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The Relationship between Mindfulness, Proprioceptive Awareness, and Interoceptive Awareness

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THE RELATIONSHIP BETWEEN MINDFULNESS, PROPRIOCEPTIVE AWARENESS, AND INTEROCEPTIVE AWARENESS

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I dedicate this work to my daughter Riley Ford.

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The goal was to understand mindfulness mechanisms of emotion regulation and body awareness and how these relate to interoceptive and proprioceptive awareness. The 23 participants completed the Five Factor Mindfulness Questionnaire (FFMQ; Baer et al., 2006) and the Multidimensional Assessment of Interceptive Awareness (MAIA; Mehling et al., 2012). Then, the participants completed a procedure on the purpose-built Active Movement Extent Discrimination Apparatus (AMEDA; Symes et al., 2010), a device used to measure proprioception at the ankle joint. The entire procedure took one hour to complete. Results did not support the hypothesis that higher levels of mindfulness were related to higher levels proprioceptive awareness. However, results showed that the observing facet on the FFMQ significantly positively correlated with the MAIA facets of noticing, attention regulation, emotional awareness, self-regulation, and body listening. Results also suggested nonreactivity to inner experience on the FFMQ significantly positively correlated with the MAIA facets of attention regulation, emotional awareness, self-regulation, body listening, and trusting. The findings from the current study can be used to further the understanding of how mindfulness relates to body awareness.

Introduction

Mindfulness, defined as attention to present moment phenomenon without judgement or preference added to the experience, has gained popularity in both the scientific and practitioner areas (Gu et al., 2015; Hölzel et al., 2011). Mindfulness involves a routine exercise known as mindful meditation, a performance of a set of complex attentional and emotional regulatory training regimens focused on present moment stimuli (Hölzel et al., 2011; Kabat-Zinn, 2003). Mindful Meditation is conceptualized as having two parts. One part is focused attention, the voluntary collecting of attention directed toward a chosen stimulus, such as the breath (Lutz et al., 2007; Vago & David, 2012). The other is known as open monitoring and involves observing the process of novel stimuli arising into awareness then receding back into unawareness (Lutz et al., 2007; Vago & David, 2012). Mindfulness meditation has been implicated in increasing insight, well-being, emotional balance, clarity, and a skill of attending to the present moment (Lutz et al., 2008; Tang et al., 2015). Mindfulness meditation has shown benefits in areas associated with mental health, such as being associated with lower levels of rumination and higher levels of effective emotion regulation (Gu et al., 2015). Research has also revealed that those who regularly engage in mindfulness meditation showed improvements in well-being and lessened psychological distress in those who engage in mindfulness practice (Gu et al., 2015).

However, there are many practical questions that exist. How does the mindfulness meditation process work? What components, or underlying mechanisms, are involved in the process of mindfulness? What areas of the brain are involved during mindfulness meditation? How does mindfulness meditation relate to mental health? Where does

research on mindfulness meditation need to be directed in the future? The overall objective of this article is to examine these questions on the nature of mindfulness meditation and the mechanisms that are at work during the process. To investigate these questions, the present article will first review the comprehensive theory of mindfulness proposed by Hölzel and collegues (2011). Then, hypotheses will be proposed to be tested and results will be reported. Next, the current limitations of research are examined. Then, future directions for theory and research will be considered. Finally, summary and implications of the current research will be discussed.

Comprehensive Theory of Mindfulness Meditation

The Comprehensive Theory of Mindfulness Meditation states that the effects of mindfulness work through four proposed mechanisms of action: attention regulation, body awareness, emotion regulation, and finally a change in perspective on the self (Hölzel et al., 2011). I will discuss each mechanism of action in detail. Mindfulness (attention regulation, body awareness, emotion regulation, and change in perspective on the self) and positive reappraisal interact in a manner that progressively and continuously enhance one another in an upward spiraling way (Hölzel et al., 2011). Positive reappraisal is the process through which stressful events are reinterpreted as not threatening or as beneficial (Garland et al., 2011). For example, imagine a client is experiencing a challenging situation due to distress from anxiety. Even though distress from the symptoms of anxiety is difficult to experience, a client can learn something from the challenging situation. The client can learn the specific present-moment physical and cognitive effects of anxiety, thereby becoming better equipped to handle the symptoms of anxiety in the future. Changing the perspective of the situation (anxiety) to a beneficial

view (positive reappraisal) with mindfulness helps to be able to repeat this process in the future. I will now examine these four mechanisms of action mentioned above.

Attention Regulation

Attention. Attention is a system structurally independent from autonomic processing systems and composed of three networks that cohesively work together (Posner & Petersen, 1990; Tang et al., 2015). These three networks are orientating network, alerting network, and executive network of attention, which I will explain in detail below (Petersen & Posner, 2012; Tang et al., 2015). This attentional system receives incoming stimuli and governs the direction of attention through a process of directing conscious awareness (Posner & Petersen, 1990; Smallwood & Schooler, 2015; Westen, 1999). The directing of conscious awareness increases sensitivity to a narrow range of experiences resulting in a sensation of consciousness (Petersen & Posner, 2012; Posner & Petersen, 1990; Smallwood & Schooler, 2015; Westen, 1999). This sensation of consciousness is dependent on the orientation of attention (Lobo et al., 2018).

Orienting Network. Attention orientation is the network of attention that filters sensory input by actively selecting key sensory experiences (Petersen & Posner, 2012). Acetylcholine, the neurotransmitter responsible for motor functioning, is involved in this network (Posner, 2012). The frontal and parietal areas of the brain are associated with this network (Tang et al., 2015). This attention orientation determines what we consciously experience based on the remains of the input through this attention filter (Petersen & Posner, 2012). The goal leads to orientation, then orientation of attention determines what stimuli are worth attending to by allowing relevant goal-oriented stimuli to enter the foreground. The other existing stimuli remains in the background of

experience. Imagine driving a car. While driving the car the attention is oriented toward the achievement of the goal, arriving safely at a destination. The foreground stimuli worth attending to would be anything that is necessary for goal achievement such as the road ahead, the steering wheel, the pedals, etc. The stimuli in the background would be anything not worth attending to, such as the trees on the side of the road, the road behind the vehicle, the sky, etc. These can be thought of as distractions toward the goal and remain in the background of consciousness. Orientation of attention can be suddenly redirected from the executive network to an alerting network of attention (Tang et al., 2015).

Alerting Network. The alerting network of attention serves to protect the individual by means of prioritizing input to unexpected threatening stimuli by redirecting the orientation of attention (Posner & Petersen, 1990; Tang et al., 2015). This network of attention involves the locus coeruleus, the area of the brain responsible for responding to stress, and the noradrenaline system (Tang et al., 2015). Noradrenaline is a neurotransmitter associated with panic and threat (Uematsu et al., 2017). Alerting redirects orientation toward the threatening stimuli allowing for survival and damage control (Posner & Petersen, 1990; Tang et al., 2015). When an unexpected stimulus comes into awareness this part of attention automatically responds (Posner & Petersen, 1990; Tang et al., 2015). This system operates more rapidly, overrides executive attention, and has a higher chance of error than the other systems of attention (Posner & Petersen, 1990; Petersen & Posner, 2012). It can be thought of as the alerting network of attention overrides the other networks of attention by coming from the background of experience to the foreground of experience, thus changing the attention orientation to

threat detection. Imagine the example of driving the car again. Attention is oriented toward the road ahead, the steering wheel, the pedals, etc. Suppose a boulder fell from the hills along the roadside. The obstacle, the falling boulder, hinders the progress of the goal, arriving safely at a destination, attention orientation is redirected to the obstacle.

Executive Network. The executive network of attention is the attentional network that monitors information and resolves conflict between the other two networks of attention referred to as conflict monitoring (Joyce et al., 2018; Posner & Petersen, 1990). Areas of the brain involved in this network are the anterior cingulate cortex, anterior insula, and basal ganglia (Tang et al., 2015). The executive network involves dopamine, the neurochemical associated with reward (Posner, 2012). This system is used to increase control of the environment and involves interlinked functions of working memory (decision-making, selection, evaluation of unfamiliar responses, error-detection, etc.), inhibitory control (concentration, emotion regulation, over-coming habitual behavior, etc.), and cognitive flexibility (adaptation to new information, prioritization of tasks, changing perspectives, etc.) (Diamond, 2013; Raver & Blair, 2016). Imagine the example of driving the car again. Decisions are being made such as whether to pass slower cars. Suppose a text is delivered while driving. The desire to look at the phone is inhibited, and attention is maintained on the task of driving. Suppose there is a traffic jam, and a detour needs to be taken. Adapting to the changing conditions on the road is necessary. Suppose you pass another car that is broken down on the side of the road. You understand what that driver is experiencing by placing yourself in the perspective of that

driver. All these are executive functions of this network. I will now discuss the regulation of these three attentional networks.

Network Cohesion. Orienting, alerting, and executive attention receive and send information along the frontal lobe and the anterior cingulate cortex (ACC; Botvinic et al., 2001; Kolling et al., 2016; Posner & Petersen, 1990). The interpreting of this information and the adjustments employed from the interpretation of that information is known as attention regulation (Botvinick et al., 2001; Kolling et al., 2016). Sometimes the information between the attentional networks conflict resulting in two possible outcomes, investigation of the stimulus or attention becomes body oriented (Tang et al., 2015).

Investigation of the stimulus occurs when the level of conflict in the ACC is sufficiently alarming enough to warrant attention (Posner & Petersen, 1990; Tang et al., 2015). Information is transferred to the lateral frontal lobe, the area of the brain associated with the executive network of attention and language (Posner & Petersen, 1990; Tang et al., 2015).

During mindfulness meditation, a specific stimulus can be chosen to be the focus of attention. Traditionally, the chosen stimulus to attend to is an internal sensation, such as the breath; however, there is a wide variety of modern and traditional mindful meditations that utilize external body sensations, such as walking meditation, eating meditation, tai chi etc. (Forkmann et al., 2016; O'Reilly et al., 2014). Distraction from that specific stimulus is noticed and returning the focus of attention to the chosen stimulus after a distraction is means to practice the act of attention regulation mentioned above (Hölzel et al., 2011). Attention regulation is the primary attentional mechanism in mindfulness and the catalyst for the other mechanisms of mindfulness to be carried out

(Hölzel et al., 2011). For example, when orienting attention toward the breath suppose a loud car passes by. Executive attention moves from the breath to the sound of the car, then back to the breath. The moving back to the breath from the sound (distraction) is an example of the act of attention regulation.

Orientation of attention toward body awareness occurs when the level of conflict in the ACC is insufficient to warrant attending to the external stimuli or novel threat, so control is passed along to the temporoparietal junction and insula cortex (Posner & Petersen, 1990; Tang et al., 2015). The insula cortex is associated with emotion regulation, consciousness, and homeostasis of the body. The temporoparietal junction is associated with body awareness, the second mechanism of mindfulness meditation. Imagine orienting attention toward breathing again. Once attention remains on the breath without distraction, the executive network of attention moves to investigation of a physical expression of breathing. The somatic reaction to breathing and body awareness becomes the focus of attention.

Body Awareness.

Body Awareness is proposed by Hölzel and colleagues (2011) to be the second mechanism of action in mindful meditation and is defined as the skill to accurately recognize intricate somatic sensations (Mehling et al., 2009; Mehling et al., 2011). Hölzel et al. (2011) state that interoceptive awareness is involved in mindfulness meditation; however, it has been proposed that proprioceptive and interoceptive awareness make up body awareness and are distinctly different (Mehling et al. 2009; 2011). I will describe both in detail below.

Interoceptive Awareness. The term interoception was first used in 1941, however the concept originated in 1906 (Freeman & Sharp, 1941; Sherington, 1906). Interoception involves both the body and the brain. The temporoparietal junction and insula cortex, mentioned above, receive information from within the body via interoceptors, receptors predominantly located in the gut area of the body (Furness et al., 2013). Integration and interpretation of internal somatic signals occur at these areas providing an internal map of the body at both a conscious and unconscious level (Mehling et al., 2018). The predominant purpose of interoception is to maintain homeostasis (Furness et al., 2013). While in homeostasis these perceptions are unconscious until homeostasis is disrupted (Mehling et al., 2018). Once this occurs, an individual becomes aware of interoceptive activity (Ceunen et al., 2016). This noticing of interoceptive activity at the conscious level is known as interoceptive awareness (Mehling et al., 2018). Imagine driving in the car again. Suddenly you feel hungry. Once this occurs, the feeling of hunger is a conscious interoceptive occurrence signaling the need to eat to maintain homeostasis. You find a snack and eat it. Eventually the feeling of fullness takes the place of hunger, signaling a need to stop eating. Once satiated the interoceptive sensations return to the unconscious level. Now imagine the snack you just ate results in indigestion. The interoceptive sensation of the upset stomach occurs, resulting in an uncomfortable feeling of being too full. Eventually you belch and homeostasis is achieved once again. Other examples of interoceptive events are the sensations of needing to eliminate, sensations of respiration, sensations related to sexual pleasure, sensation of acceleration (falling, g-force, etc.), sensations of internal organs

(appendix attack, heart attack, etc.), and physical expression of emotions (Ceunen et al., 2016; Garfinkel et al., 2015).

This recognition of internal physical sensations takes place in the anterior insula cortex, giving an encompassing sensation of the internal body state leading to a feeling of a sentient self. (Craig, 2010; Mehling et al., 2012). The skill to transition from analyzing physical aspects of the body to focusing attention on the self as an embodied physical presence is integral to the process of mindfulness that aides in emotion regulation (Dunn et al., 2011; Mehling et al., 2012; Mehling et al., 2011; Sze et al., 2011). An example of embodied physical presence occurs during mindfulness meditation once the effort to observe the breath is reduced, the breath is experienced as lung expansion, the movement of the diaphragm, the feeling of the breath in the throat, etc. This increase in physical awareness plays a role in the recognition, monitoring, and regulation of emotions (Garfinkel et al., 2015). I will now discuss the other aspect of body awareness, proprioceptive awareness and proposed methods of measuring it.

Proprioceptive Awareness. Proprioception was first conceptualized by Charles Bell (1826) but was first coined as a term by Charles Sherrington (1906) in the same work in which he conceptualized interoception. Proprioception involves both the body and the brain, specifically the cerebellum and thalamus have been proposed to interpret feedback from the body via mechanoreceptors (Tuthill & Azim, 2018). Mechanoreceptors are receptors that are located in muscles, tendons, and joints; however, other sensory receptors are involved that provide feedback from the retina and tactile sensations providing a sense of location of limbs in time and space (Tuthill & Azim, 2018). Proprioception occurs at both the conscious and unconscious level, providing

balance and protection of the body (Tuthill & Azim, 2018). Facial expressions, limb movement, balancing, joint extension, muscle tension, posture, sitting, standing, physiological signals of emotions, etc. are examples of unconscious proprioceptive events, however attention can be directed to these events providing a proprioceptive awareness (Laskowski et al., 2000; Soter et al., 2018; Tuthill & Azim, 2018).

Imagine driving the car again. The posture you maintain in the seat, the tension of the hands gripping the steering wheel, and the feeling of your feet accurately pressing the pedals to accelerate, or brake, are all proprioceptive events. Executive Attention can be directed to these events to create a proprioceptive awareness of these events (Han et al., 2016). I will now detail the attempts to objectively measure proprioceptive awareness.

Measuring Proprioception. It has been the goal of psychophysics to measure the association between objective physical stimulus and the resulting subjective perceptions since 1860 (Han et al., 2016). Cattell & Fullerton (1892) introduced measuring proprioception using active moments with physical stops to determine extent discrimination. Psychophysical experiments use three classic methods of experimentation (Han et al., 2016). These are method of adjustment, the method of limits, and the method of average error (Han et al., 2016).

The method of adjustment is employed by allowing the participant to control the stimulus level (Han et al, 2016). A reference stimulus is presented then recreated by the participant. The difference in error is recorded and an average is calculated (Han et al., 2016)

The method of limits is administered by presenting the stimulus to the participant in an ascending or descending manner (Han et al., 2016). During the ascending method,

the experimenter presents the stimulus to the participant at a level low enough that it cannot be detected (Han et al., 2016). Gradual increase is presented until the participant can discern that a stimulus is present (Han et al., 2016). During the descending method, this process is simply reversed. Typically, both methods are presented, and threshold is averaged (Han et al., 2016).

The method of constant stimulus has been proposed as the most accurate of the three classical methods, which is why I decided to use this method in the current study (Han et al., 2016). During the method of constant stimuli, the levels of stimulus intensity are presented in pairings with precisely defined start and end points (Han et al., 2016). These stimuli are randomly presented (right answers) (Han et al., 2016). Next the participant compares randomly presented movements to determine which stimulus is either greater, the absolute threshold, or accurate by comparison, difference threshold (Han et al., 2016). The current study employs the difference threshold where stimuli are matched the stimulus either a right answer or wrong answer. The right answers are averaged. To examine proprioceptive awareness, three techniques have been proposed (Han et al., 2016). These are threshold to detection of passive motion where, joint reproduction, and active movement extent discrimination assessment (AMEDA; Han et al., 2016). Threshold to detection of passive motion involves detection of joint movement at different velocities, whereas joint reproduction involves matching joint positions (Han et al., 2016).

Proprioceptive and interoceptive physiological expressions are part of emotions which I will discuss in detail below (Gross & Barrett, 2011; Jerath et al., 2015; Norman et al., 2014). Executive attention can be directed to these physiological expressions

creating a body awareness (Han et al., 2016; Hölzel et al., 2011) Proprioceptive and interoceptive awareness of the physiological signals of emotions has been proposed as a means of emotion regulation, the next mechanism of action of mindful meditation (Hölzel et al., 2011; Shu et al., 2018). I will now discuss emotion regulation in detail.

Emotion Regulation.

Emotions are psychological states that consist of three arousal responses: cognitive (thoughts), behavioral (facial expressions, muscle tensions in the body, verbal volume changes etc.), and physiological (heart rate, respiration, feeling in the gut area, etc.) that influence a subjective psychological state (Gross & Barrett, 2011; Jerath et al., 2015; Norman et al., 2014). Because emotions are shorter in duration, involve a triggering object, and involve a reactive expression, they are different from moods, which do not involve a triggering object and last longer in duration (Jerath et al., 2015). These reactions to triggering objects can either be unconditioned or conditioned and are appraised across many neural systems to determine if the current stimuli interrupt the progression of present goals (Soleymani et al., 2015). Once an emotion is recognized and appraised, responses to that evoked emotion are monitored and adjusted through emotion regulation (Braunstein et al., 2017; Oscher & Gross, 2005). Emotion regulation is a broad term that involves ways to change emotional responses (Hölzel et al., 2011). According to mindfulness, emotion regulation involves reappraisal then exposure, extinction, and reconsolidation (Braunstein et al., 2017; Oscher & Gross, 2005). I will now explain reappraisal in detail followed by exposure, extinction, and reconsolidation.

Reappraisal. During mindful meditation it is common for aversive emotions to occur. At this point attention is directed toward appraising whether the situation in which

the emotion is occurring interferes with currently active goals (Moors et al., 2013). Once the situation is appraised as not threatening to active goals, reappraisal occurs (Moors et al., 2013). Reappraisal is the changing of the emotional impact by reframing the emotionally evoking stimulus (Garland et al., 2011; Gross, 2015). This is an active process rather than passive acceptance involving the dorsal prefrontal cortex, the area of the brain whose function is associated with planning, problem solving, and controlling social behavior (Ong et al., 2019; Hölzel et al., 2011; Troy et al., 2018).).

Imagine driving a car again. Suppose another driver cuts you off, this results in arousal necessary to suddenly brake hard to avoid hitting the other driver. The current situation is appraised as warranting attention when a perceived threat occurs then reappraised in the context of the new safe situation. You notice you are angry but having an angry outburst at the other driver is unnecessary to arriving at the destination safely and is socially undesirable (Sheppes, 2015). However, all the effects of anger are still occurring. Once an emotionally evoking stimulus is reappraised, attention is directed to the emotion making it the object of meditation (Knowles, & Olatunji, 2019). The expression of anger consists of a psychological state that can be observed until the anger dissipates and attention is redirected to breathing. Thoughts may replay the incident from memory. Heartbeat and respiration might increase. Muscle tension might occur in the upper back and jaw areas. Redirecting attention to the effects of the emotion allows for extinction and reconsolidation to occur (Knowles, & Olatunji, 2019). I will now discuss extinction and reconsolidation in detail.

Exposure, Extinction, and Reconsolidation. Exposure is technique used in behavioral therapy treatment that is highly effective at decreasing anxiety and fear

responses (Chambless & Ollendick, 2001) It involves presenting a fear or anxiety provoking stimuli and preventing previously learned avoidant behaviors, thus leading to extinction. (Abramowitz, 2013). Exposure and extinction involve the ventromedial prefrontal cortex, the area of the brain associated with fear and risk, and the hippocampus, the area of the brain associated with stored memories (Abramowitz, 2013; Hölzel et al., 2011). During exposure and extinction, the ventromedial prefrontal cortex and the hippocampus work together to decrease activation in the amygdala, the area of the brain associated with previously learned fear.

During mindfulness meditation, typical avoidant behaviors are prevented along with employment of enhanced attentional regulation skills, aiding the process of exposure, extinction, and reconsolidation (Knowles, & Olatunji, 2019). Extinction is the decreasing of previously learned associations to fear or anxiety provoking stimuli (Abramowitz, 2013). Prior to extinction, memory of the anxiety and fear-provoking situation is consolidated, or stabilized, then stored for later retrieval (Troy et al., 2019). During extinction, the memory is retrieved, and the previously consolidated memory becomes unstable (Lee et al., 2017). The memory is reconsolidated, restabilized, as being not threatening then stored again for later retrieval (Lee et al., 2017). In other words, the fear or anxiety evoking consolidated memory becomes reconsolidated to a safe memory (Elsey & Kindt, 2017).

Imagine driving the car again. After the near collision and the situation is reappraised and deemed as being not threatening, the nervous system calms. Later anger occurs again. This evokes the previous subjective state consisting of all the elements of anger. Exposure to anger occurs while you start to recall the event. The effects of the

emotion are not avoided leading to extinction of anger. The memory of the event is reconsolidated and stored as being less threatening. You start to understand that the external and internal experiences occurring during the drive produces changes in you, the self. You continue on your drive taking into account who you were in each circumstance along the drive through a changed perspective. The last mechanism of mindfulness meditation is the change of the perspective on the self, which I will explain in detail below.

Change in the Perspective on the Self.

The next mechanism of mindfulness meditation is change in the perspective on the self. Repeated conscious experience of moving through time gives rise to a notion of a continuing self that is accompanied with a sense of volition, a feeling of control over mental activity and behavior (Baumeister & Vonasch, 2015). During mindfulness meditation, this feeling of control over a continuing sense of self is decentered (Hölzel et al., 2011). This results in a sense of self that is an effect of experience and a part of a changing process (Hölzel et al., 2011). This sense of self coordinates with constantly changing external stimuli and internal conscious experiences (Hölzel et al., 2011). Decentering is the change that occurs through metacognitive awareness by stepping outside of one's immediate experience of transient psychological events (Bernstein et al, 2015; Bernstein et al., 2019). It has been proposed that the change in the perspective on the self is associated with medial prefrontal cortex, posterior cingulate cortex, insula, and temporoparietal junction areas of the brain (Hölzel et al., 2011). More research is needed to determine specific neural mechanisms behind this change in the perspective on the

self. Bernstein et al., (2015) proposed a model explaining how decentering occurs called the metacognitive process model of decentering, which I will describe in detail below.

Metacognitive Process of Decentering. The metacognitive process of decentering is made up of three proposed interrelated processes, meta-awareness, disidentification from internal experience, and reduced reactivity to thought processes, which I will explain in detail below (Bernstein et al., 2015).

Meta-awareness is the orienting and directing of attention toward observing present moment subjective experiences of the contents of consciousness and related processes (Bernstein et al, 2015; Bernstein et al., 2019). This observing leads to a disidentification from internal experience where decreased identification from the self and reactivity of the contents of consciousness occurs. (Bernstein et al., 2019) Reduced reactivity to thought content occurs resulting in the impact of thought on mental processes such as emotion, motivation, motor planning, etc. to decrease while reinforcing meta-awareness (Bernstein et al., 2019).

Imagine driving the car again. While continuing to drive, a thought crosses your mind of the experiences you have encountered during the journey (e.g., the falling rock, the hunger, the reckless driver, etc.). You realize the changing reactions to events along the way have influenced your perception and behavior. External and internal experiences occur during the drive and result in changes of the self. Therefore, you realize that the self is dependent on these experiences. This allows a decrease in the concept of you, the self, as a good driver or a bad driver. Instead, you become aware of the journey and the impact of these events that interplay with your concept of self through meta-awareness. Other scenarios that used to produce high emotional reactivity, such as encountering bad

drivers, now have reduced impact. An increase in meta-awareness decreases identification of the self as an internal, controlling inhabitant, to self as a process, leading to a reduction in impact from mental processes (Bernstein et al., 2019).

Limitations of the Current Research

Although the current comprehensive theory of mindfulness meditation proposed by Hölzel and colleagues (2011) includes interoceptive awareness, the theory does not include an external aspect of body awareness. Mehling and colleagues (2012) proposed a model of body awareness that includes both interoception and proprioception. There are current therapy modalities, such as Acceptance and Commitment Therapy (ACT) and Mindfulness Based Stress Reduction (MBSR), that employ meditations that include a proprioceptive awareness aspect (e.g., walking meditation, eating meditations, posture meditations etc.) (O'Reilly et al., 2014). Even when the breath is used as the object of meditation, the act of breathing can be experienced as an external and internal sensation. For example, the chest and stomach rise with the inhale and falls during the exhale. Further examination into the involvement of proprioceptive awareness in mindfulness meditation needs to occur.

I hypothesize that mindfulness meditation involves proprioceptive awareness. Including an external aspect to body awareness can provide a more precise and complete picture than can be captured with just the use of interoceptive awareness. Understanding how the body uses proprioceptive awareness in movement, balance, external sensations, and tension, especially associated with physical expressions of emotions, would add to the understanding of mindfulness meditation. It could be said that adding a proprioceptive category as a form of body awareness opens up the possibility to use

meditation in less formal ways such as in sport, walking, dancing, and other physical activities.

As mentioned above, interoceptive awareness has been implicated to be the main aspect of body awareness in the comprehensive theory of mindfulness (Hölzel et al., 2011). Specifically, the scores on the MAIA have been related to higher levels of interoceptive awareness (Mehling et al., 2012). Also, higher scores on the FFMQ facet of observing has been related to higher levels of body awareness (Hölzel et al., 2011).

Exposure, extinction, and reconsolidation has been postulated by Hölzel and colleagues (2011). to be one of two main aspect of emotion regulation in the current theory. Specifically, scores on MAIA are predicted to be related to this aspect of emotion regulation due to interoceptive awareness potentially being implicated in emotion regulation (Guendelman et al., 2017; Mehling et al., 2012). Also, scores on the FFMQ facet of non-reactivity to inner experience have been related to higher levels of this aspect of emotion regulation (Hölzel et al., 2011). Additional research testing these areas of interoceptive awareness and mindfulness is needed to further the understanding of the comprehensive theory of mindfulness.

The Present Study

The present study will examine the currently proposed relationship between interoceptive awareness and mindfulness meditation. Also proposed to be associated in the current study, emotion regulation and mindfulness meditation will be examined. This will add to the current body of work in these areas of study. This study will also examine a potential association between mindfulness meditation and proprioceptive awareness using an observable physiological measure. This will present a new component of body

awareness to the comprehensive theory of mindfulness meditation.

Hypotheses

The following hypotheses will be examined:

1. Higher levels of mindfulness, as measured by the total score on the FFMQ, will be associated with higher levels of proprioceptive awareness, as measured by the total score on the AMEDA.
2. Higher levels of body awareness, as measured by the observe facet on the FFMQ, will be associated with higher levels of interoceptive awareness, as measured by the eight facets on the MAIA.
3. Higher levels of emotion regulation, as tested by the non reactivity to inner experience facet on the FFMMQ, will be associated with higher levels of interoceptive awareness, as measured by the eight facets on the MAIA.

Method

Participants

All volunteer participants were recruited through local organizations that remained open during covid in the community. The current study's aim was to recruit 30 participants, but due to the pandemic data were obtained from 23 participants (N = 23).

Participants' ages ranged from 18 years to 64 years (M = 40.52, SD = 13.19). There were 7 males and 16 females. Compared to U.S. census (2019), this proportion of males to females was slightly smaller than the 50.4% reported. The participants' height ranged from 157 cm to 191 cm (M = 170.90, SD = 11.64) and weighed from 52 kg to 127 kg (M = 82.48, SD = 22.09). There were 20 right-hand dominant participants and 3 left-hand dominant. Participants' weekly athletic participation ranged from 0 to 6 days per week (M = 1.52, SD = 1.56) and weekly mindful participation ranged from 0 to 7 days per week (M = 2.22, SD = 2.11).

Demographics.

Each participant was asked about Covid-19 exposure and symptoms to ensure the safety of all involved. Next, the participants completed a demographics questionnaire to assess participants' age, gender, previous athletic experience, and current athletic participation to determine if these are associated with proprioceptive awareness. See Appendix A. The participants were weighed and measured in person to assess their heights and weights. The heights were recorded in feet and inches then converted to meters. The weights were recorded in pounds then converted to kilograms. The participants were asked if they have had any lower limb, ankle, or back injuries in the last six weeks and if they have any vestibular or visual impairments, which would exclude

him/her from participation due to risk of safety. See Appendix B.

Design

A correlational design was used, and IBM SPSS was used for calculation for each hypotheses tested. The first hypotheses that was tested was higher levels of mindfulness will be associated with higher levels of proprioceptive awareness. Level of mindfulness was assigned the first variable and measured by the participants' total average scores on the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). Level of proprioceptive awareness was assigned as the second variable measured by the total correct responses on the purpose-built Active Movement Extent Discrimination Apparatus (AMEDA; Symes et al., 2010).

The second hypotheses tested was higher levels of body awareness will be associated with higher levels of interoceptive awareness. Level of body awareness was assigned the first variable and measured by the observing facet on the FFMQ (Baer et al., 2006). Level of interoceptive awareness was assigned as the second variable and measured by all eight facets: noticing, non-distracting, non-worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting on The Multidimensional Assessment of Interceptive Awareness (MAIA; Mehling et al., 2012).

The third hypotheses tested was higher levels of emotion regulation will be linked with higher levels of interoceptive awareness. Level of emotion regulation was assigned the first variable and measured by the non-reactivity to inner experience on the FFMQ (Baer et al., 2006). Level of interoceptive awareness was assigned as the second variable and measured by all eight facets again.

Measures

Five Facet Mindfulness Questionnaire

The Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006) was used to measure the participants' level of mindfulness skill. See Appendix C. The scale consists of 39 items and measures five facet domains of mindfulness on a Likert scale ranging from 1 (*never or very rarely true*) to 5 (*very often or always true*). These five facets are observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. The observing facet has been implicated as the primary facet associated with body awareness (Hölzel et al., 2011). The Non-Reactivity to Inner Experience facet has been postulated as the main facet related to exposure, extinction, and reconsolidation during the emotion regulation process (Hölzel et al., 2011). A sample item of the observing facet is, "When I'm walking, I deliberately notice the sensations of my body moving." A sample item of the describe facet is, "I'm good at finding words to describe my feelings." A sample item of the acting with awareness domain is, "When I do things, my mind wanders off and I'm easily distracted." A sample item of the non-judging of inner experience is, "I criticize myself for having irrational or inappropriate emotions." A sample item of the non-reactivity to inner experience facet is, "I perceive my feelings and emotions without having to react to them." The higher participants score on the FFMQ, the higher their level of mindfulness. The higher the score on the facet of observing on the FFMQ, the higher their level of body awareness. The higher the score on the facet of non-reactivity to inner experience on the FFMQ, the higher their level of emotion regulation. The individual facets ranged from Cronbach's α

= .78 to .88 (Baer et al., 2006), indicating the reliability of the FFMQ for this study is acceptable. A study looked at divergent validity of the FFMQ (de Bruin et al.,

Observing on the FFMQ was negatively correlated with worry (r (449) = −.25; $p \leq .01$) on the Toronto Alexithymia Scale (TAS-20; Bagby et al., 2006). Alexithymia on the TAS-20 was moderately negatively correlated with describing ($r = -.59$; $p \leq .01$) and acting with awareness ($r = -.51$; $p \leq .01$) on the FFMQ. Non-judging of inner experience was negatively correlated with (r (449) = −.; $p \leq .01$) thought suppression on the White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994). Non-reactivity to inner experience on the FFMQ was negatively correlated with worry (r (449) = −.44; $p \leq .01$) on the Penn State Worry Questionnaire (PSWQ; Meyer et al., 1990). The FFMQ total was moderately correlated with alexithymia (r (449) = −.66; $p \leq .01$) on the TAS.

The Multidimensional Assessment of Interceptive Awareness

The Multidimensional Assessment of Interceptive Awareness (MAIA; Mehling et al., 2012) was used to measure the participants' levels of interoceptive awareness. See Appendix D. The scale consists of 32 items and measures eight facets with four items per facet on a Likert scale ranging from 0 (*never*) to 5 (*always*). These facets are noticing, non-distracting, non-worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting. A sample item for the concept of noticing is, "When I am tense, I notice where the tension is located in my body." A sample item for the concept of non-distracting is, "When I feel pain or discomfort, I try to power through it." A sample item for the concept of non-worrying is, "When I feel physical pain, I become upset." A sample item for the concept of attention regulation is, "I can refocus my attention from thinking to sensing my body." A sample item for the concept of emotional awareness is,

"I notice how my body changes when I am angry." A sample item of the concept of self-regulation is, "I can use my breath to reduce tension." A sample item of the concept of body listening is, "I listen for information from my body about my emotional state." A sample item of the concept of trusting is, "I trust my body sensations." The higher participants score on the MAIA, the higher their levels of interoceptive awareness are. The MAIA has an overall Cronbach's alpha = .70. The individual facets range from Cronbach's alpha = .66 to .82 (Mehling et al., 2012), indicating the reliability of the MAIA is acceptable.

The MAIA facets appear to have convergent validity with other measures of interoceptive awareness related constructs and divergent validity in body disconnection related constructs (Mehling et al., 2012). Experiencing interoceptive stimuli r (323) = .40, $p < .0001$ on the Private Body Consciousness Scale (PBCS; Miller et al., 1981), and mind-body listening r (323) = .46, $p < .0001$ on the Body Responsiveness Questionnaire (BRQ; Daubenmier, 2005) was related to noticing on the MAIA. Perceived disconnection with the body on the BRQ was negatively correlated with not distracting (r (323) = -.38, $p < .0001$) and not worrying (r (323) = -.35, $p < .0001$) on the MAIA. Attention Regulation correlated with experiencing interoceptive stimuli (r (323) = .43, $p < .0001$) on the PBCS and mind-body listening r (323) = .48, $p < .0001$ on the BRQ. Mind-body listening on the BRQ was related to emotional awareness (r (323) = .48, $p < .0001$) and self-regulation (r (323) = .45, $p < .0001$) on the MAIA. Mind-body listening on the BRQ was moderately correlated to body listening (r (323) = .64, $p < .0001$ and trusting r (323) = .53, $p < .0001$) on the MAIA.

AMEDA Discrimination Task

The AMEDA has been revealed to have better ecological, test, and data validity than the other two methods mentioned above and is the method used to measure proprioceptive awareness in the current study (Han et al., 2016). The AMEDA apparatus to measure proprioceptive awareness at the ankle joint was built due to cost effectiveness, ease of assembly, and ease of administration by the researcher.

An AMEDA was built by referring to the design in the literature used by Han and colleagues (2016). The current device was slightly modified to enable for efficient administration by the researcher. The device is used to measure small differences in ankle inversion which can determine proprioceptive awareness at the ankle joint by means of inversion (Symes et al., 2010). See Appendix E, F, G, and H. Inversion movement is a roll toward the small toe or outside of the foot and has been found to have a strong effect on side-to-side movement in walking (Collins et al., 2015). An eversion movement is a roll in the opposite direction, toward the inside of the foot (Collins et al., 2015). Participants stood on two wooden plates. The plates are 410 mm x 410 mm, at 410 mm from the floor. The AMEDA is secured to a base board and placed in the middle of the laboratory. One plate is the top surface of a stable box. The other plate is able to rotate on a metal axle located in the center of the plate.

Sixteen individual 460 mm long, 25 mm tall, and 5 mm wide metal shafts were cut. One shaft prevents eversion movement. The other shafts have notches cut to correspond with inversion degrees and act as stoppers for the inversion movement. On the eversion side of the plate there is a 25 mm x 5 mm rectangular hole cut for the eversion restriction shaft to be placed. On the inversion side of the plate there is 25 mm x

5 mm rectangular shaped hole cut where the top of the shaft will stop the plate at the following degrees for the inversion movements, 7.6, 7.9, 8.2, 8.5, 8.9, 10.2, 10.5, 10.8, 11.2, 11.5, 13.2, 13.6, 13.9, 14.2, and 14.6. This will be repeated for the other side so the shafts can protrude through to act as a stabilizer. The measures taken by the AMEDA will be all participant's judgments and the corresponding degree of inversion. The scores had a possible range from 0 to 300 total correct responses for both feet combined, 150 correct responses per foot, and three depths per foot that consisted of 50 correct responses per depth. The total number of correct responses would then represent the current level of proprioceptive awareness at the ankle joint.

The active inversion maneuver was stopped by a metal shaft placed in the selected depth. Symes and colleagues (2010) used wooden blocks that were elevated to the proper degree using metal wedges; however, it was found that using metal shafts allowed for faster administration of the procedure by one individual. Active eversion, or ankle roll toward the big toe, movement is prevented by a removable restriction shaft. To test the other foot of the participant, the removable restriction shaft was placed on the back side of the AMEDA as mentioned above. The participants then turned around, faced the opposing wall, and performed the movements.

Procedures

After the project received Institutional Review Board (IRB) approval, participants were brought in and presented with an informed consent document. See Appendix I. The participants then filled out the demographic questionnaire. See Appendix A. The participants then filled out the FFMQ. See Appendix C. Next, the participants filled out the MAIA. See Appendix D. The participants were encouraged to complete any missing

items on the FFMQ and the MAIA before beginning the procedure on the AMEDA.

The participants removed their shoes. The participants stood on the AMEDA. A script was used by the researcher to guide the participants through the procedure. See Appendix B. Each participant was asked to step up on the device with the aid of a footstool. Then, the participant stood with his or her right foot in the center of the black gritty rectangle and the left foot on the left of the device where weight is distributed evenly. Next, the participant stared at a red circle on the wall. The researcher asked if the participant was ready then pulled out the lever to release the movable plate. The down command was given to the participant, then he or she made a fluid movement until the foot plate stopped. The return command was given, then he or she returned the foot plate to the level position. Once the plate is returned to the level position, the stabilizer shaft was reinserted. A number that represents that particular depth was told to the participant.

During the initial familiarization stage there were a total of five depths learned. The first movement was depth one, the shallowest. The second movement was depth two, third movement was depth three, fourth movement was depth four, and the fifth movement was five. The higher the number the deeper the movement, the lower the number the shallower the movement. This process was repeated until all data for the right foot was collected, then proceeded to test the left foot until all data was collected. Intermittent breaks were taken in between shallow, mid, and deep depth administrations.

After the familiarization stage, if the participant's response number matched the inversion depth number performed, a correct was noted by the researcher. If the response number did not match the inversion depth number performed, an incorrect was noted by the researcher. No feedback was given at that time. There are a total of 300 trial depths.

The inversion depths are divided into three sections consisting of five depths each. The first shallow section is called shallow, the middle section is called mid, and the deep section is called deep. For each shallow, mid, and deep set, and for each foot, 50 trials were conducted. Each inversion depth consisted of 10 trials. The sequence of the 50 trials for each of the six blocks were generated in random order. The participants were given a total of two minutes to rest between the blocks of trials. Testing the other foot required the participant to turn around and perform the procedure for the other foot. Participants were encouraged to respond immediately with a number ranging from 1 to 5 once they return the plate to the horizontal position. The experimenter watched to ensure even weight distribution and maintenance of an upright stance was achieved. Before leaving, the participants were thanked for their participation and were given a debriefing form. See Appendix J. The entire procedure took 60 minutes.

Results

Preliminary Analyses

Participants completed demographics questionnaire. Descriptive data did not correlate with proprioceptive awareness scores. Participants completed three measures and means and standard deviations were calculated, as seen in Table 1. First, the participants completed the FFMQ (Baer, et al., 2006). The FFMQ (Baer, et al., 2006), from the current study (39 items; $\alpha = .58$). Scores on the mindfulness facet, observing ranged from 17 to 37 ($M = 29.13$, $SD = 5.78$). Scores on the facet of mindfulness, describing, ranged from 16 to 36 ($M = 28.13$, $SD = 5.60$). Scores on the facet of mindfulness, acting with awareness, ranged from 17 to 40 ($M = 26.04$, $SD = 5.18$). Scores on the facet of mindfulness, non-judging of inner experience ranged from 16 to 35 ($M = 24.96$, $SD = 6.34$). Scores on the facet of mindfulness, non-reactivity to inner experience, ranged from 15 to 31 ($M = 22.39$, $SD = 3.95$). Level of mindfulness total score ranged from 18 to 31 ($M = 25.92$, $SD = 3.02$).

The participants completed the Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling, et al., 2012). The MAIA (Mehling et al., 2012), from the current study, was reliable (32 items; $\alpha = .83$). Scores on the interoceptive facets of noticing ranged from 3.75 to 5.00 ($M = 3.84$, $SD = .85$), non-distracting ranged from 0.33 to 4.00 ($M = 1.75$, $SD = 0.89$), non-worrying ranged from 1.67 to 4.00 ($M = 2.58$, $SD = .83$), attention regulation ranged from 1.14 to 5.00 ($M = 3.14$, $SD = 0.89$), emotional awareness ranged from 1.60 to 5.00 ($M = 3.73$, $SD = 0.79$), self-regulation ranged from 1.00 to 5.00 ($M = 3.29$, $SD = 1.05$), body listening ranged from 0.33 to 5.00 ($M = 2.72$, $SD = 1.13$), and trusting ranged from 2.00 to 5.00 ($M = 3.71$, $SD = 0.98$).

Finally, the participants completed the procedure on the Active Movement Extent Discrimination Apparatus (AMEDA; Symes et al., 2010). The AMEDA, from the current study, was found to be reliable (300 items; $\alpha = .82$). Level of proprioceptive awareness ranged from 38 to 79 ($M = 50.09$, $SD = 9.48$).

Table 1

Scores on the Five Facet Mindfulness Questionnaire, Multidimensional Assessment of Interoceptive Awareness, and Active Movement Extent Discrimination Apparatus

Variable	M	SD
	FFMQ	
Observe	29.13	5.78
Describe	28.13	5.60
Acting with Awareness	26.04	5.18
Non-Judgement of Inner Experience	24.96	6.34
Non-Reactivity to Inner Experience	22.39	3.95
Total Level of Mindfulness	25.92	3.02
	MAIA	
Noticing	3.83	0.85
Not-Distracting	1.75	0.89
Not Worrying	2.58	0.83
Attention Regulation	3.14	0.89
Emotional Awareness	3.73	0.79
Self-Regulation	3.29	1.05
Body Listening	2.72	1.13
Trusting	3.71	0.98
	AMEDA	
Total Correct on AMEDA	50.09	9.48

Note. $n = 23$. FFMQ = Five Facet Mindfulness Questionnaire, MAIA = Multidimensional Assessment of Interoceptive Awareness, AMEDA = Active Movement Extent Discrimination Apparatus.

Hypotheses Testing

Three hypotheses were tested as shown in Table 2, correlations of FFMQ, MAIA, and AMEDA are included.

Hypothesis 1

The first hypothesis stated higher levels of mindfulness will be associated with higher levels of proprioceptive awareness. A Pearson's 2-tailed correlation was conducted to evaluate this hypothesis. Hypothesis 1 was not supported.

Hypothesis 2

The second hypothesis stated higher levels of body awareness will be associated with higher levels of interoceptive awareness. A Pearson's 2-tailed correlation was conducted to test this hypothesis. Observing was weakly positively correlated with the facet of noticing r (21) = .43, $p < .05$. Observing was moderately positively correlated with the facets of attention regulation r (21) = .68, $p < .001$ and self-regulation r (21) = .66, $p < .001$. Observing was strongly positively correlated with emotional awareness r (21) = .76, $p < .001$ and body listening r (21) = .76, $p < .001$.

Hypothesis 3

The third hypothesis stated higher levels of emotion regulation will be associated with higher levels of interoceptive awareness. A Pearson's 2-tailed correlation was conducted to assess this hypothesis. Non-reactivity to inner experience was moderately positively correlated to attention regulation r (21) = .63, $p < .001$ and self-regulation r (21) = .61, $p < .001$. Non-reactivity to inner experience was moderately correlated to emotional awareness r (21) = .55, $p < .001$, body listening r (21) = .51, $p < .001$, and trusting r (21) = .52, $p < .05$.

Table 2

Correlations of Five Facet Mindfulness Questionnaire, Multidimensional Assessment of Interoceptive Awareness, and Active Movement Extent Discrimination Apparatus

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.															
2.	.24														
3.	.17	.23													
4.	-.19	-.01	-.14												
5.	.36	.22	.37	.11											
6.	.60**	.53*	.49*	.32	.67*										
7.	.43*	.19	-.03	-.09	.32	.21									
8.	-.35	.27	.38	.09	.23	.12	.09								
9.	-.23	-.10	.20	.22	.05	.01	-.02	.31							
10.	.68**	.14	.27	-.07	.63**	.51*	.69**	-.08	.08						
11.	.76**	.40	.27	-.04	.55**	.65**	66**	.07	-.02	.74**					
12.	.66*	.27	.44*	-.05	.61**	.70**	.61**	-.10	.08	.72**	.69**				
13.	.76**	.35	.29	-.19	.51*	.58**	.69**	-.15	-.00	.82**	.79**	.82**			
14.	.38	.20	.20	.38	.52*	.53**	.53**	-.08	.16	.63**	.53**	.39	.55*		
15.	-.10	-.15	.35	.28	.29	.13	.19	.20	.17	.06	.10	.16-	.02	.12	

Note. $n = 23$. 1 = Observe, 2 = Describe, 3 = Acting with Awareness, 4 = Non-Judging of Inner Experience, 5 = Non-Reactivity to Inner Experience, 6 = Total Mindfulness Score, 7 = Noticing, 8 = Not-Distracting, 9 = Not Worrying, 10 = Attention Regulation, 11 = Emotional Awareness, 12 = Self-Regulation, 13 = Body Listening, 14 = Trusting, 15 = Total Correct on AMEDA.
*$p < .05$
**$p < .001$

Discussion

The current study aimed to investigate how mindfulness and body awareness relate by comparing current measures to assess both constructs. The goal was to further the understanding of mindfulness mechanisms of action and how these relate to both interoceptive and proprioceptive awareness. A correlational research design was used and revealed three conclusions. Higher levels of mindfulness, measured by the FFMQ total score, were not related to higher levels of proprioceptive awareness, measured by the total correct score on the AMEDA. Higher levels of body awareness, measured by the FFMQ observing facet, were shown to be associated with higher levels of interoceptive awareness, measured by the facets on the MAIA. Higher levels of emotion regulation, measured by the non-reactivity to inner experience, were associated with higher levels of interceptive awareness, measured by the facets on the MAIA.

Results did not support the hypothesis that higher levels of mindfulness would be related to higher levels of proprioceptive awareness. Previous studies are sparse comparing these, however, previous research has shown correlation of athletic competition level (Han et al., 2014). It should be noted that there was no correlation between performance on the AMEDA and any of the demographic variables.

It was predicted that higher levels of body awareness, as measured by the FFMQ observing facet, would be associated with higher levels of interoceptive awareness, as measured by the MAIA facets of noticing, non-distracting, not worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting. Data supported the hypothesis in five of the eight analyses. In line with previous studies, observing was related to noticing, attention regulation, emotional awareness, self-

regulation, and body listening (Hanley et al., 2017; Mehling et al., 2012). This supports the current theory and the prediction that body awareness is associated with interoceptive awareness. It should be noted that noticing was related to observing, whereas trusting was not.

It was predicted that higher levels of emotion regulation, as measured by the FFMQ non-reactivity to inner experience facet, would be associated with higher levels of interoceptive awareness, as measured by the MAIA facets of noticing, non-distracting, not worrying, attention regulation, emotional awareness, self-regulation, body listening, and trusting. Data supported the hypothesis in five of the eight analyses. In line with previous studies, non-reactivity to inner experience was related to attention regulation, emotional awareness, self-regulation, body listening, and trusting (Hanley et al., 2017; Mehling et al., 2012). This supports the current theory and the hypothesis that emotion regulation is associated with interoceptive awareness. It should be noted that trusting was related to non-reactivity to inner experience, whereas noticing was not. This could imply that emotion regulation does not require a high level of executive attention but requires a trust in the message from the body experiences.

Limitations of the Research

The current study was conducted during the time COVID-19 was occurring. The WKU IRB stopped research and the testing site was shut down. The device had to be moved to another location. The WKU IRB required additional safety protocols in response to COVID-19. Once safety measures were in place, approval to continue the research was acquired. Participant recruitment through study board and local organizations was discontinued. Due to COVID-19, the difficulty in obtaining a sample

resulted in a smaller sample size than was anticipated. This makes the current study at risk for Type II error. The size of the sample was small thereby, reducing effect size. Future research needs to aim at a larger number of participants to reduce this risk. Along with altering the sample size, the pandemic had an impact on the methods used to collect the study sample. Recruitment and data collection occurred before the vaccinations were available. The zeitgeist related to the pandemic could have resulted in attention orientation distraction. The increase in stress could result in participants being affected by the alerting system of attention such that homeostasis is in a heightened alarm state. This makes the executive attention survival-oriented and concentration on the task becomes difficult. The original testing site was shut down due to COVID-19 and another site was used.

The statistical analysis used in the current study was a Pearson's two-tail correlation. Because this was the first time looking at the relationship between proprioceptive awareness and mindfulness, a two-tail correlation was performed so as to glean results from possible negative correlations. This decreases the alpha value; therefore, future studies should predict in one specific direction.

The length of time for the procedure on the AMEDA was an hour. Fatigue could have affected participants during the AMEDA procedure. Some participants commented on the length and strenuousness of the procedure. Future research needs to focus on methods to reduce these effects while maintaining reliability. Spacing sessions out could alleviate this.

There seems to be a measurement problem with AMEDA. Along with finding no correlation between proprioceptive awareness and mindfulness, the AMEDA did not

produce a correlation with any of the demographic variables. This could be because the distance between the shafts were so small that no difference was able to be noticed. The entire procedure took an hour, which may have produced fatigue and affected results. It is possible that the current study could be measuring proprioceptive accuracy instead of proprioceptive awareness. We could be measuring a component of a proprioceptive awareness rather than all of proprioceptive awareness. Other studies have shown that different proprioceptive activities did not correlate with each other (Horváth et al., 2019). Research is just beginning or rediscovering, as I will detail below, the best methods to measure proprioception. There appears to be subtle differences in terms involved like proprioception, proprioceptive awareness, proprioceptive accuracy etc. Proprioceptive related terms are still being defined.

Future Directions for Theory and Research

Future research should have the following goals. First, research should focus on measuring attention regulation and the possible connection with the other mindfulness mechanisms of action. There are two measures of attention commonly used (Hölzel et al., 2011). The Attention Network Test (Fan et al., 2002) seems to have more consistent results in those that meditate than the classical Stroop task (Stroop, 1935). Additional research is needed to determine a sufficient means of measuring attention regulation. Attention regulation has been proposed to be an important mechanism of action in early meditation and acts as a building block to access the other mindfulness mechanisms of action, therefore, researching the connection between attention regulation and the other mechanisms of action in the current theory is vital (Hölzel et al., 2011).

Next, research should focus on investigating emotional reappraisal to clearly

define the term. The current literature has found that emotion regulation has been associated with both positive reappraisal and non-appraisal (Hölzel et al., 2011). It needs to be investigated whether both of these mechanisms of action are present during mindfulness meditation.

Then, research should focus on the measurement of the change in perspective on the self. The self and the change on the perspective on self, have been difficult constructs to measure, however neuro-imaging studies have implicated the limbic area of the brain (Tang et al., 2015). Along with these attempts at measuring the self through neuroimaging, other possible methods of measuring the self need to be explored. I will now discuss potential improvements to the AMEDA.

AMEDA Improvement

Finally, future research should focus on measuring proprioceptive awareness to further the understanding of body awareness. The total distance between each shaft was only 1mm. Decreasing to two selections per level would increase the distances between the ankle depths while decreasing the total time the procedure takes to administer. Decreasing the total depth selections from 300 to 48 could decrease total time of administration and participants' fatigue. This would translate to eight selections per depth.

Investigating the other two classical methods of measuring, the method of adjustment and the method of limits, could provide a more accurate method of measuring proprioceptive related activities than the current measure (Han et al., 2016). Specifying the terms surrounding proprioceptive activities would be beneficial for measurement purposes. There is a recent study that measured ankle proprioceptive acuity with a similar

device used in the current study (Mahnan et al., 2020). Mahnan and colleagues (2020) also measured proprioceptive acuity based on just noticeable difference (JND), the rate where 75% of the participant's responses are correct. Measuring proprioceptive awareness using JND could be employed in the future.

Measuring distortions in proprioceptive awareness should be explored. Aging has been shown to effect proprioceptive signals that reduce sway in posture (Henry & Baudry, 2019). Future research should focus on investigating the effects age on proprioceptive awareness. There could be differences in proprioceptive awareness due to gender, amount of sport participation, or amount of participation in mindfulness related activities. Future study should focus on these potentially effecting proprioceptive awareness.

Implications

Body awareness, specifically interoceptive awareness, seems to play a vital role in the other mechanisms of action in the comprehensive theory of mindfulness. Body awareness has been shown to be trainable through mindful meditation body-oriented exercises and have shown improvements in clinical areas such as depression and anxiety (Melloni, 2013). Interoceptive awareness plays a role in the regulation of attention, therefore enhancement of interoceptive awareness could lead to improvement in performances that require heightened attention.

Adding to the work pioneered by Fitts (1947), The U.S. Army Aeromedical Research Laboratory (USAARL) tested a Tactile Situation Awareness System (TSAS), a body suit containing vibrotactile stimulators that covers the torso. (Lawson & Rupert, 2014). The TSAS enhances aircraft flight control through the sense of touch and was

developed with the goal of providing hover feedback and increased control in environments with decreased visual cues (Lawson & Rupert, 2014). Enhancing the connection between human and aircraft increased situational awareness, reduced workload, and decreased drift three times as much as controls during degraded visual environment (DVE) flights (Lawson & Rupert, 2014).

A similar device could be developed to enhance attention regulation in relation to satiation signals in bariatric patients. Satiation has been proposed to be a result of excitation of vagal mechanoreceptors located in the stomach wall (Gautron, 2021). If these mechanoreceptors could be manipulated results could mimic the same effect of gastric bypass surgery currently used. Similar devices, such as spinal cord stimulators, are already in use in the medical field and have been effective in pain reduction without surgery (Sdrulla et al., 2018).

Interoceptive awareness seems to be involved with emotion regulation, therefore training interoceptive awareness could result in better emotion regulation skills. A recent study found deficits in interoceptive awareness and emotion regulation in moderately to severely obese patients (Willem et al., 2019). Increasing interoceptive awareness could aid in reduction of weight while facilitating regulations of emotions. (Willem et al., 2019)

Although an association was not found between proprioceptive awareness and other variables, it could play a large role in body awareness. Activities, such as yoga, martial arts, dance, etc., that aim at increasing proprioceptive awareness could facilitate mindfulness and play as much of a role in the mindfulness of meditation theory as interoceptive awareness. More research on proprioceptive awareness is needed to understand the impact proprioceptive awareness plays in consciousness, attention, and

mindfulness.

In conclusion, this is the first study that attempted to objectively measure and propose proprioceptive awareness as an aspect of body awareness in the comprehensive theory of mindfulness meditation. The article also supported the prediction that interoceptive awareness plays a substantial role in the current theory but found no relationship between proprioceptive awareness and mindfulness. This could be due to the small sample size, the measuring challenges associated to the AMEDA, or the need to further clarify terms associated with proprioception.

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Appendix A

Demographics Questionnaire

Instructions: Please answer each of the following demographic questions, being completely honest in your responses.

Age: _____
Gender: _____
Height: _____
Weight: _____

Have you experienced any of the following problems within the last six weeks? (check all that apply)

Ankle injury: _____
Back injury: _____
Vision problems (not corrected by glasses or contact lenses): _____

Which is your dominant hand/foot: (circle one) Right Left

Over the past year, how often have you participated in athletic activities during a given week?

Over the past year, how often have you participated in a mindful activity/practice during a given week?

Have you had any contact with anyone with Covid-19?

Have you had a fever in the last 14 days?

Have you had a cough in the last 14 days?

Have you tested positive for Covid-19?

Appendix B

Researchers Script

Read the blue writing to the participant as you go along.

I am _____. We are going to be doing a series of tasks today that involve filling out forms then performing active movements on this device (show device). The procedure requires standing on the device then performing inverted ankle movements to a maximum depth of _____ (show maximum depth).

Please, fill out these forms.

Hand the participant the forms with a pencil.

Allow them to fill out the forms.

After participant fills out all documents and questionnaire.

Check the demographics and questionnaires.

Obtain height and weight of participant.

If weight of Ps is > 300lbs discontinue

If height of Ps is > 7 ft discontinue

If any injury of back or ankle is checked discontinue

If vision problem is checked discontinue

For this task you will step up on the device with the aid of the footstool. Stand with your right foot in the center of the black gritty rectangle and the left foot on the left of the device in a manner where you keep your weight distributed evenly. Next stare at the red circle on the wall. I will ask if you are ready. Upon you telling me that you are ready I will pull the stabilizer out and say down, at which point you will make a fluid movement until the foot plate stops. I will then give the command to return, at which

point you will return the foot plate to the level position. Once the plate is returned to the level position, I will reinsert the stabilizer shaft. Next, I will tell you a number that represents that particular depth. During the initial familiarization stage there will be a total five depths learned. The first movement will be depth one, the shallowest. The second movement will be depth two, third movement will be depth three, fourth movement will be depth four, and the fifth movement will be five. The higher the number the deeper the movement, the lower the number the shallower the movement. We will repeat this process until finished with the right foot then proceed to test your left foot. We will take intermittent breaks through out. Do you have any questions?

The participants will stare directly at a point on the opposite wall. Participants will then be instructed to begin an active inversion maneuver at a steady pace until their movement is stopped by a metal shaft placed in the selected depth. Ankle eversion movement will be prevented from being able to physically move by a removable restriction shaft. To test the other foot of the participant, the removable restriction shaft is placed on the back side of the AMEDA the same way as mentioned above. The participants then turn around, face the opposing wall, and perform the movements.

Appendix C

Five Facet Mindfulness Questionnaire

Description:
This instrument is based on a factor analytic study of five independently developed mindfulness questionnaires. The analysis yielded five factors that appear to represent elements of mindfulness as it is currently conceptualized. The five facets are observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. More information is available in:

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	2	3	4	5
never or very rarely true	rarely true	sometimes true	often true	very often or always true

_____ 1. When I'm walking, I deliberately notice the sensations of my body moving.
_____ 2. I'm good at finding words to describe my feelings.
_____ 3. I criticize myself for having irrational or inappropriate emotions.
_____ 4. I perceive my feelings and emotions without having to react to them.
_____ 5. When I do things, my mind wanders off and I'm easily distracted.
_____ 6. When I take a shower or bath, I stay alert to the sensations of water on my body.
_____ 7. I can easily put my beliefs, opinions, and expectations into words.
_____ 8. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.
_____ 9. I watch my feelings without getting lost in them.
_____ 10. I tell myself I shouldn't be feeling the way I'm feeling.
_____ 11. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.
_____ 12. It's hard for me to find the words to describe what I'm thinking.
_____ 13. I am easily distracted.
_____ 14. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.
_____ 15. I pay attention to sensations, such as the wind in my hair or sun on my face.
_____ 16. I have trouble thinking of the right words to express how I feel about things
_____ 17. I make judgments about whether my thoughts are good or bad.
_____ 18. I find it difficult to stay focused on what's happening in the present.
_____ 19. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.
_____ 20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.
_____ 21. In difficult situations, I can pause without immediately reacting.
_____ 22. When I have a sensation in my body, it's difficult for me to describe it because I can't find the right words.
_____ 23. It seems I am "running on automatic" without much awareness of what I'm

doing.
_____24. When I have distressing thoughts or images, I feel calm soon after.
_____ 25. I tell myself that I shouldn't be thinking the way I'm thinking.
_____ 26. I notice the smells and aromas of things.
_____ 27. Even when I'm feeling terribly upset, I can find a way to put it into words.
_____ 28. I rush through activities without being really attentive to them.
_____ 29. When I have distressing thoughts or images I am able just to notice them without reacting.
_____ 30. I think some of my emotions are bad or inappropriate and I shouldn't feel them.
_____ 31. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.
_____ 32. My natural tendency is to put my experiences into words.
_____ 33. When I have distressing thoughts or images, I just notice them and let them go.
_____ 34. I do jobs or tasks automatically without being aware of what I'm doing.
_____ 35. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.
_____ 36. I pay attention to how my emotions affect my thoughts and behavior.
_____ 37. I can usually describe how I feel at the moment in considerable detail.
_____ 38. I find myself doing things without paying attention.
_____ 39. I disapprove of myself when I have irrational ideas.

Appendix D

Multidimensional Assessment of Interceptive Awareness

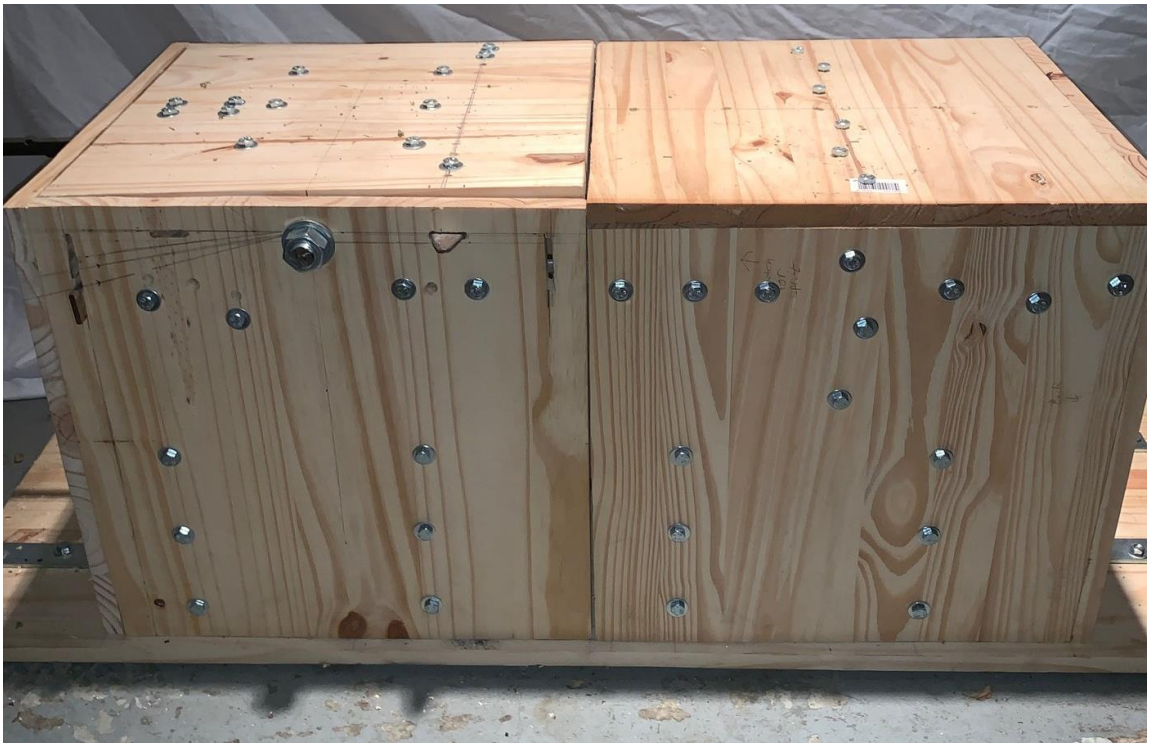
Below you will find a list of statements. Please indicate how often each statement applies to you generally in daily life.

	Never					Always
	Circle one number on each line					
1. When I am tense I notice where the tension is located in my body.	0	1	2	3	4	5
2. I notice when I am uncomfortable in my body.	0	1	2	3	4	5
3. I notice where in my body I am comfortable.	0	1	2	3	4	5
4. I notice changes in my breathing, such as whether it slows down or speeds up.	0	1	2	3	4	5
5. I do not notice (I ignore) physical tension or discomfort until they become more severe.	0	1	2	3	4	5
6. I distract myself from sensations of discomfort.	0	1	2	3	4	5
7. When I feel pain or discomfort, I try to power through it.	0	1	2	3	4	5
8. When I feel physical pain, I become upset.	0	1	2	3	4	5
9. I start to worry that something is wrong if I feel any discomfort.	0	1	2	3	4	5
10. I can notice an unpleasant body sensation without worrying about it.	0	1	2	3	4	5
11. I can pay attention to my breath without being distracted by things happening around me.	0	1	2	3	4	5
12. I can maintain awareness of my inner bodily sensations even when there is a lot going on around me.	0	1	2	3	4	5
13. When I am in conversation with someone, I can pay attention to my posture.	0	1	2	3	4	5
14. I can return awareness to my body if I am distracted.	0	1	2	3	4	5
15. I can refocus my attention from thinking to sensing my body.	0	1	2	3	4	5
16. I can maintain awareness of my whole body even when a part of me is in pain or discomfort.	0	1	2	3	4	5
17. I am able to consciously focus on my body as a whole.	0	1	2	3	4	5
18. I notice how my body changes when I am angry.	0	1	2	3	4	5
19. When something is wrong in my life I can	0	1	2	3	4	5

feel it in my body.						
20. I notice that my body feels different after a peaceful experience.	0	1	2	3	4	5
21. I notice that my breathing becomes free and easy when I feel comfortable.	0	1	2	3	4	5
22. I notice how my body changes when I feel happy / joyful.	0	1	2	3	4	5
23. When I feel overwhelmed I can find a calm place inside.	0	1	2	3	4	5
24. When I bring awareness to my body I feel a sense of calm.	0	1	2	3	4	5
25. I can use my breath to reduce tension.	0	1	2	3	4	5
26. When I am caught up in thoughts, I can calm my mind by focusing on my body/breathing.	0	1	2	3	4	5
27. I listen for information from my body about my emotional state.	0	1	2	3	4	5
28. When I am upset, I take time to explore how my body feels.	0	1	2	3	4	5
29. I listen to my body to inform me about what to do.	0	1	2	3	4	5
30. I am at home in my body.	0	1	2	3	4	5
31. I feel my body is a safe place.	0	1	2	3	4	5
32. I trust my body sensations.	0	1	2	3	4	5

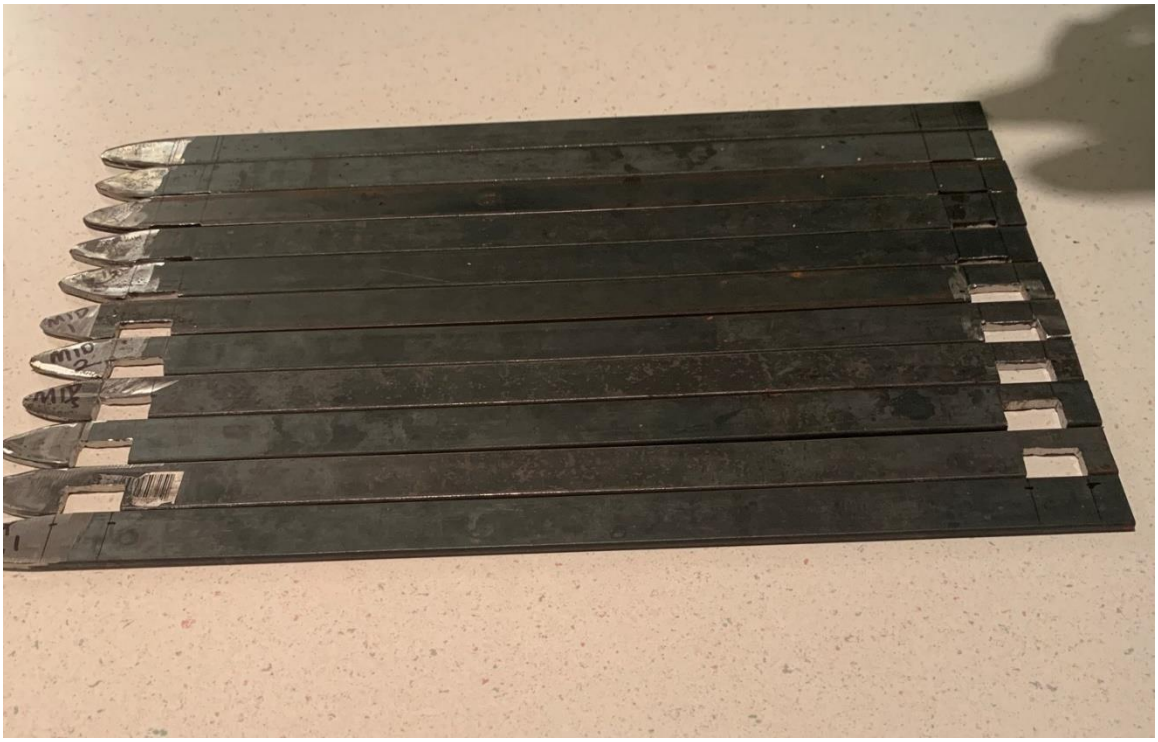
Appendix E

Active Movement Extent Discrimination Apparatus Full View



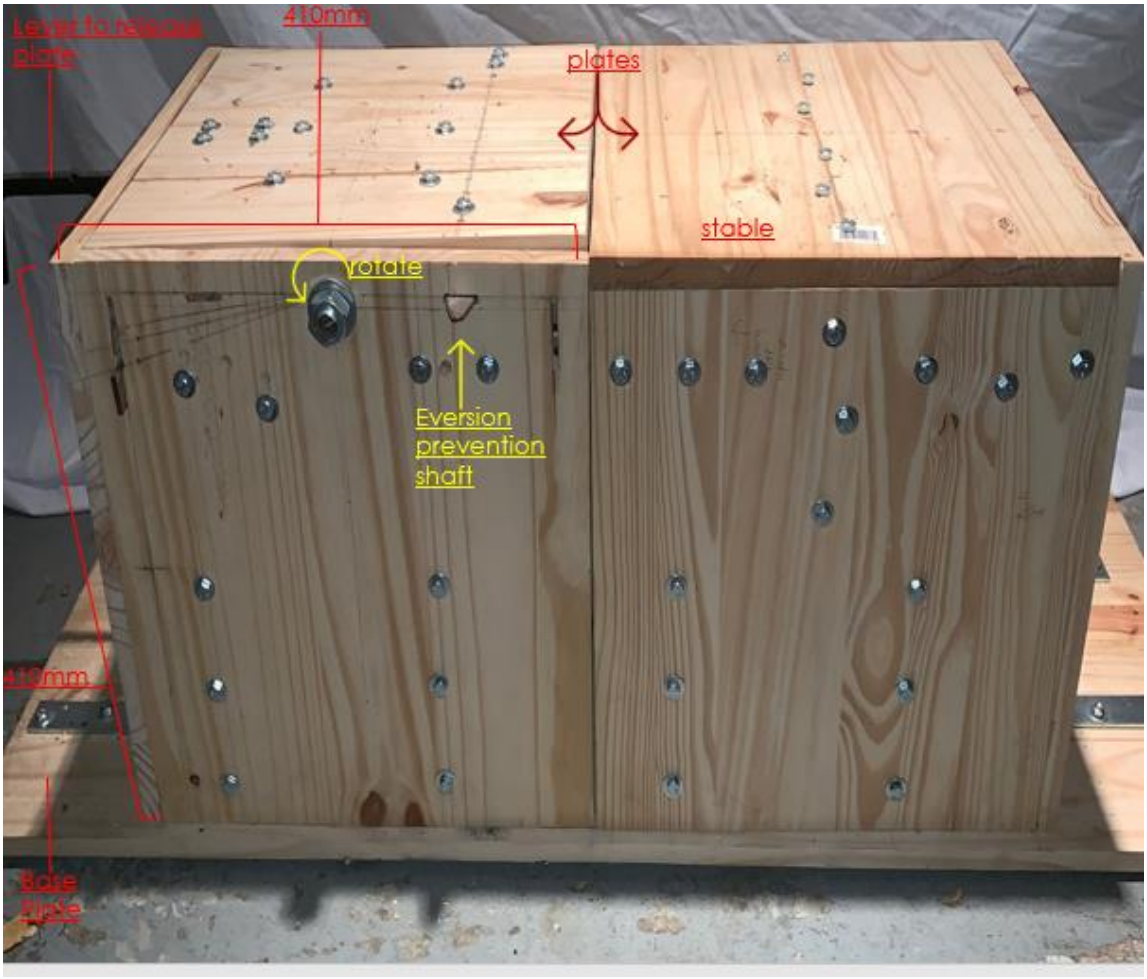
Appendix F

Active Movement Extent Discrimination Apparatus Individual Shafts



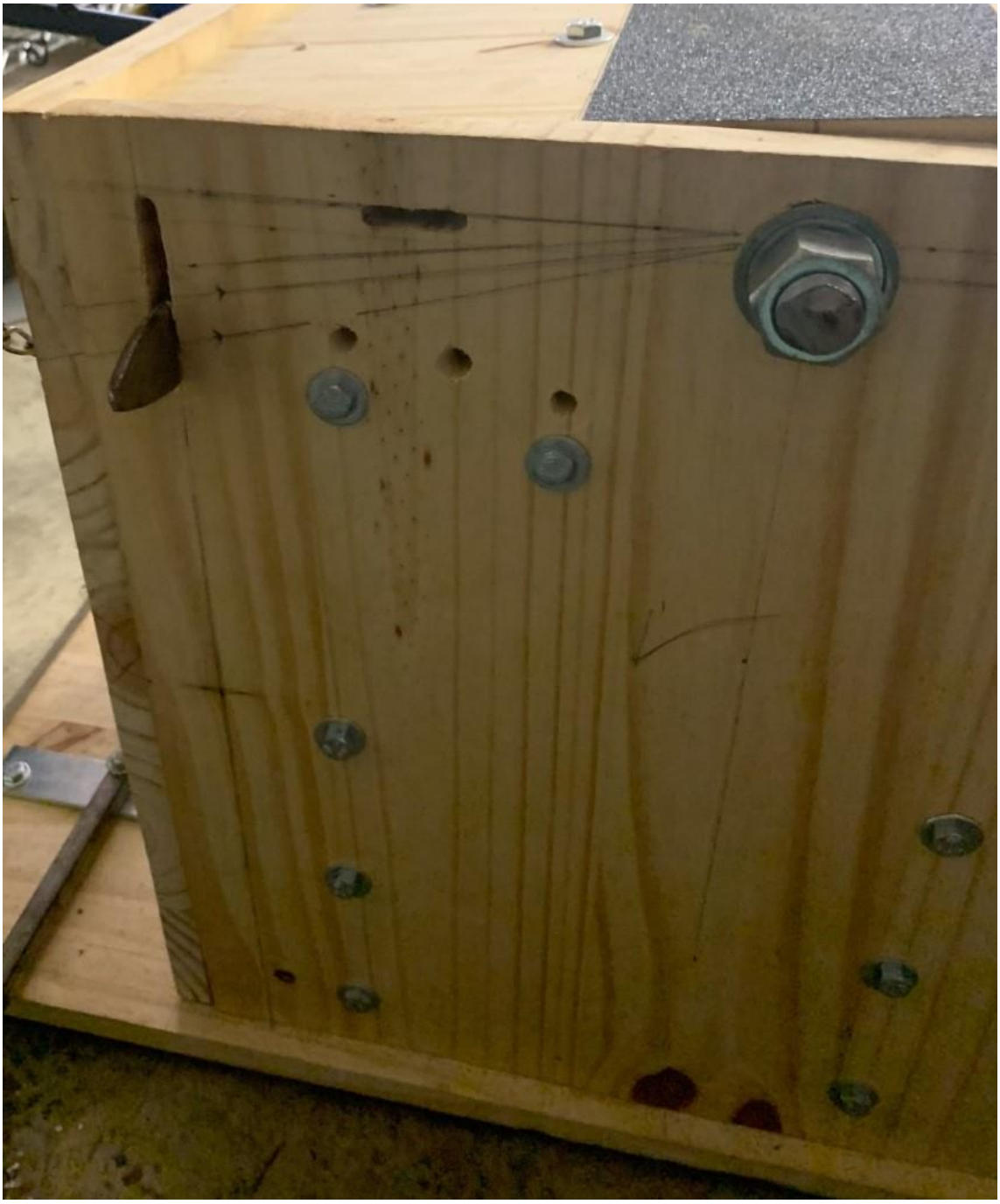
Appendix G

Active Movement Extent Discrimination Apparatus



Appendix H

Active Movement Extent Discrimination Apparatus Shaft Protrusion



Appendix I

Informed Consent

INFORMED CONSENT DOCUMENT

Project Title: The Relationship between Mindfulness, Proprioceptive Awareness, and Interoceptive Awareness.
Investigator: Casey Ford, WKU Department of Psychology, casey.ford174@topper.wku.edu
Faculty Sponsor: Dr. Rick Grieve, WKU Department of Psychology, rick.grieve@wku.edu

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.
You must be 18 years old or older to participate in this research study.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have. If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** This project is looking at mindfulness and body awareness in the form of interoceptive awareness and proprioceptive awareness. We are interested in whether a relationship between mindfulness, interceptive awareness, and proprioceptive awareness might exist.

2. **Explanation of Procedures:** You will be asked to complete two questionnaires about mindfulness and interoceptive awareness. There are also 8 demographic questions and a performance on a discrimination task at the ankle joint. It should take between 45 minutes to 60 minutes to complete the entire procedure.

3. **Discomfort and Risks:** There are minimal risks involved in this study; however, a chance of experiencing negative consequences is possible in any study. Please let the examiner know if this happens to you.

4. **Benefits:** Researchers and participants could gain a better understanding of how mindfulness impacts body awareness (interoceptive and proprioceptive awareness) and vice versa.

5. **Confidentiality:** Participation in the current study will be entirely confidential. Names and any other identifying information will not be associated with the resulting data from study participation. Records will be viewed, stored, and maintained in private, secure files only accessible by the P.I. for three years following the study, after which time they will be destroyed.

WKU IRB# 20-153
Approved: 9/18/2020
End Date: 12/06/2021
EXPEDITED
Original: 12/06/2019

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks. If a medical emergency does occur, you understand that you are responsible for any costs incurred, including but not limited to the services of Emergency Medical Technicians, emergency room care, hospitalization, etc. We strongly encourage you to ensure that you have adequate health insurance coverage or other means of satisfying any costs for which you will be liable.

_____ _____

Signature of Participant Date

_____ _____

Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Robin Pyles, Human Protections Administrator
TELEPHONE: (270) 745-3360

WKU IRB# 20-153
Approved: 9/18/2020
End Date: 12/06/2021
EXPEDITED
Original: 12/06/2019

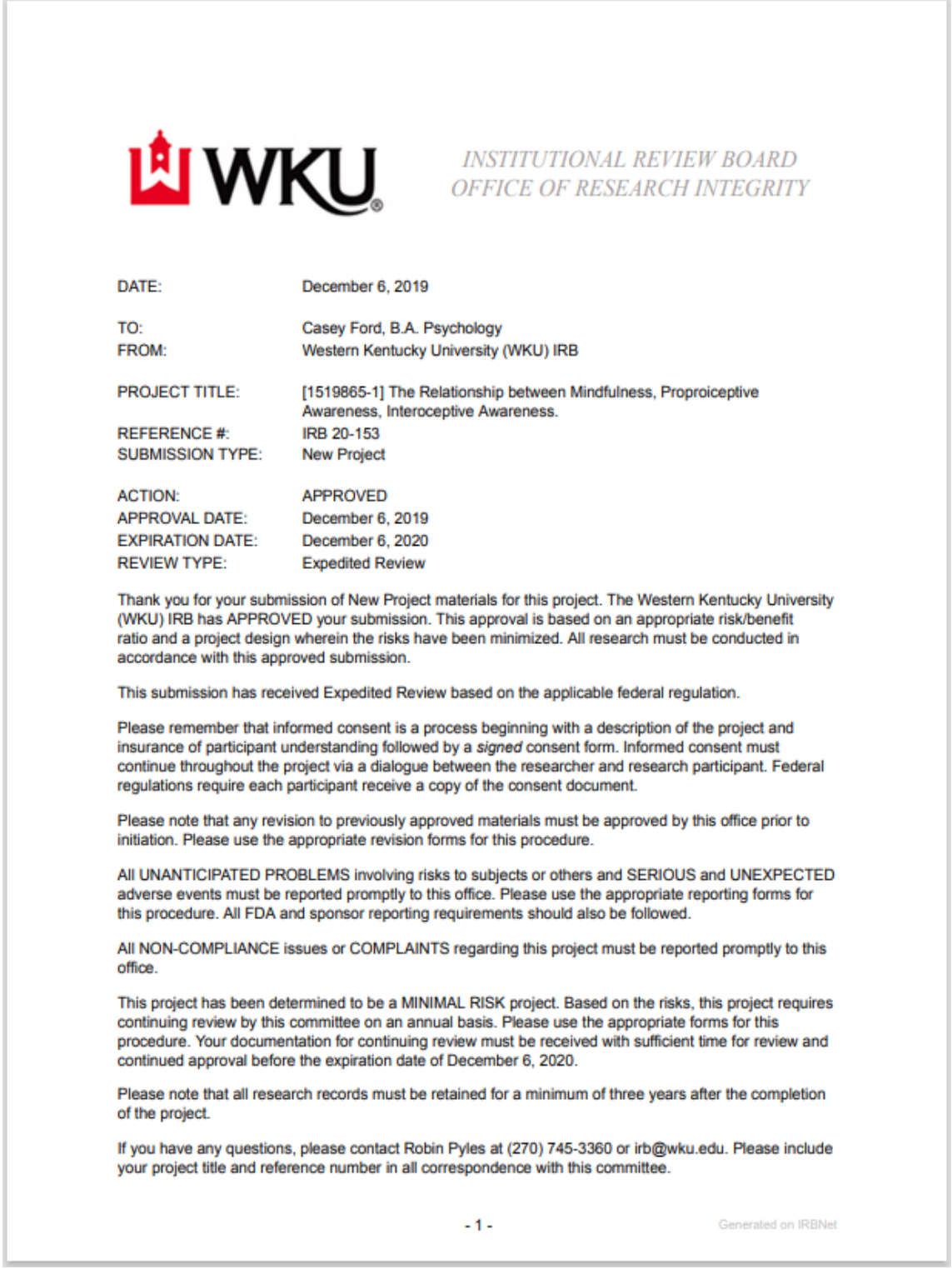
Appendix J

Debriefing

We would like to thank you for your participation in this research. The purpose of this study is to gain a better understanding of the relationship of mindfulness and two aspects of body awareness, interoceptive awareness and proprioceptive awareness. Specifically, we are investigating whether or not persons who score higher on mindfulness measures would likely score high on interoceptive awareness and proprioceptive awareness measures. If you would like a final copy of the research findings, please contact, after December, 2021, Casey Ford, B.A., at (270) 501-0739 or at the Department of Psychology, 1906 College Heights Boulevard #21030, Western Kentucky University, Bowling Green, KY 42103.

Appendix K

Institution Review Board Approval



INSTITUTIONAL REVIEW BOARD
OFFICE OF RESEARCH INTEGRITY

DATE: December 6, 2019

TO: Casey Ford, B.A. Psychology
FROM: Western Kentucky University (WKU) IRB

PROJECT TITLE: [1519865-1] The Relationship between Mindfulness, Proproiceptive Awareness, Interoceptive Awareness.
REFERENCE #: IRB 20-153
SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: December 6, 2019
EXPIRATION DATE: December 6, 2020
REVIEW TYPE: Expedited Review

Thank you for your submission of New Project materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a *signed* consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a MINIMAL RISK project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of December 6, 2020.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Robin Pyles at (270) 745-3360 or irb@wku.edu. Please include your project title and reference number in all correspondence with this committee.

- 1 -

Generated on IRBNet

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Western Kentucky University (WKU) IRB's records.

Appendix L

Institutional Review Board Continuing Review

WESTERN KENTUCKY UNIVERSITY

Institutional Review Board
Continuing Review Report

If this is your third year for your Continuing Review Request, please complete a new application.
Otherwise; DO NOT include the complete application in describing modifications and requests for additional time to collect data.

Name of Project: The Relationship between Mindfulness, Proprioceptive Awareness, Interoceptive Awareness.
Name of Researcher: Casey Ford, Dr. Rick Grieve
Department: Psychology

How many total subjects have participated in the study since its inception? 0

How many subjects have participated in the project since the last review? 0

Is your data collection with human subjects complete? ☐ **Yes** ☒ **No**

1. Has there been any change in the level of risks to human subjects? (If "Yes", please explain changes on a separate page). ☐ Yes ☒ No

2. Have informed consent procedures changed so as to put subjects above minimal risk? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

3. Have any subjects withdrawn from the research due to adverse events or any unanticipated risks/problems? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

4. Have there been any changes to the source(s) of subjects and the Selection criteria? (If "Yes", please describe on a separate page). ☒ Yes ☐ No

5. Have there been any changes to your research design that were not specified in your application, including the frequency, duration and location of each procedure. (If "Yes", please describe on a separate page). ☒ Yes ☐ No

6. Has there been any change to the way in which confidentiality of the Data is maintained? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

7. Is there desire to extend the time line of the project? ☒ Yes ☐ No
On what date do you anticipate data collection with human subjects to be completed? December 6, 2021

4. Selection for participants now includes showing no known symptoms of Covid-19.

5. The location for the procedure has changed to an off-campus location. The address for the location is 281 Morris Duff Road, Woodburn, Kentucky 42170. The participants and researcher are to wear protective masks and maintain specified distance throughout the procedure.

WKU IRB# 20-153
Approved: 9/18/2020
End Date: 12/06/2021
EXPEDITED
Original: 12/06/2019