mean age of participants was 25.75(*SD*=3.5).While all four performers took part in the stimuli creation process, it was later decided only to use three performers' recordings for the experiment, and movement analysis. This decision was made with the aim of minimising the length of the listening procedure. One performer was still a university student and had considerably less performing experience than the others so this performer was dropped from the rest of the experiment. The three remaining performers were ex-music students of the University of Jyväskyla. For two performers, violin was their principal study instrument, and for one it was their second study, but all participants had significant solo performance experience and were of at least ABRSM (Associated Board of the Royal Schools of Music) grade eightstandards. All performers described themselves as semi-professional musicians, when asked to choose between professional, semi-professional and amateur. The participants' nationalities were as follows: 1 Finnish, 1 German, 1 USA (United States of America). All three participants reported that, as well as classical music, they also played folk music.

4.1.2 Listeners

For the listening perception task, 40 participants (25 female, 15 male) aged between 19 and 62 (M = 26.48, SD = 6.88),were recruited via a combination of word of mouth, and Facebook advertising. Participants were from various nationalities, but all were currently studying or working in Jyväskylä, Finland. 31 of the participants reported being able to sing or play a musical instrument to some extent, while 19 considered themselves to be musicians, and 15 either held or were studying for a music degree, or undertook occasional paid work performing music. The sample was therefore relatively well balanced in terms of musicianship. The sample was a convenience sample, and most participants were students or ex-students of the University of Jyväskylä. The nationalities of participants were also quite unbalanced, with considerably more Finnish participants than any other nationality, meaning that generalisations from this sample to a larger population may be limited.

4.2 Procedure

4.2.1 Musical material

The music provided for the performance procedure consisted of two sets of unaccompanied violin melodies. The first set contained four short melodies, validated by Vieillard et al. (2008) as having the specific emotional contents: *happy, sad, scary and tender* (See Appendix A). The second set contained four longer excerpts, chosen, for this study, from typical violin repertoire (See Appendix B). The emotion-validated melodies were originally composed for experimental purposes as piano melodies with harmonies (Vieillard et al., 2008), and were subsequently adapted for unaccompanied violin playing by Thompson, Vuoskoski, and Clarke (2016). The *tender* melody is the only melody not taken directly from Vieillard et al. (2008), but was adapted by Thompson, Vuoskoski, and Clarke (2016) from the *sad* melody, by changing the minor key to the tonic major. In addition, preliminary data from Thompson, Vuoskoski, and Clarke (2016) indicates that their versions of the melodies conveyed the intended emotions. Therefore, these four short melodies were considered suitable for violin performance to convey the emotions of *happy, sad, tender and scary*.

The second set of excerpts included more naturalistic, and longer excerpts that were composed for violinists, and that violinists are often required to play. This aimed to provide more scope for expressive playing, as well as creating enough stimuli for the perceptual part of the study.These four, longer excerpts were each intended to also convey one of the emotions of *happy, sad, tender* and *scary,* and it was expected that listener's perceptual ratings would confirm the emotional contents of these excerpts. The selection of these melodies was based on previous literature that defines acoustic and structural features associated with these emotions (Vieillard et al., 2008; Juslin, 2000), as well as the valence and arousal components expected for each emotion type (Eerola & Vuoskoski, 2011). These melodies were taken from the following pieces of classical music: Tchaikovsky's Violin Concerto in D major, Op. 35, Canzonetta; Vivaldi's Concerto no. 1 in E major, Op. 8. RV

269, “la Primavera”; Mussorgsky’s Pictures at an Exhibition, No. 9 “The Hut on Hen’s Legs (Baba Yaga)” and Elgar’s Salut D’amour, Op. 12 (see Appendix B).

4.2.2 Stimuli Creation

Performers were given the musical material in advance and asked to prepare expressive performances as they would for an audition. Performers were asked to prepare each melody under two conditions: *Visually expressive* and *Immobile*. The *immobile* condition was derived from the same condition used by Thompson & Luck (2012), although slightly different instructions were given in the current study, and the *visually expressive* condition was a new condition, intended to encourage performers to use more expressive body movement during the performance. The instructions for the conditions were given in advance so that the performers were able to practise the conditions, as this was considered to reflect real life situations in which performers practise different ways of playing. However, it should be noted that the performers did not practise the melodies in advance, and some technical performance issues were observed. In addition, a metronome was used to indicate the tempo for each melody before the performers started to play, but the metronome did not play throughout the performance, allowing performers to make us of expressive timing. Performers were asked to portray the intended emotion for each melody, and to follow any articulation and performance instructions in the musical score as much as was possible. Written Instructions to the performers are provided in Appendix D.

Two of the performers performed all melodies in the *visually expressive* condition first, followed by all melodies in the *immobile* condition; while one performed all melodies first in the *immobile* condition followed by all melodies in the *visually expressive* condition. The aim here was to control for order effects of condition, but as only three performers were included in the analysis, the order of conditions was not equally balanced. Performers were allowed to repeat the melodies as many times as they wanted, until they were satisfied with their performance.

4.2.3 Apparatus

Wanderley (1999) pointed out that a musicians’ body movement could be problematic when recording using a fixed microphone. As the musicians’ movement alters the distance between the instrument and the microphone, changes in the volume of the recorded music will be heard.In the current study, audio was recorded using instrument mounted microphones (DPA, d:vote, 4099), and in this way the distance between the microphone and the sound source was maintained regardless of the performers’ body movements. Audio was recorded using ProTools (version 11.0.3) software, and movement was recorded using an eight-camera optical motion-capture system (Qualysis Pro-Reflex) with a sample rate of 120 frames per second. Performers were outfitted with 25 reflective markers to record the movement of their bodies.

All performers played on the same violin and bow to control for sound quality changes between instruments, although performers were allowed to use their own shoulder-rest if they wanted to. The violin used was a 2005 violin by English maker Roger Hansell, modelled on a violin by Joseph Guarnerius of Cremona. Performers were given a chance to warm up on the instrument, and the violin was tuned to A=440Hz at the beginning of each new participant’s session.

4.2.4 Editing and mixing of audio stimuli

While the initial approach was to keep the audio stimuli as un-edited and true to the original performances as possible, some issues with the stimuli arose.Firstly, as the violins were recorded using an instrument mounted, close microphone, the sound was very dry and was not an ecologically valid aesthetic of how violin music is normally heard. In addition, some breathing sounds and mechanical sounds of playing (such as fingers falling heavily on the fingerboard or bow scraping sounds) were intrusively present on the recordings. Thus, it was decided to add some reverb effects to create a more natural aesthetic, and to help to mask the unwanted sounds. Secondly, in one performance of the long-happy melody, Performer 3 played an incorrect note. This note considerably affected the tonality of the music, changing the end of the melody from a minor tonality to a major one. It was decided that this incorrect note may interfere with the experimental effect by altering the emotional content of the melody, so the note was corrected using CelemonyMelodyne software (version 4). The resulting sound was considered to be un-noticeably different from the other melodies, so this edited version was used in the experiment, instead of the original.

Audio was edited and mixed in pro-tools (version 11). First the correct version of each performance was selected according to the performer's decision, as in some instances the performer chose to perform the melody a few times until they were happy with their performance. When the correct melody had been identified, the clip was trimmed so that there was no excess silence at the start or beginning of the clip. Equal amounts of reverb were added to all stimuli, as well as a high pass surgical EQ at 180Hz, 6db/8ve. All clips were normalised, using peak normalisation, to -1dB. This normalisation process did not affect the dynamic range of the performance but ensured all clips were heard at the same peak level, thus producing a more consistent volume level across all performances. For some melodies fade outs were applied to get rid of pops and clicks at the ends of the stimuli. Finally, levels were mixed to be the same across all stimuli. While there were still some slight differences in sound quality between the stimuli, due to performers' different playing styles, the aim was to produce as even a sound as possible while keeping the mix numerically the same between performers.

The same normalisation and mixing levels were also applied to the two professional recording clips that were used as practice runs in the experiment. Although all stimuli were normalised to the same dB level there was still a perceptible difference in volume level. This was due to difference in sound quality between the experiment stimuli and the professional recording clips. All audio files were bounced as 16 bit, 44.1kHz WAV files.

The difficulty in treating the stimuli equally when editing and mixing should be noted. For example, if a performer plays slightly louder in one condition, adding the same amount of synthetic reverberation to both versions will affect the louder recording more than the quieter one. However, it was not the aim of the experimenter to either iron out or exaggerate these differences between conditions, but to preserve them. A subjective choice had to be made about the optimal level of reverberation to add considering all stimuli, and the experimenter therefore became somewhat involved in the artistic process of creating the stimuli. Thus, it was impossible to stay completely true to the performer's rendition, and the sound recording process may have interfered with experimental effects. However, such complications were kept to a minimum, by only applying the same amount of editing to each stimulus.

4.2.5 Listening procedure

The audio stimuli were presented using Max/MSP software, in which a patch was designed and created for the specific purposes of this experiment. The patch presented experiment instructions and stimuli, and collected ratings. Participantsundertook the perceptual task individually, listening through AKG K141 Studio headphones, in a quiet room, free from distractions. Participants were asked to rate the expressivity (*not expressive at all – very expressive)* of each performance, as well as the perceived emotional content for *happy, sad, tender* and *scary* (*absent – present*), on a linear scale of 1 – 7. The expressive rating scale was modelled on the scale used by Vuoskoski et al. (2014), and the emotional content rating scale was modelled on the scale used by Vieillard et al. (2008). It was decided that the discrete emotion rating approach was suitable for the purposes of the current study, as the purpose of the emotion ratings was to test the validity of the discrete emotion labels assigned to the melodies. Furthermore, the discrete model avoided the assumption of the bipolarity of emotional valence, and, as participants were required to rate all four emotions for every performance, allowed for the identification of mixed or ambiguous emotions.

To make the process of rating expressivity easier for listeners, the meaning of expressivity was explained. Kendall & Carterette (1990) define musical expression as “the intended message generated by the performer and directed at the listener” (p. 135), and compare musical expressivity to the way in which an actor might speak their lines. For the current study, this comparison of musical expressivity with an actor’s spoken lines was embellished upon to create an explanation of expressivity which was given to participants. This explanation can be found in Appendix E.

Stimuli were presented in a semi-randomised order, which meant that the same melody would never be played twice in a row, and with 8 seconds of natural forest sound played between each stimulus, to minimise carry over effects from one stimuli to another.

Before beginning the actual experiment, participants listened to a clip of a professional recording of J.S Bach’s partitas for solo violin and set a comfortable volume level. This level then remained constant throughout the listening task. In addition, participants were given two practice rating tasks, to ensure they understood the procedure. For these ratings, the stimuli were also short clips taken from professional violin recordings of J.S Bach’s Partitas for solo violin; one in a major key and one in a minor key.After completing the rating procedure, participants filled out a short questionnaire providing demographic and musical background information. The entire procedure took between 45minutes and one hour.

4.2.6 Performer Questionnaire

After the stimuli creation process, performers were given a short questionnaire which asked four questions:

1. Briefly describe what your experience of the two movement conditions was like. Did you prefer one to the other and did they feel natural? Have you ever practised in these ways before?

2. Do you ever consider how you use your whole body in preparation for a performance or during performance?

3. Have you ever discussed expressive body movement, or use of the whole body while playing, with your violin teacher or in a masterclass?

4. Do you think awareness of the whole body when you play is important or not, and why?

The purpose of the questionnaire was to provide some qualitative insight into the performers' experience of the experimental process and the movement conditions, as well as their general opinions, attitudes, and experiences of whole-body movement during performance.

5 RESULTS

Results are given for the four analyses of this study; melody emotion validation through listener ratings of emotional content, analysis of listener ratings of expressivity, motion capture data analysis, and a report of performer questionnaire answers.

5.1 Listener Ratings

Due to a problem in the max patch which collected listener ratings, some ratings were not saved. Out of a total of 1920 ratings, 24 (1.25%) were not saved. Missing ratings were replaced with the mean rating of the appropriate variable rounded to the nearest whole number. Before discussing the results of this analysis, some issues with the data and parametric assumptions are discussed.

5.1.1 Parametric Assumptions

Two issues arose with the listener ratings data regarding parametric assumptions. Firstly, as listeners gave ratings on a 7-point scale, the data might be considered ordinal rather than continuous, thus violating the assumption of continuous data required for parametric tests (Field, 2009). Secondly, the distribution of several variables deviated significantly from a normal distribution when examined using the Shapiro-Wilks test of normality, thus violating the assumption of normally distributed data. As the assumption of normally distributed data essentially refers to the distribution of variable residuals, the residuals were also checked for normality using the Shapiro-Wilks test, and a substantial number of variable residuals also deviated significantly from normality. Due to the factorial design of the current study, using non-parametric tests seemed to be a poor option, so a review of relevant literature investigated the consequences of violating these parametric assumptions.

An overview of recent studies that have explored listener ratings of emotion in music using linear rating scales showed that parametric tests are commonly used for this type of data despite the possible problems with the assumption of continuous data (e.g Vieillard et al., 2008; Vuoskoski & Eerola, 2011; Vuoskoski, Thompson, Clarke, & Spence, 2014). This suggested that it may be acceptable to use analysis of variance (ANOVA) for the current analysis. Furthermore, research on rating scale data suggests that when a scale is presented as numbers with verbal anchorsat each end of the scale, participants will have a conception of that number scale that can be considered continuous, known as the *Spatial Numerical Association of Response Codes* (Harpe, 2015). In addition, studies using computer simulated data have shown that the ANOVA F-test is robust to deviations from normality and to the use of ordinal data, and that numerical rating scales with at least 5 points are acceptable for using parametric tests (Hsu & Feldt, 2018; Norman, 2010).

Considering the empirical evidence that ANOVA should be robust to abnormally distributed and rating scale data, the ubiquity of the use of ANOVA with rating scale data, and the factorial design of the study, it was deemed appropriate to use a factorial repeated measures ANOVA for this analysis.

5.1.2 Emotion Validation Results

The aim was to validate the perceived emotional content of the melodies used in the experiment by testing Hypothesis 1:

H1: Each melody will yield significantly higher emotion ratings for the intended emotion, compared to the other three emotion ratings.

Listeners gave a rating for each emotion category *sad*, *happy*, *tender* and *scary*, for each melody. A factorial, repeated measures ANOVA was performed on the emotion ratings with emotion (4), performer (3), and condition (2) entered as factors, and the eight melodies entered as separate measures. The main effect of emotion describes how the ratings differed depending on which emotion category was being rated. So, if a melody truly conveyed the intended emotion it was expected that there would be a significant main effect of emotion for that melody, and that pairwise comparisons would show the intended emotion to be rated as significantly higher than the other three emotions. This approach allowed for the identification of mixed emotions, and considered that if the intended emotion was the main emotion, then the emotion label would be considered valid for that melody.

5.1.3 Effects of emotion

Table 1 displays results for the main effect of emotionon emotion ratings for the eight melodies. Mauchley's test of sphericity showed that, for all melodies, sphericity was violated for effect of emotion, so the Greenhouse-Geisser corrected degrees of freedom are reported. A significant main effect of emotionwas found for all melodies, with large effect sizes (above .65) for all except the short-scary melody, whose effect size was small (.16).

TABLE 1: Mauchley's test of Sphericity and main effect of emotion category on emotion ratings from repeated measures factorial ANOVA

Mauchley's test of sphericity				Main effect of emotion			
Melody	χ^2	df	p	F	df	p	η^2
Melody A	17.401	5	<.05	186.30	2.23, 84.80	<.001	.75
Melody B	14.407	5	<.05	126.533	2.44, 92.74	<.001	.67
Melody C	45.023	5	<.001	203.279	2.13, 80.94	<.001	.78
Melody D	41.892	5	<.001	238.367	2.19, 83.30	<.001	.81
Melody E	26.093	5	<.001	12.079	2.03, 72.28	<.001	.16
Melody F	26.447	5	<.001	122.571	1.99, 75.71	<.001	.70
Melody G	12.871	5	<.05	117.097	2.48, 94.22	<.001	.68
Melody H	39.549	5	<.001	94.901	1.82, 69.22	<.001	.65

To further understand these findings, estimated marginal means were plotted and Bonferroni pairwise comparisons were conducted. Results showed that each melody was generally rated highest in the intended emotion category, apart from the short-tender melody, which received higher ratings for *sad* than for *tender*. Pairwise comparison results showed that the highest rated emotion was also the expected emotion, and was rated significantly higher, at $p < .05$, than all other emotions, for all melodies except the tender-short and scary-short melodies. For the tender-short melody, *tender* and *sad* ratings were not significantly different from each other, but were significantly higher than*happy* and*scary* ratings, at p<,001. For the scary-short melody, *scary* and *sad* emotions were not significantly different from each other, but were significantly higher than *happy* and *tender*, at p<.05.

These results are visualized in figures 1-4, which display estimated marginal means for each emotion rating within each melody.

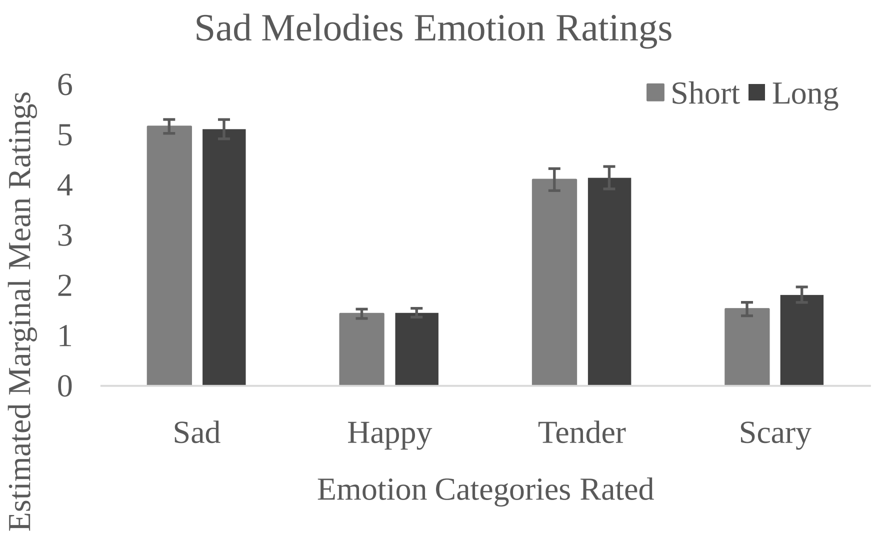

FIGURE 1. Estimated Marginal Means plot for effect of emotion category on emotion ratings for sad melodies. Error bars denote one standard deviation around the mean.

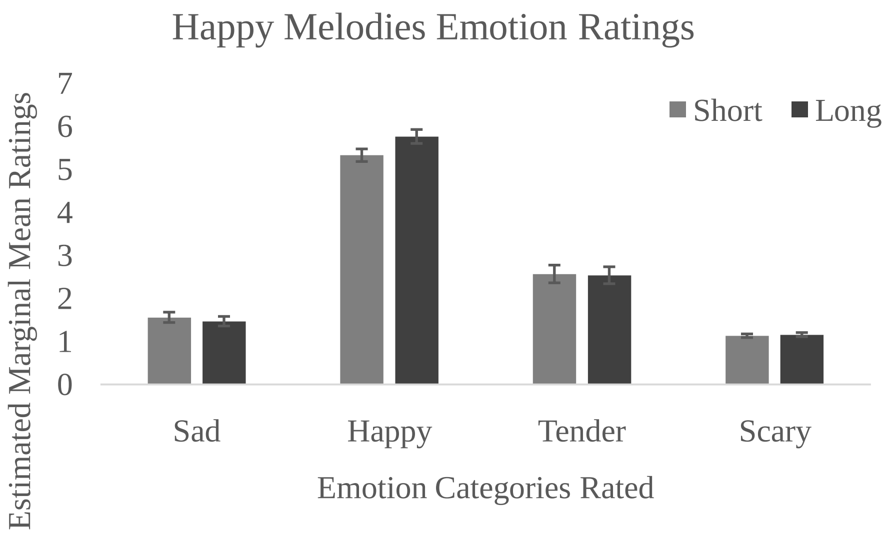

FIGURE 2. Estimated Marginal Means plot for effect of emotion category on emotion ratings for happy melodies. Error bars denote one standard deviation around the mean.

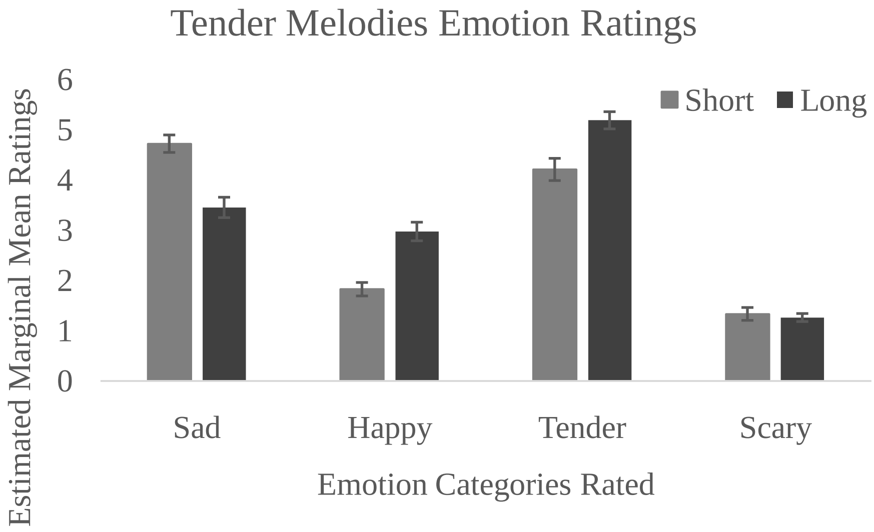

FIGURE 3: Estimated Marginal Means plot for effect of emotion category on emotion ratings for Tender melodies. Error bars denote one standard deviation around the mean.

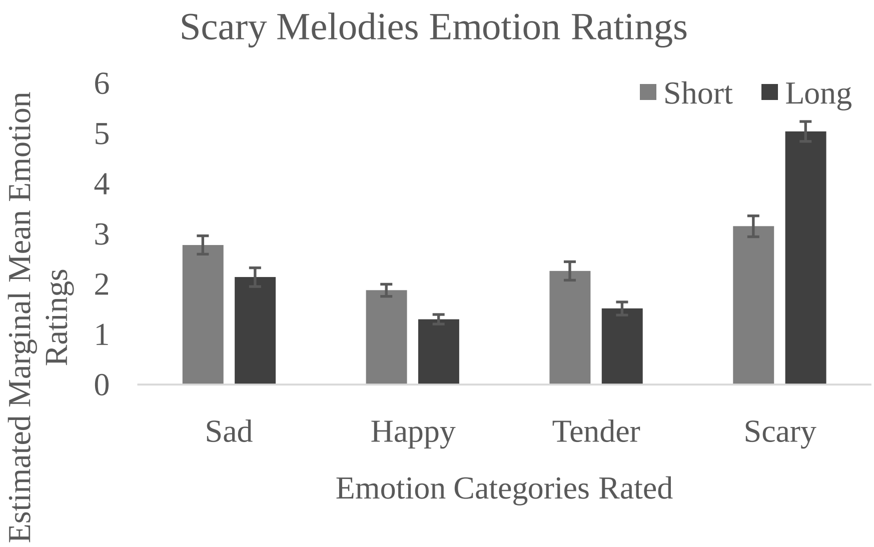

FIGURE 4.Estimated Marginal Means plot for effect of emotion category on emotion ratings for scary melodies. Error bars denote one standard deviation around the mean.

5.1.4 Effects of performer and condition

There was a significant main effect of performer on emotion rating for the short-happy melody, $F(2, 76) = 4.10$, $p = .02$, η^2=.02,the long-happy melody, $F(2, 76) = 6.17$, p =.003

η^2=.03, theshort-scary melody, $F(2, 76)$ =11.47, p <.001, η^2=.04, the long-scary melody, $F(2, 76)$ =7.14, p =.001 η^2=.04, the long-sadmelody, $F(2, 76)$ =8.67, p <. 001, η^2=.04 and the long-tender melody,$F(2, 76)$ = 7.01, p =.002 η^2 =.04.This means that the overall ratings of perceived emotion in the melodies were mediated by performer differences.

Bonferroni pairwise comparisons were conducted to show between which performers there were significant differences. The results are displayed in table 2.

TABLE 2: Bonferroni pairwise comparison results for effect of performer on emotion ratings

	Mean emotion ratings and standard errors			p values for significant pairwise comparisons		
Melody	Performer	Mean Rating	SE	P1* P2	P1* P3	P2*P3
Short-sad	P1	3.00	.11			
	P2	3.15	.11			
	P3	3.02	.10			
Long-sad	P1	3.31	.12	.004	.001	
	P2	3.05	.09			
	P3	3.02	.10			
Short-happy	P1	2.72	.09	.021		
	P2	2.54	.10			
	P3	2.68	.09			
Long-happy	P1	2.87	.08	.018	.012	
	P2	2.66	.09			
	P3	2.66	.09			
Short-tender	P1	3.05	.12			
	P2	3.01	.10			

	P3	3.01	.12			
Long-tender	P1	3.37	.10		.001	
	P2	3.23	.11			
	P3	3.06	.09			
Short-scary	P1	2.56	.11		.004	<.001
	P2	2.66	.12			
	P3	2.33	.11			
Long-scary	P1	2.64	.09			
	P2	2.47	.09			
	P3	2.38	.10			

Note: Left side displays mean expressivity ratings and standards errors for performers 1, 2, and 3, for each melody. Right side displays p values below .05 for pairwise comparisons. P values above .05 are not reported.

There was a significant effect of condition on emotion rating, $F(1, 38) = 4.66$, $p = .037$ $\eta^2 = .01$ for the long-sad melody only, with slightly higher ratings in the *visually expressive* condition ($M = 3.19$, $SE = .10$) than in the *immobile* condition ($M = 3.06$, $SE = .10$) meaning that for the long-sad melody, the *visually expressive* performance condition resulted in higher ratings of overall emotion conveyed, but for all other melodies, it did not.

5.1.5 Interaction effects

There was a significant interaction effect of performer and emotion for the short-happy melody, $F(6, 228) = 6.12$, $p < .001$ $\eta^2 = .05$, the long-happy melody, $F(6, 228) = 6.66$, $p < .001$ $\eta^2 = .07$ the short-scary melody, $F(6, 228) = 5.16$, $p < .001$ $\eta^2 = .05$ the long-scary melody, $F(6, 228) = 3.57$, $p = .002$ $\eta^2 = .03$ the long-sad melody, $F(6, 228) = 3.39$, $p = .003$ $\eta^2 = .03$ and the long-tender melody, $F(6, 228) = 4.72$, $p < .001$ $\eta^2 = .06$,meaning that the effect of emotion category on the ratings was mediated by individual performer differences. There was also a significant interaction of condition and emotion, $F(3, 114) = 3.41$, $p = .020$ $\eta^2 = .02$ for the short-happy melody only, meaning that the effect of emotion category on ratings was mediated by the performance condition. As the specific details of these interactions were not important to the research question, they were not explored further.

5.1.6 Expressivity Ratings Results

This analysis tested Hypothesis 2:

H2: There will be an effect of movement condition on listener ratings of audible expressivity. The direction of the effect is not predicted.

A factorial repeated measures ANOVA was conducted with listener ratings of expressivity as the dependent variable. Performance condition (2) and performer (3) were entered as factors, and the eight melodies were entered as separate measures. Results for each melody are discussed.

Results showed significant effects of condition for the short-sad melody,$F(1, 39) = 5.10$, $p = .03$, $\eta^2 = .03$, the short-happy melody, $F(1, 39) = 6.78$, $p = .013$, $\eta^2 = .02$ and the long-sad melody, $F(1, 39) = 7.70$, $p = .008$, $\eta^2 = .04$. For the short-sad melody, the *visually expressive* condition (M =5.00SE =.16)was rated higher than the *immobile* condition (M =4.68, SE =.13).For the long-sad melody, the *visually expressive* condition (M =5.36, SE =.14)was also rated higher than the *immobile* condition (M =4.97, SE = .18). For the long-happy melody, the *visually expressive* condition (M =4.80, SE = .22)was rated lower than the *immobile* condition (M =5.13, SE =.18).For all other melodies, there was no significant effect of condition.

For the effect of performer, Mauchely's test of sphericity was violated for the long-happy melody,χ^2 (2) = 6.59, p = .037, and for the long-scary melody, χ^2 (2) = 6.39, p = .041, so for those melodies the Greenhouse-Geisser corrected degrees of freedom are reported.There were significant effects of performer on expressivity ratings for all melodies, which are displayed is Table 3. Bonferroni pairwise comparisons showed that significant differences between performers were different for different melodies, however Performer 1 received the highest ratings of expressivity for six of the eight melodies. Mean emotion ratings, standard errors and pairwise comparison results are displayed in table 4.

TABLE 3: Main effects of performer on expressivity ratings for each melody

Melody	F-test	df	p	η^2
Short-sad	4.812	2	0.011	0.05
Long-sad	7.495	2	0.001	0.06
Short-happy	11.819	2	<.001	0.08
Long-happy	24.669	1.725	<.001	0.14
Short-tender	3.586	2	0.032	0.04
Long-tender	16.62	2	<.001	0.15
Short-scary	7.255	2	0.001	0.06
Long-scary	22.633	1.732	<.001	0.13

Note: Greenhouse-Geisser corrected degrees of freedom are reported for long-happy and long-scary melodies.

There was a significant interaction effect betweenperformer and condition,$F(2, 78) = 6.95$, $p = .002$, $\eta^2 = .06$ for Melody G only, showing that the effect of condition on expressivity ratings was different for each performer. As the specific details of these interactions were not important to the research question, they were not explored further.

TABLE 4: Bonferroni pairwise comparison results for effect of performer on expressivity ratings

	Mean emotion ratings and standard errors			p values for significant pairwise comparisons		
Melody	Performer	Mean rating	SE	P1* P2	P1* P3	P2*P3
Short-sad	P1	4.85	0.15	-	-	0.011
	P2	5.15	0.160			
	P3	4.52	0.20			
Long-sad	P1	5.50	0.15	0.035	<.001	-
	P2	5.13	0.16			
	P3	4.84	0.21			
Short-happy	P1	4.83	0.20	<.001	-	0.008
	P2	3.81	0.25			
	P3	4.41	0.24			
Long-happy	P1	5.75	0.18	<.001	<.001	-
	P2	4.43	0.24			
	P3	4.73	0.24			
Short-tender	P1	4.70	0.20	-	0.022	-
	P2	4.60	0.18			
	P3	4.13	0.23			
Long-tender	P1	5.65	0.18		<.001	<.001
	P2	5.69	0.17			
	P3	4.64	0.21			
Short-scary	P1	4.21	0.18	-	0.001	0.009
	P2	3.99	0.20			
	P3	3.53	0.20			
Long-scary	P1	5.30	0.20	0.001	<.001	0.001
	P2	4.71	0.24			
	P3	3.90	0.27			

*Note:*Left side displays mean expressivity ratings and standards errors for performers 1, 2, and 3, for each melody. Right side displays p values below .05 for pairwise comparisons. P values above .05 are not reported.

5.2 Motion capture data

5.2.1 Motion capture data pre-processing

Motion capture recordings were pre-processed inQualisys Track Manager software.First, markers were labelled as representing the correct body parts, and “bones” were added to join the labelled markers, thus creating a stick figure resembling the performer. A model for each performer was created to automate the labelling procedure, and models were checked and corrected for errors.Recordings were gap-filled in Qualisys Track manager and trimmed so that each clip began 0.5 seconds before the performance was judged to begin, and 0.5 seconds after the performance was judged to end. This trimming process was based on a subjective decision.

For Performer 1 and Performer 3, motion capture recordings were generally sucsessful, with little missing data. However, recordings of Performer 2 yielded a lot of missing markers. Subsequently, to allow a comparison of motion capture data across performers, the original 25 body markers were reduced to 16 markers. The 16 markers were converted to 11 joints using the Mocap Toolbox function *mcm2j* (Burger &Toiviainen, 2013). This process involved reducing the four head markers to one joint that represented the middle point of the head, reducing two diagonal hip markers to one hip joint representing the middle of the hips, and reducing the two left wrist markers to one wrist joint representing the middle of the wrist. Data was then exported from Qualisys Track Manager software in tab separated value (tsv) format, and imported to MATLAB where the Mocap Toolbox (Burger &Toiviainen, 2013) was used to extract movement features. It should be noted that the loss of data means that the current analysis is limited. For example, the right shoulder was included in the analysis, but the left shoulder was not, while the left elbow and left wrist were included, but the right elbow and right wrist were not.

5.2.2 Motion Capture Analysis Results

The purpose of the motion capture data was simply to describe how the experimental performance conditions affected the three performers in this study, and to relate those findings to the results from the listening experiment. Therefore, inferential statistical tests were not carried out, but descriptive statistics were employed. It should be emphasised that no intention is made to generalise about how the performance conditions affected the performers. Therefore, this analysis tested Hypothesis 3, only in the context of the current study:

H3: The *visually expressive* condition will result in a greater amount of performer bodily movement than the *immobile* condition.

Using the Mocap Toolbox (Burger & Toivianinen, 2013), the movement features cumulative distance, velocity, acceleration, and jerk were estimated from themotion data, for each joint. Cumulative distance, calculated using the function *mcdist*was considered to be a measure of the overall amount of movement, and was the main feature of interest for this study. The other features were included as exploratory measures. The *mcdist* function gives values of the cumulative distance travelled by each marker for each frame, so as a measure of the total distance travelled, the value for the final frame measured was taken. Velocity, acceleration and jerk were calculated using the function *mctimeder,* with velocity representing the first time derivative, acceleration representing the second time derivative, and jerk representing the third time derivative. As acceleration represents change in velocity over time, jerk represents chage in acceleration over time, and can be thought of an an inverse measure of smoothness of movement. For example, bow movements when playing *legato* would yield lower jerkiness than when playing *staccato.*The default parameters using a Butterworth smoothing filter were applied. The function *mcnorm* was used to calculate the Euclidean norm of each vector, and the function *mcmean*was used to give a mean value across all frames. This resulted in one value for each movement feature for each joint, for each participant. Cumulative distance is measured in metres (m), velocity in metres per second (m/s), acceleration in m/s^2, and jerk in m/s^3.

As performance length was intentionally not controlled, to allow performers to make use of expressive timing, movement feature values were divided by the length of the performance, in seconds, to give a value of that feature per second. A whole-body value for each movement feature was calculated for each performer, by summing the values for each joint, resulting in one value for each performance. A total value for each performer, per condition was calculated by summing each whole-body value for all performances in the *immobile* condition, then for all performances in the *visually expressive* condition.

To test Hypothesis 3, cumulative distance was used as a measure of amount of movement. The differences between the two conditions, for each performer, are displayed in figure 4.

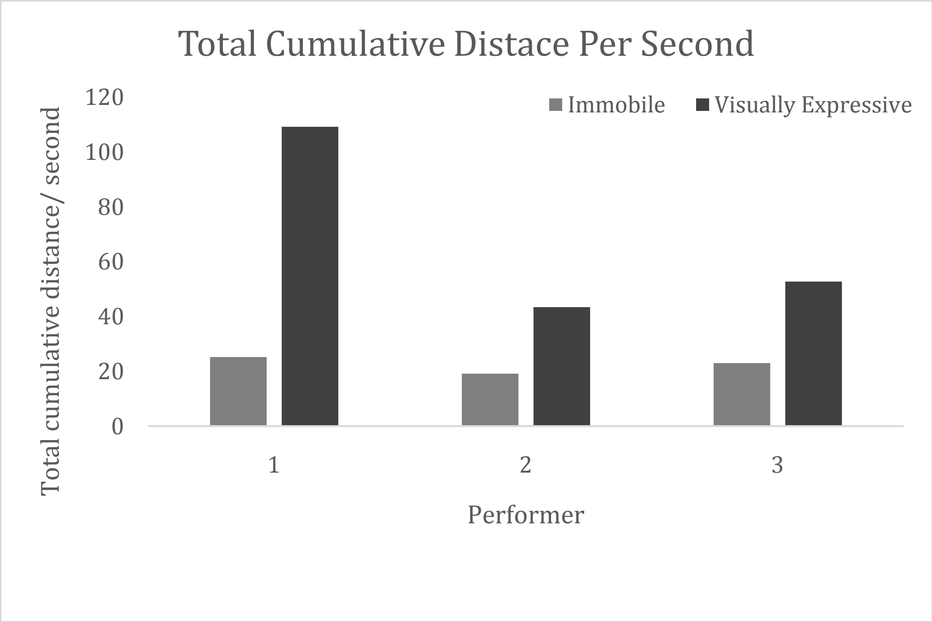

FIGURE 4. Total cumulative distance in metres (m), per second for each condition and each performer.

From figure 4, it can be seen that the cumulative distance was considerably higher in the *visually expressive* condition for all three performers, although it should be noted thatdifferent musicians may yield different results.

Next, a more exploratory approach was taken to see how the performance conditions affected the other movement features for each performer. The results are displayed in figures 5 - 7.

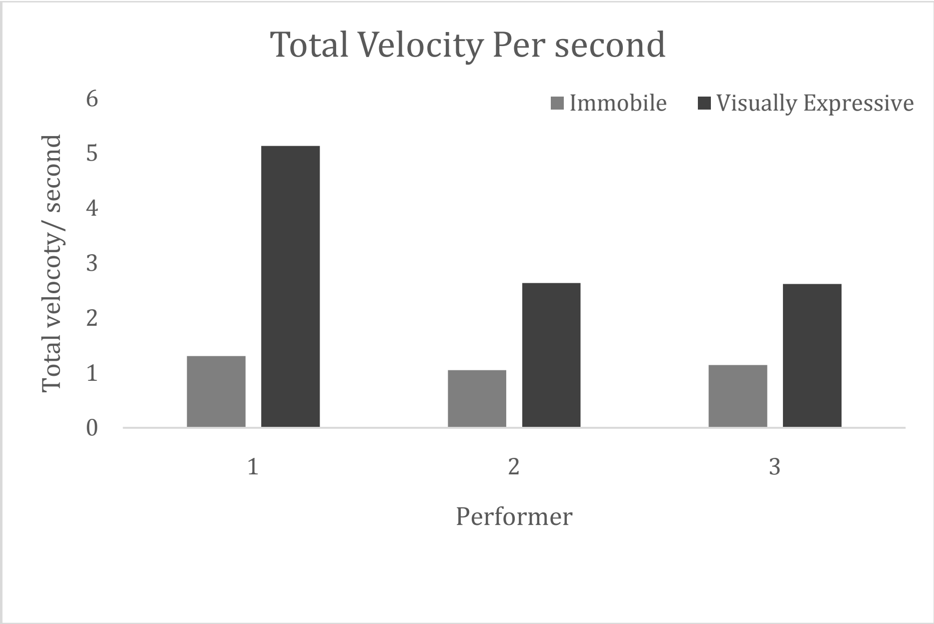

FIGURE 5. Total cumulative velocity, in m/s, per second for each condition and each performer.

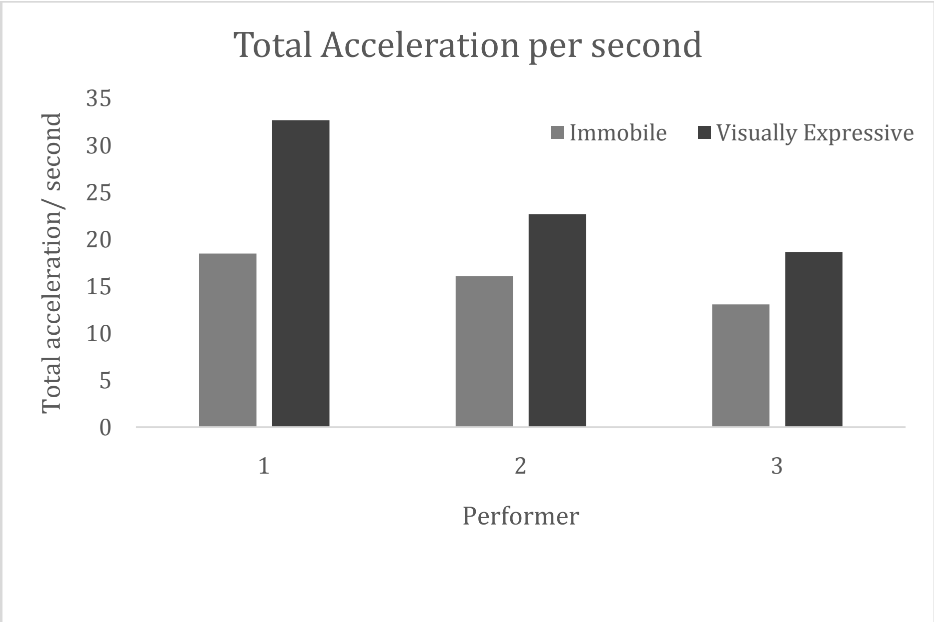

FIGURE 6. Total cumulative distance in m/s^2, per second for each condition and each performer.

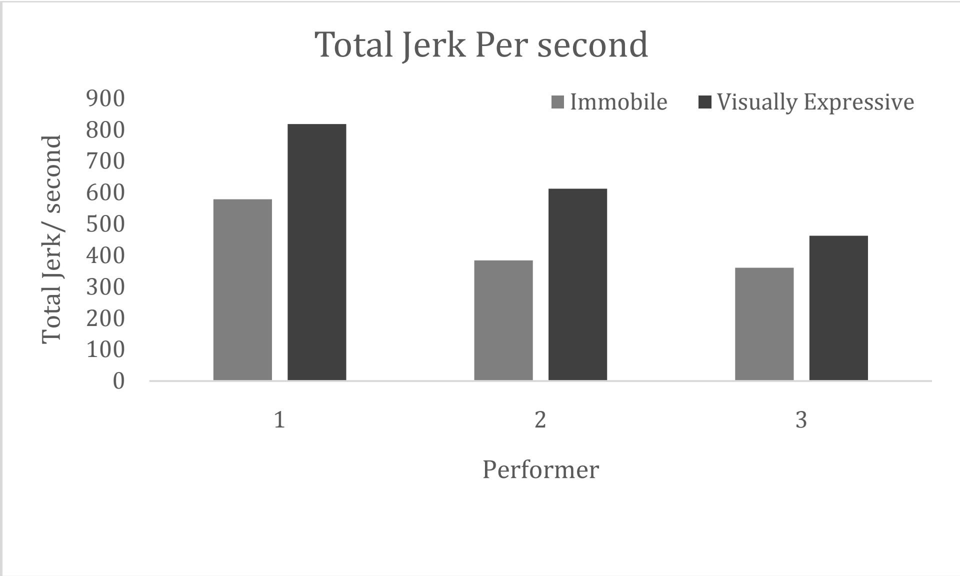

Figure 7. Total jerk in m/s^3 per second for each performer and each performance condition.

Figures 5 - 7showthat for each performer, every movement feature was considerably higher in the *visually expressive* performances compared with the *immobile* performances. It can also be seen that Performer 1 exhibited considerably higher values for all movement features, compared to Performers 2 and 3. Performer 1 also exhibited the largest difference between the two conditions for all movement features, compared to Performers 2 and 3.

Next, an exploratory examination of the differences between joints within each performer was carried out. This time, instead of using the whole-body values previously calculated, a value was summed for each joint across all performances in the *visually expressive* condition, and for all performances in the *immobile* condition. The difference between each condition was then calculated by subtracting the value for the *immobile* condition from the *visually expressive* condition. Table 5 displays the difference in cumulative distance between the two conditions, for each joint, within each performer. Positive values indicate more movement in the *visually expressive* condition, and negative values indicate more movement in the *immobile* condition.

TABLE 5: The difference in cumulative distance between *visually expressive* and *immobile* conditions, for each performer's 11 joints.

Joint	Performer 1	Performer 2	Performer 3
Head	1035.27**	477.38*	470.30*
Right Shoulder	704.42	320.73	334.33
Left Elbow	945.36	423.59***	401.18
Left Wrist	1101.43*	-102.66	410.37***
Hips	1018.28***	432.49**	416.90**
Right Knee	595.34	175.42	236.77
Left Knee	647.01	205.08	203.23
Right Ankle	316.38	60.21	68.67
Left Ankle	178.74	71.28	59.53
Right Toe	-1.30	71.16	12.11
Left Toe	195.63	-1.05	7.69

*Highest value, **Second highest value, *** Third highest value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive*.Measurements are in metres (m), per second.

Table 5 shows that, for all performers, the joint with the highest difference in cumulative distance between the movement conditions was the head joint, and the second highest was the hip joint. For Performer 1 and Performer 3, the third highest value came from the left wrist and for Performer 2 it came from the left elbow. Table 5 also shows that almost all joints had a positive difference, showing that they moved more in the *visually expressive* condition. However, for Performer 2 the left elbow shows a positive difference while the left wrist shows a negative difference. This analysis was repeated for the movement features velocity, acceleration and jerk, and the results can be found in Appendix C. The results are summarised in table 6, which shows the three joints that exhibited the highest three difference values for each performer.

TABLE 6: Top three joints exhibiting the biggest change in movement features between the *visually expressive* and *immobile*conditions, for each performer.

Movement feature	Performer 1	Performer 2	Performer 3
Cumulative Distance	Head, hips, left wrist	Head, hips, left elbow	Head, hips, left wrist
Velocity	Head, right shoulder, left elbow	Head, right shoulder, left elbow	Head, right shoulder, left wrist
Acceleration	Head, right knee, left knee	Head, left elbow, left knee	Head, left elbow, left wrist
Jerk	Right knee, left knee, left toe	Left elbow, left wrist, left toe	Left elbow, left wrist, left knee

Finally, the difference in movement features between conditions was examined for each melody. This time, the whole-body values for each movement feature were summed, for each performer, to give an overall value for each melody. The aim was to see if the melodies which resulted in statistically significant changes to expressivity ratings between conditions in the listening experiment, also resulted in the biggest changes to movement features between the conditions, as this may have explained the experimental effect. The results for cumulative distance are displayed in table 7, and the results for velocity, acceleration and jerk can be found in Appendix C.

TABLE 7: Difference in cumulative distance between *visually expressive* and *immobile* conditions for each melody for each performer, and in total.

Melody	Performer 1	Performer 2	Performer 3	Total
Short-sad	252.98	574.04	284.96	1111.99
Long-sad	283.50	594.10	454.63	1332.23
Short-happy	787.61	351.99	229.42	1369.01
Long-happy	606.60	572.76	456.55	1635.91
Short-scary	779.58	1007.64	13.36	1800.59

Long-scary	632.69	913.57	293.43	1839.69 ***
Short-tender	633.47	786.76	492.21	1912.43 **
Long-tender	840.82	818.50	396.51	2055.83 *

* Highest total value, ** Second highest total value, *** Third highest total value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in metres (m), per second.

For all melodies, and all movement featuresthere was a positive difference, meaning that for all melodies movement was generally greater, faster, more accelerated and jerkier, in the *visually expressive* condition than the *immobile*. The three melodies which resulted in significant changes to perceived expressivity did not appear as the top three melodies for the changes in movement features between condition.

5.3 Performer questionnaire data

After the performance process, the performers were issued short questionnaires about their experience during the experiment. All performers reported that they preferred the *visually expressive* condition to the *immobile*, and made some reference to the *immobile* condition being "unnatural", or the *visually expressive* condition being "more natural". Performer 2 and Performer 3 reported that they had never performed in an "immobile" way before, and Performer 1 thought that under the *immobile* condition he was not able to achieve the correct expression. Performer 3 reported finding it difficult to separate functional from expressive movements, and felt less in control of her sound when playing under the *immobile* condition.

The performers showed quite different attitudes towards body movement when performing. Performer 1 reported rarely thinking about whole-body movement. Performer 2 reported having some awareness of body movement while playing, mainly focusing on breathing. Performer 3 was very conscious of utilizing the whole-body to achieve an optimal performance. Performer 3 also commented that she felt body movement was essential for communication with other musicians and with the audience. Performer 1 had no experience of being taught expressive body movement, Performer 2 had a little experience in this, and Performer 3 had been taught to use her body “to emphasise dynamics and phrasing”. When asked if they thought that awareness of the whole-body was important while performing, each performer had a different answer. While Performer 1 thought that bodily awareness was important, he also emphasized that movements should not be over-rehearsed as they may appear unnatural. Performer 2 believed whole-body movement would have a big effect on the sound produced during performance, and seemed to equate *immobile* playing with inexpressive playing. Performer 3 also believed body movement to be important, and stressed that moving more would help the performer to learn, and to enjoy performing.

6 DISCUSSION

This study explored the role of music performer bodily gesture in creating expressive sounding music performances. Three violinists performed eight melodies, which conveyed the emotions *happy, sad, tender and scary,* with two melodies for each emotion. Each melody was performed under two performance conditions; *immobile* (aiming to be as still as possible) and *visually expressive* (focusing on a visually expressive performance). The performances were recorded through audio and motion capture technology, and a listening experiment was carried out in which participants rated the expressivity and emotional content of the performances, as perceived through sound alone, not visuals. Motion capture data showed that under the *visually expressive* condition, performers exhibited more movement, faster movement, more accelerated movement and jerkier movement, and that the biggest changes between movement conditions took place in the head, hips and left arm. Analysis of listener ratings showed that performance condition affected ratings of expressivity only for the two sad melodies, and the short-happy melody. For all other melodies, performance condition did not significantly affect listener ratings of expressivity. Performer questionnaires showed that all three performers preferred playing under the *visually expressive* condition, and attitudes towards body movement differed among the performers. Results, implications and limitations are discussed.

6.1 Emotion ratings

The purpose of this analysis was to test the validity of the emotion labels given to the melodies used in the experiment, by testing Hypothesis 1 that each melody would yield significantly higher emotion ratings for the intended emotion, compared to the other 3 emotion ratings. The melodies were each labelled as one of the emotions*sad, happy, tender* or *scary*, with one short, and one long melody for each emotion category, totalling eight melodies. Participants rated each melody on how much sadness, happiness, tenderness and scariness was conveyed, on a 7-point linear scale. A repeated measures ANOVA with emotion, performer and condition explored the effects of emotion category, performer and performance movement condition on listeners' ratings for each melody. Results showed the presence of perceived mixed emotions in all melodies in that there was a rating of higher than

1 for more than 1 emotion in every melody. This is consistent with previous evidence that music elicits mixed emotional reactions (e.g Hunter, Schellenberg, &Schimmack, 2010). Results also showed thatfor all melodies except the short-tender melody and short-scary melody, the intended emotion was rated significantly higher than all other emotions. Therefore, Hypothesis 1 was accepted for 6 of the 8 melodies, and the emotion labels given to these melodies can be considered valid. This means that these melodies would be suitable for use in future studies wishing to convey those emotions. The short-sad melody was shown to convey mainly equal amounts of sadness and tenderness, while the short-scary melody, was shown to convey mainly equal amounts of scariness and sadness. The main effect of emotion category on the rating given was large for all melodies except the short-scary melody, which indicates that for this melody the difference between ratings of the four emotions was small, while for the others it was large. The short-scary melody can therefore be considered the most emotionally ambiguous, with the short-tender melody can be considered the second most emotionally ambiguous.

This finding, that both of the *happy* melodies and both of the *sad* melodies were unambiguously recognised, is in line with previous research that the basic emotions of *happy, sad, angry* and *fearful* are the most clearly conveyed in music (Gabrielsson & Juslin, 1996; Hailstone et al., 2009; Laukka & Gabrielsson, 2000) and that happiness and sadness may be the easiest emotions to communicate through music (Juslin & Laukka, 2004). Tender and scary are not basic emotions, and may have caused some confusion as emotion labels. Although tenderness appears as one of the nine musically induced emotions in the GEMS model of musically induced emotions (Zentner et al., 2008), and has been frequently used in music and emotion studies before (Eerola, &Vuoskoski, 2013), Juslin (1997) found that compared to *happy, sad* and *fearful* acoustic emotion profiles*, tender* acoustic profiles were the least accurately decoded by listeners. Thus, tender may or may not be a problematic emotion label. Alternative labelling of *angry*as *scary,* and *tender* as *loving*might have yielded better results.In addition, it should be noted that all long melodies were unambiguously recognised for emotional content, implying that emotion recognition was easier in the longer melodies.

The main effect of performer showed how the different musicians influenced how high or low the emotion ratings were in general, across all emotion categories. This can be thought of as a measure of how expressive the performer was, without reference to a particular emotion category, and can provide a comparisonfor the expressivity ratings. Results showed that for the short-sad and short-tender melodies there was no significant difference in emotion rating between performers. For the short-scary and long-tender melodies, Performers 1 and 2 received significantly higher emotion ratings than Performer 3, and for the short-happy, long-happy, long-scary and melodies long-sad melodies performer one received significantly higher ratings than performers two and three. Consistent with previous findings that the music performer, as well as the structural features of the music, influences the emotion conveyed, (Juslin, 2000) these results suggest that the performers influenced the strength of the emotional messages in the music, and that overall, Performer 1 conveyed the strongest emotions in their playing. These findings will be discussed in relation to the expressivity ratings in Section 6.2.

There was a main effect of condition on emotion ratings, only for the long-sad melody, with slightly higher ratings in the *visually expressive* condition, and a small effect size. This shows that for the long-sad melody, the *immobile* condition produced slightly lower ratings of emotion than the *visually expressive* condition. For all other melodies, the performance condition did not affect the emotion ratings, showing that the emotional content of the melody stayed constant across performance conditions. Again, these findings will be discussed in relation to the expressivity ratings in Section 6.2.

Significant interaction effects of performer and emotion were shown for all melodies except the short-tender and short-sad melodies. This means that the effect of emotion category on ratings was mediated by performer differences, essentially showing that the performers had an influence on the perceived emotional content of the melodies. Again, this is consistent with the findings of Juslin (2000) that performers can alter the emotional content of a melody through acoustic cues in their performance. The details of these interactions would likely reflect individual performer differences and as this was not important to the research questions, the interactions were not explored further.

Finally, there was a significant interaction between condition and emotion category for the long-sad melody only. This interaction, although it was only of small effect size, shows that the performance condition affected the perceived emotional content of the melody. This exploratory finding is highly relevant to the research question as it implies that the performers' approach to body movement changed some expressive aspect of the way this melody was perceived. Although this finding does not directly support Hypothesis 2, it does inform the research question, in that use of expressive body gesture did seem to have an influence on the emotional quality of the performances.

6.2 Expressivity Ratings

Participants rated each performance for expressivity on a 7-point scale from 'not expressive at all' to 'very expressive'. The aim of this analysis was to test Hypothesis 2, that the movement conditions undergone by the performer would affect listener ratings of expressivity. A factorial repeated measures ANOVA was carried out, entering performance condition and performer as factors, and each melody as a repeated measure. Hypothesis 2 was accepted for the sad-short, happy-long and sad-long melodies only. For the other melodies, the null hypothesis, that performance condition would not affect listener ratings of expressivity was accepted.

The two sad melodies both showed significantly lower ratings of expressivity in the *immobile* condition compared to the *visually expressive* condition with very small effect size.For the long-happy melody, ratings were significantly higher in the *immobile* condition compared to the *visually expressive* condition, again with a very small effect size.The experimental effect for the long-happy melody could be explained by the technical demands of the melody, as this was probably the most technically demanding performance, requiring fast, staccato playing and at least one left-hand position shift. Expressive movements during staccato playing can create technical difficulties due to the changing position of the violin, and this could be the reason that this melody was rated as less expressive in the *visually expressive* condition. Therefore, these results suggest that when a violin melody includes fast, staccato playing, suppressing expressive gesture can help to improve expressivity, through reducing the technical demands of the playing. This effect may have been a result of the level of playing among the violinists who took part in this study, and the fact that the violinists did not practise the melodies beforehand, despite instructions to do so. However, this finding is a good example of how technical and expressive aspects of musical performance can intertwine

(Auer, 1960; Sloboda, 1996), and the importance of considering issues of instrument technique when studying expressive playing.

As both sad melodies exhibited significantly lower ratings in the *immobile* condition compared to the *visually expressive* condition, it can be concluded that, for the 3 performers who took part in this study, the audible expressivity of their performances of sad music was heightened when the performers made use of expressive body movement, compared to when they inhibited body movement. These results suggest that violinists playing sad, slow, legato music can increase the audible expressivity of their playing by focusing on a *visually expressive* performance. However, due to the very small sample size of performers, replication of these results with different performers would be requiredin order togeneralise this finding. In relation to Sloboda's (1996) conception of how performer's use knowledge of body motion to create expressive playing, and Juslin's (2003) GERM model of musical expression, this finding is very relevant as it suggests that bodily gesture while performing can be important to the performer's cognitive process of creating expressive sounding sad music. However, it should be noted that the effect size was very small, and the specificity of this effect to sad music only is unexpected and unexplained.

In relation to previous research on the effects of the *immobile* condition, the results for the *happy, tender and scary* melodies support the findings of Thompson and Luck (2012) that performers were able to play at a normal level of expressivity under the *immobile* condition, while the results for the *sad* melodies support the findings of Wanderley et al. (2005) that the *immobile* condition impaired performers' expressive playing ability. Thus, these findings do not clarify the effects of the *immobile* condition, but illuminate further the complexity of this issue. Further research is needed, to explore these issues in different performers, different instrumentalists, and different types of music.

For the long-sad melody, there was also a significant interaction between effects of condition and performer, meaning that the effect of condition was different for each performer. This finding shows that individual performer differences are important in this effect, again highlighting the need for these results to be replicated with different performers, before any conclusions could be drawn about the effect of the movement condition on violinists in general.Such research would be advised by the present findings to focus on using sad, slow, legato music in a minor key.

Additionally, there were significant main effects of performer on expressivity ratings for all melodies, with Performer 1 as the most expressive performer, overall. This result can be compared with the emotion ratings results, which also showed that Performer 1's performances received the highest perceived emotion ratings. Thus, both ratings indicate that performer one can be considered the most expressive performer.

Similarly, the effects of condition on both expressivity and emotion ratings can be compared. The long-sad melody was the only melody to show a significant effect of condition on emotion ratings, but for expressivity ratings, there was also a significant effect of condition for the short-sad and long-happy melodies. As the long-sad melody also exhibited the biggest effect size for effect of condition on expressivity ratings, the rating of expressivity may have been a more sensitive measure than the ratings of emotional content for detecting changes in a performer's expressive playing. Overall the emotion ratings show a similar pattern to the expressivity ratings, suggesting that the two ratings are connected, and suggesting that the use of expressivity ratings were reliable.

6.3 Motion CaptureData

The purpose of the motion capture analysis was, firstly, to test Hypothesis 3 that performers would move more in the *visually expressive* performance condition, and less in the *immobile* condition. As only three performers were included in the study, it was not possible to conduct inferential statistics, and descriptive statistics were considered adequate for the purposes of relating peformers' movement characteristics to the listening experiment results. Descriptive statistical analysis of the cumulative distance of body markers confirmed that performers moved considerably more in the *visually expressive* condition compared to the *immobile* condition. Further movement features of velocity, acceleration and jerk were also explored, and descriptive statistics showed that performers' movements were faster, more accelerated and jerkier in the *visually expressive* condition.

These descriptive statistics also showed that Performer 1 exhibited movements that were greater, faster, more accelerated and jerkier than Performers 2 and 3, who exhibited similar amounts of movement to each other, and that Performer 1 showed the biggest differences in all movement features between conditions. This is interesting, as Performer 1 was also the most expressive performer in the listening experiment. While these results cannot suggest causation between movement characteristics and expressive sounding music, it could provide a pointer for future research, in posing the question ‘do performers who naturally move more, produce higher ratings of expressivity through sound?’

The next aim was to locate where in the performers’ bodies the biggest changes in movement between the conditions occurred. Results showed differences between performers, but some trends remained constant across all three performers. For example, the head exhibited the biggest change between conditions for amount, velocity, and acceleration of movement. More broadly, for all performers, amount of movement was most changed between the conditions in the head, hips and left arm (wrist and elbow). Changes in velocity were seen mainly in the head, right shoulder and left elbow, and for changes to acceleration and jerk there was more variation between performers, but the biggest changes seemed to occur lower in the body, for example in the knees and toes. Due to the small number of performers, and the constraints of descriptive statistics only, these results cannot be generalized to other performances. In addition, these findings are limited by the fact that not all body parts were included in the analysis due to missing data. However, these findings can inform future research that aims to locate where in the body violinists mostly show visually expressive gesture, in that for these performances, the head, hips and left arm seemed to play an important role in creating visually expressive body movements.

In addition, these results can be considered in light of previous findings that piano players showed expressive gesture mainly in the parts of their bodies which they were most free to move, i.e the head, neck and shoulders. It is difficult to compare these results, as it is not easy to specify which parts of the body are most free to move for a violinist. It could be argued that violinists are just as free to move their legs and feet as they are to move their head and hips. However, it is interesting that in both the current study and Thompson and Luck (2012) the head was implicated as showing high amounts of expressive movement.

Furthermore, the findings here that differences in amount and speed of movement between conditions was mainly in the upper part of the body, but that differences between conditions in acceleration and jerkiness were more in the legs and ankles, are partially consistent with previous findings. For example, Van Zijl and Luck (2013a), found that movement conditions did not significantly affect amount of movement in violinists' legs, but did affect their upper bodies, and that acceleration and jerkiness of violinists' knees were significantly affected by performance condition. Therefore, the current findings support these previous findings that violinists increase amount of expressive movement mainly through the upper body, and that when moving more expressively, movements in the legs become more accelerated and jerkier, though not bigger or greater. Again, more research is needed to generalize these findings, but the results can inform future research.

An interesting observation was made with regards to vibrato usage. For Performer 2, the motion capture data showed that while the left elbow exhibited a greater amount of movement in the *visually expressive* condition, the left wrist exhibited a lesser amount of movement. This is interesting, as one would assume that any extra movement made by the left elbow would also result in more movement in the left wrist. One possible explanation for this could be that this performer played with more vibrato in the *immobile*condition, as wrist vibrato would result in higher amount of wrist movement without affecting the amount of elbow movement. It is possible then, that this performer's experience of playing in the *immobile* condition brought their attention to use of vibrato, perhaps through increased attention to sound, or to the body. This explanation is merely speculative, and was not reflected in Performer 2's questionnaire data. Future studies could explore the performer's experience of the *immobile* condition, and changes to vibrato usage under different movement conditions.

The third and final aim, was to explore in which melodies the biggest changes in movement between conditions occurred, across all performers. The aim was to see if the 3 melodieswhich resulted in statistically significant changes to perceived expressivity during the listening experiment might have also resulted in the biggest changes to movement features. This was not found to be true, showing that the observed effect of performance condition in the *sad* melodies was not caused by bigger movement differences in the *sad* melodies.This implies that the *sad* melodies were more sensitive to the effects of condition than the other melodies. It is also possible that the expressivity results could be explained by changes in movement that this motion analysis was not able to capture, or by movement changes to the right arm and bow, which were not included in this analysis due to missing data. The latter would make some sense, as the right arm is directly involved in sound production. Despite such limitations of this descriptive analysis, the findings suggest that the expressive sound of the *sad* melodies was more sensitive to changes in body motion, than in the other melodies.

6.4 Performer Questionnaires

The performer questionnaires provided important insight into the violinists’ experiences of performing in relation to whole-body movement. The importance of individual differences became clear, as performers reported having different opinions on, and experiences of whole-body movement while performing. For example, Performer 2 centred her ideas of body movement around breathing, which was likely related to the fact that she was a principal study singer, whilethe other two performers did not mention breathing. Thisfinding highlights how the experience of singing can influence a performer’s instrumental playing. The influence of the principal study teacher also seemed to be strong among these performers in their attitudes towards whole-body movement. Performer 1 had never discussed whole-body movement in violin lessons, and had never thought about it much himself. He also suggested that paying too much attention to body movement could be a bad thing, by making performances seem unnatural, an opinion which was reminiscent of Galamian (2013) and Mozart (1985). Performer 2 had only discussed whole-body movement with her teacher in relation to breathing, and this was how she continued to view the issue. Performer 3 expressed the opinion that whole-body movement was very important for musical communication, which reflected what she had been taught: to use the body to show dynamics and phrasing. It is interesting that Performer 1 gave the least thought to body movement in his playing, but was the performer who moved most, was most affected by the movement conditions and received the highest ratings of expressivity, even though Performer 3 had been explicitly taught to use expressive body movement. One explanation for this could be that Performer 1 had implicitly learned to use body movement for expressive playing through ‘aural modelling’ (Laukka, 2004; Woody, 2000), and that this implicit learning was more effective in producing expressive sounding performances than Performer 3’s explicit learning. Future studies could explore this further.

Finally, all performers reported finding the *immobile* condition difficult, and preferred the *visually expressive* condition. Firstly, this suggests that the *visually expressive* condition is suitable for use in future experiments, as it made sense to performers and there were no problems adopting this condition. Secondly, that performers disliked the *immobile* condition is consistent with previous findings of Thompson and Luck (2012). Performers 1 and 2 also thought that the *immobile* condition hampered their ability to play expressively, and Performer 3 thought that she had less control over sound production under the *immobile* condition. It is interesting that the performers had such strong opinions about the influence of the *immobile* condition on their playing, as the results of the listening experiment showed that the *immobile* condition only significantly impaired expressivity in 2 melodies, and even then, the effects were very small. The performers' experiences then, did not align very well with the listeners' perceptions. Further studies could explore how different movement approaches to performance may affect the performer's enjoyment.

6.5 Limitations

Several limitations to this study should be noted. Firstly, the findings of this study are applicable only to western classical music violinists, and similar studies exploring other genres and instrumentalists would most likely yield different results. Next, the effects of performance movement conditions cannot be generalised to all western classical musicians, but are specific to the three violinists used here. The results can, however, inform future research which might aim to replicate these findings in a bigger sample of musicians.

Missing data wasa problem for both motion capture data and listener ratings. This was particularly unfortunate in the case of the motion capture data, as many markers were lost, meaning that the analysis could not include movements of the right arm or bow, which are important for observing sound producing gestures.

Next, there were some problems with the randomisation of melodies for the stimuli creation process. Performers played all melodies in one condition, then all melodies in the other condition, and while the order of conditions was swapped for each performer, only three performers were used in the listening experiment, meaning that the condition ordering was not equally balanced. In addition, the order of the melodies within each condition was not randomised. The 3 melodies which yielded significant changes to expressivity in the listening experiment were also the first 3 melodies in the performance order, which could mean that as performers proceeded through the melodies, they became more accustomed to the performance condition and it affected them less. In retrospect, a way of solving this would have been to randomise the order of the melodies and the condition for each melody, meaning that the performer had to regularly switch between the 2 conditions.

Finally, there were some problems with the data for the listening experiment. Firstly, the sample was quite small (n=40), the data was not normally distributed, and it could be argued that the data should have been considered ordinal rather than normal. This resulted in a violation of the parametric assumption of normally distributed data, and an arguable violation of the assumption of interval data. While use of ANOVA despite these problems was rationalised and backed up by research, this situation was not ideal, and it could be argued that the validity of the effect sizes and post-hoc tests is questionable. Secondly, the sample of listeners was imbalanced in terms of nationality, and mainly consisted of university students in their twenties. Thus, generalisation from this sample to the wider population is problematic. Future studies aiming to replicate these results, should collect a much larger sample, of balanced nationalities, and could measure ratings on a continuous line instead of a seven-point scale, to lessen the problem of ordinal data.

6.6 Conclusions

The results of this study contribute empirical findings to the theoretical discussion of how whole-body movement is involved in creating expressive sounding music. In this experiment, it was shown that when performers focused on increasing expressive gesture, compared to inhibiting it, the perceived audible expressivity of their performance increased, but only when they were playing *sad* melodies. For *happy*, *tender*, and *scary* melodies there was no effect of condition on perceived expressivity, apart from one of the *happy* melodies, which was particularly technically difficult, and which yielded higher ratings of perceived expressivity when expressive gesture was suppressed. These results highlight the complexity of this issue, suggesting that the role of expressive body movement in shaping expressive sound depends on the emotion being conveyed, and demonstrating how the expressive and technical abilities of a musician intertwine (Auer, 1960; Sloboda, 1996). These results offer some support for

Juslin's (2003) psychological model of expressivity in music. This model asserts that an important aspect of expressivity in music is knowledge of biological motion, which these findings support, by showing that during performance, a change in approach to expressive body movement can affect the perceived expressivity of the sound produced.Precisely why the effect was only present in sad music is not known, and warrants further study.

These findings can also add to previous inconclusive findings about how the *immobile* condition affects performers. On the one hand, for six of the eight melodies in this experiment, the *immobile* condition did not impair perceived expressivity, but on the other hand, for the two *sad* melodies, it did. In addition, for one performer, motion capture data suggested that use of vibrato (an expressive device) was higher in the *immobile* condition.The use of the *immobile* performance condition is very rare in current research, and more research is needed to explore these effects further. However, this study was consistent with previous findings that performers found the *immobile* condition difficult, and preferred not to play that way (Wanderley et al., 2005; Thompson & Luck, 2012).

This study also yielded exploratory findings about the effects of these different approaches to body movement during performance, which raise some questions for future study. Firstly, it was shown that the performance movement conditions also significantly affected the perceived emotional content of the melodies, raising the question of whether different approaches to body movement are more suited to expression of different emotions. Secondly, individual differences between the performers seemed to interact with the overall effect of performance condition, suggesting that further research is needed to explore how individual performers respond differently to movement approaches and what factors might influence these responses. Thirdly, it was observed in this study that the performer who moved the most, and exhibited the biggest difference in movement between the two performance conditions, was also rated by listeners as the most expressive performer. This finding suggests that future studies should explore the link between performers who naturally move more, and perceptions of audible expressivity. In relation to this, that same performer, who moved the most and produced the most expressive sounding playing, also reported giving the least thought to body movement during performance in general, and expressed the view that it was important that body movements arose naturally from a performer. These views about the naturalness of body movement are reflected in pedagogical writing (Galamian, 2013; Mozart,

1985) and these findings suggest that this particular performer may have learned to useexpressive body movement implicitly, possibly through the ‘aural modelling’ technique (Laukka, 2004; Woody, 2000). Future studies could explore if and how performers learn expressive body movement implicitly, and if this implicit learning is more effective in aiding expressive sounding performance, than explicit learning. At least in this study, the performer who seemed to have learned expressive gesture implicitly, also moved more and produceda more expressive sound than the other 2 performers, who reported having some explicit awareness of their body movements.

While the motion capture data from this study was descriptive only, and therefore limited in its generalisability, it can contribute some knowledge on how expressive gesture can be manifested in the bodies of violin performers. Consistent with previous research on violinists (Van Zijl & Luck, 2013a), this study showed that the change from *immobile* playing to *visually expressive* playing resulted in greater movement and faster movement in violinists' upper bodies, and more accelerated and jerkier movements in the legs. Also, consistent with Thompson and Luck (2012), the head was implicated in showing high amounts of expressive gesture. Further study, utilising larger numbers of musicians, is needed to more deeply explore where and how expressive gesture is manifested in violinist's performances.

This study also yielded some useful findings on the methodological approach of this experiment. Firstly, the *visually expressive* condition was a novel approach, implemented here for the first time, and the results show that the use of this condition was successful in producing increased body movement in all performers. In addition, performers did not report any confusion of difficulty with the *visually expressive* condition, showing that the instructions were effective and non-disruptive to the performance process. Secondly, the validity of using ratings of expressivity, as a measure of the strength of emotion conveyed in a performance was supported, as ratings of emotional content showed similar patterns to ratings of expressivity. It was further suggested that the expressivity rating was a more sensitive measure to changes in a musical performance than the emotional content rating.

An additional aim of this study was to perceptually validate the emotional content of the melodies used here. 6 of the 8 melodies were validated as conveying mainly the intended emotion, and mixed emotions were perceived to some extent in all melodies. Those 6 melodies are therefore suitable for use in future studies wishing to convey the emotions of *happy*, *sad*, *tender* and *scary*. The 2 melodies which were not validated as conveying the intended emotions were the short-scary and short-tender melodies. This suggests, in line with previous research, that *happy* and *sad* are the most easily identifiable musical emotions (Juslin, 1997; Juslin & Laukka, 2004), and that the longer melodies were easier to emotionally identify than the short melodies. Future studies would be advised to use melodies longer than four bars long in this type of experiment, and to reconsider the labels *tender* and *scary*. This study was also consistent with previous findings that the performer influences the perceived emotional content of a melody (Juslin, 2000).

The findings presented here have provided a valid contribution to the topic of embodied music cognition, and how knowledge of motion contributes to expressivity in music performance. This study indicates that for violinists, adopting different movement approaches during the performance of sad music can impact the perceived audible expressivity of their playing. A replication study would be needed to confirm that this effect exists in a larger population of performers. Further research could also explore how different movement approaches result in acoustic changes to performance sound, using music information retrieval. These findings can also inform music performance practice and pedagogy, in promoting thoughtful attention to expressive musical skills, and whole-body movement during practice and performance.

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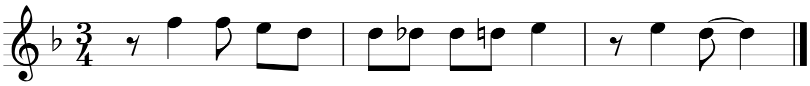
7 APPENDIX A

Musical stimuli set 1 consisting of emotion validated melodies from Vieillard et al. (2008) and adapted by Thompson, Vuoskoski, and Clarke (2016).

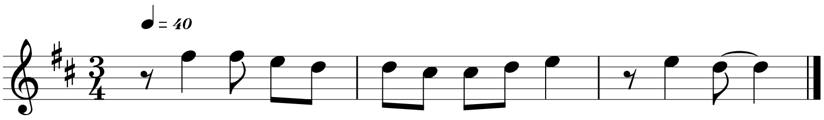
Short-sad melody



Short-happy melody

Short-scary melody

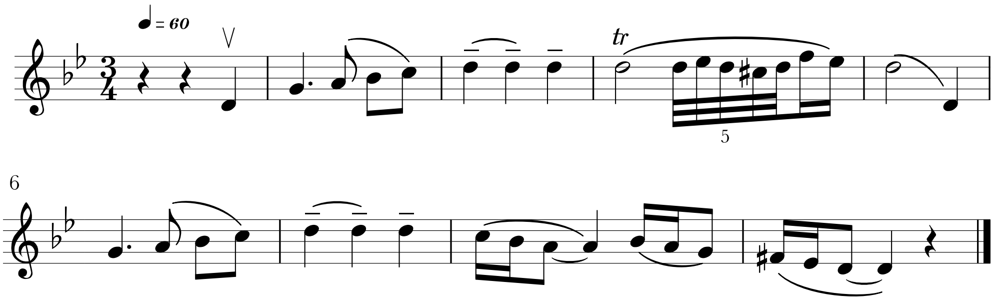
Short-tender melody



8 APPENDIX B

Musical stimuli set B consisting of selected excerpts from western classical music violin repertoire.

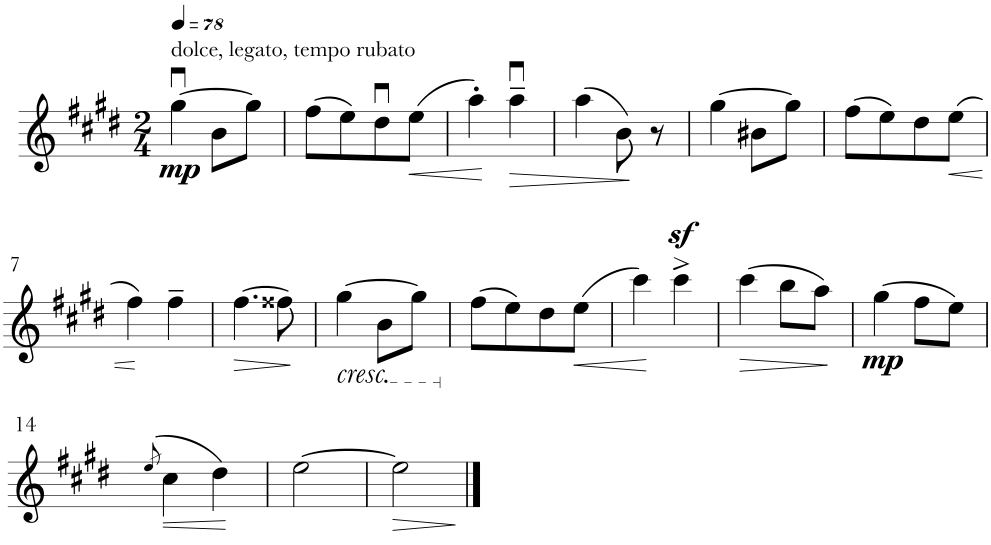
Long- sad melody. Taken from Tchaikovsky Violin Concerto in D major, Op. 35, Canzonetta.



Long- happy melody. Taken from Vivaldi Concerto no. 1 in E major, Op. 8. RV 269, “la Primavera”

Long-scary melody. Taken from Mussorgsky Pictures at an Exhibition, No. 9 “The Hut on Hen’s Legs (Baba Yaga)”

Long-tender melody. Taken from Elgar Salut d’amour, Op. 12



9 APPENDIX C

Tables displaying the difference in velocity, acceleration and jerk between *visually expressive* and *immobile* conditions, for each performer's 11 joints.

TABLE 8:The difference in velocity between *visually expressive* and *immobile* conditions, for each performer's 11 joints.

Joint	Performer 1	Performer 2	Performer 3
Head	56.07*	25.98*	22.92*
Right Shoulder	49.28**	23.15**	20.51**
Left Elbow	44.45***	21.87***	19.73
Left Wrist	52.29	19.84	19.94***
Hips	39.09	17.92	16.88
Right Knee	29.16	9.44	11.28
Left Knee	31.55	11.44	10.31
Right Ankle	15.96	2.83	3.57
Left Ankle	9.21	3.64	3.61
Right Toe	0.08	2.84	0.94
Left Toe	9.84	0.61	0.61

*Highest value, **Second highest value, *** Third highest value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s per second.

TABLE 9: The difference in acceleration between *visually expressive* and *immobile* conditions, for each performer's 11 joints.

Joint	Performer 1	Performer 2	Performer 3
Head	201.17*	66.27*	81.30**
Right Shoulder	122.94	48.11	52.94
Left Elbow	128.65	63.45**	76.66***
Left Wrist	142.11	117.86	88.78*
Hips	98.21	49.60	35.01
Right Knee	158.38**	41.39	52.25
Left Knee	150.65***	62.17***	41.74
Right Ankle	106.31	26.39	20.51
Left Ankle	74.08	42.34	20.32
Right Toe	-42.69	55.57	12.01
Left Toe	108.92	8.63	8.03

*Highest value, **Second highest value, *** Third highest value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s^2 per second.

TABLE 10: The difference in jerk between *visually expressive* and *immobile* conditions, for each performer's 11 joints.

Joint	Performer 1	Performer 2	Performer 3
Head	2454.63	1272.69	1093.58
Right Shoulder	1394.46	1513.80	827.87
Left Elbow	1643.32	2249.68***	1269.19***

Left Wrist	1656.58	6885.41**	1491.14**
Hips	1258.56	1559.00	389.11
Right Knee	3428.48*	980.73	1289.46
Left Knee	2850.66***	1462.88	900.03
Right Ankle	2247.01	843.01	599.94
Left Ankle	2048.74	1517.68	506.29
Right Toe	-1101.82	1474.27	343.00
Left Toe	3169.36	298.31	237.61

*Highest value, **Second highest value, *** Third highest value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s^3 per second.

TABLE 11: Difference in velocity between *visually expressive* and *immobile* conditions for each melody for each performer, and in total.

Melody	Performer 1	Performer 2	Performer 3	Total
Short-sad	41.53	25.83	14.94	82.29***
Long-sad	41.15	21.30	0.44	62.88
Short-happy	54.46	18.94	18.17	91.57**
Long-happy	34.16	16.10	16.52	66.78
Short-scary	72.76	20.32	24.14	117.22*
Long-scary	27.28	7.30	23.05	57.63
Short-tender	35.85	23.86	18.82	78.53
Long-tender	29.82	5.91	14.24	49.97

* Highest total value, ** Second highest total value, *** Third highest total value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s per second.

TABLE 12: Difference in acceleration between *visually expressive* and *immobile* conditions for each melody for each performer, and in total.

Melody	Performer 1	Performer 2	Performer 3	Total
Short-sad	105.44	77.58	56.27	239.29
Long-sad	151.89	164.49	5.31	321.68***
Short-happy	237.03	65.55	16.77	319.34
Long-happy	159.62	61.08	64.35	285.05
Short-scary	298.18	83.35	93.06	474.58*
Long-scary	118.19	45.07	167.88	331.15**
Short-tender	67.23	58.56	47.55	173.34
Long-tender	111.15	26.11	38.36	175.63

* Highest total value, ** Second highest total value, *** Third highest total value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s^2 per second.

TABLE 13: Difference in jerk between *visually expressive* and *immobile* conditions for each melody for each performer, and in total.

Melody	Performer 1	Performer 2	Performer 3	Total
Short-sad	1951.18	1611.20	1207.61	4769.99
Long-sad	2966.92	2084.58	161.53	5213.03
Short-happy	1850.79	10379.39	59.26	12289.44*

Long-happy	2425.81	1517.19	1094.07	5037.07
Short-scary	6810.36	1559.44	1636.39	10006.19**
Long-scary	2551.40	733.73	3314.01	6599.15***
Short-tender	949.01	1409.16	783.64	3141.81
Long-tender	1544.49	762.79	690.72	2997.99

* Highest total value, ** Second highest total value, *** Third highest total value

Note. The difference was calculated by subtracting the total value for *immobile* from the total value for *visually expressive.*Measurements are in m/s^3 per second.

10 APPENDIX D

Written performance instructions given to the performers.

You will be asked to perform each melody under the following two conditions:

Visually Expressive Performance: *Perform the melody expressively. Imagine that you are playing for an audition in which the panel is both listening to you, and watching you. Focus on making your performance as visually expressive as possible, while still taking care of the expressive sound. Perform in the way that you consider optimal under this condition.*

Immobile Performance: *Perform the melody expressively. Imagine that you are playing for an audition in which the panel can hear you, but cannot see you. Focus on keeping your body as still as possible, but without excess tension in the body. Aim to perform only the necessary movements required to play expressively. Perform in the way that you consider optimal under this condition.*

A metronome will indicate the required tempo before you start each performance. Please practise each melody at the tempo indicated on the score, and aim to portray the correct intended emotion for each melody

Please take some time to practice each condition until you are happy with the performances.

11 APPENDIX E

Explanation of the term ‘expressivity’ given to listener participants.

In your opinion, how strong is the message or emotion conveyed by the performer? This is a judgment on how successful the performer is at conveying emotion in their playing. You can think of this like an actor saying their lines. The actor may deliver a line with no expression, reading the words robotically; with a little expression, giving some indication of their mood or intention; or with a lot of expression, in a very dramatic and over the top way.