Heartbeat Perception and its Association with the Multidimensional Assessment of Interoceptive Awareness (MAIA)

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by

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CHAPTER 1
INTRODUCTION

The conscious perception, or awareness, of sensations arising from the body can be encompassed by the term interoceptive awareness. Other definitions of interoceptive awareness include: the conscious perception of bodily signals influenced by one’s experiences that give rise to an overall condition of the body, detecting signals arising from the inner organs, the processes/mechanisms of visceral sensory psychobiology, the representation and perception of physiological feedback, and more simply, the awareness of bodily signals (Barrett, Quigley, Bliss-Moreau, & Aronson, 2004; Cameron 2001; Mehling, Price, Daubenmier, Acree, Bartmess, & Stewart, 2012; Mussgay, Klinkenberg, & Ruddel, 1999; Weins, 2005).

An organism’s ability to detect internal, visceral signals is vital to processes that contribute to survival. The maintenance of balanced physiological states, or homeostasis, is one such process that relies on accurate perception of visceral signals (Craig, 2002; Farb, Daubenmier, Price, Gard, Kerr, & Dunn, 2015). For example, attention to heat signals arising from the body, such as sweat, is required for an organism to engage in behaviors that will decrease body temperature. In this case, heat signals arising from the body act as a motivator and indicator to seek a solution to decrease body temperature and return to homeostasis. Without accurate perception of body signals, conditions such as heat stroke, hypothermia, and even improper calorie intake would be unavoidable. Interoceptive awareness also provides a framework for consciousness, which gives
organisms the feedback to navigate, as well as adapt to their environment. Such a
t framework has been referred to as the “material self” (Craig, 2002), which provides a
base for subjective feelings, emotions, and self-awareness.

The role of interoceptive awareness in the experience of emotion has been the
subject of great interest for decades. For example, the James-Lange theory of emotion
states that the origin of emotion is self-observation (Lange & James, 1922). That is, the
experience of emotion is the physiological reaction to an event. The two-factor theory of
emotion coined by Schacter and Singer (1962) theorizes that emotion is both dependent
on physiologic responses as well as the context in which they are experienced; this
combination of physiological response and context in which it is derived give rise to the
“labeled” emotion that is experienced. Finally, Damasio’s somatic marker hypothesis
proposes that body signals act as a guide for behavior (Damasio, Tranel, & Damasio,
1991). For example, as an individual is confronted with uncertainty in his or her
decision-making, the internal feeling that accompanies each option aids in determining
the “best” choice. That is, internal cues “mark” the decision that is perceived to be most
desirable. Furthermore, the foundation of Damasio’s (2000) theory of consciousness
relies on basic physiological changes in the body which give rise to emotion, referred to
as the “proto-self.” The second tier, core consciousness, is the awareness of emotions
defined as “feeling a feeling.” The third and higher level, extended consciousness,
emerges from the lower two levels and uses past experiences to extend consciousness
beyond the moment. Overall, there appears to be an intimate connection between
visceral signals and the experience of emotion and consciousness.
Empirical investigations of the relationship between IA and emotion have found that variations in interoceptive ability are linked to differences in levels of experienced emotional reactions and affect regulation. For example, when individuals viewed three videos; one to elicit fear, one to evoke anger, and another to inspire amusement, findings indicated that individuals with higher interceptive awareness experienced a greater intensity of emotion across all three emotional valences compared to individuals with poor interoceptive awareness (Weins, Mezzacappa, & Katkin, 2000). Arousal focus, or representation of the attenuation to emotion states, has also been linked to IA such that individuals who are more sensitive to body signals (e.g. heart rate) also experience more subjective activation and deactivation of emotion (Barret et al., 2004). Specifically, individuals with higher IA were better able to track their emotions in the moment; for example, individuals with higher IA reported feeling greater differences in experienced emotion throughout the day compared to individuals with lower IA (Barret et al., 2004), further solidifying IA’s role in emotional arousal and recognition.

Increased interoceptive awareness is also linked to enhanced regulation of emotion in response to stressful events by way of cognitive reappraisal (Fustos, Granann, Herbert, & Pollatos, 2013). Cognitive reappraisal is an emotional regulation strategy in which an individual deliberately reevaluates the meaning of emotional stimuli, including body sensations associated with the arising emotions (Gross & John, 2003; Gross & Thompson, 2007). The notion is that greater sensitivity and ability to recognize bodily reactions allows one to recapture and reevaluate emotional reactions. Specifically, Fustos and colleagues (2013) found that individuals with more attuned interoceptive awareness
were better able to down-regulate negative affect after viewing unpleasant pictures consisting of violent deaths, starving individuals, aimed guns, and other unsettling depictions. Increased interoceptive ability is also related to the cortical processing of emotional stimuli. In a recent electroencephalogram (EEG) study, participants viewed pleasant, unpleasant, and neutral pictures from the International Affective Pictures system (Lang, Bradley, & Cuthbert, 2008; Pollatos, Kirsch, & Schandry, 2005). Cortical processing of emotional stimuli was indicated by the participants’ P300 amplitude, an event related potential (ERP) thought to be involved in the transfer of information into consciousness (Picton, 1992). Results showed that individuals who had previously been rated as having good interoceptive awareness found the emotional slides more arousing as evidenced by greater P300 mean amplitudes compared to individuals with poor interoceptive awareness, thus providing a link between cardiac perception (interoceptive ability) and cortical processing of emotional stimuli.

Attention to bodily signals is not only implicated in one’s own emotion regulation but also in understanding the emotions of others. Indeed, one study demonstrated an increase in the neural mechanisms of empathy following an interoceptive period in which participants attended to their heartbeats (Ernst, Northoff, Boker, Seifritz, & Grimm, 2012). Specifically, participants were better able to empathize with facial expressions after an interoceptive task of tracking their own heart rate. Functional magnetic resonance imaging (fMRI) results showed increased activation in the bilateral insula – considered the interoceptive center of the brain (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004; Pollatos et al., 2005) - as well as various midline regions when the empathy
task followed the interoceptive period. Increased activity in the bilateral insula resulting in an enhanced ability to perceive body signals suggests benefits not only to self-related emotion but also comprises the neural mechanisms of empathy.

Keen interoceptive ability is also linked to informed and better decision-making. For example, individuals with high interoceptive accuracy made more frequent correct choices and engaged in less-risky decision making while completing the intuitive reasoning task (IRT); an evolved version the widely-used Iowa gambling task (Dunn, Galton, Morgan, Evans, Oliver, Meyer, Cusack, Lawrance, & Dalgleish, 2010). The Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara, Tranel, Damasio, & Damasio, 1996) and IRT measure an individual’s ability to make intuitive decisions, determined by an individual’s capability to learn the optimal behavior strategy in which to succeed in the game. One explanation for these results is that somatic changes, specifically heart rate, are relied upon when a situation, or decision, becomes increasingly complex (Werner, Jung, Duschek, & Schandry, 2009; Bechara, 2007). As proposed by Damasio’s somatic marker hypothesis, attention to body signals while making a decision can enhance learning by recognizing the way the body reacts to certain circumstances. For example, when making a risky decision, or one that may not be rewarding, the body may react before the mind. Together, the physiological changes and cognitive process dedicated to rational decision-making may ultimately increase the probability of making the “correct” decision.

Although healthy IA has been linked to better decision-making, emotional regulation, empathy, and affect regulation, aberrant IA has been implicated in both
anxiety and depression. Anxiety is the most common mental illness effecting millions of Americans above the age of 18, which is around 18% of the American population (Kessler, Chiu, Demler & Walters, 2005). Although higher IA is linked to better decision-making, cognitive reappraisal, and affect regulation, most studies have documented a positive association between IA, as measured by heartbeat perception, and anxiety symptoms (Pollatos, Traut-Mattausch, Schroeder, & Schandry 2007). Indeed, individuals with anxiety and anxiety sensitivity typically demonstrate increased IA sensitivity (Mallorqui-Bague, Garfinkel, Engels, Eccles, Pailhez, Bulbena, & Critchley, 2014; Stewart, Buffett-Jerrott, & Kokaram, 1999). In such cases, such high sensitivity to body signals may actually be detrimental to well being. However, recent studies have indicated that high IA that is maladaptive can be attributed to judgmental processing of body signals rather than oversensitivity to body signals (Farb, 2015; Yoris Esteves, Couto, Belloni, Kichic, Cetkovich, Favaloro, Moser, Manes, Ibanez, & Sedeno, 2015). For example, Yoris and colleagues (2015) assessed interoceptive sensitivity and metacognitive interoception (preconceived worries and beliefs about internal sensations) in individuals with anxiety and panic attacks compared to controls. They found that individuals with anxiety and panic attacks did not differ from controls in interoceptive ability, but did differ in metacognitive IA, in that individuals with panic attacks had increased worry about somatic markers.

Conversely, depression is linked to poorer perception of visceral signals (Dunn, Dalgleish, Ogilvie, & Lawrence, 2007; Paulus & Stein, 2010; Pollatos, Traut-Mattausch, & Schandry, 2009) The notion is that depressed individuals are not able to “feel” or use
their body’s signals to experience emotion; thus giving rise to anhedonia (Dunn, Stafanovich, Evans, Oliver, Hawkins, & Dalgleish, 2010). Given that both anxiety and depression are often comorbid, Dunn et al (2010) examined IA in individuals with symptoms of both anxiety and anhedonia. Results demonstrated that the positive association between IA and anxious arousal is moderated by anhedonia levels specifically, as anhedonia increased the relationship between IA and anxious arousal became less strong.

IA is also linked to conditions such as alexithymia and anorexia nervosa. Alexithymia can be defined as the inability to recognize emotions stemming from the “self” and can lead to dysfunction in emotional awareness, emotional regulation, social attachment, diminished imagination, and interpersonal relating (Lesser, 1981). Interoceptive awareness has been found to be significantly, negatively correlated with alexithymia symptoms (Herbert, Herbert, & Pollatos., 2011). It also has been documented that restrictive anorectics, binge-purging anorectics, purging bulimics, obese individuals with binge eating disorder, and also individuals that were obese with binge eating disorder all typically score higher on measures of IA (Fassino, Piero, Gramaglia, & Abbatae-Daga., 2004). This suggests individuals with eating disorders are somatically sensitive and may reduce caloric intake to induce “sameness” in order to dampen undesired emotion responses (Merwin, Zucker, Lacy, & Elliot, 2010). Contradictory to the previous study, it has been found that individuals recovering from anorexia nervosa experience regional cerebral blood flow changes (rCBF) associated with increased interoceptive awareness. Interoceptive awareness is also indicated in healthy sexual
function, specifically in women (Silverstein, Brown, Roth, & Britton, 2011). It was found that women who participated in a meditation laboratory aimed at increasing interoceptive awareness saw decreased reaction time to sexual images, which correlated with fewer symptoms associated with anxiety and depression.

Given the relevance of visceral signal perception to normative and disordered emotional functioning, it is important to develop reliable and valid measures of IA. A validated measure will allow for the further investigation of IA as well as a better understanding of how IA relates to both anxiety and depression. Behavioral measures of interoceptive awareness typically include perception of visceral signals, such as heartbeats (Schandry 1981; Stormer, Heiligtag, & Knoll, 1989; Whitehead, Drescher, Heiman, & Blackwell, 1977) gastrointestinal tract signals (Herbert, Muth, Pollatos, & Herbert, 2012), and signals related to respiration (Daubenmier, Sze, Kerr, Kemeny, & Mehling, 2013).

Interoceptive awareness, operationalized as the perception of heartbeats, has been traditionally assessed by either Schandry’s (1981) mental tracking test, or a heartbeat discrimination task (Stormer, Ulrich, & Joachim, 1989; Whitehead, Drescher, Heiman, & Blackwell, 1977; Yates, Jones, Marie, & Hogben, 1985). In the heartbeat discrimination task, participants are asked to differentiate between their actual heartbeats versus falsely presented heartbeats via sounds, vibrations, or light. Theoretically, individuals with higher IA should possess a greater ability to distinguish between coincident and noncoincident trials.
The hearbeat tracking task (Schandry, 1981) is the most widely used heartbeat perception paradigm which requires participants to silently count and report the number of heartbeats they experience during various intervals of time. Time intervals are typically 25, 35, and 45 seconds in length, each presented twice for a total of six trials. Participants are instructed to report how many heartbeats they perceive during each trial while an electrocardiogram (ECG) records their actual number of heartbeats. IA accuracy is determined by the comparison between the estimated number of heartbeats in a trial against the actual number of heartbeats as recorded by the ECG. In theory, individuals whose subjective reports align more closely to their actual number of heartbeats recorded during each trial are conceptualized as having greater interoceptive awareness.

Both the heartbeat discrimination and tracking tasks have advantages and disadvantages. It has been argued that the heartbeat discrimination task is better suited for studies which seek to observe the subtle difference between perception abilities while the heartbeat tracking task should be used when the words “estimation” and “perception” can be used interchangeably (Störmer, Heiligtag, & Knoll, 1989). Furthermore, the heartbeat tracking task is better suited for studies in which the extremes for very good and very poor perceivers are to be compared (Knoll & Hodapp, 1992). These two cardioperception measures have been found to correspond, especially when measuring very high and very low IA (Knoll & Hadapp, 1992). The present study employed the heartbeat tracking task as the objective measure of IA, as it is easily implemented, non-invasive, and empirically validated (Dunn et al., 2007; Dunn et al., 2010; Katkin, Wiens, & Arne, 2001; Schandry & Montoya, 1996). Fewer confounds are expected with the
Schandry task as it does not require ingestion, is less complex than introducing breathing apparatus, and is more readily able to discriminate between individuals with good and poor IA, especially at the extremes (Stormer, Ulrich, & Knoll, 1989). The heartbeat tracking task is also thought to be more reliable than the heartbeat discrimination task, as discrimination requires the use of external stimuli which can act as distraction and require other abilities besides interoception (e.g. exteroception).

Efforts have also focused on developing self-reported measures of IA; however, many current self-report questionnaires that assess IA lack reliability, validity, and a multidimensional construct (Mehling, Gopisetty, Daubenmier, Price, Hecht, & Stuart, 2009). Specifically, Mehling and colleagues (2009) argue that unidimensional operationalizations of IA are unable to detect subtle differences in IA, including the way in which individuals relate to and understand their own body signals. Indeed, recent conceptualizations of interoceptive awareness extend to include various dimensions of IA such as metacognitive interoception (i.e. reflexive beliefs and thoughts about ones own beliefs about body sensations) (Yoris et al., 2015), interoceptive coherence, interoceptive sensibility, interoceptive sensitivity and many more (Farb 2015). In their review of body awareness self-report measures, Mehling and colleagues (2009) examined 12 questionnaires intended to measure some form of body awareness. The authors noted several limitations of the current body-awareness self-report measures. First, a significant limitation is that there is no standard measurement of IA, as each questionnaire varies in its perception and evaluation of IA. Many of the questionnaires also lack structured development and possess unidimensional measures. Current self-
report IA questionnaires possessing a unidimensional construct cannot differentiate between body awareness linked to maladaptive behaviors from the non-judgmental mindful awareness of body sensations. For example, high IA can be found within two different individuals that perceive their visceral signals in completely different ways. One individual may not trust the their own body sensations, but the other may use the same sensations to guide decision making. Of all the 12 measures, the Body Awareness Questionnaire (BAQ; Shields, Mallory, & Simon, 1989) and Body Consciousness Questionnaire – Private Body Consciousness (PBCS) (Miller, Murphy, & Buss, 1981) have received the most attention in the literature. However, the PBCS and BAQ are both uni-dimensional. Specifically, the BAQ lacks attention to emotions and pain arising from the body that Mehling and colleagues (2009) found to be key in the assessment of “mindful” body awareness.

The Multidimensional Assessment of Interoceptive Awareness (MAIA), a self-report questionnaire developed by (Mehling et al., 2012), holds promise in not only measuring IA but also capturing different facets believed to comprise interoceptive awareness, which allows for a better and more comprehensive assessment of an individual’s interoceptive ability. The MAIA began development with the analysis of current self-report measures of IA from a previous study (Mehling et al., 2009), multiple expert and patient reviews, and a field test.

After the review of current self-report measures of IA (Mehling et al., 2009), an initial four dimensions were created; awareness of body sensations, quality of attention, attitude of interoceptive awareness, and mind-body integration. These four preliminary
dimensions were used as the basis of the MAIA’s construct. Awareness of body sensations encompasses the ability to identify internal sensations, which indicate the emotional/physiological state of the body. The quality of attention is a concept that allows for the distinction between maladaptive and beneficial forms of body awareness. The attitude of interoceptive awareness assesses how an individual relates to their body cues. Mind-body integration is described as emotional awareness and the “embodied self”.

The initial framework of the MAIA was then reviewed by a focus group (FG1) consisting of instructors specializing in mindfulness/body awareness practices such as body awareness therapies, yoga, Tai Chi as well as the patients from such disciplines. Their overall goal was to review and develop interoceptive concepts by discussing which items in the initial framework were considered important for their field of practice, as well as contemplating what self-assessment questions needed to be added or modified. This conceptual framework was then discussed at a conference by an expert panel that were tasked to assess: item language, items ability to assess changes in specific mindfulness modalities, the reflection of breath awareness in each dimension, and finally, items reflection of positive, negative, and neutral body sensations. This framework was then sent back to the focus group (FG2) for the purpose of reviewing items relationship with concepts. This focus group was divided into instructors and patients. The instructor group revised conceptual framework further while also creating new items and further developing item language. This was followed by further revisions made by the patient group who were instructed to rate items from 0 (useless questions) to 5 (perfect question)
in their relation to the patient’s specific mindfulness modality, as well as to delete, modify, and create items as they felt necessary. Finally, this framework was carefully assessed by the research team resulting in a pre-test in preparation for a field test.

The pre-test was based on cognitive interview testing to assess the questions’ difficulty, response choices, as well as the understanding of questions. The framework for initial field-testing consisted of awareness of body sensations, emotional reaction and attentional response to sensations, the capacity to regulate attention, trusting body sensations, beliefs about the importance, and mind-body integrations. Through field study testing of 325 participants from varying countries around the world, a conceptual construct was finalized. The five concepts developed and their measurements are the following:

1) Awareness of body sensations measured by noticing
2) Emotional reaction and attentional response to sensations as measured by not distracting and not worrying,
3) Capacity to regulate attention measured by attentional regulation
4) Awareness of mind-body integration measured by emotional awareness, self-regulation, and body listening.
5) Trusting body sensation measured by trusting.

The eight facets within the five concepts of the MAIA are intended to encompass all aspects of body awareness. The final structure of the MAIA consists of the following
scales: noticing (e.g., Awareness of uncomfortable, comfortable, and neutral body sensations), not-distracting (e.g., Tendency to ignore or distract oneself from pain or discomfort), not-worrying (e.g., Emotional distress or worry with sensations of pain or discomfort), attention regulation (e.g. Ability to sustain and control attention to body sensations), emotional awareness (e.g. Awareness of the connection between body sensations and emotional states), self–regulation (e.g. Ability to regulate psychological distress by attention to body sensations), body listening (e.g. Actively listening to the body for insight), and finally trusting (Experiencing one’s body as safe and trustworthy).

The MAIA’s finalized conceptualization and corresponding item measures were then tested against the same self-report body awareness questionnaires it was based off and followed by the analysis of construct validity in the form of differences between known groups and the incremental validity for the MAIA scales.

Research has shown that the MAIA is effective in measuring the difference between experienced and less experienced participants involved in varying mindfulness techniques such as yoga and Tai Chi (Mehling et al., 2012). All scales performed as expected; in which individuals with more experience in either yoga or Tai Chi scored better, and as expected on the MAIA’s subscales. Interestingly, the greatest difference between individuals with greater experience versus individuals with less in their respective mindfulness modalities was observed in the scales of noticing and attention regulation. The MAIA’s scales also bridge the gap between body awareness and anxiety (Mehling et al., 2012). Specifically, noticing, not distracting, not worrying, self-
regulation, trusting, and emotional awareness were able to account for the variance that is shown in the other self-report measures.

Although the MAIA has been systematically developed, is multidimensional, and has been successful tested against other self-report measures of body awareness, it has yet to be compared to behavioral measures of interceptive awareness and indicators of psychopathology. Thus, the purpose of our study was to examine the convergent validity of the MAIA by investigating its relationship to performance on the heartbeat tracking task. We hypothesized that the MAIA scales would correlate in a theoretically predictable manner with performance on the heartbeat tracking task. Specifically, higher scores on the MAIA scales (indicating positive body awareness) would be associated with higher scores on the heartbeat tracking task (indicating more accurate cardiac perception). In particular, we hypothesized that the MAIA scales of attention regulation and noticing would evidence stronger associations with cardiac perception, relative to the other MAIA scales. This is because the attention regulation and noticing scales are intended to require the skills necessary to perform well on the heartbeat perception task. Noticing and attention regulation were also noted by Mehling and colleagues (2012) to accurately distinguish between individuals with more mindfulness practice experience and individuals with less experience, suggesting that these two MAIA indices may be the most sensitive to differences in interoceptive ability. Furthermore, this study also aimed to investigate the relationships between the MAIA and the heartbeat tracking task to other behavioral and psychological measures such as the BAQ, QIDS-SR_{16}, and GAD-Q-IV. To the author’s knowledge, no study to date has examined the relationship between the
MAIA and indicators of self-reported psychopathology. We hypothesized that the heartbeat tracking task would evidence a significant, positive correlation with the BAQ. Also, in accordance with previous research, the heartbeat perception task should be positively associated with GAD-Q-IV as it is a measure of anxious symptoms and negatively with the QIDS-SR_{16} as it is a measure of depressive symptoms (Dunn, Ogilvie, & Lawrence, 2007; Stewart, Buffett-Jerrott, & Kokaram, 2001). The MAIA has not yet been investigated in clinical populations, but we hypothesized that lower scores on the MAIA's scales, indicating less body positive awareness, would correlate significantly with higher scores on the GAD-Q-IV and QIDS-SR_{16}, while correlating positively with the BAQ.
CHAPTER 2

METHOD

Participants

87 participants were obtained from a large Midwestern university (68 female, 19 male; mean age = 19.65 years, SD = 2.05). The age of the students ranged from 18 to 30 years. The ethnic make up of the sample resembled the college community and consisted of 10 African-American, 62 Caucasian, 3 Hispanic/Latino, 2 Asian, 4 biracial and 6 others. Local IRB approval was obtained for this study and all participants provided informed consent. Participants received compensation in the form of credit toward their psychology courses.

Procedure

Following informed consent, height, weight, and blood pressure measurements were recorded. Participants then completed the MAIA, in addition to other self-report questionnaires, some not included in the present analyses. Ag/AgCl sensors (Biopac Systems, Galeta California) were placed both above the left hipbone and below the right collarbone of the participant to record electrocardiogram (ECG). Physiological data were collected with a Biopac machine (Galeta, California) and AcqKnowledge (Biopac Systems, Galeta California) software. Baseline measurements and other cardio dynamics were collected for three-minutes during a resting state. Participants then completed the Schandry Task (heartbeat perception task). A live camera feed and a post-questionnaire were used to determine participant compliance with all task procedures.
*Interoceptive Awareness*

Interoceptive awareness was operationalized as accuracy of cardiac perception, as assessed by the Schandry task. Participants were required to count their heartbeats without taking their pulse or holding their breath, but instead focusing on their cardiac activity. Participants completed two blocks (three trials each) of heartbeat perception for a total of six trials: trials I and IV were 35 seconds, II and V were 25 seconds, and III and VI were 45 seconds. Participants were given a 30 second rest period between each trial. Trials were signaled by differing start and stop auditory tones. Three trials of time perception were presented in between the two heartbeat perception blocks. Participants were instructed to estimate how many seconds had passed during each trial; trials were 23, 40, and 56-seconds. Correlations between cardiac perception and perceived time determined if a participant’s accuracy was due to an ability to estimate time rather than heart beats (Dunn et al., 2010). Participants did not receive feedback regarding their accuracy on any trial.

Cardiac perception was calculated by subtracting the actual number of heart beats from the estimated number, and then dividing by the actual number of heartbeats followed by multiplying that number by one hundred \[\frac{(actual - estimated)}{actual} \times 100\]. The inverse of the equation expressed accuracy as a percent for each trial such that higher scores indicate greater accuracy and lower scores indicated lower accuracy.
**Multidimensional Assessment of Interoceptive Awareness (MAIA)**

The *Multidimensional Assessment of Interoceptive Awareness* (MAIA; Mehling et al., 2012) is a 32-item self-report questionnaire, which measures interoceptive awareness across eight dimensions. The eight scales, and an example question for each are:

- **Noticing** (“I notice where in my body I am comfortable”),
- **Non-distracting** (“I distract myself from sensations of discomfort”),
- **Not-worrying** (“When I feel physical pain, I become upset”),
- **Attention regulation** (“I can return awareness to my body if I am distracted”),
- **Emotional awareness** (“I notice how my body changes when I am angry”),
- **Self-regulation** (“I can use my breathe to reduce tension”),
- **Body listening** (“I listen to my body to inform me about what to do”), and
- **Trusting** (“I trust my body sensations”).

Each question is answered on a Likert-type scale ranging 0 (never) to 5 (always), and each scale is scored by calculating the average. Higher scores on each scale indicate a higher level of positive body awareness. Internal consistencies for the current study ranged from $\alpha = .52$ (Not-worrying) to $\alpha = .89$ (Trusting).

**Generalized Anxiety Disorder Questionnaire for DSM-IV (GAD-Q-IV)**

The Generalized Anxiety Disorder Questionnaire for DSM-IV (GAD-Q-IV; Newman, Kachin, Constantino, Przeworski, Erickson, & Cashman-McGrath, 2002) is a 9-item self-report questionnaire that incorporates and reflects the criteria for Generalized Anxiety Disorder as stated by the DSM-IV (APA, 1994). Most of the questionnaire is dichotomous (YES/NO) and assesses the presence of GAD criteria, such as excessive worry. One question is open-ended as to assess the participant’s most frequent worrying
topics. Lastly, two questions are rated from zero (“None”) to eight (“Very severe”), which measures functional impairment and subjective distress. Findings indicate that a 7.67 represents the optimal cut off score when screening individuals likely to meet clinician-assessed diagnosis of GAD (Moore, Anderson, Barnes, Haigh, & Fresco, 2013). Internal consistency for the current study was .87.

**Quick Inventory of Depressive Symptomology Self Report (QIDS-SR16)**

The Quick Inventory of Depressive Symptomology Self Report (QIDS-SR16; Rush, Trivedi, Ibrahim, Carmody, Arnow, Klein, Markowitz, Ninan, Kornstein, Manber, Thase, Kocis, & Keller, 2003) is a brief self-report questionnaire taken from Inventory of Depressive Symptomology (IDS; Rush, Giles, Schlesser, Fulton, Wissenburger, & Burns, 1986; Rush, Gulion, Basco, Jarrett, & Trivedi, 1996) that consists of 16-items that assess the 9 diagnostic symptoms domains that make up a depressive episode according to the DSM-IV (APA, 1994). Items are rated from 0 (absence of a specific symptom in the past week) to 3. Totaled scores can range from 0 to 27 with severity of rated as the following: mild (6-10), moderate (11-15), severe (16-20), and very severe (≥ 21) (Rush et al., 2003). Internal consistency for the current study was .68 and was.73 to .92 in the original article (Rush et al., 2003).

**Body Awareness Questionnaire (BAQ)**

The Body Awareness Questionnaire (BAQ; Sheilds, Mallory, & Simon, 1989) is 18-item self-report measure that measures attentiveness to normal and nonemotive body
processes. Specifically, the total score reflects sensitivity to body cycles, rhythms, changes in normal functioning, the ability to detect subtle changes in normal function as well as the ability to anticipate bodily reactions. Responses are given from 1 (not at all true of me) to 7 (very true of me).
CHAPTER 3
RESULTS

Data were cleaned using SPSS version 22. Two outliers were removed from the Schandry task (Z-scores > 3 SDs from mean), two participants had missing data, and eleven participants’ data from the heartbeat perception task were unusable due to unusable ECG data (e.g., noise artifacts, non-compliance). First, comparisons were made between the original Mehling and colleagues (2012) study and the current study, including comparisons of means, standard deviations, and reliability. Table 1 presents means and standard deviations. Assessments of internal consistency, Chronbach’s alpha, revealed that the majority of scales demonstrated adequate to excellent reliability, except for noticing and not-worrying. Overall, internal consistencies ranged from $\alpha = .52$ (Not-worrying) to $\alpha = .89$ (Trusting). Table 2 presents a comparison of internal consistencies between the current study and Mehling and colleagues (2012) study. Descriptive characteristics of blood pressure, BMI, subjective fitness level, GSR, resting heart rate, as well as performance on the Schandry task are reported in Table 3.

Correlational analyses were conducted to investigate the relationship between the MAIA scales and performance on the Schandry task. Schandry task performance did not significantly correlate with any of the MAIA scales. However, several intercorrelations among MAIA scales were observed as seen in Table 4. Correlational analyses were also conducted to investigate the relationship between the MAIA and the Body Awareness Questionnaire (BAQ; Shields et al., 1989). Noticing, attention regulation, emotional
awareness, self-regulation, body listening, and trusting all correlated significantly with the BAQ, while non-distracting and not-worrying did not, also seen in Table 4. The MAIA scales emotion regulation $r(83) = .56 \ p < .01$ and body listening $r(80) = .48 \ p < .01$ had the strongest correlations with the BAQ. Further correlational analysis of IA (heartbeat tracking task) with both the QIDS-SR$_{16}$ ($M = 6.91$, $SD = 3.93$, range 2 – 20) and GAD-Q-IV ($M = 5.05$, $SD = 3.23$, range 0 – 12.25) showed significant negative correlations as seen in table 5. Finally, MAIA total score correlated significantly with the BAQ $r(79) = .61 \ p < .001$, but not with self-reported depression or anxiety; QIDS-SR$_{16}$ $r(74) = -.12 \ p > .05$, GAD-Q-IV $r(74) = -.06 \ p > .05$.

Tests of dependent correlations were conducted to determine the relative strength of correlation between the heartbeat perception task, MAIA subscales and various criteria of interest. Table 5 presents dependent correlational analyses investigating the criterions BAQ, QIDS-SR$_{16}$, and GAD-Q-IV and their relationships with both IA and the eight MAIA indices. Heartbeat perception was more strongly related to self-reported depression, relative to MAIA subscales noticing and emotional awareness. The MAIA scales noticing, body listening, emotional awareness, self-regulation, and trusting were more strongly associated with the BAQ than the heartbeat perception task, while the heartbeat perception task was more strongly associated with scores of self-reported anxiety, specifically, more than the MAIA domains of noticing and emotional awareness.
CHAPTER 4
DISCUSSION

The present study aimed to explore the relationship between the Multidimensional Assessment of Interoceptive Awareness (MAIA) with a well-validated heartbeat perception task. In the current study, 87 participants completed the MAIA and an objective measure of IA, the Schandry mental tracking task, in addition to the Body Awareness Questionnaire (BAQ) and measures of self-reported depression and anxiety symptoms. We hypothesized that better performance on the Schandry task, indicating high interoceptive awareness, would be associated with high scores on the MAIA scales indicating positive body awareness. Specifically, the scales of noticing and attention regulation were expected to be highly, positively correlated with the scores on the Schandry task. Correlational analyses did not reveal a significant association between the MAIA and the heartbeat perception task. However, the MAIA scales (except not-worrying and non-distracting) evidenced significant associations with the BAQ, whereas the heartbeat perception task unexpectedly did not demonstrate a significant association with the BAQ. Interestingly, the heartbeat perception task did correlate significantly, and negatively with both depression and anxiety measures (QIDS-SR16 and GAD-Q-IV) while only the MAIA scales of noticing, not-worrying, and trusting correlated significantly with self-reported anxiety and only the scales of non-distracting, not-worrying, and trusting correlated significantly with self-reported depression.

The MAIA’s noticing domain was developed to assess an individual’s ability to perceive body sensations, which is important when trying to “feel” your heart within the
body. Attention regulation was also hypothesized to positively correlate with the heartbeat perception task, as it is theorized to measure the ability to direct attention to one’s body signals, which is crucial to tracking heart rate. The combination of both noticing and attention regulation seem to be essential to perform well on the heartbeat perception task. Contrary to our hypothesis, it was found that the heartbeat perception task did not significantly correlate with any of the MAIA scales. From the present investigation, one explanation for the results is that the MAIA and the heartbeat perception task are not measuring the same facets of IA.

The results of the current study suggest that the heartbeat perception task and the MAIA assess distinct, or unrelated aspects of interoception. For example, in the process of creating the scales of the MAIA, two different forms of IA were proposed: non-judgmental IA and IA linked to maladaptive behavior (Mehling et al., 2009; Mehling et al., 2012). Given that performance on the Schandry task simply reflects the degree to which individuals are aware of their own heartbeats, there remains no a priori reason why performance on this task would also capture non-judgmental or maladaptive aspects of interoception. It is possible that the MAIA may provide a more comprehensive assessment of an individual’s interoceptive ability as a participant may score low on one dimension of the self-report questionnaire assessing pure detection ability, but higher on another dimension assessing the way in which the individual interprets body signals. In this instance, the Schandry task would be limited in its ability to assess interoception. Precisely, heartbeat perception tasks are not equipped to assess the way in which an individual appraises body signals (e.g. non-judgmental vs. judgmental; adaptive vs.
maladaptive). This may explain previous findings suggesting that mindfulness training does not improve IA based from cardioperception. A more comprehensive assessment of IA can provide explanations for previous research that has not been able to pick up differences in IA, especially after mindfulness training (Khalsa, Rudrauf, Damasio, Davidson & Tranel, 2008). This may be possible as the MAIA was partially constructed by teachers as well as patients in differentiating mindfulness techniques (Mehling et al., 2012).

Although our hypothesis was not supported, the MAIA performed similarly to Mehling et al. 2012’s study shown by chronbach’s alpha, mean, and standard deviation score comparisons. The MAIA also performed well against other self-report measures of IA during the present investigation. For instance, when compared to the Body Awareness Questionnaire (BAQ) many of the MAIA subscales correlated significantly suggesting that the MAIA performed as an indicator of body awareness. The performance of the heartbeat perception task was further supported in this study by its negative significant correlation with the QIDS-SR_{16} (depression measure). Lower IA has been linked to depression and depression symptoms in previous research (Dunn et al., 2007; Paulus & Stein, 2010; Pollatos et al., 2009). Finally, the heartbeat perception task also correlated significantly with the GAD-Q-IV (anxiety measure), but the correlation was not positive as previous studies would suggest, as high IA has been found in individuals with anxiety and anxiety sensitivity (Mallorqui-Bague, et al., 2014; Pollatos et al., 2007; Stewart et al., 1999). As previously mentioned, metacognitive IA may account for the relationship between high IA and anxiety symptoms; perception of somatic markers may be as
important in psychopathology as actual interoceptive ability (Yoris et al., 2015).
Specifically, Yoris et al. (2015) found that controls and participants with anxiety and panic did not differ in IA ability, but did differ in the way they perceived somatic markers. Thus, one explanation for the finding in the current study that anxiety was negatively associated with IA is that the current sample did not maintain, on average, negative beliefs and worries about their body signals. However, future studies should seek to measure metacognitive IA to test this relationship.

Dependent correlational analyses conducted to determine the strength of the relationship between the heartbeat perception and MAIA subscales against measures of self-reported anxiety, depression, and body awareness yielded interesting results. First, heartbeat perception was found to be more strongly associated with self-reported depression than the MAIA scales of noticing and emotional awareness suggesting that heartbeat perception may be a better indicator for depressive symptoms. Similarly, heartbeat perception more strongly associated with self-reported anxiety when compared to the MAIA scales of noticing and emotional awareness, suggesting again that heartbeat perception is a stronger indicator of self-reported anxiety symptoms. Conversely, the MAIA scales, noticing, emotional awareness, self-regulation, body listening, and trusting were all more strongly related to self-reported body awareness, suggesting that MAIA may be a better indicator of overall body awareness. Taken together, it would appear that performance on a heartbeat perception task is more indicative of psychopathology, whereas scores on the MAIA are more indicative of actual body awareness.
The results of the current study should be considered in light of its limitations. First, the participants in the present study were mostly Caucasian women of college age, which is strikingly different than the sample used to construct and test the MAIA. Specifically the MAIA included experts and patients in a variety of mindfulness practices. The sample was endorsed levels of depression in the mildly depressed range as assessed by the QIDS-SR16. The Schandry task has also recently been criticized for its rating of cardioperception (Ring, Brener, Knapp, & Mailloux, 2015); specifically, Ring at al. (2015) demonstrated that performance on the heartbeat perception task could be modulated by false feedback.

Future research should examine associations between the MAIA against other existing objective measures of IA such as the water load or breathing tasks. For example, the MAIA’s development included breathing awareness into each domain suggesting that the breathing task may hold the ability to better assess IA and it’s relation to the MAIA. It also may be the case that generalization of overall IA capabilities driven by one body sensation may not be feasible. Given that interoception has been found to extend across modalities, a more reliable measurement may include a task, which assesses visceral signal perception across body systems (Ceunen, Van Diest, & Vlaeyen, 2013). Given the differential effects of interoceptive ability in depression and anxiety, future studies should also assess the MAIA’s findings in depression and anxiety, which are associated with differential effects on interoceptive ability (Dunn et al., 2010).

Overall, the results for the current study did not evidence an association between heartbeat perception and the MAIA indices. This study was not able to validate the
MAIA with a heartbeat perception task; however, the MAIA performed comparably to Mehling et al (2012)’s original study. The MAIA’s future utility in understanding interoceptive awareness as a multi-faceted construct still holds promise, however further investigation is required to elucidate the relationship between the MAIA and heartbeat perception.
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<tr>
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<tr>
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<tr>
<td>Self-Regulation</td>
<td>3.79 (.74)</td>
</tr>
<tr>
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<tr>
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<td>Mehling et al., 2012</td>
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<td>62.85 (16.86)</td>
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Key: IA = Interoceptive Awareness  
BMI = Body Mass Index  
Resting HR = Resting Heart Rate  
BP = Blood Pressure  
GSR = Galvanic Skin Response
### Table 4. Correlational Analysis

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**Key:** *denotes significance to the .05 level, **denotes significance to the .01 level

IA = Interceptive Awareness
BAQ = Body Awareness Questionnaire
QUID = Quick Inventory of Depressive Symptomology Self Report
GADQIV = Generalized Anxiety Disorder Questionnaire for DSM-IV
Table 5. Dependent Correlational Analysis

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Key: BAQ = Body Awareness Questionnaire
QUID = Quick Inventory of Depressive Symptomology Self Report
GADQIV = Generalized Anxiety Disorder Questionnaire for DSM-IV
IA = Interceptive Awareness
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