Trait Empathy Associated with Agreeableness and Rhythmic Entrainment in a Spontaneous Movement to Music Task: Preliminary Exploratory Investigations

Abstract

The simulation theory of empathy suggests that we empathise through modelling the actions of others through motor processing. Similarly, research into embodied music cognition posits that music, particularly musical rhythm, is perceived as a motor stimulus. In both cases, the human Mirror Neuron System (MNS) is put forward as a potential underlying mechanism. If this is the case, some overlap may exist between the ability to empathise with others, and the ability to perceive rhythm in music. The present study investigated this relationship indirectly, through the study of individual differences in Trait Empathy and rhythmic entrainment. Undergraduate students (n = 237) completed a questionnaire battery including the EQ-Short, BFAS and questions about musical and dance experience. A relationship was observed between Agreeableness on the BFAS and the EQ-Short (r = .554). Tests on a controlled sample of these participants (n = 11) found a relationship between Trait Empathy and performance on a rhythmic entrainment task, involving spontaneous movement to a musical stimulus (r_τ = -.686). A novel measure of rhythmic entrainment was used, assessing each participant on the time taken to re-establish entrainment following an abrupt change in tempo. The findings suggest that Empathy and rhythmic entrainment may utilise similar brain regions. These regions may also be associated with the MNS, although neuroimaging data would be required to confirm this. Qualitative observations of the participants' responses to the various musical stimuli were also recorded, and may inform future study. Furthermore, the observed relationship between Agreeableness and Trait Empathy may have implications for how these personality constructs are treated in the literature.

Trait Empathy Associated with Agreeableness and Rhythmic Entrainment in a Spontaneous Movement to Music Task: Preliminary Exploratory Investigations

Recent interest in music and empathy has suggested that music may elicit social empathy, offering an exciting explanation for the power of music in a range of contexts (e.g., Clarke, DeNora, & Vuoskoski, 2015). However, although empathy has been studied extensively in individual differences research, research into the neurological mechanisms behind the trait is sparse. Some authors have suggested that Trait Empathy has a neurological basis in the Mirror Neuron System (MNS) within the Motor Cortex, based upon observed relationships between MNS activity and Trait Empathy measurements (Gallese & Goldman, 1998; Rizzolatti, 2005). This is further supported by assertions from Embodied Cognition theorists that empathising is a fundamentally embodied process (Iacoboni, 2009). It is thought that understanding others comes from cognitively simulating their actions.

The importance of motor mirroring has been identified in the activities of music and dance. Observing the nearly instinctive movement that accompanies musical listening and performance has led to the application of Embodied Cognition theory to music, proposing that movement is a physical expression of musical perception (Leman, 2007). Some studies have found that motor cortex activation is associated with music perception, indicating that there may even be a movement component to music even without a physical response (Molnar-Szakacs & Overy, 2006; Overy & Molnar-Szakacs, 2009). However, although some studies have examined individual differences in musical ability in relation to general personality traits (Burger, Polet, et al., 2013; Luck, Saarikallio, Burger, Thompson, & Toiviainen, 2010, 2014), few have investigated Trait Empathy specifically.

The musical ability in question, for the present study, is the ability to entrain movement to a musical beat. Music often induces spontaneous movement, which usually matches the beat of the music (Leman, 2007, p. 96). This coordination of regular, periodic movement with an external actor may be considered rhythmic entrainment, and may occur between individuals or between an individual and a musical stimulus (Clayton, 2012). When multiple individuals are involved, this leads to complex systems of social entrainment where the motor output from each individual becomes the stimulus for the others (Phillips-Silver, Aktipis & Bryant, 2010). For rhythmic entrainment to be successful, an individual must be able to perceive and produce rhythmic signals, while being able to integrate perception and motor production to adjust when necessary and fully embody the beat of their target (Large, 2000; Phillips-Silver et al., 2010). The present study investigates the relationship between music, movement and Trait Empathy through studying individual differences in Trait Empathy and the capacity for rhythmic entrainment to a single auditory stimulus.

Empathy

Empathy may be measured as a personality trait, and individual differences in Trait Empathy have been studied by numerous authors. Sex is a powerful predictor of Trait Empathy, with females consistently scoring higher than males (Auyeung et al., 2009; Baron-Cohen, Knickmeyer, & Belmonte, 2005), while autistic traits have an inverse relationship with Trait Empathy and are higher in males on average (Baron-Cohen & Wheelwright, 2004). This may be due to exposure of the developing brain to testosterone, inhibiting the development of regions implicated in empathising (Chapman et al., 2006). These sex differences are well established, but the mechanisms behind them are still poorly understood.

Researchers of personality have also begun to investigate individual differences in musical experience with Trait Empathy. Previous research has found that experienced musicians possess higher Emotional Intelligence than inexperienced musicians (Petrides, Niven, & Mouskounti, 2006), an ability which (despite now being considered a problematic construct) may really be measuring a combination of General Intelligence with personality traits such as Trait Empathy (Waterhouse, 2006). Studies into individual differences in sensitivity to emotion in music have found that people with high Trait Empathy experience greater music-induced emotion than people with low Trait Empathy (Saarikallio, Vuoskoski, & Luck, 2012; Vuoskoski & Eerola, 2011). People with high Trait Empathy are also more likely to enjoy experiencing negative music-induced emotion than people with low Trait Empathy (Garrido & Schubert, 2011). Highly empathetic listeners appear to experience a particular type of Moving Sadness, referring to an enjoyable and intensely emotional response to sad music (Eerola, Vuoskoski & Kautiainen, 2016). What is most interesting to the present study is that the authors call this "Moving Sadness", implying movement is somehow important to the process. These previous studies suggest a relationship may exist between Trait Empathy and musicianship, however personality research of this kind is often only descriptive, not explaining why the relationship is observed unless it can be related to an underlying mechanism.

Mirror Neurons

While personality research describes general trends in a population, research into the Mirror Neuron System (MNS) may provide a theoretical basis for these observations. Research on monkeys has identified mirror neurons which fire whenever an individual performs an action or observes another, through either sight or sound, performing the same action (Gallese & Goldman, 1998; Keysers et al., 2003). Similar activity has been observed in regions of the motor cortex in humans, which may be considered homologous to mirror neurons in monkeys and are often referred to as the human MNS (Rizzolatti, 2005). If there is a MNS in humans, this may be an underlying mechanism behind empathy in primates.

Although there have not been studies to identify individual mirror neurons in humans, as there have been in monkeys, there is mounting evidence for the existence of a MNS as a neural substrate responsible for imitation and empathy (Iacoboni, 2009). Iacoboni and Woods (1999) found heightened activity in pre-motor regions when performing imitation tasks. Furthermore, more activity in this region has been observed when watching another person experience pain or touch (Bufalari, Aprile, Avenanti, Di Russo, & Aglioti, 2007). This response in the motor cortex when observing or imitating the actions of others may be important for experiencing empathy.

Previous neurophysiological studies have suggested a relationship between the MNS and Trait Empathy. High Trait Empathy, as well as related traits such as Agreeableness and Empathic Concern, have been associated with greater brain volume and activity in regions associated with the MNS, such as the superior temporal sulcus and inferior frontal gyrus (DeYoung et al., 2010; Kaplan & Iacoboni, 2006; Molenberghs, Brander, Mattingley & Cunnington, 2010). Autistic individuals often have reduced MNS activity in sensorimotor areas, as well as showing impaired imitation ability (Oberman et al., 2005), and Neuropsychology studies have found that damage to the prefrontal cortex, adjacent to the pre-motor cortex, results in impaired empathy (Eslinger, 1998). It may be that imitation of others, enabled by the MNS, is a key component of empathy.

Some neuroimaging studies have implied that we understand the actions of others through simulation. Greater activation of premotor areas, often associated with the MNS, has also been observed in trained dancers when viewing familiar routines (Cross, Hamilton, & Grafton, 2006), or familiar styles (Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005) of dance. This activity may be associated with motor learning, as viewing a familiar routine activates learned pathways, although the rhythm of the movement may also be an important factor.

Further to its function in empathy, the MNS is suspected to be involved in musical perception. It has been observed that the MNS activates when participants entrain to, or imagine, a musical stimulus (Chen, Zatorre, & Penhune, 2006; Nistri, Ostroumov, Sharifullina, & Taccola, 2006), leading authors to suggest that the MNS may have a mechanism for integrating audio and visual stimuli (Schlaug, 2009). Neuroimaging research by Grahn and Brett (2007) has found that pre-motor areas, those often associated with mirroring, are active during beat perception for both musicians and non-musicians, although there were some difference in the patterns of activation for musicians. Similarly, some research has associated musical training with increased MNS activity (Schlaug, 2009). Based on these observations, it is possible that the MNS plays a role in understanding the actions of others, as well as in rhythmic perception and entrainment; thus it may be a key mechanism for the purpose of synchronising or empathising, through either a visual or auditory medium.

Music, Movement and Empathy

Given that rhythmic perception and empathy may be related cognitive abilities, engaging the MNS, it has been suggested that the MNS may also be an important mechanism in recognising the emotion in music. Music implies movement, which is in turn recognised as emotion through the MNS, as proposed in the Shared Affective Motion Experience model (SAME) by Overy and Molnar-Szakacs (2009). Based upon the idea that the MNS is used in both perception and production of action, the SAME theory suggests that the MNS is an integral neural mechanism for integrating action and intention, whether the action is perceived through sight or sound; in this way, the MNS acts as a conduit through which emotion can be perceived in musical actions (Overy & Molnar-Szakacs, 2009). If the MNS is an underlying mechanism for both understanding observed actions (either through vision or audition, such as through music) and affect, as the SAME model suggests, then it might be expected that empathetic and rhythmic perception could be related. The present study aimed to test this theory through the study of individual differences in Trait Empathy and rhythmic ability.

Rhythmic ability was examined in participants' spontaneous movement/dance responses to music with regular pulses. Many studies have investigated rhythmic entrainment through finger tapping (for review, see Repp, 2005). These have found some differences in performance based on musical experience, specifically that percussionists often perform better (Repp, 2005), or that musicians have greater internal consistency (Spiro & Himberg, 2012). While much of the previous research into rhythmic entrainment has measured finger tapping, researchers are increasingly allowing full body movement to investigate rhythmic entrainment in a more naturalistic setting (Burger, Thompson, Luck, Saarikallio, & Toiviainen, 2014). This reveals the true complexity of rhythmic entrainment, as there may be multiple levels of entrainment within the body; different limbs may synchronise with different layers of a metrical hierarchy (Burger et al., 2014). The present study allowed participants to move freely in a motion capture setting, to maintain ecological validity, despite the complexity this adds to analysis.

Previous studies have found that most people self-report spontaneously moving to music (Lesaffre et al., 2008). It has also been suggested that dancing behaviour may express aspects of the dancer's rhythmic perception, such as the hierarchy of meter (Toiviainen, Luck, & Thompson, 2010). Furthermore, music-induced movement may also reveal something about the listener's emotional experience of the music with Saarikallio and others (2013) finding that the experience of positive affect is expressed in a greater amount and complexity of movement. As the present study aimed to observe spontaneous movement to music in relation to Trait Empathy, participants were allowed to dance freely, rather than completing more restricted finger tapping trials.

Some studies have specifically examined a relationship between Trait Empathy and rhythmic movement. Carlson, Burger, London, Thompson and Toiviainen (2016) found an effect of Conscientiousness and Extraversion, but not Agreeableness and Trait Empathy, on responsiveness to tempo. Conversely, Strauß and Zentner (2015) found that Trait Empathy enhanced performance on a tempo perception task. It could be argued that the observations of Carlson et al. (2016) are due to experimental design, as participants were specifically instructed to dance to the music, and thus it may be that the more Conscientious participants were actually displaying a greater desire to follow instructions, rather than rhythmic ability. For this reason, the present study did not provide specific instructions, but rather examined purely spontaneous movement.

For the present study, rhythmic ability was inferred by the time taken to entrain to a novel musical beat. This measure has an advantage in that participants were not explicitly aware that they were being measured on rhythmic ability. For the purposes of the present study, the specific rhythmic ability being measured was the ability to adapt to a change in rhythm. Importantly, this requires perceiving an external rhythm and entraining to it, rather than maintaining an internal rhythm. Entrainment, in this sense, was considered to be achieved when any part of the body established a periodic movement in time with the newly presented music. It was hypothesised that high Trait Empathy would be associated with a shorter delay in the onset of rhythmic entrainment to a musical stimulus. Secondarily, it was expected that participants with high Trait Empathy would gain more enjoyment from rhythmic entrainment (or in this case, dancing) than those with low Trait Empathy, and that a positive relationship would be observed between Trait Empathy and the Agreeableness factor on the BFAS, given the similarity between these personality constructs.

Method

Participants

Complying with human ethics protocols of the Australian university where the study was carried out, participants for this study were recruited through promotion on social media and electronic mailing lists. The survey was also promoted in university e-newsletters and in a wide variety of Facebook groups, such that even if there were an overall bias there would still be adequate variation within the sample to establish individual differences. The selection process for the second phase of the study aimed to resolve any initial biases in the sample.

There were 237 participants who completed the online questionnaire. The majority of these were current undergraduate students. After this, 46 participants were invited to participate in the lab task, of which only 21 responded and were tested. Lab participants were between the ages of 18-23 with 13 males to 8 females. Participants were selected on the basis of personality results, to ensure a broad range of Trait Empathy scores, by selecting respondents in brackets based upon the EQ-Short. An equal number of participants, with equal numbers of Males and Females, were selected from each bracket for the lab task, however not all of those selected agreed to be tested. Ultimately, the breakdown of the lab sample was as follows: High (EQ > 30, N = 8, Females = 4), Low (EQ < 14, N = 8, Females = 3) and Medium EQ ($14 \leq EQ \leq 30$, N = 5, Females = 1). It should be noted that the brackets were only to ensure diversity in the sample through the recruitment process and were not used in analysis, as the sample was too small to consider dividing it into groups.

To reduce the influence of musical and dance training, no participants were selected who had more than 5 consecutive years of dance training, or who had studied music at a tertiary level.

Previous studies have found musical experience, specifically training in percussion, is known to improve rhythmic entrainment performance on finger tapping studies (Repp, 2005), thus no percussionists were included in the study. Given that participants had to be called back and filmed, it was impossible to preserve anonymity for lab participants, although all records were kept securely, and none are identified by name in this paper. All selected participants were contacted by the e-mail address they provided and invited to come into the lab.

Materials

The Empathy Quotient (EQ), developed by Baron-Cohen and Wheelwright (2004), is a psychometric measure of Trait Empathy. It is a self-report questionnaire that specifically measures Trait Empathy, to the exclusion of other related social traits, and was originally developed to accompany the Autism Quotient (AQ) and Systemising Quotient (SQ) in the study of Autistic traits (Baron-Cohen & Wheelwright, 2004). Although developed to complement the AQ as a diagnostic tool, the EQ has been used with non-clinical populations as a reliable measure of Trait Empathy as a single factor (Allison, Baron-Cohen, Wheelwright, Stone, & Muncer, 2011). To reduce the overall length of the questionnaire battery, the present study used the EQ-Short, developed by Wakabayashi et al. (2006), as it only contains 22 items which reduces participant fatigue.

The Big Five Aspect Scale (BFAS) was used as a general assessment of personality. It is a self-report questionnaire of 100 items which contains five scales, corresponding to the Big Five personality factors (DeYoung, Quilty, & Peterson, 2007). The Agreeableness scale was used in comparison with the EQ-Short; the other scales served to provide a complete personality profile of participants, to ensure a diverse sample was taken through the screening process.

Motion capture was used to record movement in the lab component. Motion capture techniques, utilising multiple infrared cameras and body markers, have been used by Luck et al.

(2010) to compare aspects of movement to personality traits. However, the present study had restraints due to the availability and cost of these motion capture systems. Movement was recorded using a Sony Playstation Eye camera, with the CL-Eye driver and Kinovea software package, which enabled video to be recorded at 75 frames-per-second at 640 × 480 pixels. As Kinovea is unable to record audio, a separate sound recorder was used to record audio, enabling movement to be compared to musical beat once synchronised using a reference point from a clapperboard.

The musical stimulus was a 296 second track consisting of six pieces, edited using Sony ACID Xpress audio editing software. A range of excerpts was included of vastly different tempo and genre, with abrupt transitions between them to force a rapid change in the participants' movements. The excerpt taken from each piece was chosen for having a well-established pulse, and was allowed to play for a complete phrase or section. Excerpts were of varying and irregular lengths, to prevent participants from anticipating the changes in music. The six musical excerpts were presented in the order shown in Table 1. Each piece had a steady and consistent pulse, although would not necessarily be considered dance music. Music was chosen that would be unfamiliar to participants, to prevent learned responses; for example, playing the Macarena would have elicited a stereotypical response which was not the purpose of this experiment. Familiarity and preference for the musical stimuli was checked in a short interview at the conclusion of the experiment, and was noted as possible grounds for excluding participants, although none were excluded on this basis. The only exception to this was the Daft Punk track, which was popular at the time of testing and included as a warm up track to introduce participants to the task and make them feel at ease. Music that would not traditionally be danced to, such as the Vivaldi and the Philip Glass pieces, were included for exploratory purposes, although the transition to the Vivaldi had to be excluded in analysis due to the lack of movement that it elicited. The presentation order of the stimuli was kept constant, so that comparisons could be made between participants at each transition point.

<< insert table 1 here >>

A Visual Analogue Scale (VAS) of 220 mm was employed for participants to show their degree of enjoyment in the lab activity, being asked to mark on the line how much they enjoyed the task, left being no enjoyment, right being high enjoyment. This was chosen as a quick measurement of subjects attitudes with a high degree of precision, without requiring them to complete a long questionnaire, during which the initial impression of the task may be lost. Visual Analogue Scales have been used as a viable alternative to numerical scales, with similar reliability, for a number of different psychological constructs such as mood, fatigue and pain (Boer et al., 2004; Lee, Hicks, & Nino-Murcia, 1991; McCormack, de L. Horne, & Sheather, 1988). The participant's response on the VAS was converted into a score out of 220, rounded to the nearest whole-number, measuring from the left-most point of the line up to the right-most mark made by the participant on the line.

Procedure

Following recruitment, participants completed the online questionnaire battery. This battery included the EQ-Short, BFAS and demographic questions (see Appendix S1 in the Supplemental Material Online). Demographic questions were used to control for musical and dance experience in the selection process, as outlined in the Participants section.

The next phase of testing involved a lab experiment in which selected participants were played a selection of music while their responses were recorded by a camera. Participants were reassured that the video data would be stored securely and only viewed by the experimenter, and that the experimenter would leave the room for the duration of testing to reduce any potential self-consciousness or embarrassment.

Instructions were minimal and kept consistent between participants to avoid any priming effects that may increase empathy (Cook & Bird, 2012). Participants were simply instructed to 'respond freely to the music.' The researcher waited outside the lab for the entire 296 second duration of the task.

Following the task, participants were debriefed. Participants were asked to indicate how much they enjoyed the task and how much they usually enjoy dancing, using the VAS. There were variations in markings, with some participants using thicker lines or crosses; in all cases the leading edge, or right most intersection with the scale was used for measurement. Participants were also asked to verbally reflect upon the task in a short, semi-structured interview. The VAS and interview questions used in the post-test measurements may be found in Appendix S2 in the Supplemental Material Online.

Data Analysis

Video and audio were recorded separately due to technical limits in the Kinovea software, and subsequently synchronised using the clapperboard technique. Kinovea was used to mark frames of interest in video data, specifically start of music, changes of music and the point at which participants re-entrained their movement to the beat.

The point at which participants re-entrained their movement to the beat was found through manually determining when the participant had re-established a regular pulse in movement after a change in music. This was determined by qualitative observations made by two independent raters, with a third asked to verify a small sub-set of observations. The raters watched through each video and noted when deliberate rhythmic movement had resumed and in which part of the body. In almost all cases, the participant immediately ceased movement when presented with the new stimulus, and subsequently made a clear effort to entrain their movement to the music again after a short pause. Entrainment is considered to have been achieved when body movement can be perceived as entrainment by an observer.

After initially watching the video and finding a rough point of re-entrainment, the rater would scroll through frame-by-frame to identify the first beat of a sequence of periodic movements. The first embodied beat was marked at the frame in which reversal of movement occurred, on the limb which begun moving rhythmically, and the time recorded to the nearest millisecond. The metrical level to which periodic movement was entrained (be it to the crotchet, quaver, minim or whole bar) was not recorded, nor was the consistency or accuracy of entrainment, only the starting point. The time at a change of music was subtracted from the time at the onset of re-entrainment to determine the delay in entrainment. The mean delay in re-entrainment was calculated, assigning each participant a 'Re-Entrainment Delay' score. In this way, qualitative observations were converted to a quantitative measure which could then be used as a rating of the individual's responsiveness to changes in tempo.

Results

Through completion of the BFAS, it was possible to assign participants scores on Extraversion, Openness, Agreeableness, Conscientiousness and Neuroticism. This established a general personality profile of each participant. Descriptive statistics for the BFAS, EQ-Short and

Age are shown below in Table 2. Statistical analysis was completed using the PAST statistics package (Hammer, Harper, & Ryan, 2001).

<< Insert table 2 here >>

Certain expectations were tested within this sample. Pearson's correlation tests revealed a strong correlation between EQ-Short and Agreeableness, $r = .55$, $p < .001$, 95% CI [.45, .63], two-tailed, although many weaker correlations were also found between EQ-Short and the BFAS, and within the BFAS itself. All observed correlation coefficients (r values) are shown in Table 3. The correlation between EQ-Short and Agreeableness was further investigated through a Pearson's correlation with the two facets of Agreeableness: Compassion and Politeness. A strong correlation was found between EQ-Short and Compassion, $r = .64$, $p < .001$, 95% CI [.56, .71], two-tailed, and a weaker correlation between EQ-Short and Politeness, $r = .32$, $p < .001$, 95% CI [.20, .43], two-tailed.

<< Insert table 3 here >>

Participants were selected from the questionnaire to cover a wide range of EQ-Short scores, while controlling for age, sex, musical experience, and dance experience. Table 4 shows descriptive statistics for this sample. The sample which was selected maintained some difference in EQ-Short score between males (Median = 19) and females (Median = 24), however this was not statistically significant, Mann-Whitney $U = 36$, $n_{\text{Males}} = 13$, $n_{\text{Females}} = 8$, $p = .26$ (one-tailed).

<< Insert table 4 here >>

A Kendal's Tau correlation was conducted between Enjoyment of Activity and EQ-Short score; parametric statistics could not be used as the assumption of normality was violated. This test revealed a significant, positive correlation, $r_T = .36$, $p < .05$, 95% CI [-.08, .68], two-tailed, as shown in Figure 1.

<< Insert Figure 1 here >>

Rhythmic ability was measured by finding the mean time from change in music to the time at which a participant re-established a regular pulse in their movement. The re-establishment of rhythmic movement was defined as the first reversal in movement on any part of the body which preceded a sequence of rhythmic movements, and was always measured by two independent raters and the results averaged; this gave each participant a Re-Entrainment Delay score. The independent raters sometimes identified different starting points for rhythmic movement, indicating that they may have had different standards of when entrainment was achieved, however the difference was sufficiently consistent between trials to exhibit an inter-rater reliability of $r = .96$, $p < .001$, 95% CI [.85, .99], two-tailed.

<< Insert Table 5 here >>

Some participants were excluded due to technical difficulties with the video, or because they made no measurable rhythmic movements to one or more of the stimuli. Descriptive statistics of this reduced sample may be found in Table 5. A significant negative correlation was found between EQ-Short and Re-Entrainment Delay , $r_\tau = -.69$, $p < .05$, 95% CI [-.91, -.15], two-tailed (see Figure 2). Furthermore, a significant negative correlation was observed between the Agreeableness factor of the BFAS and Re-Entrainment Delay, $r_\tau = -.59$, $p < .05$, 95% CI [-.88, .01], two-tailed. No other significant correlations were observed between personality factors and Re-Entrainment Delay or the Enjoyment of Activity.

<< Insert Figure 2 here >>

As a supplementary analysis, mean Re-Entrainment Delay between stimuli was also calculated. No significant difference was found within participants, between the stimuli.

Descriptive statistics for the Re-Entrainment Delay of each stimulus may be found in Table 6. There are no statistics for the Daft Punk piece, as it was included only as a warm-up track.

<< Insert table 6 here >>

Discussion

The present study aimed to test the hypotheses that Trait Empathy is related to Agreeableness on the BFAS, and that both are associated with the ability to entrain movement to a set pulse. It was also expected that those with higher Trait Empathy would enjoy the dancing task more than those with low Trait Empathy.

Empathy and the Big Five

In the first part of this study, a relationship was observed between EQ-Short and Agreeableness on the BFAS. This finding supports previous research that has suggested that Agreeableness and Trait Empathy may be related, and engage similar areas of the brain (Del Barrio, Aluja, & García, 2004; DeYoung et al., 2010; Kaplan & Iacoboni, 2006). In reviewing previous research, the present study has assumed that measures of Agreeableness and Trait Empathy are measuring a similar personality construct, an assumption which is supported by this finding.

Significant, but smaller correlations were also observed between the EQ-Short and the Extraversion, Openness and Conscientiousness scales. Although all five factors of the BFAS should be entirely independent, other authors have observed correlations within the Big Five, leading to the theory that there may be two higher-order factors above the Big Five (Anusic, Schimmack, Pinkus, & Lockwood, 2009; Digman, 1997). The model proposed by Digman (1997) would suggest a relationship between Neuroticism, Agreeableness and Conscientiousness, as one higher-order factor, and Openness and Extraversion as the other. However, these expected relationships were not observed in the present study.

Models of higher-order factors above the Big Five do not seem to explain the correlations observed here with the EQ. The relationship between the EQ and Openness in this study may be explained by the relationship observed between Agreeableness and Openness in this data, as that correlation is of a similar strength to the correlation between Openness and EQ. Similarly, the relationship between EQ and Extraversion may, in part, be explained by Extraversion's relationship to Agreeableness in this data. Previous research by Del Barrio, Aluja and Garcia (2004) also observed weak, positive correlations between Conscientiousness, Extraversion, Openness and Empathy, although the authors observed a much stronger relationship between Agreeableness and Empathy. These findings would seem to match the observations of the present study, however it must be noted that Del Barrio, Aluja and Garcia (2004) used different tools to measure these personality constructs.

The BFAS used by the present study provides a model for sub-factors or facets of the Big Five. DeYoung and others (2007) suggest two aspects of Agreeableness: Compassion and Politeness. In the present study, a stronger relationship was observed between Empathy and Compassion, than between Empathy and Politeness. From this, it may be possible to consider Empathy, as measured by the EQ-Short, to be a sub-factor of Agreeableness, closely related to the Compassion aspect, in the BFAS. More research would be required to support this, as currently there is little research that has included measures of Trait Empathy along with the Big Five. If Trait Empathy is related to Agreeableness, perhaps as a kind of sub-factor, this would have implications on the literature, potentially integrating research which has studied these personality constructs independently.

Empathy and Enjoyment of Dancing

It was hypothesised that there would be a positive relationship between Trait Empathy and Enjoyment of dancing. This hypothesis was supported by the results, as it was found that highly empathetic participants enjoyed the dancing activity more than participants of lower Empathy. Most participants reported enjoying the activity, consistent with the idea that synchrony generates pleasure (Hodges, 2009; Leman, 2007). It is likely that participants who enjoy dancing more also perceive themselves as being more competent at it, and thus are more likely to enjoy it (McAuley, Wraith, & Duncan, 1991). This was corroborated by the next part of the experiment.

Empathy, Agreeableness and Rhythmic Entrainment

The negative correlation found between Re-Entrainment Delay and EQ-Short score supports the hypothesis that a relationship exists between Trait Empathy and rhythmic ability. Participants who scored higher on the EQ-Short were faster at entraining their movement to a newly presented rhythmic stimulus. In addition, a correlationwas also found between Agreeableness and Re-Entrainment Delay, supporting the proposition that Agreeableness and Empathy may be related constructs. It is worth noting, however, that due to the small sample size, the confidence intervals on these correlations are very broad, such that claims about the exact strength of this relationship cannot be made. Nevertheless, the results indicate that a relationship may exist between empathy, agreeableness and rhythmic entrainment.

This was expected based on the predictions by Overy and Molnar-Szakacs (2009); if both Empathy/Agreeableness and rhythmic entrainment are related to the Mirror Neuron System (MNS) in some way, then more empathetic people should be better at synchronising with a beat, due to their more active MNS. These results are also consistent with the observations of Strauß and

Zentner (2015). However, these findings contradict those of Carlson et al. (2016), in which Conscientiousness but not Empathy influenced responsiveness to tempo. This is possibly due to the open-ended instructions given to participants in the present study. Specifically instructing participants to dance may have caused an interaction with the Conscientiousness scores of participants, due to their desire to carry out instructions. The present study found no effect of Conscientiousness on Re-entrainment Delay, as a measure of tempo responsiveness.

Given the nature of this study, it must be considered that the measure of Re-Entrainment Delay was not measuring the participants' ability to keep in time, but rather their willingness to do so. As already stated, those with higher Trait Empathy self-reported enjoying the task more. It may be that the empathetic dancers were more enthusiastic about moving, perhaps as a way of expressing the emotional contagion they experienced, as other authors have suggested that emotional contagion may be experienced through motor processing (Juslin & Västfjäll, 2008). Alternatively, the more empathetic dancers may have 'felt' a greater positive affect from the music. Saarikallio and others (2013) previously observed that experience of positive affect is expressed through greater and more complex music-induced movement. It may be pertinent here that the more empathetic dancers in the present study also self-reported enjoying the task more, as well as being faster at entraining to the beat; they could have been more receptive to the positive affect in the music.

The less empathetic dancers may not have had a greater delay from a lack of ability, but a lack of motivation, or lack of emotional perception/expression. These competing explanations may, in fact, complement each other, as someone with a greater natural talent for rhythmic entrainment may also be more confident, and thus faster, at moving to music. Further studies with more precise motion capture systems, or different measures of rhythmic entrainment, may be able to disentangle the factors of ability, confidence/motivation and emotional perception/expression in determining how quickly someone will establish spontaneous entrainment to music.

Unfortunately some participants had to be removed from this part of the study. This was due mainly to technical difficulties in synchronising the audio and video. However, there were also some participants for whom Re-Entrainment Delay scores could not be determined as they did not make any discernible rhythmic movements during one or more of the musical excerpts. Future studies may improve on the methodology used here, by using more precise measurements of rhythmic entrainment without compromising external validity.

The participants who were excluded shared no consistent personality traits. When questioned during a short interview, participants who did not dance often reported either not feeling inspired to do so by the music, or not being sure how to dance to it. In most cases it seemed a conscious decision was made that they would not dance to that track, which raises questions about the conditions required for spontaneous movement to occur.

Spontaneous Movement to Music

It was noted that nearly all lab participants began moving to the musical stimulus when it was presented, despite being provided with no explicit instructions to do so. This is consistent with previous research which has found that up to 95% of people self-report spontaneously moving to music (Lesaffre et al., 2008). The most prominent “time-keepers” of the body, as identified by observers, were the hands, head and feet. Specifically, the music was most often embodied through claps, foot-stomps, finger clicks and head-bobs. It was apparent, however, that participants displayed certain musical preferences in their movement.

Qualitative observations from the video data revealed that many participants had greater difficulty finding the pulse in the Vivaldi excerpt. Their movements in this excerpt were also a little less dance-like, with some participants choosing to conduct along with the beat (perhaps showing their prior musical experience). In interviews afterwards, some participants reported finding both the Vivaldi and the Glass excerpts difficult to move to. The difficulty participants reported in entraining to the Glass and Vivaldi is partly supported by the data, as these pieces resulted in the longest average delay in the onset of rhythmic entrainment (see Table 6),although this was not a significant difference. Participants suggested that the lack of a consistent bass beat was problematic, and this may be supported by the literature.

Previous studies have observed that a strong pulse in the lower frequencies contributes to regular music-induced movement (Burger, Thompson, Luck, Saarikallio, & Toiviainen, 2013; Dyck et al., 2013). In addition, Burger and others (2013) suggest that music with low percussiveness tends to induce less regular movement. Although the excerpt by Vivaldi had a very regular pulse, it could not be considered a highly percussive pulse, and was lacking bass frequencies in comparison to the other pieces. Previous studies have also found that positive affect promotes a greater amount of movement (Saarikallio et al., 2013), and both the Glass and Vivaldi are perhaps less positive than the other stimuli. The Vivaldi was also the only stimulus not in a 4/4 metre, which may have been a source of confusion for some participants. It is also possible that there was a learned response, in that participants had been culturally conditioned not to dance to ‘classical’ music. The ideal conditions for music-induced movement, and the extent to which these are the product of enculturation, may be an interesting topic of further research.

General Discussion

The present study was limited by the sample and equipment available, however the results do show promise. It would be worthwhile replicating this study with a larger, and perhaps more diverse, sample as all participants were drawn from the population of an Australian university. It would be interesting to see if the observed relationship between Trait Empathy and dancing behaviour could be replicated in different groups, perhaps of different sex, age or cultural backgrounds. Attempts were made in the present study to control for sex through the recruitment process, as sex could have been a potential confounding variable, however future studies could specifically test sex differences. Similarly, trained dancers were specifically excluded from this study, but further research may also investigate the performance of dancers, musicians, or even others with a highly-developed sense of rhythm such as runners, on a similar task. Conversely, there is emerging evidence of a type of beat deafness, a condition in which people are unable to perceive or entrain to a beat (Phillips-Silver et al., 2011). In the study by Phillips-Silver and others (2011) it was observed that beat deafness was expressed as both an inability for rhythmic entrainment, as well as for perceiving rhythmic entrainment when observing others dancing to music. Measuring Trait Empathy in people with a profound lack of rhythmic perception may prove to be a useful avenue of enquiry. Including comparisons on this basis would improve the generalisability of the present results.

The present study used the EQ-Short, as it has been used previously as a reliable measure of empathy. Furthermore, the EQ was developed from a theoretical backing that attempts to explain individual differences in Trait Empathy on the basis of pre-natal androgen differences during brain development (Baron-Cohen & Wheelwright, 2004); this theory has gained some support from the literature (Chapman et al., 2006). Some authors have begun to discuss the implications of this theory for musical behaviour (Greenberg, Rentfrow, & Baron-Cohen, 2015), so further study could include investigating a possible relationship between the capacity for rhythmic entrainment and pre-natal androgen levels, or the inclusion of participants with Autism Spectrum Disorders. However, there are also many other measures of Trait Empathy, so an alternative future study could seek to replicate the present results using different measures such as the Interpersonal Reactivity Index (Davis, 1980) or Toronto Empathy Questionnaire (Spreng, McKinnon, Mar, & Levine, 2009). Theories explaining empathy as a personality construct do differ, and the approach to measuring Trait Empathy may yield different results.

Given the difficulties in analysis created by some stimuli, future studies may benefit from keeping musical features more controlled between the stimuli, only varying the tempo. This would reduce the possibility of participants moving to some stimuli, and not others. Ideally, musical stimuli should have a strong and steady bass beat, as this elicited the most consistent movement: an observation which was confirmed by participants' own reflections in the subsequent interview. Music could also be selected to be of similar motivational quality, using a measure such as the Brunel Music Rating Inventory-2 (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006), which may lead to greater consistency in elicited movement. Furthermore, the effect of syncopation could be investigated, as it is thought enhance the 'groove' of a piece, which is theorised to increase music induced movement at low to medium levels, although previous studies have suggested that this effect may be too small to be noticeable, and may become detrimental to movement at high levels (Witek et al., 2016). Investigating different stimuli would be an important step to improving the methods of the present study.

The present study suffered from recording methods used, which in turn dictated the possible methods of analysis. There are more robust methods of motion capture available, such as the optical system used by Luck and others (2010), or the Wiimote used by Phillips-Silver and others (2011), which would enable more precise measuring of the features in participants' movements, rather than just the general delay in rhythmic entrainment. These systems have an advantage in that analysis of the data can be done more precisely using tools such as the MoCap Toolbox (Burger &

Toiviainen, 2013), rather than relying upon subjective human observers. With different equipment, the point of re-entrainment could have been determined computationally, or other measures of rhythmic ability could have been used, such as the consistency or accuracy of synchronisation.

The limitations of using human observers to identify rhythmic entrainment are worth exploring further. Firstly, it must be noted that inter-rater reliability was very high. Nevertheless, it is possible that the raters may have missed more subtle movements. Raters were also not asked to indicate how well any given participant moved in synchrony, as it is assumed these ratings would not be reliable, given the generous degree of error allowed when humans perceive audio-visual synchrony (Spence & Squire, 2003). Despite only reporting when rhythmic entrainment commenced (or re-commenced after a change in music), and the potential for lost precision, using human observers does establish a useful threshold for entrainment. Entrainment, in this study, was achieved when it could be perceived by others; a kind of socially displayed entrainment. Because of this, we may infer that the participants who achieved lower Re-Entrainment Delay scores were not just better at perceiving a musical beat and moving to it, but also better at displaying this entrainment with music to others.

Although the present study aimed to investigate spontaneous music-induced movement, an alternative task could specifically instruct participants to keep time with the music. This may help to tease out the reasons why the variation in Re-Entrainment Delay was observed; if participants are instructed specifically to entrain to the beat as quickly as possible, this may remove motivation or emotional expression as a factor contributing to the speed at which they establish rhythmic entrainment. Alternatively, more specific instructions may produce confounding effects with other personality traits, such as Conscientiousness (e.g., Carlson et al., 2016). Such further investigation would be needed to refine the methods used in the present study.

As for the theoretical underpinnings of the present study, it must be considered that the MNS is still controversial in neuroscience. Two competing hypotheses relating to the MNS in humans are that the MNS evolved specifically to enable understanding of observed actions, or that it is a by-product of sensorimotor associative learning (Heyes, 2010). Although emotional expression is innate, empathy must, to some degree, be learned (Tonks et al., 2009). This would seem consistent with the associative learning hypothesis, favoured in the review by Heyes (2010), if empathy is using the MNS; we must learn to read emotions in others just as we must learn to understand their actions.

In the context of the present research, future studies may find an association between empathy and motor learning. Perhaps highly empathetic people may perform better on general motor learning tasks, not specifically those involving rhythmic entrainment, or perhaps longitudinal studies may find that empathy can be trained in association with development of pre-motor brain regions. If there is a developmental association between motor-learning, musical abilities and empathy, then there may be therapeutic possibilities of musical training in treating disorders of empathy, such as Autism Spectrum Disorders (Baron-Cohen & Wheelright, 2004), or motor-processing disorders such as Dyslexia (Overy, 2000). As previously mentioned, further studies into this area should be conducted with different groups of participants, and this could include clinical populations or young children with developing motor skills, in order to investigate speculation about possible therapeutic or developmental benefits of music and dance.

Despite its shortcomings, the findings of the present study add weight to the SAME model as proposed by Overy and Molnar-Szakacs (2009). The observed relationship between Trait Empathy and rhythmic entrainment suggests a common neural mechanism; based on previous research, this mechanism is quite possibly the MNS. The present study did not include any neuro-imaging, and any future studies which could relate brain activity in the motor-cortex to empathy and rhythmic entrainment would provide valuable supporting evidence for the MNS theory. Alternative methods could also be used to disentangle ability from motivation or desire for physical expression, although these may be related rather than competing explanations of the observed results. This study would need to be replicated with a larger sample if it were to be conclusive; however, the observed relationship between Trait Empathy, Agreeableness and rhythmic entrainment results show great promise, even with low statistical power. The MNS provides an appealing explanation for these observations, and would support an embodied perspective of empathy: we learn to empathise by learning to use our bodies and to perceive movement in others, through either sight or sound.

The observed relationship between Agreeableness and Trait Empathy was rather more robust, given the larger sample for that part of the study. This supports what has been suggested by others, that Agreeableness and Trait Empathy are closely related constructs (Del Barrio et al., 2004). The implications of this are important for reviewing the literature of Neuropsychology and Personality. Brain regions that have observed associations with either Trait Empathy or Agreeableness, may be common to both.

Conclusion

The present research brings together two areas of empirical research, with the theoretical basis of the SAME model (Overy & Molnar-Szakacs, 2009). While this is considered a preliminary study, it shows great promise in the area that warrants further investigation. It would seem that there is a relationship between Trait Empathy and movement, in that people with high empathy are quicker to spontaneously move to music. However, it remains unclear whether empathy has an effect on rhythmic entrainment ability, self-expression or motivation in a dance setting. Rhythmic entrainment, in this study, was measured using human observers; thus, it may be that participants who performed better on the task were also more effective at communicating their rhythmic movements to others. Further to this finding, the observed effects of musical features on spontaneous movement are consistent with the findings of Burger and colleagues (2012), suggesting that a strong bass beat is ideal for eliciting spontaneous rhythmic movement. Finally, the strengthening of the association between Agreeableness and Trait Empathy has implications for how the literature has treated research into personality and music. It would appear that the Agreeableness scale and the EQ are measuring very similar constructs, which must be taken into consideration when interpreting previous studies into individual differences. Ultimately, these findings may shed some light on the relationship between music, movement and empathy, which points towards possible neurological underpinnings, and may help us understand the power of music to evoke emotions and feelings of social empathy.

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Supplemental Material

Tables and figures/audio files with the index “S” are available as Supplemental Online Material, which can be found attached to the online version of this article at http://msx.sagepub.com. Click on the hyperlink “Supplemental material” to view the additional files.

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Tables

Table **1**. *Play order of musical stimuli.*

Title	Artist	Length of Stimulus (s)	Tempo (bpm)
Get Lucky	Daft Punk	82.62	120
Lightning	Philip Glass	57.41	100
Love Me Do	The Beatles	21.53	90
Concerto No. 2 in G minor, Op. 8, RV 315, 3rd Movement	Antonio Vivaldi	21.41	150
Mas Que Nada	The Idea of North (Arr.)	51.31	95
Carameldansen	Caramel	61.72	135

Table 2. *Descriptive statistics for age, EQ-Short and BFAS.*

	Mean	SD	N
Age	23.09	7.55	237
EQ-Short	21.33	8.61	237
Openness	79.58	9.00	237
Extraversion	68.53	11.36	237
Agreeableness	78.59	10.79	237
Conscientiousness	62.55	12.10	237
Neuroticism	57.74	14.66	237

Table 3. *Pearson's Correlation tests between EQ-Short and the five factors of the BFAS.*

	EQ-Short	Neuroticism	Agreeableness	Conscientiousness	Extraversion
Neuroticism	-0.11				
Agreeableness	0.55***	0.02			
Conscientiousness	0.22***	-0.21***	0.07		
Extraversion	0.48***	-0.35***	0.14*	0.20**	
Openness	0.21***	-0.09	0.24***	0.01	0.24***

Note. All correlations two-tailed. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. *Descriptive statistics for lab sample on EQ-Short and Enjoyment of Activity.*

	Mean	SD	N
Age	21.19	2.06	21
EQ-Short	20.57	13.46	21
Enjoyment of Activity	146.81	41.72	21

Table **5**. *Descriptive statistics for lab sample on Re-Entrainment Delay and EQ-Short.*

	Mean	SD	N
EQ-Short	17.45	14.92	11
Re-Entrainment Delay (s)	4.57	2.03	11
Agreeableness	76.09	14.03	11
Age	20.82	2.04	11

Table 6. ***Descriptive statistics for Re-Entrainment delay on the basis of stimuli.***

	Mean Delay	SD	N
Philip Glass	7.663	6.671	12
The Beatles	3.705	2.297	12
Vivaldi	5.151	2.207	9
The Idea of North	4.969	4.382	12
Caramel	4.523	4.074	12

Figures

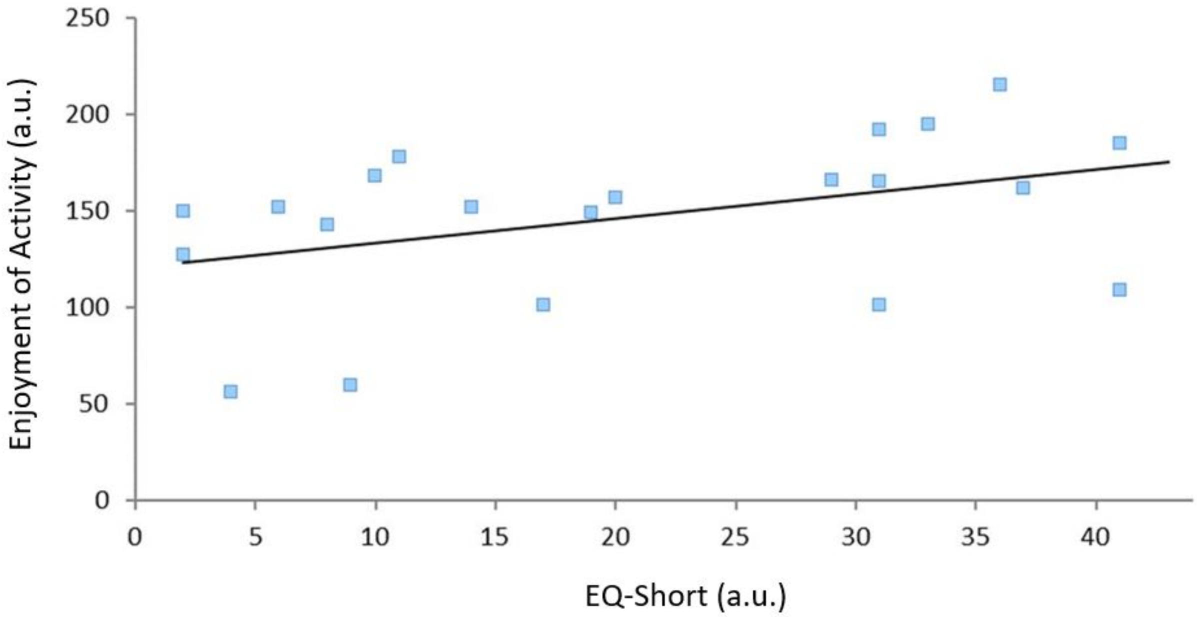

Figure 1. Self-reported enjoyment of the spontaneous music-induced movement activity against EQ-Short score.

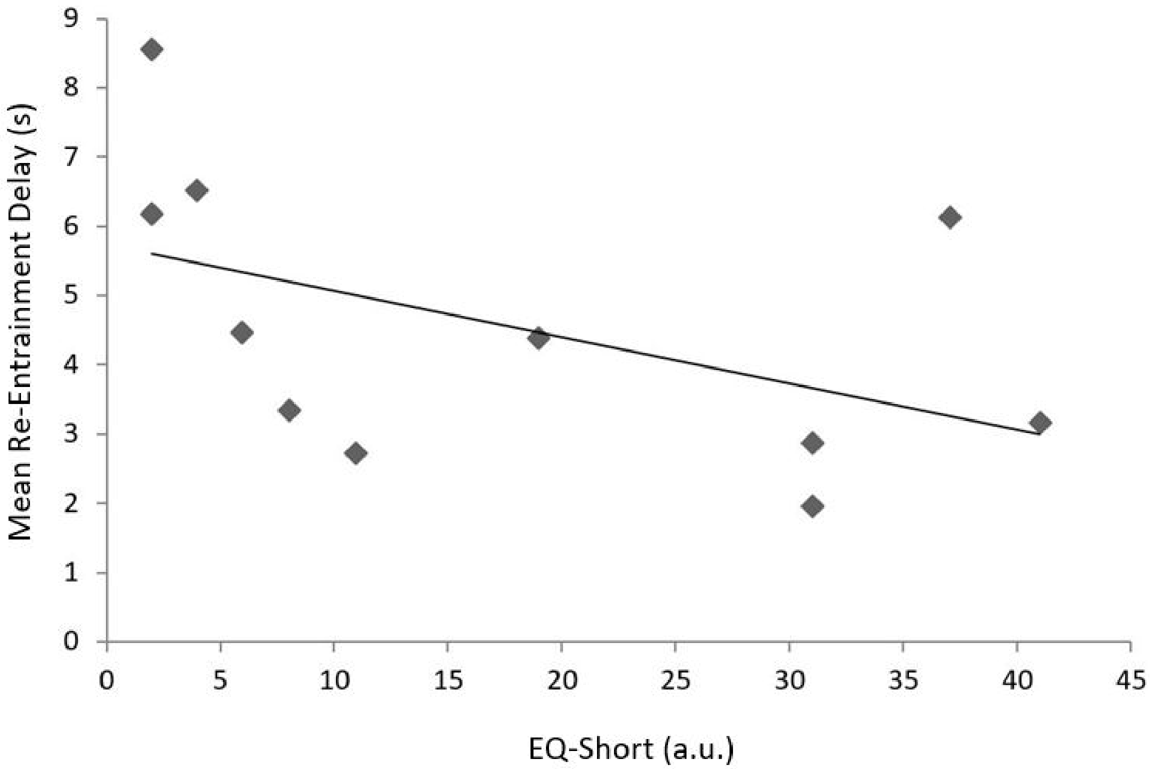

Figure 2. Mean Re-Entrainment Delay against EQ-Short score.