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The Effect of Mindfulness Meditation on Mu-rhythm Suppression and Pain Empathy

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The Effect of Mindfulness Meditation on Mu-rhythm Suppression and Pain Empathy

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Abstract

Objective: The current study investigated the effects of a 15-minute mindfulness meditation on mu suppression during a pain empathy task to determine if mindfulness meditation can impact empathy and its neural correlates. The current study also included a behavioral portion to investigate the effect of mindfulness meditation on self-report empathy for pain.

Method: In the EEG portion of the study, 50 Participants were enrolled in the EEG portion of this task, and 31 for the behavioral portion. Both groups were randomly assigned to listen to a 15-minute mindfulness meditation, or a control recording. Both groups completed a pain empathy task. In the EEG study, the dependent variable was mu-rhythm to the painful images during the task. In the behavioral study, the dependent variable was the perceived pain rating of each image shown. Participants also completed surveys to gather information on trat mindfulness (FFMQ-15), state mindfulness following the manipulation (TMS) trait empathy (EQ), and perceived childhood emotional invalidation (ICES). ***Results:*** It was found that there was no difference between groups in mu-rhythm suppression. There was however a nearly significant correlation between decentering state mindfulness scores and mu-rhythm suppression. There was also no difference found between groups in the behavioral study for ratings of pain empathy, although there was a significant relationship between curiosity state mindfulness scores and pain empathy ratings.

Conclusion: This finding shines a light on the potential relationship between state mindfulness in the forms of decentering and curiosity following a brief mindfulness meditation and empathy and should be further investigated. This finding suggests that increases of decentering and curiosity may play a role in increasing empathy.

The Effect of Mindfulness Meditation on Mu-rhythm Suppression and Pain Empathy

Empathy is an ability that encompasses subjectively feeling and understanding another person's emotional experiences and includes both affective and cognitive processes (Preston and de Waal, 2002). Empathy plays an important role in social interactions (Decety & Jackson, 2004; de Waal, 2012) and has been found to be associated with increased compassionate and prosocial behaviors toward others (Decety, Bartal, Uzefovsky, & Knafo-Noam, 2016; Eisenberg & Miller, 1987). This link between empathy and its role in social interactions illustrates the importance of understanding empathy and its neural underpinnings. The importance that empathy and its related behaviors play in the development of healthy social behavior has led to an increased interest in this area of research.

To understand empathy, it must first be understood as a related but different concept to Theory of Mind. Theory of mind (ToM) is a term that was coined by Premack and Woodruff (1976), and essentially describes the ability to be in another person's shoes. In other words, this entails the cognitive ability to make accurate appraisals, inferences, and attributions about another individual's mental state including their perspectives, beliefs, and intentions. ToM has also been referred to as "mentalizing" (Frith, 1999). This research was expanded into clinical populations by Baron-Cohen, Leslie, and Frith (1985), who investigated ToM in children with autism. They found that children with autism had a significantly higher rate of failure on the False Belief Test, which measures the perspective taking of a third person. It is now widely supported that individuals with impaired theory of mind abilities also experience difficulties in their interactions and relationships with others (Baron-Cohen, Leslie, & Frith, 1985; Derksen, Hunsche, Giroux, Connolly, & Bernstein, 2018).

Empathy is similar to ToM in that it also incorporates understanding the mental state of others, yet it is distinct in that the mental state evaluated is specific to the person's emotions. There are two primary types of empathy - cognitive empathy and emotional empathy. Cognitive empathy entails the ability to identify and understand the emotion one is experiencing, while emotional empathy pertains to sharing and experiencing the emotions of another person (Buck, Powers, & Hull, 2017; Lecker, Yini, Zhang, & Bonin, 2021). Whereas empathy involves explicitly understanding someone's emotional state and sharing that emotion, emotional contagion simply refers to implicitly mimicking that person's emotional state without understanding the larger context that emotion is being experienced in (Clark, Robertson, & Young, 2018). Results of a meta-analysis suggested that the neural network underpinning empathy includes largely the dorsal anterior cingulate cortex (dACC), anterior mid cingulate cortex (aMCC), supplementary motor area (SMC), and bilateral insula. Additionally, it was found that cognitive empathy specifically involved the dorsal aMCC and emotional empathy specifically involved the right anterior insula (Fan, Duncan, de Greck, & Northoff, 2011).

Similar to having empathy for another individual's feelings, we as humans also have an ability to understand and identify another person's subjective feelings of pain, which is called pain empathy (Wang, Zhu, Mo, Li, & Wang, 2021). Interestingly, levels of empathy have been found to be associated with pain empathy. Specifically, it was found that when watching individual's facial expression as they were completing a painful task, higher levels of self-report empathy were associated with increases in estimates of pain and more accurate estimates of pain being observed (Green, Tripp, Sullivan, & Davidson, 2009). Similarly, when nurses were given apparatuses to mimic the chronic pain felt by patients, their self-report empathy levels increased significantly (Simko, Rhodes, Gumireddy, Schreiber, Booth, & Hawkins, 2021).

It has also been found that perception of pain in others may have an effect on the observers own motor response. When participants were shown a hand being pricked by a needle, approach response by participants (pressing down on a keyboard key) was slowed down and the withdrawal response (releasing the key) was faster (Morrison, Poliakoff, Gordon, & Downing, 2007). This motor system response has also been found when using transcranial magnetic stimulation when participants were watching individuals get pricked by needles. Specifically, inhibition of motor evoked potentials that was found in the muscles of the observer correlated to the muscles being pricked, and this inhibition was correlated with the participants' subjective qualities of the pain being observed, indicating that the observer understood the pain that person was experience and the motor system responded accordingly (Avenanti, Bueti, Galati, & Aglioti, 2005). These authors argued that the automatic motor response of the observer based on the pain they are observing may be crucial for social learning relating to reaction of pain in others.

Mu Rhythm and Motor Resonance

Neural oscillations produced by neurons in the brain can be measured using electroencephalogram (EEG). Neural oscillations are classified according to their frequency range and often indicate a general brain state. For example, delta waves occur at the frequency range between 0.5-4 Hz, and commonly occur during sleep. Alpha rhythm is another neural oscillation, and ranges from 8-12 Hz. This wave frequency is commonly studied in EEG research, and is commonly associated with an awake, relaxed, eyes closed state (Goldman, Stern, Engel, & Cohen, 2002). Alpha rhythm is also associated with higher level cognitive states, such as when performing an attention or memory task (Klimesch, 2012; Knyazev, Slobodskaya, & Wilson, 2002). Similar to alpha rhythms, mu rhythms are measured within the 8-12 Hz frequency range. What makes these oscillations distinct, however, is that they occur over the sensorimotor cortices, and become suppressed (have a lower frequency when compared to baseline frequency) during motor movements, whereas alpha oscillations are suppressed during changes in attention and in response to visual stimuli (Pfurtscheller, Neuper, & Edlinger, 1997). Interestingly, mu suppression also occurs when watching someone else perform a motor action (Gastaut & Bert, 1954), which was also later indicated in the finding of the possible network of the mirror neuron system.

The mirror neuron system is a proposed network involved in ToM and more recently empathy (Gallese, 2001). Mirror neurons were first identified during single cell recording in the brain of macaque monkeys. Bimodal neurons were identified, such that the same neuron was activated when the monkeys observed a specific action, as well as when the monkeys themselves performed that same action (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). These neurons therefore ‘mirrored’ the activity involved with both doing and seeing an action performed, which could explain in part why some mammals are able to identify, interpret, and predict the actions of another. It has been argued therefore that a mirror neuron system (MNS) exists in the human brain, involving a complex interaction between different regions including the interior frontal gyrus and inferior parietal lobe (Buccino, Binkofski, & Riggio, 2004). A more recent term for this MNS response to observed and performed actions is called motor resonance. Motor resonance has been linked to empathy and has been quantified by a decrease in power of mu rhythm over the sensorimotor cortex (Fox et al., 2015; Moore & Franz, 2017).

This suppression of mu rhythm is thought to reflect mirror neuron activation, such that more suppression relates to increased mirror neuron activity. This has subsequently been found to be related to increased empathic response (Joyal, Neveu, Boukhalfi, Jackson, & Renaud, 2016). Similarly, when recording from central sensorimotor channels using EEG (C3, Cz, and

C4) it was found that mu rhythm suppression (i.e., mirror neuron activity) was greater for painful images compared to non-painful images (Arnett, Roach, Elzy, & Jelsone-Swain, 2018).

Some studies have found that physical traits of another person can have an impact on mu-rhythm response to empathy. Gutsell, Simon, and Jiang (2020 investigated motor resonance in response to individuals observing a same race hand or a different race hand squeeze a stress ball. In this study, it was found that watching someone of the same race squeeze a stress ball was associated with a significantly higher level of mu rhythm suppression than watching someone of another race do the same. Participants were also shown a picture of someone who was a different race than them and were told to write a story about that person's day by taking their perspective. Interestingly, when this was the case there was no longer a significant difference in mu rhythm suppression between races. Building on this idea that perspective taking dampens the differences in mu rhythm suppression when witnessing the pain of an individuals of the same or different race, it was found that using video manipulation to create a visuospatial overlap between observer's hand and the hand receiving the pain increased mu rhythm suppression for both same race and different race targets (Riecansky, Lengersdorff, Pfabigan, & Lamm, 2020). The idea behind this manipulation was to increase self-other bodily overlap, or mapping the body states of others on to our own body. When doing this, it was found that those who reported stronger bodily self-attribution to the hand experiencing the pain showed stronger mu rhythm suppression regardless of racial concordance/discordance (Riecanksy et al., 2020). This finding shows that racial bias in pain empathy response may develop later in childhood. Due to these differences in mu power across racial concordance/discordance, there was an attempt to control for this in the current study.

While mu rhythm suppression has been used consistently throughout the literature as a measure of mirror neuron system engagement, and in turn a measure of empathy, there have been inconsistent findings when determining if this is a valid measure of this engagement. Hobson and Bishop (2016) conducted a study with 61 adults to determine if mu suppression is a valid measure of mirror neuron system activity. They found that although there was strong mu suppression during hand movements, the overall claim of using mu suppression as an indicator of mirror neuron activity is unreliable, weak, and can be easily confounded with alpha suppression. Hobson and Bishop (2017) later elaborated on this claim by describing that because alpha suppression occurs during changes in attention, attentional differences in between tasks in a study could produce alpha suppression that mimics mu suppression. Another concern with the use of mu suppression as an indicator of mirror neuron system engagement is that few studies investigate changes in mu power at electrodes other than the central electrodes; as such, changes in mu power may be coming from elsewhere and simply picked up by the central electrodes being focused on (Hobson & Bishop, 2017).

Despite Hobson & Bishop's (2016, 2017) contention that mu rhythm suppression cannot be validly used as an indicator of empathy, several studies support the validity of mu suppression as a measure of empathy across different types of behaviors and tasks. For example, a factor that has been found to impact levels of mu suppression as a neural indicator of pain empathy is level of self-reported compassion. Specifically, when shown painful and non-painful images, it was found that the more compassion participants reported feeling towards people in the images, the more mu rhythm was suppressed for painful compared to non-painful images (Lübke, Sachse, Hoenen, & Pause, 2020).

Studies have also shown that mu suppression in response to empathy is not limited to visual stimuli. When studying the effects of auditory stimuli on mu suppression, Hoenen, Lübke, and Pause (2018) found that a pain related sound (someone yelling), increased mu suppression. This effect was present both when the pain stimuli were presented congruently (painful image and pain related sound presented together) or incongruently (one painful stimuli, one non-painful stimuli). When investigating the effects of chemosensory stimuli on mu suppression, Hoenen and colleagues (2018) found that smelling stress sweat compared to general sport sweat globally suppressed mu activity when viewing non-painful images to the point where there was no difference in mu suppression between painful and non-painful images. This could suggest that chemosensory information may override visual input when observing others in painful or non-painful situations.

It has also been found that individual's ability to feel the pain of another person, as opposed to just understanding the pain they are feeling, can have an effect on mu rhythm suppression in response to pain empathy. In a study conducted by Grice-Jackson, Critchley, Banissy, and Ward (2017), participants were shown short videos of individuals experiencing pain and were told to rate if they felt a sensation of pain in their own body. It was found that individuals who felt a localized sensation of pain (pain in the same area as the observed individual experiencing pain) had a significant difference in mu suppression between painful and non-painful images. These individuals also had significantly greater mu suppression than those who felt only a general sense of pain or no sensation of pain in response to the pain observation. This finding is in line with Green and colleagues (2009) findings that accuracy of subjective pain rating by the observer is correlated with levels of empathy.

Another aspect related to differences in mu suppression in response to pain empathy is mood, with negative mood resulting in lower mu suppression and less difference in mu suppression in painful vs non-painful conditions (Li, Meng, Li, Yang, & Yuan, 2017). Gender differences have also been found in mu suppression during a pain empathy task, with females showing more mu rhythm suppression in response to painful and non-painful stimuli (Yang, Decety, Lee, Chen, & Cheng, 2009). Interestingly, mu rhythm suppression was positively correlated with participant's self-reported distress for the person in the image during the pain empathy task for females, but not males.

Emotional Invalidation

Emotional invalidation is the trivializing or criticizing of the communication of emotional experiences. This construct can also include the repeated punishment of emotional expression that is appropriate and the intermittent reinforcing of emotional expression that is inappropriate or extreme (Selby, Braithwaite, Joiner, & Fincham, 2008). Experiencing repeated emotional invalidation can lead to an impaired understanding of emotions, or the impaired ability to identify the emotional expression of others or themselves (Linehan, 1993).

Emotional invalidation in childhood has been linked to a number of psychological disorders and their respective symptoms. For example, Linehan (1993) described in the biosocial theory that symptoms of borderline personality disorder (BPD) result from an invalidating environment in childhood and a biological predisposition for affective instability. Further research supports this theory that perceived invalidation in childhood is related to BPD symptomology. For example, features of BPD are linked to current romantic relationship functioning, and perceived childhood emotional invalidation mediates this relationship (Selby et al., 2008). Additionally, adolescents with BPD perceived their caregivers to be more invalidating and less supportive compared to their healthy peers (Bennett, Melvin, Quek, Saeedi, Gordon, & Newman, 2019). Emotional invalidation in childhood is also strongly associated with chronic emotional inhibition in adulthood (e.g thought suppression, stress avoidance, and ambivalence over expressing emotions; Krause, Mendelson, & Lynch, 2003). Additionally, this study found that chronic emotional inhibition in adulthood predicted psychological distress.

Emotional invalidation has also been found to be related to empathy. Recent evidence supports a negative relationship between emotional invalidation experienced during childhood and levels of trait empathy in adulthood (Arnett et al., 2018; Morrison, Elzy, & Jelsone-Swain, 2021). Additionally, it was found that childhood emotional invalidation is related to the activity of mu oscillations during a pain empathy task (Arnett et al., 2018). Expanding on this idea, Waller, Corstorphine, and Mountford (2007) found a link between emotional invalidation and alexithymia, or the difficulty in expression of emotions caused by lack of recognition and poor processing of emotions. Alexithymia can cause individuals to avoid tasks or situations that may involve emotional awareness. (Waller et al., 2007). Additionally, one of the core aspects of alexithymia is lack of ability to empathize (Messina, Beadle, & Paradiso, 2014). However, the relationship between empathy and emotional invalidation however is not well established, thus warranting further investigation. Importantly, a history of emotional invalidation should be considered when examining empathy and mu rhythm. For this reason, perceived childhood emotional invalidation will be controlled for in the current study.

Mindfulness Meditation

Mindfulness is a way of behaving that involves purposefully paying attention to the present moment and the unfolding of current experiences in a non-judgmental way. Mindfulness can be measured in the form of trait (every-day levels of mindfulness) and state mindfulness (mindfulness levels at a given moment). Mindfulness can increase through training, and can be brought on through forms of meditation (Verhaeghen, 2020). Mindfulness has been utilized in many ways in the field of health sciences including Mindfulness-Based Stress Reduction, Mindfulness-Based Cognitive Therapy, and Dialectical Behavior Therapy (Thompson & Waltz, 2007). Mindfulness meditation training has been found to increase episodic memory and related brain activity (Nyhus, Engel, Pitfield, & Vakkur, 2020), reduce pain intensity (e.g., reducing chronic pain), and increase activation in brain regions associated with cognitive modulation of pain (Zeidan et al., 2015).

Mindfulness may also be related to empathy. In a study investigating the effect of mindfulness meditation on state empathy, it was found that individuals who listened to a recording of a guided mindfulness meditation before and after watching an emotion inducing video reported higher levels of empathy in response to the video than the control group (Martin-Allan, Leeson, & Lovegrove, 2021). It has also been found that trait mindfulness was positively correlated with both emotional and cognitive empathy and meditative mindfulness was positively correlated with emotional empathy (Trent, Park, Bercovitz, & Chapman, 2016). In the study conducted by Tent and colleagues (2016), meditative mindfulness is described as the awareness that arises when paying attention to the present moment in a non-judgmental way. A link between mindfulness and empathy was also found in a study conducted by Hafenbrack, Cameron, Spreitzer, Zhang, Noval, and Shaffakat (2020). This study examined the role of a brief mindfulness meditation on prosocial behavior and found that mindfulness meditation significantly increased prosocial behavior, in the form of compassionate responding, and this effect was significantly meditated by the increase in empathy and perspective taking in the mindfulness group.

Although the previous studies have shown an increase in empathic processing post mindfulness activities, the literature is mixed. Specifically, Ridderinkhof, de Bruin, Brummelman, and Bögels (2016) found that a short 5-minute mindfulness manipulation had no significant effect on levels of empathy for someone being excluded in an online ball-tossing game. Similarly, when testing the effect of a 15-minute mindfulness manipulation on levels of empathy while controlling for personality types, it was found that a brief mindfulness meditation had no effect on levels of emotional empathy (Winning & Boag, 2015). Additionally, this study found that the mindfulness manipulation decreased levels of empathy for certain personality types. There are some possible explanations for such mixed results. A mediation analysis found that trait mindfulness, or everyday levels of mindfulness, mediated the relationship between mindfulness practice and empathy using self-report measures of mindfulness and empathy (de la Feunte-Anuccibay, González-Barbadillo, Ortega-Sánchez, & Pizarro-Ruiz, 2020). Specifically, it was found that mindfulness practice increased levels of trait mindfulness, which increased levels of empathy. ~~This construct of trait mindfulness and its effect on mindfulness meditation has been studied numerous times~~. It was also found that trait mindfulness is predicted by trajectories of state mindfulness during meditation training (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). This means that when state mindfulness during meditation increases with practice, an individual's level of trait mindfulness may also increase. For this reason, the current study will control for participant's level of trait mindfulness.

Mindfulness and Motor Resonance

Given the connection between mindfulness and empathy, a logical next step would be to establish the connection between mindfulness and brain activity related to mu rhthym. Thus far, research shows a relationship between these (Cahn & Polich, 2006; Chow, Javan, Ros, &

Frewen, 2016; Kerr et al,. 2011; Lomas, Ivtzan, & Fu, 2015), although sometimes in opposite directions. This may be related to the task, as mindfulness meditation was found to decrease mu-suppression while participants completed a Stroop task (Chow et al., 2016). The Stroop task is a measure of inhibitory control, which is a higher-level cognitive ability involving attention. It also appears that those who have been meditating long-term on a regular basis may have more stable resting mu-rhythm compared to non-meditators, whose resting mu levels were more active and noisy (Jiang, Lopez, Stieger, Greco, & He, 2021).

While there is evidence of mindfulness meditation having an effect on neural oscillations observed while completing a task, much of this has been conducted using long-term meditation. Although this appears to be the case, there is some evidence that supports the use of a brief mindfulness manipulation on neural activity. The study referenced earlier conducted by Chow and colleagues (2016) suggests that neural oscillations can be impacted by a brief mindfulness manipulation that precedes a task. This idea is further supported by two separate meta-analyses that investigated the effect mindfulness manipulation has on neural activity, both of which included studies using continuous EEG recording (Cahn & Polich, 2006; Lomas et al., 2015), These findings further support the use of brief mindfulness manipulation in this study. Additionally, a systematic review of the effect of mindfulness on mu power found that mu activation during meditation is related to the proficiency of practice of the meditation in question (Cahn & Polich, 2006). This study further supports the rationale for the current study to control for trait mindfulness.

Current Study

Empathy is described as the ability to understand and identify with others' emotional experiences, as well as understand and identify with another person's pain (Preston and de Waal, 2002). Empathy has been linked to compassionate and prosocial behavior and plays an important role in social interactions (Decety, Bartal, Uzefovsky, & Knafo-Noam, 2016; Eisenberg & Miller, 1987). Given the importance of empathic processing within social interactions, this concept remains a widely studied topic of interest. Understanding the neural mechanism of this ability is therefore an important next step, as changes in neural behavior can evidently result in changes of empathic abilities (Joyal, Neveu, Boukhalfi, Jackson, & Renaud, 2016). Previous research indicates that empathy can increase or attenuate following some experiences, such as with mindfulness meditation (Martin-Allan, Leeson, & Lovegrove, 2021) or childhood emotional invalidation (Morrison, Elzy, & Jelsone-Swain, 2021), respectively. These possible influences provide opportunity to evaluate the possibility of empathy intervention, which may be reached through increased mindfulness by changes in the mu rhythm power. This study therefore aimed to explore the how mindfulness may have an effect on the neural response to empathy by incorporating a between-groups experimental design involving a mindfulness manipulation, pain empathy task, EEG recording of mu activity, measurement of childhood emotional invalidation, trait empathy, and mindfulness.

Hypotheses

Hypothesis 1: State mindfulness levels will be higher in the mindfulness meditation group compared to those in the control group after listening to the respective recordings.

Hypothesis 2: Participants in the mindfulness meditation group will have greater mu-rhythm suppression during the pain empathy task compared to those in the control group.

Hypothesis 3: Childhood emotional invalidation will account for a significant amount of variance in mu rhythm suppression when added as a covariate when investigating hypothesis 2.

Hypothesis 4: Trait mindfulness will account for a significant amount of variance in mu rhythm suppression when added as a covariate when investigating hypothesis 2.

Hypothesis 5: Pain ratings during the behavioral task will be higher in the mindfulness meditation group compared to those in the control group.

Hypothesis 6: Childhood emotional invalidation will account for a significant amount of variance in pain ratings when added as a covariate when investigating hypothesis 5.

Hypothesis 7: Trait mindfulness will account for a significant amount of variance in pain ratings when added as a covariate when investigating hypothesis 5.

Method

EEG Participants

EEG data was collected from students at the University of South Carolina Aiken, high school students in the Summer Scholars program at USC Aiken, and individuals who volunteered after hearing about the study from investigators or professors. Participants signed up through an online recruiting system to receive research credit for class or were given the opportunity to volunteer by reaching out to the principal investor of the study via email. A power analysis determined that a sample size of 52 participants was needed for the EEG portion of the study. Fifty participants were recruited and 47 were used for final analysis, thus making the EEG portion of the study slightly underpowered. The rationale for the three participants being removed from final analysis is described in the EEG Data Analysis section. The mindfulness group consisted of 25 participants (19 female, 6 male, average age = 20.5, range = 17-53). The control group consisted of 22 participants (19 female, 3 male, average age = 22.5 years old, range = 16-41) (Table 1). Groups were compared on several measures to check for any potential differences that may have existed through random assignment.

Table 1

Demographic Characteristics of EEG Participants

Group	Mindfulness		Control		Total	
	n	%	n	%	n	%
Biological Sex						
Male	6	24	3	13.6	9	19
Female	19	76	19	86.4	38	81
Race/Ethnicity						
White/Caucasian	18	72	13	59.1	31	66
Hispanic/Latino	1	4	4	18.2	5	10.6
Black/African American	3	12	1	4.5	4	8.5
Two or more	3	12	4	18.2	7	14.9
Psychiatric Diagnosis						
Yes	9	36	7	31.8	16	34
No	16	64	15	68.2	31	66
Traumatic Brain Injury						
Yes	5	20	2	9	7	14.9
No	20	80			40	
			20	91		85.1
Meditation Experience						
Yes	11	44	6	27.3	17	36.2
No	14	56	16	72.7	30	63.8

Handedness						
Right	22	88	19	86.4	41	87.2
Left	3	12	3	13.6	6	12.8
Current Medication Use						
Yes	9	3	9	40.9	18	38.3
No	16	64	13	59.1	29	61.7

Behavioral Participants

Behavioral data was collected from students at the University of South Carolina Aiken, high school students in the Summer Scholars program at USC Aiken, and individuals who volunteered after hearing about the study from investigators or professors. Participants signed up through an online recruiting system to receive research credit for class or were given the opportunity to volunteer by reaching out to the principal investor of the study via email. A different group of people were recruited so that painful images were only seen once by each participant and were not confounding results through a habituation effect. A power analysis determined that a sample size of 52 participants was needed for the behavioral portion of the study. Thirty-one participants were recruited 28 were used for final analysis, thus making the behavioral portion of the study underpowered. Three participants were removed from final analysis for not responding correctly during the pain empathy task, making it impossible to interpret their responses. The mindfulness group consisted of 13 participants (11 female, 2 male, average age = 20.5, range = 18-23). The control group consisted of 15 participants (10 female, 5 male, average age = 24.1, range = 18-70) (Table 2).

Table 2

Demographic Characteristics of Behavioral Participants

Group	Mindfulness		Control		Total	
	n	%	n	%	n	%
Biological Sex						
Male	2	15.4	5	33.3	7	25
Female	11	84.6	10	66.7	21	75
Race/Ethnicity						
White/Caucasian	4	30.8	3	20	7	25
Hispanic/Latino	0	0	1	6.7	1	3.6
Black/African American	7	53.8	9	60	16	57.1
Two or more	2	15.4	2	13.3	4	14.3
Psychiatric Diagnosis						
Yes	2	15.4	3	20	5	17.9
No	11	84.6	12	80	23	82.1
Traumatic Brain Injury						
Yes	2	15.4	2	13.3	4	14.3
No	11	84.6	13	86.7	24	85.7
Meditation Experience						
Yes	1	7.7	7	46.7	8	28.6
No	12	92.3	8	53.3	20	71.4

Handedness						
Right	13	100	14	93.3	27	96.4
Left	0	0	1	6.7	1	3.6
Current Medication Use						
Yes	6	46.2	4	26.7	10	35.7
No	7	53.8	11	73.3	18	64.3

The study was sent for review to the University of South Carolina Institutional Review Board and was approved to be conducted.

Materials

Demographics Questionnaire

In order to obtain further knowledge of the participant sample, a demographics questionnaire was used to obtain information relating to age, gender, and ethnicity. Also, to gather descriptive information related to brain activity that could have potentially been used during data pre-processing and artifact rejection, I asked about current medication use, psychiatric disorder diagnosis, and handedness. Participants were asked to describe previous or current meditation practices, as it has been found that individuals who practice meditation regularly may have increased state mindfulness following the manipulation, as well as increased levels of overall empathy. (See Appendix A)

Screening Form

The screening form was used to determine eligibility in the study. The exclusion criteria were designed to ensure EEG recordings will not confounded by abnormal brain activity. These exclusion criteria are being under the age of 16 and having a current diagnosed seizure disorder.

Participants were also asked prior to participation if they had consumed alcohol or recreational drugs within the last 8 hours. (See Appendix B)

The 15-Item Five Facet Mindfulness Questionnaire

The 15-item Five Facet Mindfulness Questionnaire (FFMQ-15) (Baer et al., 2008***)*** is a 15- item self-report instrument measuring levels of trait mindfulness that assesses five facets of mindfulness: Observing, describing, non-judgement, non-reactivity, and acting with awareness (Baer et al., 2006). The FFMQ-15 is a shortened version of the 39-item FFMQ developed by Baer and colleagues (2006). The FFMQ-15 contains 3 items from each of the original five facets from the 39-item version. Participants are asked to rate items based on their own opinion of what is generally true for them. Items are scored by participants on a five-point Likert scale with one indicating "never or very rarely true" and five indicating "very often or always true". Examples of questions pertaining to the five facets include: "I pay attention to sensations, such as the wind in my hair or sun on my face" (Observing), "I am good at finding words to describe my feelings" (Describing), "I find myself doing things without paying attention" (Acting with awareness), "I think some of my emotions are bad or inappropriate and I should not feel them" (Non-judging of inner experience), and "When I have distressing thoughts or images I just notice them and let them go" (Non-reactivity to inner experience). Scores can range from 15-85, with higher scores indicating higher levels of trait mindfulness. Each facet has been tested across multiple samples and demonstrated adequate-to-good internal consistency, with alpha coefficients ranging from .72 to .92. (See Appendix C)

The Toronto Mindfulness Scale (TMS)

The Toronto Mindfulness Scale (TMS) (Lau et al., 2006), is a 13-item self-report scale that is designed to measure an individual's level of mindfulness in the current moment following a mindfulness exercise. The TMS measures two aspects of mindful thinking: Decentering and curiosity. Curiosity is described by as awareness of present moment experience with a quality of curiosity and decentering is described by as awareness of one's experience with some distance and disidentification rather than being carried away by one's thoughts and feelings. Items are scored on a four-point Likert scale with one indicating "not at all" and 4 indicating "very much". The TMS asks people to answer questions based on how well each statement describes what they just experienced, referring to the manipulation. Examples of the decentering items include: "I experienced myself as separate from my changing thoughts and feelings" and "I was more concerned with being open to my experiences than controlling or changing them". Examples of the curiosity items include: "I was curious about what I might learn about myself by taking notice of how I react to certain thoughts, feelings, or sensations" and "I was curious to see what my mind was up to from moment to moment". Scores can range from 0-52, with higher scores indicating higher state mindfulness elicited by the manipulation. Decentering and curiosity were measured for consistency separately, but were both found to have good internal consistency (Decentering Chronbach's alpha = 0.91, Curiosity Chronbach's alpha = 0.93) (Lau et al., 2006). (See Appendix D)

Invalidating Childhood Environment Scale (ICES)

The Invalidating Childhood Environment Scale (ICES) (Mountford, Corstorphine, Tomlinson, & Waller, 2007) is a self-report measure of perceived emotional invalidation experienced by individuals from their primary caregivers. The ICES consists of 18 items, 14 of them relating to behaviors exhibited by caregivers that reflect eight aspects of an invalidating childhood environment: Ignore emotions, ignore thoughts and judgments, negate emotions, negate thoughts and judgments, over-react to emotions, over-react to thoughts and judgments, oversimplify problems, and overestimate problem solving (Linehan, 1993). The 14 questions relating to these aspects are answered using a 5-point Likert scale (1 = never, 2 = rarely, 3 = some of the time, 4 = most of the time, 5 = all of the time). Higher scores reveal greater perceived amount of emotional invalidation from caregivers, with scores ranging from 14 to 70 for each caregiver (Robertson, Kimbrel, & Nelson-Gray, 2013). The other four items assess the three different types of invalidating environments (chaotic, typical, and perfect). Participants were asked to answer based on experiences from before the age of 18 years old. Due to the nature of the study, participants were asked to complete the 14 items that relate to the behaviors exhibited by their caregivers. Participants with two primary caregivers rated each caregiver individually to determine scores for each, in order for these scores to be averaged and develop a global estimate of perceived childhood emotional invalidation by both caregivers, also called "parental invalidation" by the developers of the measure. (See Appendix E)

The Empathy Quotient (EQ)

The Empathy Quotient (EQ) (Baron-Cohen & Wheelsright, 2004) is a self-report measure of trait empathy. The EQ consists of 60 questions, with 40 of the questions relating to empathy and the remaining 20 being control items. Examples of items that relate to empathy include: "I can usually apppreciate the other person's viewpoint, even if I don't agree with it", "I can easily work out what another person might want to talk about", and "Seeing people cry doesn't really upset me". Participants rate the questions by selecting strongly agree, slightly agree, slightly disagree, or strongly disagree. Twenty-one of the 40 items measuring empathy are scored by agreeing with the statement, where slightly agree is scored 1 point, strongly agree is scored 2 points, and both slightly and strongly disagree are scored 0 points. Nineteen of the 40 items are reversed, where slightly disagree is scored 1 point, strongly disagree is scored 2 points, and both slightly and strongly agree are scored 0 points. Scores range from 0 to 80, with higher scores indicating higher levels of trait empathy. The EQ has a Cronbach's alpha of .92 and has a high test-retest reliability of .97 (Baron-Cohen & Wheelsright, 2004). (See Appendix F)

Mindfulness Manipulation

The mindfulness manipulation being used is a 15-minute guided mindfulness meditation recording developed by Martin-Allan, Leeson, and Lovegrove (2021). The script that will be used was developed to focus on the idea of non-judgmentally paying attention to the present moment, which is a component of mindfulness outlined by Kabat-Zinn (2011). The recording will focus on paying attention to breathing, because it is thought to be attended to in a neutral, non-judgmental way for most individuals. Participants were told to note any distractions that causes their mind to drift away from their breath during the recording and label them with one word like "thinking" or "planning". This labeling of distractions is designed to facilitate non-judgement towards thoughts and distractions during the recording. This allows for breathing, as well as distractions to breathing, to be incorporated into the idea of present-focused attention and thus incorporated into the meditative practice.

Control Condition

The control condition, also developed and recorded by Martin-Allan and colleagues (2021), is a 15-minute audio recording on the history of the telephone. In addition to being identical in length, the recording is controlled for pace and tone to be similar to the mindfulness recording.

EEG Pain Empathy Stimuli and Task

The pain empathy task that was administered involves participants observing a set of images designed to induce feelings of pain empathy. The original stimuli, developed and provided by Jackson, Meltzoff, and Decety (2005), includes 128 digital color images. Of these images, 64 show right hands and right feet in painful situations (painful trials) and 64 show right hands and right feet in neutral situations that were matched to the 64 painful images (non-painful control trials). The painful images show the hand or foot experiencing different types of pain including thermal, mechanical, and pressure pain. The painful images are also designed to depict normal, every-day scenarios that also include a behavioral action (e.g. cutting a vegetable with a knife) in order to attempt to target the mirror neuron system. The images have reliably been found to elicit pain empathy in past studies using EEG to examine mu suppression (Arnett et al., 2018; Yang et al., 2009). Due to a lack of diversity in the images in the original stimuli and findings by Gutsell and colleagues (2020) showing a potential racial bias in mu rhythm response to pain empathy, 32 of the painful images and 32 of the non-painful images were recreated using hands and feet of varying skin tones. The photos were recreated in the attempt to control for all other stimuli in the photos, so the only difference is skin tone of the hand/foot.

All photos were presented on a Dell 32-inch monitor using Eprime software. The participants were seated approximately 100 cm from the monitor and a mechanical table was adjusted based on participant height to ensure a viewing angle for all of the images centered at 0 degrees. Participants were also asked to keep eye fixation on the center of the screen throughout the tasks.

Images were shown within 4 blocks, each separated by a self-paced break. Each block contains 32 painful images and 32 non-painful (64 total). Prior to each image being shown, a white fixation screen was shown with a small black crosshair on the center of the screen. The fixation screen was shown in a jittered inter-trial interval ranging from 250 ms - 750 ms, meaning the screen was shown for either 250 ms, 375 ms, 500 ms, 625 ms, or 750 ms, with each time being used equally throughout the study. Regardless of fixation time, baseline mu rhythm was measured from the 200 ms immediately before the image is shown. Following the fixation screen, a painful or non-painful image was shown to participants for 1,500 ms. Immediately following the image, participants used the computer keyboard to rate the images as either painful (1 key on the keyboard) or non-painful (2 key on the keyboard) as an attempt to validate the pain perception of the images being shown. Participants held their index and middle fingers over the "1" and "2" keys to reduce as much hand and eye movement as possible that would confound EEG data. Another jittered fixation screen with the same parameters as the first was presented to ensure the motor response from clicking the keyboard is not included in EEG data.

The fixation intervals were jittered in order to decrease expectancy effects prior to the image, decrease any carry over effects from the previous image, and to decrease any contamination in EEG data that could potentially be caused by the movement of participants pressing on the keys. Based on findings by Hobson and Bishop (2017), and consistent with the procedure used by Arnett and colleagues (2018), the intervals being used in this study were slightly longer than other experiments using these images to ensure validity of the baseline activity being recorded. Based on these time intervals, trials ranged from 2 - 3 seconds. EEG activity was monitored during the activity to ensure the quality of data being currently collected.

Behavioral Pain Empathy Stimuli and Task

Likert scale rating of images is not feasible with EEG due to movement artifact, I conducted a second study with a different set of participants to address this aim. From the same picture set used in the EEG portion of the study, 30 painful images and 8 non-painful images were used for the behavioral portion of the study. These participants rated the images on a scale from 0 (no pain) to 9 (extreme pain) on a keyboard during the pain empathy task. Participants also rated each image based on person distress experienced from the image on a scale from 0 (no distress) to 9 (extreme distress). Participants were able to work at their own pace and EEG data was not collected.

EEG Recording

BrainVision PyCorder was used to record Electrical brain activity along the scalp. For the present study, 32 active Ag/AgCl electrodes was positioned in an EEG-cap (EasyCap, Brain Products GmbH, Munich, Germany) using the International 10/20 system sites (Klem, Lüders, & Jasper, 1999) with FPz being used as the ground electrode. Data was collected continuously from all electrodes at a sample rate of 500 Hz. While data was recorded from all 32 channels, only the central sensorimotor channels were used for final analyses (C3, Cz, C4). The vertical and horizontal electro-oculograms (EOGs) were recorded to account eye movement and blinks, so this activity could be rejected. Online triggers determining the start of each trial was sent from the presentation computer to PyCorder Recording Software through a parallel port connection. To reduce potentially confounding environmental noise differing between participants, all participants were seated at a distance of 100 cm away from the monitor and the overhead lights were dimmed for every participant. Room temperature was also kept at or below 72°F for each participant during recording. Participants were asked to keep all personal electronics outside of the room to avoid electrical interference.

EEG Data Analysis

All data was preprocessed using BrainVision Analyzer Software. Data from two participants in the control group were unable to be added to the BrainVision software due to unknown technical errors and were in turn not pre-processed or analyzed. Data was re-referenced offline using the linked average mastoid electrodes, and a high (.5 Hz) and low pass (30 Hz) filter was applied in order to try to reduce any activity not related to the present task that is being picked up by the EEG recording (e.g. electrical noise or participant movement). Data was then segmented into separate epochs of 200 ms pre-stimulus to establish a baseline measurement and 1300 ms post-stimulus (based on Arnett et al., 2018) for painful and non-painful trial types. This segmentation resulted in four separate epochs per participant: Painful task, painful baseline, non-painful task, and non-painful baseline. A Gratton and Coles (Gratton et al., 1983) built-in ocular correction was also applied for each participant to account for eye movement. Three participants from the mindfulness group also had to have one electrode interpolated each (P7, CP1, & FC6) to account for a bad channel during recording, where the channel activity was referenced to surrounding electrode channels. Prior to analysis, data was examined and removed for artifacts and participants with lower than 60% clean data were removed from further processing. One participant from the control group was removed from further pre-processing due to having 82/127 (64.57%) of data removed for one epoch. Fast Fourier Transforms (FFTs) were performed in Brain Analyzer on the clean EEG data segments, where a 10% Hanning window was applied. Next, mu power was averaged across the four epochs. FFT data was then exported for all conditions for the electrodes surrounding the sensorimotor cortex (C3, Cz, and C4). Mu suppression for each participant was measured as mu power over electrodes C3, C4, and Cz during the averaged painful and non-painful trials divided by the mu power during their respective baseline averages, which is based on previous efforts to control for differences in scalp thickness and electrode impedance (Oberman, Ramachandran, & Pineda, 2008; Oberman, McCleery, Hubbard, Bernier, Wiersema, Raymaekers, & Pineda, 2013; Yang et al., 2009). All data was entered into the statistical software program IBM SPSS Statistics v.28 to compare mu suppression between different trials.

EEG Procedure

A total of 50 participants signed up for the study through an online recruiting system or emailed the principal investigator directly to sign up to participate in the study. Participants were able to receive research credit for classes if the professor made it an option, or participants were recruited to volunteer through word-of-mouth from investigators on the study. Participants were sent an informed consent document over email to read prior to participation. Participants were able to participate if they were over the age of 16 years old. If participants were under the age of 18 years old, the document was signed by a parent or legal guardian. Participants were also sent an online questionnaire that included the demographic questionnaire, screening questionnaire, the FFMQ-15, and the EQ. Upon arriving to the lab, participants signed the informed consent electronically on the computer in the EEG lab if they did not already do so before arrival.

Next, participants had the EEG cap fitted and placed on along with eye electrodes. Electro-conductive gel was applied to each electrode site until all electrodes had an impedance level below 5. Participants were then randomly assigned to receive the experimental condition or the control condition. The experimental condition consisted of a 15-minute guided mindfulness meditation recording. The control condition consisted of a recording of equal length that describes the history of the telephone and was designed to be similar in tone and pace to the mindfulness recording. After listening to the recording, participants completed the TMS to measure state mindfulness following each recording. The rationale behind administering the mindfulness manipulation after the cap placement had to do with ensuring the least amount of time passing between the manipulation and the task. Participants then began the pain empathy task. The pain empathy task consisted of participants being shown photos of individual's hands or feet in painful or non-painful scenarios and rating these images as painful or non-painful. Once the pain empathy task was complete, the participants then completed the ICES questionnaire on the same computer the pain empathy task was administered on. Upon completion of the ICES, the cap was removed, and participants were given materials to clean their head.

Behavioral Procedure

A total of 31participants signed up for the study through an online recruiting system or emailed the principal investigator directly to sign up to participate in the study. Participants were able to receive research credit for classes if the professor made it an option, or participants were recruited to volunteer through word-of-mouth from investigators on the study. Participants were sent an informed consent document over email to read and sign prior to participation. Participants were able to participate if they were over the age of 16 years old. If participants were under the age of 18 years old, the document was also signed by a legal guardian. Participants were also sent an online questionnaire that included the demographic questionnaire, screening questionnaire, the FFMQ-15, and the EQ. Upon arriving to the lab, participants signed the informed consent electronically.

Participants were then randomly assigned to receive the experimental condition or the control condition. Following the listening of the recording in either condition, participants completed the TMS to measure state mindfulness elicited from each recording. Participants then began the pain empathy task. The participants rated 38 images for perception of pain on a scale from 0 (no pain) to 9 (extreme pain). Participants also rated these images for personal distress experienced from a scale of 0 (no distress) to 9 (extreme distress). Once the pain empathy task was completed, the participants then completed the ICES questionnaire on the same computer the pain empathy task was administered on.

Results

EEG Study

The first portion of my study was aimed to target the dependent variable of mu suppression. Therefore, the following results pertain to only the EEG portion of this study.

Survey Data

There was no significant difference between the mindfulness group and the control group for trait mindfulness *(t* (45) = 1.030*, p* = 0.310, *Cohen's d* = .300) or perceived childhood emotional invalidation *(t* (45) = -1.495*, p* = 0.142, *Cohen's d* = .437). There was a difference nearing significance between the mindfulness group and the control group for trait empathy *(t* (45) = -1.709*, p* = .094, *Cohen's d* = .500) (Table 3).

Table 3

Survey Data for EEG Participants

Group	Mindfulness		Control	
	M	SD	M	SD
FFMQ-15	47.32	7.02	49.30	6.07
EQ	46.04	10.22	41.05	9.74
ICES	33.32	8.40	29.82	7.55

Note. M = Mean, SD = Standard Deviation, FFMQ-15 = 15-Item Five Facet Mindfulness Questionnaire, EQ = Empathy Quotient, ICES = Invalidating Childhood Environment Scale

Hypothesis 1

Hypothesis 1, which was state mindfulness levels will be higher in the mindfulness meditation group compared to those in the control group after listening to the respective recordings was tested using an independent samples t-test with group as the independent variable and TMS scores as the dependent variable. It was found that state mindfulness on the TMS following the mindfulness manipulation (*M* = 35.32, *SD* = 5.105) was nearly significantly higher than those in the control recording (*M* = 31.409, *SD* = 8.075), (*t* (45) = -2.009, *p* = .051, *Cohen's d* = .587). It was found that decentering scores on the TMS in the mindfulness group (*M* = 18.04, *SD* = 3.714) were significantly higher than decentering scores in the control group (*M* = 15.272, *SD* = 5.082), *(t* (45) = -2.149*, p* = .037, *Cohen's d* = .628). As far as curiosity scores on the TMS, there was no significant difference found between the mindfulness group (*M* = 17.28, *SD* = 3.234) and the control group (*M* = 16.136, *SD* = 4.673), (*t (45)* = -.985, *p* = .330, *Cohen's d* = .288*).*

EEG Data Analysis

A parametric check was applied to the data for mu rhythm suppression for painful and non-painful images to investigate normality of data using Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, Q-Q plots, histograms, and boxplots. All data was found to be normal. Hypotheses 2, 3, and 4, which were that participants in the mindfulness meditation group will have greater mu-rhythm suppression during the pain empathy task compared to those in the control group, and trait mindfulness and perceived childhood emotional invalidation will account for a significant amount of variance in mu-rhythm suppression when added as a covariates, was tested using a repeated measures ANCOVA with group and painful vs. nonpainful images as the independent variables, mu-rhythm suppression as the dependent variable, and trait mindfulness and perceived childhood emotional invalidation as covariates. When comparing differences between the mindfulness group (*Madj* = -.930, *Std. Error* = .025) and control group *(Madj* = -.930*, Std. Error* = .023) when viewing painful vs nonpainful images using perceived childhood emotional invalidation and trait mindfulness as covariates, there was not a significant difference found (F (1, 43) = .116, p = .735, *partial* eta^2 = .003). There was also not a main effect found for either trait mindfulness (F (1, 43) = .019, p = .891, *partial* eta^2 < .000) or perceived childhood emotional invalidation (F (1, 43) = 1.303, p = .260, *partial* eta^2 = .029) on mu rhythm suppression. It was also found that there was not a significant difference in mu-rhythm suppression between painful (*Madj* = -.928, *Std. Error* = .018) and non-painful images (*Madj* = -.921, *Std. Error* = .017) across the mindfulness and control groups when using perceived childhood emotional invalidation and trait mindfulness as covariates (F (1, 43) = .122, p = 0.728, *partial* eta^2 = .003).

Exploratory Analyses

To ensure participants viewed the painful images as painful and the non-painful images as non-painful, an independent samples t-test was used with group as the independent variable and accuracy of the participant's responses as the dependent variable. It was found that there was no significant difference found between the mindfulness group (*M* = .899 accuracy , *SD* = .087) and the control group (*M* = .904, *SD* = .055) where *M* = the percent of correct responses, of the perception of images shown (t (46) = -.227, p = .821, *Cohen's d* = .073). As it has been found that there is a link between state mindfulness following meditation and levels of trait mindfulness, three univariate ANCOVAs were run with group as the dependent variable, the three TMS scores as dependent variables for each of the three tests run, and trait mindfulness added as a covariate for each. It was found that there a difference nearing significance between the mindfulness group (*Madj* = 35.259, *Std. Error* = 1.351) and the control group (*Madj* = 31.479, *Std. Error* = 1.441) for TMS scores (F (1, 44) = 3.619, p = .064, *Partial* Eta^2 = .076) and there was no main effect found for trait mindfulness (F (1, 44) = .191, p = .665, *Partial* Eta^2 = .004). It was found there was a significant difference between the mindfulness group (*Madj* = 18.108, *Std. Error* = .890) and the control group (*Madj* = 15.195, *Std. Error* = .950) for decentering scores on the TMS (F (1, 44) = 4.948, p = .031, *Partial* Eta^2 = .101) and there was no main effect found for trait mindfulness (F (1, 44) = .540, p = .466, *Partial* Eta^2 = .012). There was no significant difference found between the mindfulness group (*Madj* = 17.151, *Std. Error* = .785) and the control group (*Madj* = 16.283, *Std. Error* = .838) for curiosity scores on the TMS (F (1, 44) = .564, p = .457, *Partial* Eta^2 = .013) and there was no main effect found for trait mindfulness (F (1, 44) = 2.509, p = .120, *Partial* Eta^2 = .054).

As perceived childhood emotional invalidation, trait mindfulness, and trait empathy have been linked to empathy response, a Pearson's Correlation was run to investigate the relationship between these constructs and mu-rhythm suppression in response to painful images. It was found that there was no significant relationship between perceived childhood emotional invalidation and mu rhythm suppression (r = .034, p = .823), trait mindfulness and mu-rhythm suppression (r = -.043, p = .774), or trait empathy and mu-rhythm suppression (r = -.102, p = .494).

Due to the current study being underpowered, two additional repeated measures ANCOVAs were run with both including group as the independent variable and mu-rhythm suppression during painful vs. non-painful images as the dependent variable, and perceived childhood invalidation being used as the covariate in one model and trait mindfulness being used as a covariate in the second model. It was found when adding perceived childhood emotional invalidation as a covariate there was no difference between the mindfulness group (*Madj* = -.929, *Std. Error* = .023) and the control group (*Madj* = -.919, *Std. Error* = .024) for mu-rhythm suppression (F (1, 44) = .979, p = .328, *Partial* Eta^2 = .022). There was no main effect found for perceived childhood emotional invalidation (F (1, 44) = 1.357, p = .250, *Partial* Eta^2 = .030). Similarly, when adding trait mindfulness as a covariate there was no difference between the mindfulness group (*Madj* = -.928, *Std. Error* = .023) and the control group (*Madj* = -.921, *Std. Error* = .024) for mu-rhythm suppression (F (1, 44) = .078, p = .782, *Partial* Eta^2 = .002). There was no main effect found for trait mindfulness (F (1, 44) = .042, p = .839, *Partial* Eta^2 = .001).

As there was no between group differences in mu power between groups, as well as differences between groups in decentering but not curiosity, I further investigated if there was a relationship between state mindfulness, as well as the two the two constructs within the state mindfulness scale of curiosity and decentering, with mu power using a Pearson's bivariate correlation analysis. It was found that there was a near-significant negative correlation between decentering scores on the TMS and mu rhythm suppression, (r = -.266, p = .071), albeit not significant when applying a Bonferroni correction. There was not a significant correlation between curiosity scores on the TMS and mu rhythm suppression (r = -.103, p = .489), nor was there a significant correlation between total TMS scores and mu rhythm suppression (r = -.236, p = .110).

Behavioral Study

The second portion of my study was aimed at targeting the dependent variable of pain empathy from a rating scale. Because Likert scale rating of images is not feasible with EEG due to movement artifact, I conducted a second study with a different set of participants to address this aim. A different group of people were recruited so that painful images were only seen once by each participant and were not confounding results through a habituation effect. Therefore, the following results pertain to only the behavioral portion of this study.

Survey Data

There was no significant difference between the mindfulness group and the control group for trait mindfulness (t (26) = 1.607, p = .120, *Cohen's d* = .61), trait empathy (t (26) = 0.651, p = 0.521, *Cohen's d* = .25), or perceived childhood emotional invalidation (t (26) = -1.363, p = 0.185, *Cohen's d* = .52) (Table 4).

Table 4

Survey Data for Behavioral Participants

Group	Mindfulness		Control	
	M	SD	M	SD
FFMQ-15	46.08	6.92	50.20	6.64
EQ	41.85	11.25	44.47	10.07
ICES	34.27	9.87	29.83	7.31

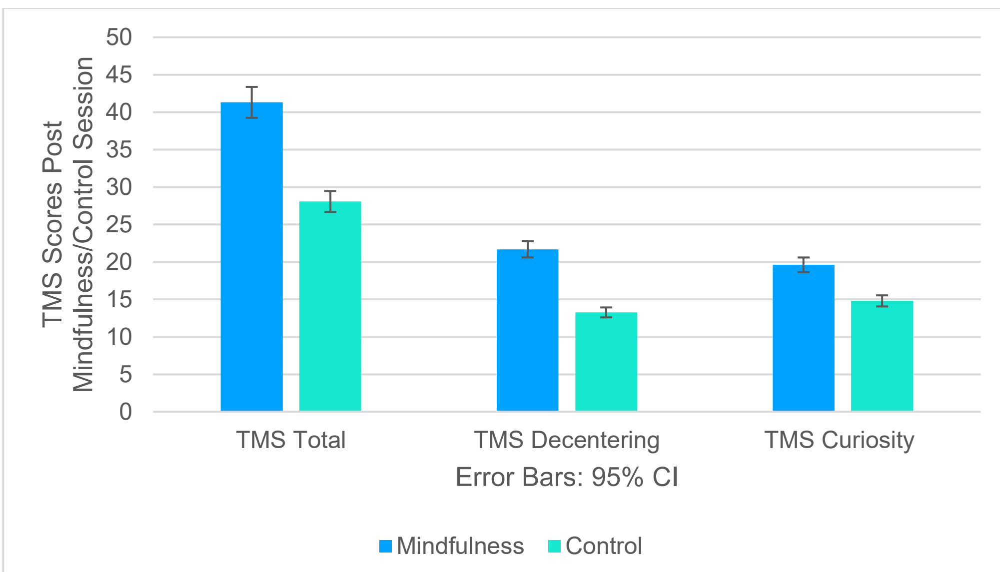
Note. M = Mean, SD = Standard Deviation, FFMQ-15 = 15-Item Five Facet Mindfulness Questionnaire, EQ = Empathy Quotient, ICES = Invalidating Childhood Environment Scale

Hypothesis 1

Hypothesis 1, which was state mindfulness levels will be higher in the mindfulness meditation group compared to those in the control group after listening to the respective recordings was tested using an independent samples t-test with group as the independent variable and TMS scores as the dependent variable. It was found that state mindfulness following the mindfulness manipulation (*M* = 41.307, *SD* = 8.097) were significantly higher than state mindfulness following the control recording (*M* = 28.067, *SD* = 11.247), (*t* (26) = -3.523, *p* = .002, *Cohen's d* = 1.335). It was found that decentering scores on the TMS in the mindfulness group (*M* = 21.692, *SD* = 7.239) were significantly higher than decentering scores in the control group (*M* =13.267, *SD* = 5.216), (*t* (26) = -3.568, *p* = .001, *Cohen's d* = 1.352). Similarly, it was found that curiosity scores on the TMS in the mindfulness group (*M* = 19.615, *SD* = 2.501) were significantly higher than curiosity scores in the control group (*M* = 14.8, *SD* = 6.538), (*t* (26) = -2.497, *p* = .019, *Cohen's d* = .946) (Figure 1).

Figure 1

Toronto Mindfulness Scale Scores for Behavioral Participants



Behavioral Data Analysis

A parametric check was applied to the data for pain empathy ratings to investigate normality of data using Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, Q-Q plots, histograms, and boxplots. All data was found to be normal. Hypotheses 5, 6, and 7, which were that participants in the mindfulness meditation group will have greater pain empathy ratings compared to those in the control group, and trait mindfulness and perceived childhood emotional invalidation will account for a significant amount of variance in pain empathy ratings when added as covariates, was tested using a univariate ANCOVA with group being the independent variable, pain empathy rating being the dependent variable, and perceived childhood emotional invalidation and trait mindfulness being added as covariates. There was no significant difference found in pain empathy ratings between the mindfulness group (*Madj* = 6.937, *Std. Error* = .304) and control group *(Madj = 6.536, Std. Error* = .304) (F (1, 24) = .744, p = .397, *partial* eta^2 = .030). There was not a main effect found for either trait mindfulness (F (1, 24) = .278, p = .603, *partial* eta^2 = .011) or perceived childhood emotional invalidation (F (1, 24) = 2.498, p = .127, *partial* eta^2 = .094) on pain empathy ratings.

Exploratory Analyses

As it has been found that there is a link between state mindfulness following meditation and levels of trait mindfulness, three univariate ANCOVAs were run with group as the dependent variable, the three TMS scores as dependent variables for each of the three tests run, and trait mindfulness added as a covariate for each. It was found that there was a significant difference between the mindfulness group (*Madj* = 41.359, *Std. Error* = 2.879) and the control group (*Madj* = 28.022, *Std. Error* = 2.671) for TMS scores (F (1, 25) = 11.015, p = .003, *Partial* Eta^2 = .306) and there was no main effect found for trait mindfulness (F (1, 25) = .006, p = .938, *Partial* Eta^2 < .001). It was found there was a significant difference between the mindfulness group (*Madj* = 21.712, *Std. Error* = 1.809) and the control group (*Madj* = 13.250, *Std. Error* = 1.678) for decentering scores on the TMS (F (1, 25) = 11.232, p = .003, *Partial* Eta^2 = .310) and there was no main effect found for trait mindfulness (F (1, 25) = .002, p = .962, *Partial* Eta^2 = .000). There was a significant difference found between the mindfulness group (*Madj* = 19.647, *Std. Error* = 1.477) and the control group (*Madj* = 14.773, *Std. Error* = 1.370) for curiosity scores on the TMS (*F* (1, 25) = 5.589, *p* = .026, *Partial* Eta^2 = .183) and there was no main effect found for trait mindfulness (*F* (1, 25) = .009, *p* = .925, *Partial* Eta^2 < .001).

Due to the current study being underpowered, two additional univariate ANCOVAs were run with both including group as the independent variable and pain empathy ratings as the dependent variable, and perceived childhood invalidation being used as the covariate in one model and trait mindfulness being used as a covariate in the second model. It was found when adding perceived childhood emotional invalidation as a covariate there was no difference between the mindfulness group (*Madj* = 6.977, *Std. Error* = .315) and the control group (*Madj* = 6.501, *Std. Error* = .293) for pain empathy ratings (*F* (1, 25) = 1.181 , *p* = .288, *Partial* Eta^2 = .045). There was no main effect found for perceived childhood emotional invalidation (*F* (1, 25) = 2.651, *p* = .116, *Partial* Eta^2 = .096). Similarly, when adding trait mindfulness as a covariate there was no difference between the mindfulness group (*Madj* = 6.835, *Std. Error* = .332) and the control group (*Madj* = 6.624, *Std. Error* = .308) for pain empathy ratings (*F* (1, 25) = .208, *p* = .652, *Partial* Eta^2 = .008). There was no main effect found for trait mindfulness (*F* (1, 25) = .334, *p* = .568, *Partial* Eta^2 = .013).

In order to further address the lack of statistical power when running ANCOVAs, a one-way ANOVA was used to compare mean differences in pain empathy ratings between the mindfulness and control group without including trait mindfulness and perceived childhood emotional invalidation as covariates. There was no significant difference found between pain empathy ratings in the mindfulness group (*M* = 6.8782, *SD* = 1.09008) and the control group (*M* = 6.5867, *SD* = 1.20019), (*F* (1, 26) = .447, *p* = .510). A one-way ANOVA was also used to compare mean differences in personal distress ratings between the mindfulness and control group. There was no significant difference found between personal distress ratings in the mindfulness group (M = 4.9462, SD = 2.15525) and the control group (M = 4.9111, SD = 2.19294), (F (1, 26) = .002, p = .966).

As perceived childhood emotional invalidation, trait mindfulness, and trait empathy have been linked to empathy response, a Pearson's Correlation was run to investigate the relationship between these constructs and pain empathy ratings. It was found that there was no significant relationship between perceived childhood emotional invalidation and pain empathy ratings (r = -.263, p = .178), trait mindfulness and pain empathy ratings (r = -.148, p = .453), or trait empathy and pain empathy ratings (r = .087, p = .660).

As there was no between group differences in pain empathy response between groups, I further investigated if there was a relationship between state mindfulness, as well as the two constructs within the state mindfulness scale of curiosity and decentering, with pain empathy and personal distress scores using a Pearson's bivariate correlation analysis. It was found that there was a significant positive correlation between curiosity scores on the TMS and pain empathy ratings (r = .497, p = .007) and a significant positive correlation between curiosity scores on the TMS and personal distress scores (r = .403, p = .034) There was not a significant correlation found between decentering TMS scores and pain empathy ratings (r =.101, p = .607) or between decentering TMS scores and personal distress ratings (r = .144, p = .465). Additionally, there was not a significant correlation found between TMS total scores and pain empathy ratings (r = .298, p = .124) or between TMS total scores and personal distress ratings (r = .280, p = .149).

Discussion

The current study hypothesized that there would be a significant increase in mu-rhythm suppression in response to a pain empathy task between a group who listened to a 15-minute mindfulness meditation vs. a control group when controlling for perceived childhood emotional invalidation and trait mindfulness. It was also hypothesized that trait mindfulness and perceived childhood emotional invalidation would account for a significant amount of variance in this model. The current study also included a behavioral component, where it was hypothesized that separate participants who received the mindfulness manipulation would rate the images as more subjectively painful than those in the control group. While these hypotheses were not supported, exploratory analysis helped to determine that increased state mindfulness may relate to increased mirror neuron system and empathic functioning.

It was found through exploratory analysis that decentering scores on the TMS were nearly-significantly negatively related to mu rhythm suppression when viewing painful images. Previous research has found the relationship between trait mindfulness levels and trait empathy levels were mediated by levels of decentering (Fuochi & Voci, 2020). This study also describes how being decentered is likely to lead to an enhanced ability to take the perspective of someone else, which would in turn increase empathy. Perspective taking has been shown to increase levels of mu-rhythm suppression when viewing painful images (Gutsell, Simon, and Jiang 2020; Riecansky, Lengersdorff, Pfabigan, & Lamm, 2020). These studies support the finding the de-centering specifically may have an effect on mu-rhythm in response to empathy due to the in-creased likelihood of perspective taking when having a decentered approach. Interestingly, it was found in the behavioral portion of the study that curiosity scores were significantly correlated with levels of pain perception and with levels of personal distress when viewing painful images, but decentering scores were not. Curiosity is described by Lau and colleagues (2006) as awareness of present moment experience with a quality of curiosity. It was found by Barata, Acar, and Bostanci (2022) that self-report mindful awareness significantly predicted self-report cognitive empathy. Additionally, it was found using fMRI that a period of interoceptive awareness significantly enhanced neural activity to empathy (Ernst, Northoff, Boker, Seifritz, & Grimm, 2012). While this is inconsistent with the current study that found no relationship between the present moment awareness and neural response to empathy, fMRI was not used in the current study to investigate this relationship. What these studies do suggest though, is that present moment awareness (or curiosity) is related to empathy, which is supported by the current study. Due to previous findings that show perspective taking can increase mu-rhythm suppression to empathy, it is thought that those who had higher decentering scores in the current study would in-turn be more prone to taking the perspective of those in the images, and thus had more-mu-rhythm suppression in response to these images, explaining the correlation between decentering and mu-rhythm suppression. Additionally, curiosity was found to be related to pain empathy response, but not mu-rhythm suppression. This suggests that the relationship between mindfulness and mu-rhythm suppression response to empathy is facilitated by perspective taking and is thus more specific decentering. This also suggests that the relationship between curiosity and empathy is facilitated by present moment awareness which is why this construct was related to pain empathy response in the behavioral study, but not related to mu-rhythm suppression in the EEG portion of the study. While previous research has found a relationship between mindfulness meditation and empathy, the current study suggests that these two facets of state mindfulness, curiosity and decentering, are uniquely related to different ways of measuring empathy, which warrants further research into this topic.

Additionally, a systematic review of the effect of mindfulness on mu power found that mu activation during meditation is related to the proficiency of practice of the meditation practice (Cahn & Polich, 2006). This is important because of the findings by Lau and colleagues (2006) when developing the TMS, which found that state mindfulness scores on the TMS increased following an 8-week mindfulness-based stress reduction course. Essentially, it is possible that as meditation practice and proficiency increases, so do levels of state mindfulness, and empathy and mu activation may be affected. This is supported by the finding in the current study of the relationship between levels of decentering and mu rhythm, as well levels of curiosity and pain perception in the behavioral task. This tells us that state mindfulness in the form of decentering may relate to increased mirror neuron system and empathic functioning, while state mindfulness is the form of curiosity may relate to increased self -report empathy for pain.

It was also found that state mindfulness scores in the mindfulness group were nearly significantly higher than state mindfulness scores in the control group for the EEG participants, while in the behavioral group this difference was much more significant. This suggests that completing the mindfulness manipulation without being hooked up to EEG equipment was more effective at eliciting mindfulness. Additionally, it was found that curiosity scores were significantly higher in the mindfulness group than the control group for the behavioral participants, but not the EEG participants, while decentering scores were significantly higher in the mindfulness group than the control group for both the EEG and behavioral participants. This suggests that having the EEG cap on your head, eye electrodes on, and gel applied may have been uncomfortable and distracting for participants during the manipulation and may have had an effect on levels of state mindfulness, specifically in the form of curiosity, following the manipulation.

There were no significant differences found in mu rhythm suppression between the mindfulness and control groups, as well as no difference found in pain perception in the behavioral participants between the mindfulness and control groups. These findings are somewhat consistent with previous literature on a brief mindfulness meditation and empathy, as there are mixed results. Specifically, one study using a 15-minute mindfulness meditation found significant increases in empathy (Martin-Allan, Leeson, & Lovegrove, 2021), while another study using a 15-minute mindfulness meditation found no increases in empathy, and even a decrease in empathy for certain personality types (Winning & Boag, 2015). Studies have also found that long-term mindfulness-based programs may increase empathy (Can Gür & Yilmaz, 2020) and have an effect on mu-rhythm activity (Jiang, Lopez, Stieger, Greco, & He, 2021). As mentioned previously, state mindfulness scores using the TMS increased following an 8-week mindfulness-based stress reduction course (Lau et al., 2006). The findings in the current study that levels of state mindfulness are associated with mu-rhythm in response to painful images, as well as subjective pain empathy ratings in the behavioral task, highlight the importance of increases in state mindfulness throughout these long-term mindfulness-based programs, and the effect this may have on empathy. Further support of this idea is shown in a study that found that trait mindfulness is related to state mindfulness during meditation training, specifically that trajectories of state mindfulness following meditation predict increases in trait mindfulness (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). Additionally, it was found that trait mindfulness mediated the relationship between mindfulness practice and empathy (de la Feunte-Anuccibay, González-Barbadillo, Ortega-Sánchez, & Pizarro-Ruiz, 2020). Specifically, it was found that mindfulness practice increased levels of trait mindfulness, which increased levels of empathy. What these studies may also tell us is that although trait mindfulness was accounted for in this study, if an individual had low trait mindfulness due to lack of practice, the short one-time manipulation may have been ineffective in increasing state mindfulness to the point where there was a significant change in empathy or mu-rhythm suppression. Essentially, this lends additional support to the idea that a brief mindfulness meditation in the current study may not have been sufficient in finding an effect on mu-rhythm suppression or pain empathy response between the mindfulness and control groups, but that levels of state mindfulness are correlated with mu-rhythm suppression and pain empathy response.

Another potential explanation for the null findings on these hypotheses is due to the additional pictures showing individuals with black skin being added to the picture set. Gutsell and colleagues (2020) found that discordance in skin tone between participants and images shown was associated with less mu rhythm suppression when viewing these images, in that white individuals had less mu-rhythm response when viewing images of black hands in painful scenarios, and vice versa for black individuals viewing white hands. In the EEG portion of the study, 66% of the participants identified as White/Caucasian and 8.5% identified as Black/African American. Additionally, in the behavioral portion of the study 57.1% of the participants identified as Black/African American and 25% identified as White/Caucasian. Given the differences between these groups in diversity, it is plausible that the addition of these images impacted the overall mu rhythm suppression and empathy response across both studies as participants were shown both images of white and black hands and feet. The effect stated above from the added images could also begin to explain why there was not a difference in mu-rhythm suppression between painful and non-painful images when combining the groups, as this is a finding that has been consistently replicated. Additionally, this may explain why perceived childhood emotional invalidation did not account for variance in any of the models across the studies, as it has in a previous study using the same picture set without the new images added (Arnett, Roach, Elzy, and Jelsone-Swain, 2018). If this speculation is true, it would add to the literature that skin tone of the images perceived has an effect on mu rhythm suppression and thus should be further investigated.

Limitations and Future Directions

One of the limitations of the current study included being underpowered in both the EEG and behavioral portions of the study due to originally only recruiting from college student from an undergraduate class and having participants not show for scheduled sessions to participate. A longer time period to be able to continue to collect data to add to the power of the study may have been helpful and could possibly be returned to in the future. Another limitation of the current study was the potential ineffectiveness of the mindfulness manipulation in the EEG group. Replication of this study and attempting to use different mindfulness manipulations or techniques to achieve a higher level of state mindfulness in the experimental group is something that should potentially be investigated in future directions as well. Specifically, based on the findings of the relationship between state mindfulness and empathy and the previous findings that show increased state mindfulness with longitudinal mindfulness practice, it may be interesting to have participants complete the pain empathy tasks before and after a long-term mindfulness training program. Another limitation of the current study was the inability to complete the EEG study with individuals with certain haircuts like dreadlocks or braids. When an individual would come to the lab, an attempt would be made to place the EEG cap on and use the electroconductive gel to obtain an appropriate impedance level. It was found that with certain hairstyles like the ones listed above, certain electrodes would be blocked from making a connection to the scalp, thus not obtaining appropriate impedance levels. In these instances, participants completed the behavioral portion of the study and still received full credit for participating in the EEG portion of the study.

This limitation in EEG research led to a less diverse EEG sample with 66% of participants identifying as Caucasian, while in the behavioral sample, 57.1% of participants identified as Black/African American. Another potential limitation in the current study is the images added to the picture set. While the idea of adding the pictures is based in research, the new picture-set itself should be further tested for validity and possibly modified. Additionally, because perceived childhood emotional invalidation had been found previously to account for variance using the same picture set without the new images, it may be beneficial to analyze differences in mu-rhythm suppression and empathy responses between the light-skin images and dark-skin images. Another potential limitation of the current study is the length of the task and averaging mu power across all trials. It is possible that participants may become habituated to seeing these images and have less mu-rhythm suppression towards the end of the study compared to the start. Additionally, it is possible that state mindfulness levels begin to decrease as the experiment continues due to more time elapsing after the manipulation. A future direction may include looking at trends of mu-rhythm suppression or pain empathy response over the course of the study.

Conclusions

Overall, the main hypotheses for this study were found to be null. These null findings may be explained by racial discordance masking differences in pain empathy response, lack of power, or ineffectiveness of the mindfulness manipulation in EEG participants. Exploratory analyses however found a relationship between state mindfulness levels and mu rhythm during painful images, as well as a relationship between state mindfulness levels and subjective pain empathy ratings. These results together support the notion that increased state mindfulness may increase the neural and perceptual empathic response toward others in pain, which is not dependent upon a formal mindfulness intervention. Based on this finding, as well as previous findings that state mindfulness increases with practice, the next step in this line of research should be to investigate the effect of a long-term mindfulness-based training program on empathic functioning, which could possibly be utilized with people at risk for impaired empathy processing. Mindfulness-based techniques are widely used in therapeutic approaches like cognitive behavioral therapy and dialectical behavioral therapy and are also being studied as a potential way of increasing empathy. The findings of the current study highlight the importance of state-mindfulness levels post mindfulness intervention, and emphasizes the need to continue to investigate trajectories of state-mindfulness with practice and how this may impact empathy.

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Appendix A

Demographics Questionnaire

1) Please List Below Your:
    a. Age ____________________
    b. Gender______________________________________
    c. Biological sex_______________________________
    d. Race/ethnicity______________________________________
    e. College Year ______________________________________

2) What hand do you primarily write with?

3) Are you currently taking any medications? If yes, please list:

4) Have you ever been diagnosed with a psychiatric disorder, such as ADHD or Major Depressive Disorder? If yes, please list:

5) Have you ever experienced brain damage, such as from a concussion or accident? If so, please describe. If you've suffered brain injury, please include your age of accident:

6) Do you have any experience with meditation? If yes, would you care to explain?

Appendix B

Screening Form

Are you over the age of 18?

Yes _____ No_____

Have you ever been diagnosed with a seizure disorder?

Yes _____ No _____

Have you consumed alcohol or recreational drugs in the last 8 hours?

Yes _____ No _____

Appendix C

The 15-Item Five Facet Mindfulness Questionnaire (FFMQ-15)

Please rate each of the following statements using the scale provided. Write the number in the blank that best describes your own opinion of what is generally true for you.

1 = never or very rarely true

2 = rarely true

3 = sometimes true

4 = often true

5 = very often or always true

_____ 1. When I take a shower or bath, I stay alert to the sensations of water on my body.

_____ 2. I'm good at finding words to describe my feelings.

_____ 3. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.

_____ 4. I believe some of my thoughts are abnormal or bad and I shouldn't think that way

_____ 5. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.

_____ 6. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.

_____ 7. I have trouble thinking of the right words to express how I feel about things.

_____ 8. I do jobs or tasks automatically without being aware of what I'm doing.

_____ 9. I think some of my emotions are bad or inappropriate and I shouldn't feel them.

_____ 10. When I have distressing thoughts or images I am able just to notice them without reacting.

_____ 11. I pay attention to sensations, such as the wind in my hair or sun on my face.

_____ 12. Even when I'm feeling terribly upset I can find a way to put it into words.

_____ 13. I find myself doing things without paying attention.

_____ 14. I tell myself I shouldn't be feeling the way I'm feeling.

_____ 15. When I have distressing thoughts or images I just notice them and let them go.

Appendix D

The Toronto Mindfulness Scale (TMS)

We are interested in what you just experienced. Below is a list of things that people sometimes experience. Please read each statement. Please indicate the extent to which you agree with each statement. In other words, how well does the statement describe what you just experienced, just now?

0 = Not at all

1 = A little

2 = Moderately

3 = Quite a bit

4 = Very Much

Rate 0-4

______ 1. I experienced myself as separate from my changing thoughts and feelings.

______ 2. I was more concerned with being open to my experiences than controlling or changing them.

______ 3. I was curious about what I might learn about myself by taking notice of how I react to certain thoughts, feelings, or sensations.

______ 4. I experienced my thoughts more as events in my mind than as a necessarily accurate reflection of the way things ‘really’ are.

______ 5. I was curious to see what my mind was up to from moment to moment.

______ 6. I was curious about how each of the thoughts and feelings that I was having.

______ 7. I was receptive to observing unpleasant thoughts and feelings without interfering with them.

______ 8. I was more invested in just watching my experiences as they arose, than in figuring out what they could mean.

______ 9. I approached each experience by trying to accept it, no matter whether it was pleasant or unpleasant.

______ 10. I remained curious about the nature of each experience as it arose.

______ 11. I was aware of my thoughts and feelings without overidentifying with them.

______ 12. I was curious about my reactions to things.

______ 13. I was curious about what I might learn about myself by just taking notice of what my attention gets drawn to.

Appendix E

Invalidating Childhood Environments Scale (ICES)

The following questions address your experiences of how your parent(s)/carer(s) responded to your emotions when you were young. For each item, please choose the rating from 1 to 5 that most closely reflects your experience up to the age of 18 years. Because your parent(s)/carer(s) may have been very different, please rate them separately. Please write your response in the spaces provided underneath each statement.

1	**2**	**3**	**4**	**5**
Never	**Rarely**	**Some of the time**	**Most of the time**	**All of the time**

1. My parent/carers would become angry if I disagreed with them.

Primary Caregiver #1 ____ Primary Caregiver #2 ____

2. When I was anxious, my parent/carers ignored this.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

3. If I was happy, my parent/carers would be sarcastic and say things like: “What are you smiling at?”

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

4. If I was upset, my parent/carers said things like: “I'll give you something to really cry about!”

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

5. My parent/carers made me feel OK if I told them I didn't understand something difficult the first time.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

6. If I was pleased because I had done well at school, my parent/carers would say things like: “Don't get too confident”.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

7. If I said I couldn't do something, my parent/carers would say things like: “You're being difficult on purpose”.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

8. My parent/carers would understand and help me if I couldn't do something straight away.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

9. My parent/carers used to say things like: “Talking about worries just makes them worse”.

   Primary Caregiver #1 ____ Primary Caregiver #2 ____

10. If I couldn't do something however hard I tried, my parent/carers told me I was lazy.

    Primary Caregiver #1 ____ Primary Caregiver #2 ____

11. My parent/carers would explode with anger if I made decisions without asking them first.

    Primary Caregiver #1 ____ Primary Caregiver #2 ____

12. When I was miserable, my parent/carers asked me what was upsetting me, so that they could help me.

    Primary Caregiver #1 ____ Primary Caregiver #2 ____

13. If I couldn't solve a problem, my parent/carers would say things like: “Don't be so stupid — even an idiot could do that!”

    Primary Caregiver #1 ____ Primary Caregiver #2 ____

14. When I talked about my plans for the future, my parent/carers listened to me and encouraged me

    Primary Caregiver #1 ____ Primary Caregiver #2 ____

Appendix F

The Empathy Quotient (EQ)

Below is a list of statements. Please read each statement carefully and rate how strongly you agree or disagree. For each item, please choose the rating from 1 to 4 that most closely reflects your perspective. Please write your answer in the space to the right of each statement. There are no right or wrong answers, or trick questions.

1	2	3	4
Strongly Agree	Slightly Agree	Slightly Disagree	Strongly Disagree

Examples

E1. I would be very upset if I couldn't listen to music every day. ____

E2. I prefer to speak to my friends on the phone rather than write letters to them. ____

E3. I have no desire to travel to different parts of the world. ____

E4. I prefer to read than to dance. ____

1. I can easily tell if someone else wants to enter a conversation. ____
2. I prefer animals to humans. ____
3. I try to keep up with the current trends and fashions. ____
4. I find it difficult to explain to others things that I understand easily, when they don't understand it first time. ____
5. I dream most nights. ____
6. I really enjoy caring for other people. ____
7. I try to solve my own problems rather than discussing them with others. ____
8. I find it hard to know what to do in a social situation. ____
9. I am at my best first thing in the morning. ____
10. People often tell me that I went too far in driving my point home in a discussion. ____
11. It doesn't bother me too much if I am late meeting a friend. ____
12. Friendships and relationships are just too difficult, so I tend not to bother with them. ____
13. I would never break a law, no matter how minor. ____
14. I often find it difficult to judge if something is rude or polite. ____
15. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking. ____
16. I prefer practical jokes to verbal humor. ____

17. I live life for today rather than the future. ____

18. When I was a child, I enjoyed cutting up worms to see what would happen. ____

19. I can pick up quickly if someone says one thing but means another. ____

20. I tend to have very strong opinions about morality. ____

21. It is hard for me to see why some things upset people so much. ____

22. I find it easy to put myself in somebody else's shoes. ____

23. I think that good manners are the most important thing a parent can teach their child. ____

24. I like to do things on the spur of the moment. ____

25. I am good at predicting how someone will feel. ____

26. I am quick to spot when someone in a group is feeling awkward or uncomfortable. ____

27. If I say something that someone else is offended by, I think that that's their problem, not mine. ____

28. If anyone asked me if I liked their haircut, I would reply truthfully, even if I didn't like it. ____

29. I can't always see why someone should have felt offended by a remark. ____

30. People often tell me that I am very unpredictable. ____

31. I enjoy being the center of attention at any social gathering. ____

32. Seeing people cry doesn't really upset me. ____

33. I enjoy having discussions about politics. ____

34. I am very blunt, which some people take to be rudeness, even though this is unintentional. ____

35. I don't tend to find social situations confusing. ____

36. Other people tell me I am good at understanding how they are feeling and what they are thinking. ____

37. When I talk to people, I tend to talk about their experiences rather than my own. ____

38. It upsets me to see an animal in pain. ____

39. I am able to make decisions without being influenced by people's feelings. ____

40. I can't relax until I have done everything I had planned to do that day. ____

41. I can easily tell if someone else is interested or bored with what I am saying. ____

42. I get upset if I see people suffering on news programs. ____

43. Friends usually talk to me about their problems as they say that I am very understanding. ____

44. I can sense if I am intruding, even if the other person doesn't tell me. ____

45. I often start new hobbies but quickly become bored with them and move on to something else. ____

46. People sometimes tell me that I have gone too far with teasing. ____

47. I would be too nervous to go on a big rollercoaster. ____

48. Other people often say that I am insensitive, though I don't always see why. ____

49. If I see a stranger in a group, I think that it is up to them to make an effort to join in. ____

50. I usually stay emotionally detached when watching a film. ____

51. I like to be very organized in day-to-day life and often make lists of the chores I have to do. ____

52. I can tune into how someone else feels rapidly and intuitively. ____

53. I don't like to take risks. ____

54. I can easily work out what another person might want to talk about. ____

55. I can tell if someone is masking their true emotion. ____

56. Before making a decision I always weigh up the pros and cons. ____

57. I don't consciously work out the rules of social situations. ____

58. I am good at predicting what someone will do. ____

59. I tend to get emotionally involved with a friend's problem. ____

60. I can usually appreciate the other person's viewpoint, even if I don't agree with it. ____